Agroforestry Systems (2006) 66:151–164
DOI 10.1007/s10457-005-6074-1

Indigenous agroforestry systems in Amazonia: from prehistory to today

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Received 24 August 2004; accepted in revised form 18 April 2005

Key words: Amazonian Indians, Fruit tree domestication, Homegardens, Indigenous knowledge

Abstract

Understanding the historical development of indigenous systems will provide valuable information for the design of ecologically desirable agroforestry production systems. Such studies have been relatively few, especially in Amazonia. The agroforestry systems in Amazonia follow a trail that begins with the arrival of the first hunter-gatherers in prehistoric times, followed by the domestication of plants for agriculture, the development of complex societies rich in material culture, the decimation of these societies by European diseases, warfare, and slavery, the introduction of exotic species, and finally, the present-day scenario of widespread deforestation, in which agroforestry is ascribed a potential role as an alternative land use. Despite the upheavals which occurred in colonial times, greatly reducing the population of native tribes, a review of anthropological and ethnobiological literature from recent decades indicates that a great variety of indigenous agroforestry practices still exist, ranging from deliberate planting of trees in homegardens and fields to the management of volunteer seedlings of both cultivated and wild species. These practices result in various configurations of agroforestry systems, such as homegardens, tree/crop combinations in fields, orchards of mixed fruit trees, and enriched fallows. Together they constitute a stock of knowledge developed over millenia, and represent technologies that evolved along with the domestication of native forest species and their incorporation into food production systems. This knowledge is the basis for the principal agroforestry practice employed by farmers in Amazonia today, the homegarden, and has potential to contribute to the development of other agroforestry systems.

Introduction

Until the 1980s, the prevalent model for the human ecology of indigenous populations in the Amazon Basin postulated that environmental factors such as poor soils and low density of wild game and fishery resources constrained population sizes, limiting the pattern of human occupation to small villages. The presence of large archeological sites in locations such as Marajó Island, in the mouth of the Amazon, and other locations along the main river course, was thought to be an anomaly, the result of populations that migrated down river from an Andean origin and occupied more fertile floodplain soils (Meggers 1971). This model of human ecology and social organization in the Amazon Basin is reflected in the works of the influential French anthropologist Claude Levi-Strauss, who classified native societies as 'hot' or 'cold,' with Amazonian tribes being good examples of 'cold' societies, characterized by a lack of hierarchy and social stratification, existing in a timeless equilibrium of nature and society (Wiseman and Groves 2000). Recent revisions of

Amazonian prehistory, however, have discarded this conceptual model, indicating instead that Amazonia supported much larger populations than previously imagined, and that cultural development was autocthonous, perhaps beginning with peoples who colonized the floodplain following migrations from the coastal regions north of Amazonia (Roosevelt 1994). The re-examination of chronicles written by the first European explorers, as well as current archeological research, support this new scenario and show that Amazonia was the location for significant cultural development, with large population complexes occupying the margins of the main rivers and developing an elaborate material culture and extensive trade networks. These peoples possessed agricultural systems based on a great variety of cultivated plants, including fruit trees, and various food storage technologies. Although these native Amazonian populations were decimated by the combination of introduced diseases, warfare, and slavery that accompanied European conquest, many elements of their agricultural and agroforestry systems have persisted, and continue to be a part of the agricultural practices of indigenous peoples until today.

In modern-day Amazonia, increasing deforestation for establishment of pastures has become an issue of global concern due to its impacts on biodiversity, climate, and local and regional hydrological cycles. Forms of land-use employing agroforestry practices could provide an alternative scenario and help to optimize land use (Smith et al. 1995; Schroth et al. 2004), and agroforestry as a sustainable form of land use is attracting increasing attention on all levels, from the small farm to the federal government. However, besides policies to ensure that agroforestry extension, investment capital, and planting material are available to settlers when they make land-use decisions, efforts to increase the adoption of perennials on Amazonian farms must first be concerned with the identification of economically and ecologically viable species that can be combined into production systems. An important step in this direction is the analysis and evaluation of existing agroforestry systems, combined with an understanding of their historical context. As a contribution to this effort, this paper provides an interpretation of the origin of agroforestry in Amazonia, based on historical records and other sources, as well as an analysis of traditional practices of tree cultivation employed by indigenous tribes of the region. Homegardens and agroforestry systems that have evolved to commercial importance following colonization, such as 'agroforests' based on the açaí palm (*Euterpe oleracea*) in the Amazon estuarine region and shaded plantation systems of commodity crops such as cacao (*Theobroma cacao*) and coffee (*Coffea arabica*), will also be discussed with regards to their relationship to indigenous systems.

Fruit trees in Amazonian prehistory

Archeological evidence indicates that pre-ceramic foraging populations were living at various sites in Amazonia between 11,000 and 10,000 years before present (b.p.). Initial occupation of the Pedra Pintada Cave near Monte Alegre, Pará, Brazil, is estimated to be from 11,200 to 10,500 b.p., and excavations there have uncovered carbonized tree fruits, wood, and faunal remains, revealing a broad-spectrum economy of humid tropical forest and riverine foraging (Roosevelt et al. 1996). In other parts of the lowland neotropics (Colombia, Ecuador, Panama, and Peru), archeological and paleobotanical research indicates that there was an intensification of practices surrounding plant exploitation and human interference with the environment between 10,000 and 8600 b.p. (Piperno and Pearsall 1998). These practices resulted in forms of horticulture emphasizing both native tubers and seed plants, and probably also involved the deliberate planting or management of trees. Whether the appearance of agriculture was related in any way with the concurrent extinction of a suite of large mammals, the Pleistocene 'megafauna,' is a question that remains open. In any case, by 7000 b.p. larger scale food production had emerged in Central America, with the cultivation of substantial areas, or fields, away from houses (Piperno and Pearsall 1998). In a site in Rondônia, Brazil, where human occupation by hunter-gatherers dates to 9000 b.p., vestiges of agricultural activity, in the form of processing utensils, begin to appear around 4500 b.p. (Miller 1992).

At some time in the past, a number of native fruit trees were domesticated and incorporated into prehistoric agricultural systems. It is possible that

this occurred initially through the 'dump heap' (*sensu* Anderson 1952) or incidental route to domestication, in which seeds of edible fruits collected in the forest were discarded near dwellings, as was observed at Pedra Pintada Cave. Notwithstanding, at some point keen observation and experimentation likely took the fore in tree domestication. While Lathrap (1977) believed the house garden of fruit trees and other useful plants to be the locus of agricultural experimentation, with root and tuber crops initially introduced as minor additions to the food supply, Piperno and Pearsall (1998) suggest that the primary focus of early agricultural systems in the neotropics was on carbohydrate-rich root or tuber crops, with trees as secondary components. For horticultural crops, advances in archeological methods, such as the botanical identification of the sources of starch grains on stone artifacts (Piperno et al. 2000), and the combined use of genetics and archeology have allowed a relative dating of domestication, as in the case of the sequence of domestication of the corn (*Zea mays*) – beans (*Phaseolus* spp.) – squash (*Cucurbita* spp.) trinity reported by Smith (2001) for Mexico and North America. For neotropical tree crops, however, less information is available. It is likely, though, that the domestication of trees went hand-in-hand with root-crop domestication, as the maintenance of gardens nearby dwellings would have provided an ideal location for the establishment of useful tree species from discarded seeds. The recognition and management of such 'volunteers' would have been the first step along the road to their domestication.

The early horticulturalists initially left sites of modest size, indicating small but stable settlements. By 3000 – 2000 b.p., however, larger villages of many hectares existed on the middle and lower Orinoco River in Venezuela. By 2000 years ago, large, socially stratified chiefdoms exhibiting elaborate ceremonial art and well-established trading networks were thriving along the principal rivers of Amazonia (Roosevelt 1994). These societies were described by the Jesuit friar Gaspar de Carvajal in his account of the first European exploration of the Amazon. Carvajal accompanied Francisco Orellana's expedition, which set out from the Napo River in Peru and traveled down the Amazon to its mouth in 1541 – 1542, encountering villages of very large size, with substantial stores of food, namely manioc (*Manihot esculenta*) bread, maize (=corn, *Zea mays*), dried fish and penned turtles (Carvajal 1970). It is possible that other means of storing foods seen today in Amazonia, such as fish flour (*piracuí*) and peach palm (*Bactris gasipaes*) flour, also were in use, but were not registered by the expedition.

Almost 100 years later, in 1639, the Jesuit priest Cristobal de Acuña found a similar scenario while descending the Amazon. He described the province of the Omagua nation as extending for more than 200 leagues (1 league = 4.5 to 5.0 km), with many villages, and one village of the Yorimane nation extending for more than one league along the riverbank (Acuña 1994). Based on various historical sources and remote sensing imagery, Porro (1996) estimated the Omagua population to be around 18,000 persons at that time. In less than 100 years after Acuña's report, however, the great chiefdoms along the Amazon had succumbed to epidemics of imported diseases, enslavement and missionization, and their sophisticated culture and political and trade networks had collapsed and large stretches of the main river and its tributaries were totally deserted (Daniel 1976).

The historical accounts that record the impressions of the first Europeans to travel the Amazon provide only scant information on the nature of the indigenous agroforestry systems existing at that time. Carvajal, for example, mentions only that 'much fruit of all kinds' was found in one village, and that the road leading to another village was planted to fruit trees on one side and the other (Carvajal 1970). Acuña records that along with the staple crops of manioc, sweet potatoes (*Ipomea batata*), yams (*Dioscorea* sp.), and others, the Indians cultivated pineapple (*Ananas comosus*), guava (*Psidium guajava*), abiu (*Pouteria caimito*), Brazil nuts (*Bertholletia excelsa*) and 'bananas.' This last mention is intriguing, as the true banana (*Musa* sp.) is reported to have arrived in the Caribbean in 1516 (Oviedo and Valdéz 1959). However, the existence of efficient trade networks linking the chiefdoms of Amazonia with surrounding regions is the most likely explanation for the appearance of this important exotic crop. Acuña also praised the plantations of cotton (*Gossypium* sp.) and tobacco (*Nicotiana tabacum*), with an eye to their potential for commerce, as well as the numerous medicinal plants (Acuña 1994).

Although the great chiefdoms had disappeared by the time the Portuguese became firmly established in Amazonia, accounts by the chroniclers of

the colonial period do offer more detail and give us a better idea of what pre-Columbian agriculture may have been like. Father João Daniel's two-volume tome, written between 1757 and 1776, and based on his 17 years in Amazonia, describes in detail indigenous methods of slash-and-burn agriculture with stone axes, and mentions some of the fruit trees cultivated. The abiu, for example, was described as one of the most commonly cultivated fruits. The custard apple (*Annona squamosa*) and the biribá (*Rollinia mucosa*) are listed as dooryard fruits (*fructos hortenses*), and the cashew (*Anacardium occidentale*) as the fruit most cultivated by both 'wild' and 'tame' Indians, with several varieties, distinguished by color, size, and acidity. The cashew was also said to grow in great abundance in sandy areas, beaches, and riverbanks. Two types of genipap (*Genipa americana*) were distinguished, a large-fruited cultivated variety, and a smaller wild one. The guava was described as cultivated, but also growing spontaneously in savannas and open areas. Papaya (*Carica papaya*) was described as growing anywhere, without any special care. Indians grew passion fruit (*Passiflora edulis*) on trellises in their fields. Some other species, such as the various species in the genus *Inga*, the pitomba (*Talisia esculenta*), and the ginja (identity unknown, perhaps *Eugenia uniflora*), are also mentioned, although no details are given about their cultivation. Nevertheless, it is probable that these were also cultivated, as other fruits such as the mangaba (*Parahancornia mangaba*), the cupuí (*Theobroma subincanum*) and sorva (*Couma utilis*) are specifically described as wild fruits (Daniel 1976).

The Brazilian naturalist Alexandre Rodrigues Ferreira, employed by the Portuguese crown to scientifically explore the Amazon from 1783 to1792, found that despite the colonial decimation of native peoples, a richness of indigenous material culture still existed, as shown in his portraits of members of the Yurupixuna and Mura tribes (Figures 1a, b). Ferreira described the peach palm as highly appreciated, and one of the first trees do be planted by farmers in front of their houses and in their fields. Indians planted them around their villages, and for river travelers, the tall palms seen from afar were sure signs that human habitation was near (Ferreira 1972). The palms depicted growing next to a Curutu village, on the Japurá river, are most likely peach palms (Figures 1c). This is probably the first visual record of an Amazonian homegarden!

Although the paucity of historical records does not permit us to know the full extent to which trees were cultivated by pre-Columbian societies in Amazonia at the time of European conquest, the few documents that do exist indicate that many forest fruits had been domesticated. It is also possible that many more species were in a state of incipient domestication (Clement 1999a). A number of commonly cultivated Amazonian fruit trees have the characteristics of long periods of selection and genetic improvement. Clement (1989, 1999b) suggests a center of crop diversity in Western Amazonia, based on the genetic diversity of fruit tree domesticates, such as abiu, South American sapote (*Quararibea cordata)*, peach palm, biribá, mapatí (*Pourouma cecropiifolia*), and araçá-boi (*Eugenia stipitata*). The domestication and genetic improvement of native fruit trees also occurred in other locations around Amazonia. Clement (1989) cites guaraná (*Paullinia cupana* var. *sorbilis*) from the Maués region, in Amazonas, and murici (*Byrsonima crassifolia*), from the region of Santarém, Pará. In the Parakanã Indian Reserve (Pará), murici trees planted from seeds obtained from a regional market bear fruit in a variety of shapes, sizes, and flavor, a possible indicator of a past selection process (RPM, pers. obs.). Large pajurá fruits (*Couepia bracteosa*), sold in the Manaus market, much larger than those produced by wild forest trees, also come from the Santarém region (Ducke 1946 and RPM, pers. obs.). Inhabitants of Alter-do-Chão, a region of savanna near Santarém, are reported to cultivate a number of cashew varieties, each with a specific use (I.S. Miranda, pers. comm. 1989). Populations of cashew growing in the savannas of Roraima are possibly of pre-Columbian origin (A. A. Weiduschat, pers. comm. 1999). The breeding of a 'precocious' variety of cashew in the Northeast of Brazil, the principal cashew-growing region of the country, was based on genetic material from Amazonas (Barros et al. 2002). The cashew traditionally cultivated by the Waimiri Atroari tribe, whose territory straddles parts of the states of Amazonas and Roraima, generally fruits in less than 1 year after planting from seed (RPM, pers. obs.). Early bearing may be an indicator of genetic selection and domestication, and is observed in some varieties of abiu.

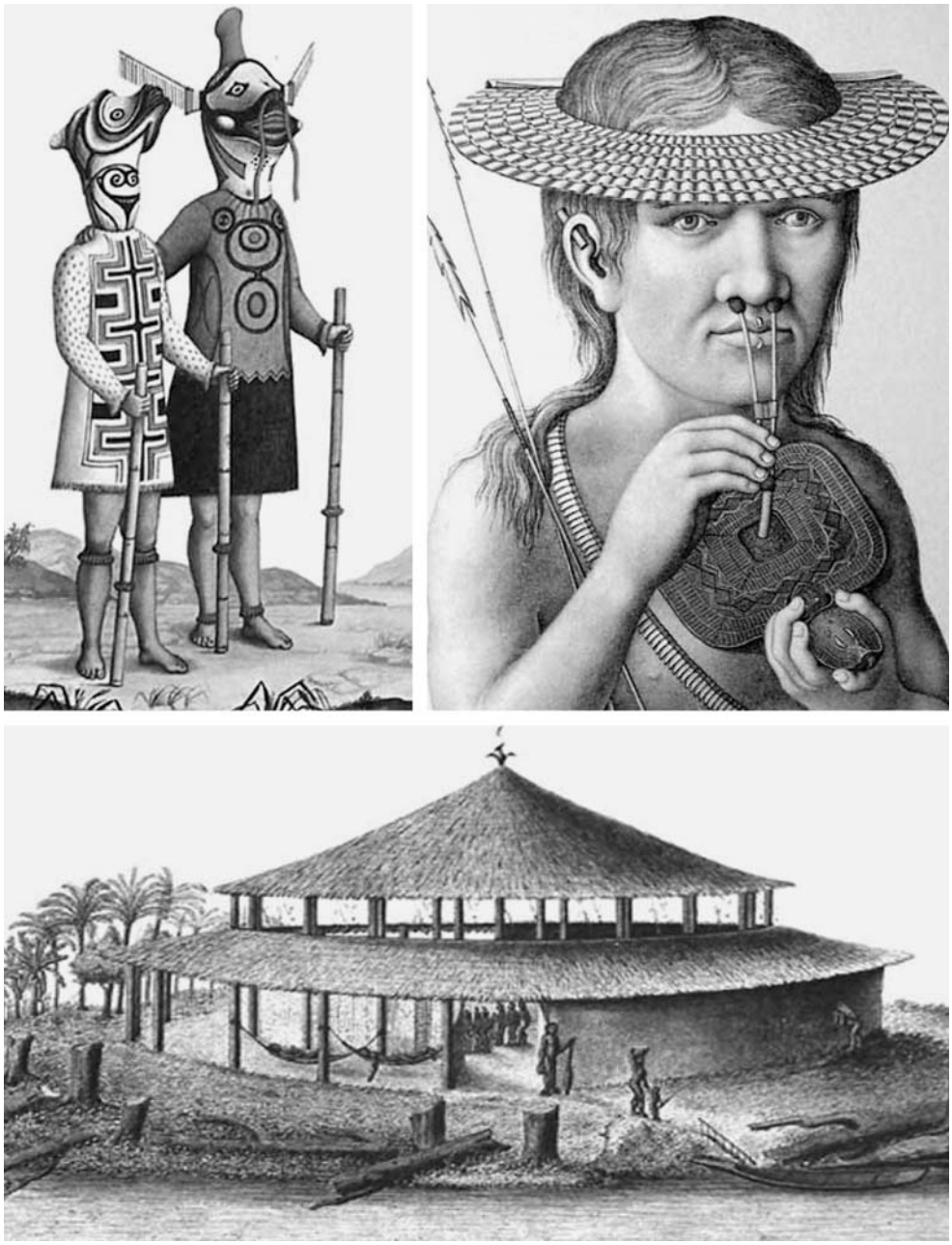

Figure 1. Images from Alexandre Rodrigues Ferreira's *Viagem Filosófica pela Capitanias do Grão-Pará, Rio Negro, Mato Grosso e Cuiabá (1783–1792)*: a-Ritual masks of the Ticuna Indians; b-Mura Indian with tobacco snuff; c-Village of the Curutu Indians.

Macambo fruit and trees (*Theobroma bicolor* H&B) in the Peruvian Amazon, popular in agroforestry systems there and in urban markets also exhibit distinct characteristics of domestication. Wild varieties are softer-husked and smaller, while domesticated trees bear very quickly and in more abundance, with harder and larger fruits. Detribalized ribereños still practice selection today with this popular fruit (J. Penn, pers. comm. 2005). Similar variation occurs with the tucumã palm (*Astrocaryum tucuma*), whose fruits exhibit differences in pulp thickness, presence of fibers, color and taste. A five-fold difference in wholesale prices between mediocre and superior tucumã

fruits has been observed in the markets in Manaus, and farmers readily identify palms that consistently bear better fruit (J. van Leeuwen, pers. comm. 2004).

Given the lack of solid historical accounts about agroforestry practices in Amazonia at the time of European contact, i.e., how the trees were actually cultivated and managed, perhaps the next best possible source of information is the agricultural practices of modern day indigenous peoples. This approach will be discussed in the following section.

Traditional indigenous agroforestry systems

In light of historical and archeological evidence for the existence of complex and stratified societies in Amazonia, the use of the lifestyles of modern day indigenous groups as a model for either Paleolithic adaptations or for a pre-Columbian scenario must be used with caution (Roosevelt 1989; Roosevelt et al. 1996). A more likely model is that modern tribal groups represent the fragments of populations and cultures that survived and regrouped following the colonial decimation. Agricultural systems relying on a number of domesticated plants also appear to have survived the social upheavals caused by European conquest. Clement (1999a) identified a list of at least 138 species of plants that were under cultivation or management at the time of European arrival in Amazonia, of which 68% are trees or woody perennials. An indicator of how complex the pre-Columbian agricultural systems may have been is the number of varieties of crop plants observed in modern-day indigenous fields. Chernela (1986), for example, recorded 137 cultivars of manioc in two Tukano villages in the Upper Rio Negro region of Amazonas, Brazil, and described the social practices associated with their distribution and maintenance.

Whether the specific cultivation methods employed by contemporary indigenous groups are the same as those of their ancestors is a difficult question to answer. Nevertheless, it is probable that the complex indigenous agroforestry systems described in the ethnobiological literature of the past few decades are direct descendants of the systems in existence prior to European arrival. Examples of these indigenous agroforestry systems and the species involved are given in Table 1. These systems involve one or more of the following practices:

- Fruit trees and other useful plants are planted and managed around houses;
- Seedlings are grown in house gardens for transplanting to fields;
- Useful tree species are spared when forest and old fallows are cleared for agriculture;
- Seedlings of useful forest species that regenerate in agricultural plots are spared during weeding;
- Seeds of fruit trees are interplanted with staple crops, dispersed haphazardly around houses, or planted along trails in old swiddens and forest clearings.

These various practices may result in several configurations of fruit tree establishment, such as the homegarden of fruit trees and other useful condiments and medicinal plants grown in close proximity to the house, a belt of fruit trees surrounding a village, fruit trees interspersed with field crops, orchards of mixed fruit trees, and fallows of forest species enriched with fruit trees. These last configurations have been termed 'swidden-fallow agroforestry' (Denevan and Padoch 1987).

Although there has been a great deal of recent attention given to the idea of extensive 'anthropogenic forests' in Amazonia, attributed to the activities of past indigenous populations, little concrete evidence has been presented to support this hypothesis, which has been constructed mainly on the work of Posey (1985, 1993) and Balée (1989). Balée's assessment of the vegetation types that would represent such anthropogenic forests is highly speculative and needs further corroboration from the disciplines of plant ecology and plant geography. Posey's study of the creation and management of forest islands in savanna by the Kayapó Indians was challenged by Parker (1992, 1993), and in fact, such forest islands are typical features of the dynamic transition zones between forest and savanna biomes around the world. Subsequent supporters of anthropogenic forests have contributed little in terms of explanations of the mechanisms by which such forests may have been created on a large scale. A more likely model is that prehistoric human occupation in Amazonia generated aureoles of anthropogenic vegetation around

Table 1. Examples of [@]fruit tree cultivation by indigenous communities in Amazonia.

Ethnic group	Practices
Amuesha [eastern Peru]	Old fruit trees are left in fields cleared from fallows. Cacao is planted under plantains, then underplanted with ice-cream bean. Yard gardens had up to 26 species providing an edible product (excluding herbs, medicinals, etc.); families with more diverse yard gardens had less diverse agricultural fields (Salick and Lundberg 1990).
Andoke and Witoto [southeast Colombia]	Papaya is planted between buttresses of tree stumps or in locations with abundance of ash. Other fruit trees are interplanted with initial manioc crop, with an average density of 363 trees/ha, and reach greaest production 5–10 yrs. after initial field establishment. Yard gardens next to houses include most of the tree species found in fields, along with condiments and other useful plants (Eden and Andrade 1987).
Bará [Colombia/ Brazil]	Men plant fruit trees, both in fields and close to the longhouse. Species include peach palm, mango, papaya, lime, caimito, uvilla, ice-cream bean. Other cultivated species include coca, calabash tree, yagé and tobacco (Jackson 1983).
Barí [eastern Peru]	Banana plants composing outer ring of agricultural field may be interplanted with avocado and annato (Beckerman 1983).
Bora [eastern Peru]	Agricultural plots include 10 or more species of fruit trees, as well as coca and barbasco. Fruit trees are planted as seeds or seedlings amid manioc plants. In the initial clearing of the forest, important fruit and other trees (e.g. West Indian cedar) tend to be protected. During weeding, seedlings of useful trees are often spared (Denevan and Treacy 1987).
Campa [eastern Peru]	Tree and shrub crops are inserted well after initial planting of the field. Some fruit trees germinate from seeds discarded after fruit are eaten near the houses (Denevan 1971).
Candoshi [eastern Peru]	Papaya is planted in the fields. Medicinal plants and condiments are grown adjacent to houses in a bare-earth yard (Stocks 1983).
Cocama [western Amazon, Brazil]	When secondary forests (fallows) are felled and burned for agriculture, individual Brazil nut trees are protected from fire damage by an encircling ring of uncut vegetation. This vegetation is removed afterwards (H.S. Pereira, pers. comm. 1992).
Cocamilla [eastern Peru]	Dooryard gardens emphasize plantains and bananas as well as condiments and medicinals (Stocks 1983).
Desana [Colombia/ Brazil]	Peach palm, avocado, papaya and custard apple are found near the communal dwelling in a semi-cultivated state. Cotton, tobacco and barbasco are also cultivated (Reichel-Dolmatoff 1971).
Jivaro [eastern Peru]	Fruit trees such as peach palm, papaya and others are cultivated along with staple crops in fields (Boster 1983).
Kayapó [eastern Amazon, Brazil]	Papaya is planted near or in the middle of groups of banana plants, and may be grown in a nursery next to the house and transplanted when 40–100 cm high. Brazil nuts are planted in forest clearings. Several species of fruit trees are planted in trails in old swiddens. Ashes, termite and ant nests, and spoiled fish flour are used as fertilizer (Posey 1985).
Ka'apor [eastern Amazon, Brazil]	After houses are established in a new swidden plot, the area around the houses is planted to a number of fruit trees and useful plants (a total of 66 species) Baleé (1993).
Machiguenga [southeast Peru]	70 species of plants are cultivated in house gardens for teas, relishes, medications and crafts (Johnson and Behrens 1982).
Siona-Secoya [Ecuador]	Peach palm seedlings are grown in house gardens for transplanting to fields. House gardens are 1/3 to 1/2 ha in size, and make up 35–40% of total cultivated land (Vickers 1983).
Waimiri Atroari [northern Amazon, Brazil]	Seeds of fruit trees are planted in new swiddens surrounding the communal house, often next to stumps, or in the case of peach palm or papaya, where there is abundant ash. Some species are spontaneous from seeds in domestic trash discarded in the swidden. Over time, a belt of fruit trees is established around the village (Miller 1994).
Yanoama [Venezuela]	Peach palm is intercropped with plantains. Papaya is spontaneous on trash heaps near dwellings (Smole 1976).
Yanomamo [Venezuela]	Papaya and banana form a discontinuous canopy underplanted with cocoyam and many other herbaceous crops. Peach palms, plantains and cotton are usually the only crops surviving in gardens after the 4th year (Hames 1983).

@ Botanical identification of the plants listed:

Common name	Scientific name	Family
abiu	*Pouteria caimito* (Ruiz & Pav.) Radlk.	Sapotaceae
annato	*Bixa orellana* L.	Bixaceae
avocado	*Persea americana* Mill.	Lauraceae
banana	*Musa* sp.	Musaceae
cacao	*Theobroma cacao*L.	Sterculiaceae
calabash tree	*Crescentia cujete* L.	Bignoniaceae
cashew	*Anacardium occidentale* L.	Anacardiaceae
coca	*Erythroxylum coca* Lam.	Erythroxylaceae
coconut	*Cocos nucifera* L.	Arecaceae
cocoyam	*Xanthosoma* sp.	Araceae
cotton	*Gossypium* sp.	Malvaceae
cupuaçu	*Theobroma grandiflorum* (Willd. ex Spreng.) K. Schum	Sterculiaceae
guava	*Psidium guajava* L.	Myrtaceae
hog plum	*Spondias mombin* L.	Anacardiaceae
ice-cream bean	*Inga edulis* Mart.	Leguminosae (Mim.)
lime	*Citrus aurantiifolia* (Christm.) Swingle	Rutaceae
malay apple	*Syzygium malaccense* (L.) Merr. and Perry	Myrtaceae
mango	*Mangifera indica* L.	Anacardiaceae
mountain soursop	*Annona montana* Macfad.	Annonaceae
orange	*Citrus sinensis* (L.) Osbeck	Rutaceae
papaya	*Carica papaya* L.	Caricaceae
peach palm	*Bactris gasipaes* Kunth	Arecaceae
plantain	*Musa x paradisiaca* L.	Musaceae
tobacco	*Nicotiana tabacum* L.	Solanaceae
uvilla	*Pourouma cecropiifolia* Mart.	Moraceae
velvet tamarind	*Dialium guianensis* Steud.	Leguminosae (Caes.)
West Indian cedar	*Cedrela odorata* L.	Meliaceae
wild cacao	*Theobroma speciosum* Willd. ex Spreng.	Sterculiaceae
wild sweetsop	*Rollinia mucosa* (Jacq.) Baill.	Annonaceae
yagé	*Banisteriopsis caapi* (Spruce ex Gris.) C.V. Morton	Malpighiaceae

Source of nomenclature: Rehm (1994) and Wiersema and Leon (1999).

village sites as the direct result of clearing and burning vegetation for agriculture, a process which would have selected for more fire-resistant species, a number of which present useful qualities. Other useful trees spared during clearing of fields would be in optimal positions to colonize the secondary vegetation of fallows, regardless of whether or not their regeneration was subject to specific management. This model of a concentric zone of human influence on the vegetation is consistent with studies of anthropogenic 'black earths' associated with archeological sites, created by repeated occupations of the same location over spans of perhaps millenia, and their adjacent 'terras mulatas' (brown earths) (Lehmann et al. 2003). Clement et al. (2003) list some of the species associated with such sites. Where human populations existed in greater density, such as along the Amazon floodplain, we might expect linear, rather than aureolar, zones of anthropogenic forests remaining as the imprint of past populations. However, the fact that the floodplain region of Amazonia has been significantly altered by recent human occupation, including deforestation for cattle ranching, as well as by its own dynamic geomorphological processes, may make the identification of such vegetation signatures a difficult task.

Indigenous agroforestry systems in Amazonia represent a fine-tuning of knowledge concerning the interaction of plants and their environment, and involve as well interactions between agricultural, social, and cosmological systems. In all likelihood, indigenous agroforestry traditions represent technologies that evolved along with the domestication of Amazonian forest species and their use in agriculture, and are an important cultural heritage still retained by many Amazonian tribes. Indigenous agroforestry systems also contributed to the practices now utilized by farmers of

mixed Indian and European descent in Amazonia. This contribution is discussed in the following section.

The transformation of indigenous agroforestry systems during the colonial period

With the establishment of the Portuguese in Eastern Amazonia, in the beginning of the 17th century (Belém was founded in 1616), a number of exotic species were introduced and incorporated into indigenous agroforestry systems. The Portuguese crown officially sponsored a number of plant introductions from its Eastern colonies of Goa (India) and Macau (China) (Dean, 1995). Mango (*Mangifera indica*) and jackfruit (*Artocarpus heterophyllus*) are mentioned in Father João Daniel's tome on Amazonia (1757–1776), however, in the case of mango, more in a tone of lament that it was not cultivated as widely as in other parts of Brazil (Daniel 1976).

The efforts on the part of the Portuguese to introduce useful plants included the establishment of a botanical garden in Belém, which benefited from the skills of two Frenchmen who fled unrest in French Guiana following the French Revolution. In 1808, in retaliation for the invasion of Portugal by France, the Portuguese invaded French Guiana and were able to take advantage of the collection of useful plants cultivated at 'La Gabrielle,' the botanical garden in Cayenne. After the Portuguese takeover, Maciel da Costa, appointed as civil administrator, further developed and enriched 'La Gabrielle,' and by the time Cayenne was returned to the French in 1818, he had remitted to Belém a number of tropical species including nutmeg (*Myristica fragrans*), carambola (*Averrhoa carambola*), groselha (possibly *Malpighia punicifolia*), sapodilla (*Manilkara zapota*), breadfruit (*Artocarpus altilis*), sugarcane (*Saccharum officinarum*), as well as unspecified European fruit trees that had been acclimated in Cayenne (Holanda 1965). Even today, some plants cultivated in Brazil retain the epithet *caiano* to describe their Cayennese origin. Examples are varieties of sugarcane, a variety of papaya, and the bilimbi (*Averrhoa bilimbi*), called *limão caiano*.

By the mid 19th century, exotic fruit trees were fully incorporated into homegardens along the Amazon. Traveling on the Amazon between óbidos and Manaus in 1849, the British naturalist Henry Walter Bates described homegardens with banana, papaya, mango, orange, lemon, guava, avocado, abiu, genipap, and biribá, as well as coffee shrubs growing under the shade of the fruit trees (Bates 1988). Ten years later, French traveler Robert Avé-Lallemant recorded a variety of fruit trees growing near houses on the outskirts of Belém: banana, mango, jackfruit, various Annonaceae, orange trees, coffee, as well as the giant granadilla or maracujá-açu (*Passiflora quadrangularis*). Surrounding the dwellings of Indians near Cametá, Pará, he found native calabash trees (*Crescentia cujete*) and orange trees competing with mango, and the native açaí (*Euterpe oleracea*) and bacaba (*Oenocarpus bacaba*) palms. Income sources for these households came from 'extensive stands of cacao' and rubber trees. The presence of various Annonaceae, the bacuri (*Platonia insignis*) and Brazilnut (*Bertholletia excelsa*) trees was also noted. Continuing up the Amazon to Santarém, he found many cacao and orange groves, as well as concentrations of the native tucumã palm (*Astrocaryum tucuma*), highly appreciated for the edible mesocarp of its fruit (Avé-Lallemant 1980).

Another palm that Avé-Lallemant found to be important in human diets, and a staple food for the populace of Belém in1859, was the açaí. This palm is often found growing in concentrations in low-lying areas, and its use in the estuarine region at the mouth of the Amazon is a tradition of great antiquity. On Marajó Island, for example, archeological excavations of a site whose occupation is dated to AD 1100–1300 have found a great abundance of açaí seeds among carbonized plant remains (Roosevelt et al. 1991). Although the stratified societies or chiefdoms that existed along the Amazon and on Marajó Island disappeared in the early colonial period, it is likely that some of their subsistence practices lived on and were perpetuated by the population of mixed blood that eventually replaced them. It is not clear, however, whether in prehistoric times the açaí palm was simply harvested from natural stands or whether it was managed or cultivated as a component of agroforestry systems. Today, açaí 'agroforests' are of great economic importance, chiefly around the city of Belém, on islands in the Amazon estuary and in the nearby municipality of Cametá, at the mouth of the Tocantins River. Stands of the palm are actively managed for the fruit and palm hearts,

and regenerated by scattering seeds in appropriate locations (Anderson 1988; Strudwick and Sobel 1988).

The history of cacao bears some similarity to that of the açaí palm, as an example of a native forest tree that was widely used in Amazonia prior to the arrival of Europeans, and perhaps even managed or cultivated, and which still maintains its importance until today. Cacao was one of the first products to be exported in sizeable quantity from the Amazon by the Portuguese. Between 1678 and 1681, the Portuguese government took several measures to encourage the export of cacao from Amazonia. Besides fiscal incentives, this included the establishment of demonstration orchards near Belém. Nevertheless, when exports of cacao did pick up three and a half decades later, they came primarily from stands of wild or feral trees. According to Alden (1976), wild cacao appeared to be omnipresent, and 'was found along the banks and the adjacent islands of the main river, both in its lower reaches near Belém and especially between its confluence with the Rio Tocantins and the upriver ports of óbidos and Santarém, as well as along the margins of its major tributaries, particularly the Rio Negro, the Rio Trombetas (where Orellana had his encounter with the Amazons), the Madeira, and the Solim õ es.' Father Samuel Fritz, on the Marañon River in 1686, noted that Portuguese entered what is now Peru to extract cacao with Indians (Fritz, 1922). In 1739 French traveler Charles de la Condamine found cacao growing wild along both banks of the Marañon River in Peru, noting, however, that the Indians gave it little attention (Condamine 1944). This distribution, nonetheless, coincides with the areas occupied by the great chiefdoms encountered by the first Europeans to travel the Amazon.

Although the use of the cacao bean was first brought to the attention of Europeans during the Spanish conquest of Mesoamerica, the place of origin of cacao is Amazonia (Dias 2001). However, there is no historical or archeological evidence that pre-Columbian Amazonians used the cacao bean in any way, apparently making use of only the thin layer of sweet pulp that surrounds the seed. Regardless of whether Amazonian populations did or did not use the beans, a review of the historical evidence on the widespread occurrence of cacao in Smith (1999) concludes that indigenous people did plant it on the Amazon floodplain.

In colonial times the methods used in the cacao harvest were similar to those used in the extraction of other forest products: collecting expeditions set out upriver in large canoes, manned by a crew of Indian paddlers and supervised by a white or mixed blood master. From a central encampment they would spread out to harvest the cacao, bringing it back to be dried. Despite low quality of the beans resulting from improper drying and storage and the inclusion of green beans, by the 1730s cacao had become the dominant export from the Amazon, and remained so for more than a century (Alden 1976).

By the nineteenth century, the cacao gathering expeditions had ceased and cacao was being cultivated in plantations along the Amazon. Father João Daniel, writing in the mid-eighteenth century, described how farmers grew seedlings on raised beds for a year, then transplanted them into their manioc fields, where banana trees had been previously planted to provide shade. A number of fruit trees, such as orange, avocado, biribá, and others were also interplanted, as it was known that cacao produced better in their shade (Daniel 1976). By the end of the nineteenth century, however, cacao production had shifted to southern Bahia, and the Amazon region was preoccupied with the boom in the extraction of rubber (*Hevea brasiliensis*), another forest product.

In the last few decades, cacao cultivation in Amazonia has seen several cycles of renewed interest. As the main axes of frontier development now accompany the constructions of roads, cacao cultivation has left the *várzeas* or flood plains of the Amazon and has become more important on the *terra firme* (upland) interfluves. When the Transamazon Highway was opened in 1976, soil surveys indicated the occurrence of patches of *terra roxa* (alfisols) in the vicinity of Altamira, Pará. CEPLAC, the Brazilian cacao board, actively supported the expansion of cacao in this region, where soils are higher in fertility than most parts of Amazonia (excluding the *várzeas*) and are suited to the cultivation of a number of crops.

Although coffee is not native to Amazonia, its cultivation in the region received almost as much attention as did cacao in colonial times. Along with cacao, Father João Daniel lists coffee as one of the crops planted by the Portuguese colonists

(with the help of enslaved Indians) in the mid 18th century (Daniel 1976). Lieutenant-Captain Lourenço da Silva Araújo e Amazonas, in his *Dicionário Topográfico, Histórico, Descritivo do Alto Amazonas* (1852), lists coffee as one of the main agricultural exports of the province, along with cotton, cacao, guaraná, and tobacco (Amazonas 1984). Coffee production in Amazonia has followed a similar trajectory to that of cacao, suffering an almost complete decline with the expansion of cultivation in other parts of Brazil, in this case the states of Rio de Janeiro, São Paulo and Minas Gerais, and then regaining importance in the last three decades of the 20th century with the boom in frontier settlements, where coffee planting is increasing as a land use in agroforestry systems or as a monoculture (C. Rocha, pers. comm. 2000).

Leaving aside the commodity crops, the rapid spread of introduced species of fruit trees in the 18th and 19th century shows a willingness to experiment with new and interesting germplasm, and indicates that there was a well-established tradition of cultivating homegardens among the population of Amazonia, who at the time were *caboclos* (small-scale farmers of predominantly Indian descent) engaged in subsistence agriculture, fishing, hunting, and extraction of forest products. Some of the homegarden systems that were established in the 19th century may still be in existence today. Near Manaus, in the municipality of Manacapuru, a stretch of the left bank of the Solimões river receives the name of *Costa do Laranjal*, as it was a region that traditionally supplied Manaus with oranges. This high riverbank, far above any flood level, has an extensive anthropogenic black earth site, and homegardens with very large Brazilnut, rubber, and cupuaçu (*Theobroma grandiflorum*) trees, thought to be over 100 years old (J.B.G. Moreira, pers. comm. 1999). A similar black-earth site with many ceramic shards extends for 460 m along the riverfront of the hamlet of Vera Cruz, on the Maués river, and the dwellings are surrounded by a 'forest' consisting almost entirely of useful plants. The overstory is dominated by rubber trees with tapping scars, Brazilnut trees, and very old mango trees. In total, 34 species of fruit trees were counted at this locality (R.P.M., unpublished data). In the Maués site the mix of indigenous domesticates and introduced species raises the interesting possibility that at least in certain locations of Amazonia, where Indian villages were replaced by towns, the cultivation of fruit trees has been continuous from prehistoric times to the present day.

Modern day homegardens in Amazonia

Present day homegardens of both small-scale farmers and urban populations in Amazonia combine native species with fruit trees introduced from other parts of the globe during European colonization, as well as more recent introductions. In a survey of 33 upland homegardens, Smith (1996) found a total of 77 tree species, of which 46% are indigenous to Amazonia, and 27% are from the Old World. The importance of homegardens appears to be chiefly the domestic supply of fruits, condiments, medicines, craft materials, and shade (Smith et al.1996). Near urban centers, they may become part of both subsistence and income-earning strategies through the production of marketable fruit. Little is known, however, about how farmers manage the composition of their homegardens in order to influence production and income. It is possible that there is an ubiquitous stock of species valued for domestic consumption, while others are cultivated specifically as income-earners. Many studies of homegardens list the species that are cultivated, and their uses, yet very few provide information about the ranking of these species with regard to their relative economic importance. Likewise, little is known about any special care or management that the more important species may be receiving. Some recent studies in Amazonia, however, have begun to look at the economic importance of homegardens as a part of household livelihood systems (Miller 2001; Coomes and Ban 2004).

Studies by Rosa et al. (1998a, b) in Pará and Macapá, Amapá, found that small livestock can have considerable economic importance as components of the homegarden system. Their survey of 32 properties in the region of Macapá, capital of Amapá, found average property sizes of 90 ha, with a mix of forest and subsistence agriculture fields, and homegardens averaging 0.32 ha. More than 50% of the chickens, ducks, and pigs raised on these properties was consumed by the household. Although weekly revenue from livestock

averaged R$ 35, a value greater than that obtained from the sale of fruits such as açaí, bananas, mangos, limes, and cupuaçu, which averaged R$ 20/week, a good portion of the feed for these animals was said to come from homegarden fruit (the real (R$) was approximately equal to the US dollar at that time). In a sample of 20 households in Murinin, near Belém, capital of Pará, the average property size was found to be 1.7 ha, with an average size of 0.64 ha per homegarden. In terms of the frequency of fruit trees, 100% of the properties had açaí and cupuaçu, 90% had guava and lime, 85% had peach palm and mango, 80% had coconut, 75% had banana, and 70% had biribá and jackfruit. Families consumed 69% of the fruit, 100% of the medicinals, 85% of the vegetables, and 85% of the livestock, with the remainder being sold (Rosa et al. 1998c).

In the cases described above, the preponderant use of homegarden products is for domestic consumption, indicating that from the point of view of food security, homegardens can be a valuable option for small-scale farmers, regardless of their distance to markets. Homegardens may be of special value to farmers in frontier regions, where conditions for survival are more problematic. Homegardens may also be the locus of experimentation with new tree species and cultivation techniques, and may expand into more commercial groves, as was seen by Yamada and Gholz (2002) among farmers of Japanese descent in Tomé-açu, Pará, Brazil.

Conclusions

The most traditional agroforestry systems in Amazonia are forms of cultivation of fruit trees and other useful plants, with origins dating to the dawn of agriculture in the region, several thousands of years ago. Today, the homegardens that have descended from indigenous systems, with the addition of many exotic species introduced during colonial times, are valuable components of household livelihood systems, contributing mostly to domestic consumption. Despite the undeniable importance of introduced species, the fact that a number of native species, mostly fruit trees, were domesticated in the pre-Columbian era is a lesson concerning the potential of Amazonian flora. In view of Amazonia's tremendous biodiversity, modern institutional efforts to domesticate more species for the new demands of our technological society can best be described as timid. Continuing research is needed on the identification and improvement of potential tree crops to supply fruit, oils, resins, essences, or other products. The further development of such crops, and the markets for their products, could greatly increase the economic viability of agroforestry systems for farmers. But farmers should not be seen as just the passive recipients of new technologies. In keeping with Amazonia's millenial tradition of agroforestry and tree domestication, research agencies must take greater steps towards viewing farmers as partners to be enrolled as participants and experimenters in the development and domestication of new generations of tree crops.

Although some research has been done on homegardens and indigenous swidden-fallow systems and the constraints to expanding or further developing them for greater productivity and income generation have been identified, further study is needed as to the manner in which the configuration of species and management practices observed in traditional systems could be modified to meet increased nutrient exports and labor requirements, as well as market demands. Nevertheless, it is clear that homegardens have a very important role to play in this process of testing new species and conserving as well as multiplying germplasm for transfer to and between fields.

In the Brazilian Amazon, agroforestry is attracting increasing attention on all levels, from the small farm to various ministries of the federal government; the current configuration of extension services has, however, been unable to meet the demand for technical assistance. Given the immensity of the region, one suggestion to increase the spread and efficiency of extension services is to employ rural schools as surrogate homegardens, where interesting germplasm can be tested and multiplied, and accessed by frontier farmers, while at the same time improving nutrition for their children. If agroforestry is to achieve its promise of providing an alternative and more sustainable form of land use in Amazonia, the sociocultural practices involved in acquiring and testing new germplasm must be included in rural development projects, and stimulated by creative new approaches.

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