Chapter 4
Amazonia

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Abstract Greater Amazonia—the Amazon Basin, which stretches from the Andes to the Atlantic—is roughly the size of the continental United States. It contains the largest planetary extension of humid forests as well as a complex array of more open forest formations, savanna ecosystems, and agricultural mosaics. About 40,000 plant species are found there. Historically, Amazonia was viewed as a place where ecosystems had been minimally affected by human activity, but modern archaeological discoveries ranging from anthropogenic soils, large scale earthworks, and historical ecological studies are changing this view; the region is now viewed as one of the main civilizational hearths of Latin America, on a par with the Inca, Maya, and Aztec cultures. Recent ethnographic studies of indigenous, traditional, and diasporic populations are also recasting our understanding of the extent and forms of ecosystem management from soil, succession, cultivar, and forest manipulations. These are reviewed in this chapter, and point to the complex managed forests produced today and in the past. What is clear is that there are suites of management techniques that provide income and resilience and that protect and enhance diversity while maintaining biomass through successional processes at the landscape level.

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This knowledge and practice certainly merit greater attention for the longer term, especially given the pivotal role of tropical forests in climate systems.

Keywords Amazonia • Ecosystem management • Environmental history • Ethnobotany • Forest ecosystem management • Non-timber forest products • Terra preta • Traditional agriculture • Traditional knowledge.

4.1 Amazonia: A Brief Introduction to Complex Ecosystems

Amazonia includes the largest tract of tropical forest on the planet. The basin in its entirety covers somewhat more than 7 million km^2. Much of the region—perhaps 5.5 million km^2—is covered by lowland moist forests, with the rest divided among a great diversity of forests, savannas, and grasslands (including seasonally flooded grasslands), as well as considerable expanses of fragmented and converted forests, and a variety of agricultural mosaics (Fig. 4.1). The various forests and other land covers found in Amazonia have been put into classes and/or mapped by numerous scientists, using various tools, and for different purposes (e.g., Malleux 1983; Moran 1993; Tuomisto et al. 1995; Whitmore et al. 2001; Saatchi et al. 2007; GEOAmazonia 2009). These estimates certainly do not agree on how many significantly different forest types Amazonia may contain. For instance, botanist Prance and colleagues (1987) distinguished a total of 20 forest and non-forest habitat types for the Brazilian Amazon. Saatchi and his colleagues, who classified and mapped Amazonia to more accurately measure carbon stocks, used a combination of remote sensing and ground-truthing plots to come up with 16 distinct forest and wetland types (Saatchi et al. 2007). Tuomisto et al. (1995), however, argued cogently that far more than 100 types should be recognized in the Peruvian Amazon alone.

Amazonian peoples and societies, of course, also classify their environments, including their forests, in a variety of ways. The indigenous peoples whose classificatory systems have been studied include the Ka'apor (Balée 1994), Kuikuru (Carneiro 1978, 1983; Heckenberger 2005), and Kayapo (Posey 1996) of Brazil; and the Matses (Fleck and Harder 2000), Maijuna (Gilmore 2005), and Matsiguenka (Shepard et al. 2001) of the Peruvian Amazon. Halme and Bodmer (2007) have looked at forest classification by ribereño farmers and hunters in Peru, and Frechione et al. (1989) studied environmental zonation by Brazilian caboclos. Many of these studies found that rural Amazonian communities, whether indigenous or not, use complex classification systems that often include multiple criteria, including local geomorphology, physiognomy, soils, disturbance, and indicator plants (especially palms) and animal species to classify their environments; local communities often distinguish dozens of forest types over small scales (Anderson and Posey 1989; Elisabetsky and Posey 1989; Ellen et al. 2000; Posey and Balée 1989; Posey and Balick 2006; Posey and Plenderleith 2002; Rival 2002; Posey 1996). These systems are often not strictly hierarchical, but feature different and overlapping subsystems (Gilmore 2005). Many scholars have found that locally developed systems of forest

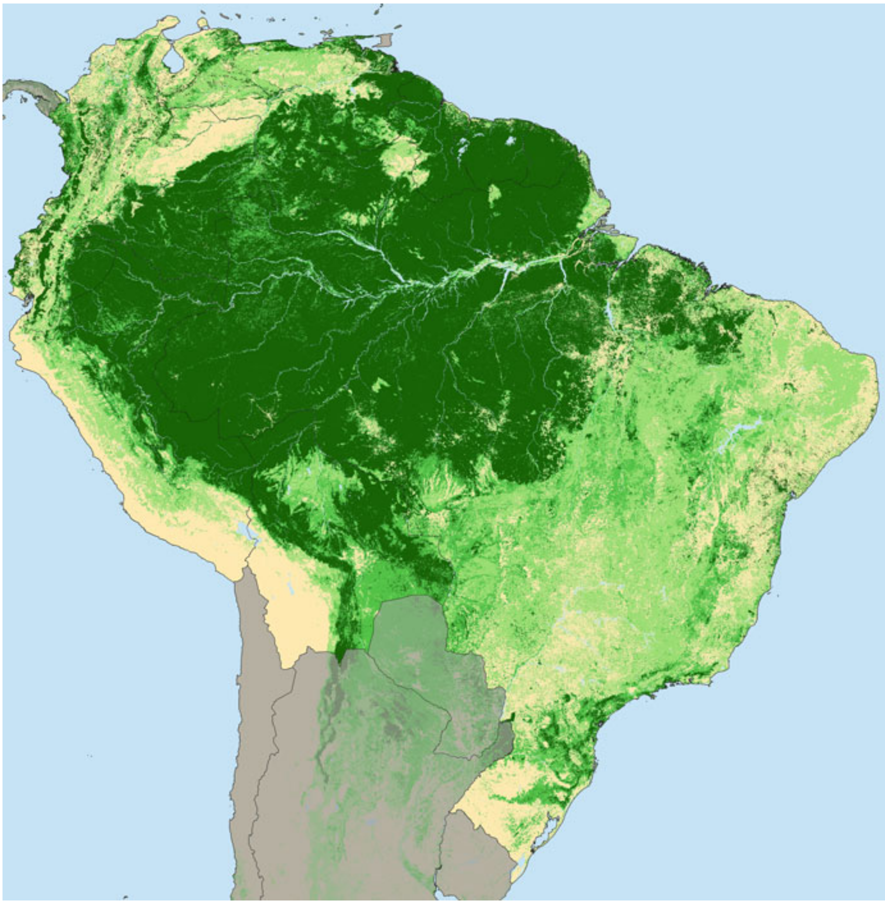

Fig. 4.1 Forest and woodland cover in the northern South America (Source: Adapted from FAO (2001)). Key: *Dark green* closed forest, *light green* open or fragmented forest, *pale green* other wooded land, *yellow* other land

and habitat classification could and should be used more widely by scientists, conservation managers and others (Posey and Balick 2006; WinklerPrins and Barrera-Bassols 2004). Halme and Bodmer (2007), for instance, suggest,

> 'for wildlife management and monitoring it is essential to know how habitat influences the density of wildlife populations. Since there is a strong agreement between the TEK (traditional ecological knowledge, in this case, forest classification) and the scientific classifications…TEK habitat analyses could be used as a valuable tool in the development and implementation of collaborative management plans. For instance, managers of the Mamirauá Sustainable Development Reserve in the Brazilian Amazon have used the "moradia system" a traditional knowledge for zoning riparian forest for the conservation and sustainable use of forests resources (Ayres 1996). The use of TEK nomenclature could increase the participation of the community members and facilitate their collaboration with conservation professionals.'

The great vegetational and other diversity that is encoded in these classifications reflects Amazonia's rarely appreciated wide variations in soils and drainage characteristics, temperature and rainfall patterns, differences in altitude, and other environmental variables, as well as the great number of ways that people have changed and continue to manage and manipulate vegetation.

Culturally, perhaps the most important division of Amazon terrestrial areas is the categorization of lands and their respective forests into 'terra firme' and 'várzea,' or dry lands /uplands and floodplains; and 'campo' and 'floresta,'or-grasslands and forests. The várzea floodplains constitute a mere 2–3% of Amazonian territory, but have long had an economic and social importance that belies their limited size. Várzea refers technically only to areas flooded by the basin's great whitewater rivers including the Amazon, Solimões, Ucayali, and Marañon. The várzea is further subdivided into the tidal or estuarine floodplain, where twice-daily tides inundate significant areas of land near the mouth of the Amazon, and the middle and upper floodplains that lie above the tide's reach and where annual floods reach heights of 10–12 m and submerge broad swaths of land and forest along the rivers for 3 months or more. Large territories are also washed by black-water rivers; the greatest of these is the Rio Negro that drains parts of Venezuela and Brazil. The lands flooded by such blackwaters are known as 'igapó' and have very different forests and sets of terrestrial and aquatic species from those of the whitewater várzeas (although in some areas on the white water tributaries, igapo refers to perennially flooded forests). Several important Amazonian rivers are classified as clearwaters; these include Brazil's Tapajos and Xingu that flow off the Brazilian Shield. Finally, savannas, grasslands, or scrubland occur in some areas with white sand soils and particular drainage conditions, as well as in areas with less total rainfall and stronger dry seasons; these are also an outcome of extensive human interactions with these systems, creating forest and grassland mosaics. Cultures that form part of the Gê linguistic group were masters of the Brazilian savannas in pre-Colombian times and influenced the structure of these environments profoundly (Anderson and Posey 1989; De Toledo and Bush 2008b; Furley et al. 1992; Hecht 2009; Mistry and Berardi 2006).

Many of the Amazon's terrestrial and aquatic habitats are characterized by high species diversity. Some estimates place the plant diversity of the entire Amazon Basin at about 40,000 plant species. Studies in the terra firme forests of the western Amazon, where the broad flat plain begins to rise into the Andes, have been characterized as the most diverse on earth, with up to about 300 plant species (over 10 cm dbh) per hectare. But as noted above, the Amazon is far from uniform, and its forests differ substantially in diversity, structure, and other essential characteristics. Most floodplain forests, for instance, have been found to have lower tree diversity than their terra firme counterparts, but the diversity of the particular ecosystems and biomes that make up the várzea can be very high; local societies recognize that fact with a rich set of terms for various features of the várzea (Pinedo-Vasquez et al. 2002; Frechione et al. 1989). Amazonia famously also harbours remarkable numbers of animal species; it sustains the world's richest diversity of birds, freshwater fishes, and butterflies.

4.2 Amazonians: History and Diversity

It is estimated that the total population of Amazonia is now more than 30 million people, although as the exact limits of the basin are disputed; so, too, are population totals (see for instance, GEOAmazonia 2009). A dispute over what might have been the population of the region before the invasion of Europeans (i.e., in 1491), however, has been going on for a long time, and is not apt to be resolved easily (e.g., Denevan 1964; Mann 2005). Estimates have ranged from 1 to 11 million. However, there is increasing agreement among most scholars that much of the Amazon was far more heavily settled in pre-Columbian times than early studies done by many prominent scholars had suggested (Meggers 1954, 1971). Many now believe that prior to the disastrous die-off of Amazonian populations that accompanied the entrance of Europeans, the peoples of Amazonia numbered in the millions, with large settlements located along major rivers and on the bluffs about the várzea floodplain as well as populations on the uplands (Church 1912; Erickson and Balée 2006; Heckenberger et al. 1999, 2008; McKey et al. 2001). It is now widely believed that some Amazonian societies not only were organized in complex ways politically and economically, but that they had the capacity to significantly alter their home environments including forests, and in fact might be usefully thought of as engineering societies (Fig. 4.2). A number of recent discoveries by archaeologists in widely separated and seemingly

Fig. 4.2 Geoglyph. At this writing more than 225 geoglyphs, that is, large-scale, geometric earthworks, have been found in the Purus watershed, including the Acre valley. These sites are taken to be the remnants of palisaded settlements in some cases, and others may have been ceremonial sites. Their most striking feature is their geometric precision (Photo: Susanna Hecht)

unlikely areas of Amazonia have helped make the case for the dense populations of the region and significant alteration of Amazonian environments. This is a large literature and expanding daily, but general overviews include Balée and Erickson (2006), Hecht (2003), Hill (1988), Hill and Santos-Granero (2002), Lehmann et al. (2006), Macia (2008), McEwan (2001), Roosevelt (1991), Woods et al. (2009).

The overwhelmingly important role of carefully planned and controlled fires in the management of soils, especially in the creation of some of the Amazon Basin's most fertile soils is only now being explored in depth. 'Terra preta' ('black earth' in Portuguese)—also known as 'Indian dark earths' or 'terra preta do índio' ('terra mulata' is a lighter-coloured, brownish version)—refers to dark, highly fertile anthropogenic soils that occur in several areas of the Amazon Basin, on every soil type. Terra preta owes its name to its very high charcoal content, and indeed appears to have been made by adding mixtures of charcoal, fish and animal bones, and manure to what may have otherwise been relatively infertile Amazonian soil over many years; thus they are distinctively the outcome of human intervention. The key element in their creation seems to be very low temperatures at burning, which creates a pyrolytic charcoal that is very stable over long periods of time and binds soil nutrients far more tightly than the typical result of 'hot fires' usually associated with deforestation. Terra preta seems to have two types of origins, one basically formed on urban residues (hence immense amount of potsherds), and the other, terra mulata, more a result of the slow cool burns on continuously managed agricultural sites.

Some of these soils have been dated to between 450 CE and 950 CE and are believed to have been created by low temperature burning of fields known as 'slash-and-burn'. Some contemporary Amazonian agriculturists, including the Kayapo who live in the state of Para in Brazil, continue to use complex sets of practices that include: specific ways of laying out agricultural fields, a range of burning technologies that produce 'cool' burns, the practice of scattering cooking residues and other garbage, and the practice of adding palm mulch and other nutrient-rich materials to soils (Hecht 2003; Hecht and Cockburn 1989; Lehmann et al. 2006; Liang et al. 2008; Peterson et al. 2001). These practices when used together have been described as potentially creating terra preta and terra mulata-like enriched soils (Hecht 2003). Terra preta soils have been identified mainly in Amazonian Brazil, although some sites have also been found in the Guaviare in Colombia, Peru, and Ecuador (Eden et al. 1984; Jackson 1999; Lima et al. 2002; Martínez 1998) and elsewhere in the Orinoco drainage. Terra preta has also been found in Central America including Panama and Costa Rica (WinklerPrins A. and W. Woods, personal communication, 2009). Originally believed to be confined only to small areas of several hectares apiece, recently terra preta sites have been found to cover areas of hundreds of hectares, again challenging preconceptions of the 'pristine' nature of much of the forested Amazon. These techniques are now part of a general effort to improve soil properties for small-scale producers (Woods et al. 2009). Overall, some 4% of Amazonia might display dark-earth characteristics (Fig. 4.3).

In the Beni region of Bolivia, geographers, archaeologists, and others have uncovered thousands of kilometres of raised fields standing above the seasonally flooded grasslands that are known as the Llanos de Moxos. Characterized by an

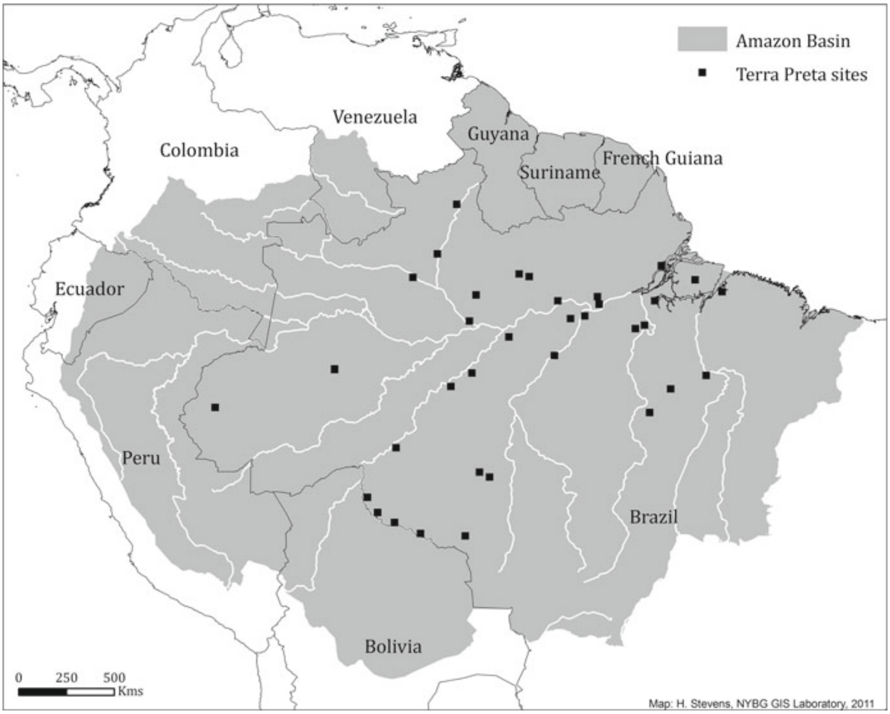

Fig. 4.3 Terra preta sites. These areas of anthropogenic soils are widespread throughout the Amazon, and reflect a unique adaptation to poor soil through the enrichment via cool burns and to create nutrient-rich, stable biochar. Terra preta and Terra mulata provided the basis for the development of large upland populations and may do so in the future (Map courtesy of H. Stevens, New York Botanical Garden, GIS Laboratory)

alternation between seasonal flooding with very intense rainfall and seasonal strong droughts accompanied by intense heat, and poor soil and drainage, the Llanos de Moxos would appear to be an unlikely region to harbour large numbers of agricultural peoples (e.g., Denevan 1970; Erickson 2006; Erickson and Balée 2006). Yet these well-developed raised bed earth work, coupled with mounds, and an array of large-scale drainage of other forms of engineering provide the production base for very large populations, perhaps even into the hundreds of thousands, who might have lived there (Erickson 2006). These ancient residents, apparently using both any existing natural differences in elevation and building thousands of artificial mounds or 'geoglyphs,' created a complex, built landscape that allowed large populations to subsist in the region on both agricultural and extracted, especially aquatic, resources. The most visible key feature is a system of planting surfaces elevated above the seasonally flooded and poorly drained flat grasslands. Research has demonstrated that management practices succeeded not only in elevating crops above the flood, but also in significantly improving the soils on the mounds, in controlling or improving drainage, and in enhancing conditions for fisheries and other provisioning activities. Archaeologist Clark Erickson and others have also suggested that the area may have been an extensive human-constructed landscape that was managed largely to increase fish production through an ingenious controlled flood-recession system that captured fish in hundreds of depressions that became ponds as floodwaters ebbed. Erickson has identified a large number of earthen fish weirs distributed across the Llanos de Moxos landscape (e.g., Erickson 2006). Similar structures have been found elsewhere as in the Xingu River (Heckenberger et al. 2008) and possibly in French Guyana.

There is also evidence that fire was an important tool used in the Beni and the Cerrado. The recurrent burning of the Llanos is assumed to have decidedly influenced the distribution of plant species, with a large assemblage of fire-resistant species favoured in the region. This active fire history is also documented in Kayapo and Xavante practices (Barbosa and Fearnside 2005; Coimbra-Junior 2004; De Toledo and Bush 2007, 2008a; Harris 1980; Hecht 2009; Mistry 2001; Santos et al. 1997).

Recent research on the southern edges of Amazonia, in the Brazilian State of Mato Grosso, has added important new information that considerably expands this story and alters yet again some of the most fervently held ‘truths’ about pre-Columbian Amazonia, its population and settlements, and the capacity of particular parts of the basin to support large numbers of humans and their developed societies. Along the upper Xingu River, archaeologist Michael Heckenberger has recently excavated sites of what he calls ‘garden cities,’ extending the concept of Ebenezer Howard’s ideas for urban sustainability. (Heckenberger et al. 2008). Linked by extensive networks of roads and canals, these settlements appear to indicate levels of population, political organization, and environmental management that were previously ascribed only to a few várzea sites or like the Llanos de Moxos, or sites to the western Amazon, such as the Chachapoya culture along the foothills of the Andes. Heckenberger identified several clusters of linked urbanized sites of varying sizes. Basing his calculations partly on present-day settlement and resource use patterns, he estimates a total population in the region that may have numbered about 50,000, distributed among numerous sites in an area the size of Belgium. Heckenberger writes that, ‘within each cluster, we estimate 100–150 ha or more of settlement space and a population in the mid-thousands (≥2,500) distributed between walled towns, which are estimated to have 800–1,000 or more persons and smaller non-walled villages (250 ± 100 persons)’ (Heckenberger et al. 2008, page1216). The settlements were connected by multiple roads and canals, and surrounded by mosaic landscapes featuring woodlands—including mature forests, plots devoted to intensive agriculture, and even ‘large compost plots’ (Heckenberger et al. 2008, page1217). Not only are these finds surprising because of their location in an upland region long thought to be hostile to large-scale settlement, but also because they suggest that a very distinct type of urbanized and yet dispersed society existed in Amazonian forests. Much larger populations are recorded in many Amazonian oral histories and ritual activities (Hill and Santos-Granero 2002; La Torre-Cuadros 2008; Vidal 2000; Whitehead 2003).

These important examples are some of the most recent and most prominent additions to a broad and increasingly convincing literature that suggests that numerous areas of the Amazon may have been densely populated and heavily managed before the European disruption of Amazonian societies. They are exciting additions to a set of evidence that appears to contradict assumptions that settlement and livelihood options in Amazonian forests, except for very limited zones, were severely limited by environments inimical to human settlement and subsistence, especially by extremely infertile soils. The corollary of this assumption was that most of Amazonia was able—at best—to support only small and unstable local populations that had little impact on forests and other environmental features. Both archaeological and historical data also point to the considerable trade and migration that occurred not only within the basin but also between Amazonia and the Andean realm. These new data powerfully question that early and still popularly held view that almost the whole of Amazonia was, on the eve of the European conquest, an uninhabited, ahistorical, pristine, and 'Edenic' forest landscape.

These complex Amazonian civilizations experienced the loss of much of their knowledge as their societies were destroyed by disease, slaving, and dislocations. However, a great deal of knowledge still resides in local societies and is encoded and reproduced in the landscapes and knowledge systems of today's inhabitants of Amazonia.

4.3 Local Knowledge and Use of Forest Plants

Researchers have estimated that at least 2,000 species of Amazonian plants have been given a particular use by humans, including as food, fibres, medicines, fuels, or for any number of other utilitarian, aesthetic, or ritual purposes (Duke and Vásquez 1994; Bennett 1992). In the Peruvian Amazon, for example, more than 1,250 species have been recorded as being used for an economic purpose by at least one local group (Pinedo-Vasquez et al. 1993), with at least 138 species of agricultural and tree crops among them (Clement 1998). Considerable work has been done on the uses of forest plants and plant lore of specific Amazonian communities, particularly on which plants that indigenous Amazonians use for medicinal purposes, as well as on the nomenclature and classification of those plants in Amazonian languages (e.g., Alexiades 2009; Balée 1994; Bennett and Prance 2000; Boom 1987; Duke and Vasquez 1994; Prance et al. 1987; Vickers and Plowman 1984; Zent and Zent 2004; Zent 2009; Anderson and Posey 1989; Balée 1994; Coimbra-Junior 2004; Elisabetsky and Posey 1989; Erickson 2006; Erickson and Balée 2006; Macia 2008; Posey and Plenderleith 2002; Stearman 1989).

The western areas of Amazonia, particularly the pre-Andean region, have been identified as centres of diversity for a number of significant crop species (Clement 1999). Globally important staples including manioc (*Manihot esculenta*), peanuts, pineapple, cacao, runner beans, peach palm ('pupunha' in Brazil 'pijuayo' in Peru), tree cotton, coca, tomatoes, and *Capsicum frutense* chiles (which include some remarkably hot cultivars such as the habanero), are believed to be among the most important plants to have been domesticated in the region.

While there are several valuable studies of forest management practiced by indigenous peoples, the plant knowledge of caboclo, ribereño, and other 'non-indigenous' Amazonian peoples has received considerably less attention (although see Amorozo and Gély 1988; Shanley and Rosa 2004; Silva et al. 2007). Many researchers have remarked on the richness of Amazonian plant knowledge, especially of local pharmacopeias. For instance, the Joti of Venezuela are said to use at least 180 species of plants as medicines (Zent 2009), while the Esse-Eja of Peru and Bolivia use some 143 species, caboclos along Brazil's Rio Negro know and use 193 plant species (Silva et al. 2007), and the Tacana of Bolivia use 150 species as medicines. Each of these groups, of course, also uses plants and plant products for a large number of other purposes including food, fibre, ritual, construction, hunting, fishing, and other utilitarian and technological needs, as well as for firewood. A number of ethnobotanists have also researched what Amazonians know about the plants that animals prefer as foods; the Joti, for instance know more than 500 species that are sought out by animals. This plant knowledge presumably helps the Joti locate places where animals can be found at particular times of the year or the day, and thus are particularly good places to hunt (Zent 2009; McKey et al. 2001; Rival 2002).

Quantifying and comparing ethnobotanical knowledge of Amazonians in a different fashion, 'quantitative ethnobotanists' have determined the percentage of plants found in a typical hectare of forest that are known to particular Amazonian groups as useful for meeting particular needs. Using this approach, Prance et al. (1987) found that the Chacobo of Bolivia had uses for 78.7% of the tree species inventoried in 1 ha, while the Ka'apor of Brazil used 76.8%, the Tembe also of Brazil used 61.3%, and the Panare of Venezuela used 48.6% (Prance et al. 1987). Of all the plant families that these groups used, palms were found to be most frequently used by all four of the groups consulted (Prance et al. 1987). Palms more generally are salient features in the landscapes, and the cultural ecology of both indigenous and peasant production systems (Henderson 1995; Kahn and Granville 1992; Porro 2005). Medical ethnobotany has been another especially important area of recent research, although controversial because of the history and potential for biopiracy (Bertani et al. 2005; Jullian et al. 2006).

Apart from documenting the surprising diversity of plants used by and the high percentage of forest plants that are given a particular use by Amazonian peoples, some recent ethnobotanical work in the Amazon basin has focused on how that plant knowledge may be changing. Although traditionally indigenous knowledge has been presented as centuries-old, accumulative, and fast-disappearing, more recent work has focused on how learning, adaptation, innovation, borrowing, and hybridization continues to occur within the various Amazonian plant knowledges, including pharmacopeias and adoption of useful plants from European sources as well as the African diaspora, such as watermelons, calabash trees, pigeon pea, and rice (e.g., Alexiades 1999, 2009; Zent 2009; Carney and Rosomoff 2009; Carney 2001; Crosby 1986; Ganson 2003; Price 1983; Schiebinger and Swan 2005; Voeks 1997). These works and others suggest that adaptation and resilience are processes that characterize local and indigenous forest knowledge and that the frequent focus on the erosion of that knowledge and its imminent demise does not tell the whole story.

Fig. 4.4 Small portable sawmills process cheap materials of fast-growing timbers produced by smallholders (Photo: Christine Padoch)

Some articles, for example have also focused on the 'hybridization' of traditional or local Amazonian knowledge with science-based or other 'modern' knowledges, including the information that indigenous and other farmers may receive from the many development, extension, and conservation projects that have been directed at Amazonian communities—from farmers' attendance at schools and training courses, from the broadcast and other media, and frequently from involvement in wage labour or participation in other market-based activities (Ayres 1996; Ellen et al. 2000; Laurie et al. 2005). For instance, working as loggers and in sawmills, many Amazonians, especially young men, acquired specialized knowledge about the particular industrial uses of forest species and their desirability in local, regional, and even international timber markets (Sears et al. 2007). In the estuarine floodplain forests of Amapá, caboclo smallholders and family-run sawmills are enjoying economic success today because they formed a new 'hybrid' forest product industry and fashioned a niche in a market left open after the regional timber boom ended in the 1970s. The phenomenon started with a diversified resource management system based on traditional knowledge of forest species, combined with the knowledge and technology gained during employment with boom-time large-scale timber operations and markets (Fig. 4.4). With this new, combined knowledge, caboclo families transformed the local and regional timber markets to include many more locally grown and locally milled timber species (Sears et al. 2007).

4.4 Modern Settlement

Politically, present-day Amazonia reaches into eight countries and one political dependency; Brazil, with almost 70% of the basin dominates; Peru has 13%; and smaller territories are found in Bolivia, Ecuador, Colombia, Venezuela, Guyana, Suriname, and French Guiana.[1] The residents and communities of this complex region are also extremely diverse. Many of them are urbanites, but regionally the level of urbanization varies, with Amazonian Venezuela, Brazil, and Peru each having about 70% or more of their populations living in urban spaces, while the Amazonian areas of Ecuador and Guyana are still predominantly rural (GEOAmazonia 2009). Several recent researchers examining urbanization trends have argued that the conventional division of Amazonian individuals or households into 'urban' and 'rural' has become increasingly difficult as a pattern of dispersed or 'multi-sited' households has emerged throughout the region (Padoch et al. 2008; Brondizio 2006; WinklerPrins and Barrios 2007). In many areas, most families and individuals are highly mobile and maintain household economies that depend simultaneously on both rural and urban incomes and resources. Such emerging patterns have been shown to affect both the extent and the composition of forests (Padoch et al. 2008). Such multi-sitedness may have deeper roots in indigenous cultural practices, which featured seasonal trekking and periodic dispersion and convergence of groups (Redmond 1998; Rival 2002; Whitehead 2003).

Ethnically Amazonia is also extremely complex. People and communities who are strictly considered indigenous by their governments are now a small minority in most of the region. Estimates by the indigenous rights organization Cultural Survival puts the number of indigenous people in the Amazon Basin today at about 2-½ million, and the number of identifiable indigenous groups at 400, or a mere 20% of what they estimate were once 2,000 cultural groups in Amazonia (Castro et al. 1993; da Cunha 1984, 1992). The Brazilian anthropologist Darcy Ribeiro indicated that 82% of the native groups recorded at the turn of the twentieth century were extinct by the middle of the 20th. This was a conflictive and desperate process, as John Hemming, the pre-eminent historian of Amazonian indigenous peoples, has shown in relentless detail (Hemming 1978, 1987, 2003).

While native populations have justifiably received a great deal of attention, many other populations continue to maintain complex relations with forests. These other populations—which include Brazil's caboclos and quilombolas, Peru's ribereños, and others—were actually outcomes of various diasporas that affected the region as a result of detribalization processes, black runaway slave communities, the rubber tappers, and colonization programmes that unfolded at various times throughout out the region, and whose descendents continue to live in Amazonia (Auricchio et al. 2007; de Mello e Souza 1996; Dos Santos Gomes 2002; Gomes 1999b; Hecht 2010;

[1] Again, as mentioned above, the precise numbers and percentages depend on the particular delimitation of Amazonia that is used. For some recent alternative numbers from the Amazon Cooperation Treaty Organization, see GEOAmazonia 2009.

Hecht and Cockburn 1989; Karasch 1996; Nugent and Harris 2004). These communities also have multiple and complex relationships with Amazonian forests and continue to maintain, evolve, and create knowledge of how to manage, create, conserve, and use the forests and other resources of the Basin.

Among these communities are African-Amazonians, whose ancestors first came as slaves from large and important rural and urban communities especially in the eastern Amazon of Brazil, Suriname, and Guyana. In Brazil many of these are designated quilombos or settlements descended from independent black communities (often of 'maroons' or slaves who escaped into the forests); these communities number in the hundreds in Brazil's eastern Amazonia. In colonial Guyana, Suriname, and French Guiana, where Africans made up the main work force during the colonial period, many of them escaped slavery and also settled in the maroon communities in the interior. In Suriname these descendants of slaves who found freedom in Amazonian forests formed a variety of separate ethnic groups including the present-day Saramaca, Djuka, Paramaka, Matawai, Aluku, and the Kwinti (Escalante 1981; Funes 1995, 2004; Gomes 1999a; 2005; Price 1975; Stedman et al. 1992). Known as 'palenques' in Venezuela, Ecuador, Bolivia, and Colombia, these maroon societies can be found throughout Amazonia. Black slaves were used in agriculture as well as gold mining, and thus gold-mining areas, such as Mato Grosso (Brazil), French Guiana, Ecuador, and Colombia, had extensive fugitive settlements.

People from many other regions and nations also came to Amazonia, and their contributions figure in the management practices and the state of its forests. Guyana saw massive immigration from India, where workers were recruited to replace African labour after slavery was abolished. In many other countries, internal migration flows brought workers from impoverished areas outside of the lowland humid tropics. The rubber boom and many subsequent economic opportunities brought large populations of Nordestinos, or peasants from Brazil's arid Northeast into the Amazon to tap rubber, gather a variety of forest and agricultural products, and eventually to settle (Barham and Coomes 1994; Dean 1987; Domínguez and Gómez 1990; Hecht 2010; Reis 1953; Santos-Granero and Barclay 2000; Santos 1980; Taussig 1986; Wolff 1999). In Peru, residents of Andean and sub-Andean communities have been descending the mountains and becoming Amazonians for millennia. Other important additions to the populations of Amazonia include the Chinese who came to work on Peruvian railroads before settling in Amazonian towns and as 'coolie' labour in gold mines and railroad development. Japanese farmers were also settled in areas of the Brazilian and Bolivian Amazon. Middle Easterners, largely from Syria and Lebanon, became an important part of the commercial class with the disruption of the Ottoman Empire and the various upheavals in the Mediterranean.

The various economic booms and busts that periodically lifted and sank Amazonian economies and recurrent political changes and crises, further enriched the ethnic diversity of Amazonia throughout the eighteenth, nineteenth, and twentieth centuries. For example, the task of building the never-completed Madeira-Mamore railway in western Amazonia reportedly involved people of about 50 nationalities (Craig 1907; Ferreira 2005). Regionally, migrants came from Bolivia, Brazil, Colombia, Ecuador, Peru, and Venezuela; outside the region, they arrived from Cuba, Granada, Ireland, Sweden, Belgium, China, Japan, India, Turkey, Russia, and many others (Hardman-Foot 1988, quoted in GEOAmazonia 2009). The earlier attempts at building the rails involved chartering a company, PC Phillips, a construction company from Philadelphia, so the region was also filled with American engineers and adventurers; many of these Americans provided important information on labour practices (Craig 1907), including denunciations of the horrors of the Casa Arana treatment of native populations, which resulted in the denunciations of terror slavery (Hardenburg and Enock 1913; Taussig 1984, 1986).

With these recurrent immigration flows, population growth rates have continually swelled and ebbed. The population of all Amazonia is estimated to have grown at an average annual rate of 2.3% from 1990 to 2007 (GEOAmazonia 2009), although there is considerable variation among regions in population dynamics. The recent growth of the Amazonian population is associated both with natural demographic increase as well as with continuing immigration that reflects many factors, including a variety of national policies that have deliberately stimulated and supported Amazon colonization and fluctuating expansion and contraction of productive activities—including agriculture, ranching, mining, timber extraction, and in some areas, coca production (Almeida 2004; Barbieri et al. 2009; Etter et al. 2008; Hardman-Foot 1988; Frost 2005; Hecht 2005; Hecht and Cockburn 1989; Hecht and Mann 2008; Hecht et al. 1988; Jepson 2006; Lavalle 1999; Pacheco 2006; Schmink and Wood 1984; Smith 1982). Population growth also reflects immigration from outside the region to the Amazon spurred by the poverty, political instability, and violence prevalent at various times in areas such as the Andean highlands.

4.5 Knowledge and Management of Amazonian Environments: Dynamism and Evolution

There continues to be considerable controversy about the exact extent and continuing importance of the management or disturbance of Amazonia's forests. However, there is little doubt that many of the forests that are now found throughout the Amazon Basin do bear the mark of management by pre-historic, historic, and contemporary peoples, probably often superimposed in a complex mixture that cannot be disentangled. These patterns of forest disturbance, management, or manipulation take many forms. Amazonians through the ages and belonging to various communities have developed highly diversified, complex, and dynamic ways of enhancing the economic value of their environments, including the production of timber and non-timber forest products (Guariguata et al. 2010). In many ways perhaps the most useful way to think about them is as 'silvo-agrarian populations' since simple categories of gathering, or settled agriculturalists, simply don't fit the realities of Amazonian livelihood strategies, which involve a complex mixture of forest-agrarian shaping and interactions, including urban-based strategies.

Although many of these management practices are subtle and 'invisible or illegible' to conventional foresters, they have been used to transform forests, to create new types of forests, and to maintain them for generations. Fire is probably the most frequently cited and most effective management tool that past generations as well as today's small farmers appear to wield for changing forests and other components of their environments. Fire is still widely used in swidden (or shifting cultivation) systems and in the management of grasslands for enhancing game production, and more recently the management of pastures for livestock production. Fire not only affects standing vegetation but also, as a plethora of recent research efforts have uncovered, the soils upon which those forests stand (Blate 2005; Hammond et al. 2007; Hecht 2009; McDaniel et al. 2005; Nepstad et al. 2001; Ramos-Neto and Pivello 2000; Rodriguez 2007; Vieira 1999).

Knowledge of the practices and methods by which Amazonian landscapes, including their topography and soils, have been and continue to be altered, has grown rapidly in the past few decades. There also recently has been considerable progress in understanding that both contemporary and past Amazonians engaged in the active manipulation of watercourses as well. In several locations of Amazonia, most notably in the estuarine floodplain, the 'course, dynamics, volume, and significance of local rivers and streams are being changed' (Raffles and WinkerPrins 2003). Raffles, for instance has described how a community of caboclos in the Brazilian state of Amapá have enlarged the main channel of a river in the estuarine floodplain and have dug a series of canals leading from the river into the neighbouring forest (Raffles 2002). This manipulation was done largely to ease access to valuable forest products, including timber, as well as to reach hunting grounds and agricultural lands. The work was done by groups of villagers working over several seasons with the help of water buffalos (Raffles 2002).

Farther upstream on the Amazon near the city of Santarém, farmers have reportedly been manipulating sedimentation processes for many years in order to fill in swampy areas, making them usable for agriculture (Raffles and Winkler-Prins 2003). Using a 'slackwater' process, farmers rely on the fact that the heavily sediment-laden Amazon waters release much of their load when their flow is slowed, thus filling in low-lying areas behind the natural levee. Raffles and Winkler-Prins (2003), cite research that shows that sediment deposition could reach rates of about 3 cm/day, 'producing a potentially significant sedimentation of up to 2 m in any flood season.' This method eventually results in substantially changing the vulnerability to floods of certain floodplain sites, raising them above the zone that is apt to be inundated most years and thus allowing for the production of flood-intolerant crops, as well as changing the forests that can grow on the sites. It is worth noting that Padoch and Pinedo-Vasquez observed other methods of using sediments to 'make land' used for farming and agroforestry that did not involve the digging of channels, but rather the spreading of palm fronds on the ground to slow the velocity of floodwaters and ensure the deposition of flood-borne sediments (Padoch and Pinedo-Vasquez 2000).

Raffles and Winkler-Prins cite many other instances of anthropogenic changes to Amazonian watercourses, including speculation that part of the 'lower reaches of the famous Casiquiare Canal linking the Amazon (via the Rio Negro) and Orinoco river systems may have been opened by Arawak labor' (Raffles and Winkler-Prins 2003, page 177). A recent particularly dramatic example of the effects that deliberate modifications of river channels can have, is provided by Coomes et al. (2009), who recount a human-initiated process that resulted in a substantial shift in the course of the Ucayali River upstream of Peruvian city of Pucallpa. The change began in the flood season of 1997 when a 71 km meander loop of the Ucayali, the major stem of the Amazon, was cut through at a site called Masisea. By 1998, the cutoff gave rise to the most dramatic change in course of the Ucayali in at least 200 years (Coomes et al. 2009). It reduced the length of the Ucayali River by about 64 km, creating a large lake and altering local flooding regimes and sediment deposition patterns all along the floodplain; it even produced a significant shift in the river that is now threatening the port of the city of Pucallpa. Coomes et al. (2009, page130) also report that due to this change, 'long-term shifts are expected in local edaphic and ecological conditions, particularly with respect to vegetation, fish, and other aquatic life in the area'. Their research also indicated that agricultural conditions and general livelihoods up and downstream from the site of the cutoff have been profoundly affected. The massive Masisea cutoff, Coomes et al. (2009, page 132) report, 'resulted from the work of a small number of people who, using simple tools in an incremental but steady manner, took advantage of natural large river dynamics;' their interviews reveal that local residents dug ditches, cleared brush, and engaged in other seemingly small earthmoving activities, thereby changing the river to facilitate their own river transport. The result was far larger in scale and effect than they had anticipated, reflecting the power of the river currents that were unleashed. In a broader historical perspective, this recent example is particularly important as it suggests that

> 'the course and floodplains of major meandering rivers can be strongly influenced by small groups of people working with simple tools, with important consequences—both upstream as well as downstream—for people and the environment; such is the case today and perhaps also in prehistoric times, when rural riverine Amazonia was much more densely populated' (Coomes et al. 2009, page 133).

One can only speculate on how many watercourses and their surrounding forests that are now accepted as completely natural may have resulted from pre-Columbian fluvial manipulation. Those processes are now lost to history and hidden from view.

4.6 Managing Amazon Forests

Present-day methods of directly managing forest vegetation may also give clues to the past. The methods and tools that are being used by today's small farmers are only now being discovered. Apart from the use of fire, the Amazon farmer's and forester's toolbox includes various forms of planting and transplanting (often within forest stands), as well as selective weeding, and a plethora of silvicultural treatments including maintenance of seed trees and other forms of managing natural regeneration, protection of seedlings and saplings, and pruning of trees. Amazonian forests abound in patches and swaths that are particularly rich in economically valuable species, including timbers, fruits, and others. Many of these forest patches are almost

Table 4.1 List of some important types of manchales

Remnant managed forests	Characteristics
1. Caobales (Spanish) or Mogonais (Portuguese)	Forests that include clusters of mahogany trees and were found all over Amazonia (Balée 2003)
2. Cacaois (Portuguese) or Cacauales (Spanish)	Forests where the sub-canopy is dominated by dense stands of cacao (Peters et al. 1989)
3. Zapotales (Spanish) or Zapotais (Portuguese)	Forest where the dominant canopy is the zapote (*Quararibea cordata*) fruit species called (Pinedo-Vasquez 1995)
4. Babaçuais	Forest where the most dominant species is the palm babaçu. These forests are the product of fire
5. Castanhal (Portuguese) or Castañales (Spanish)	Dominated by Brazil-nut trees forming dense stands (Almeida 2004)
6. Siringal (Portuguese) or Shiringal (Spanish)	Dominated by rubber trees and very low-density sub-canopy vegetation (Almeida 2004)
7. Açaizais	Flooded forests dominated by dense stands of açaí palms (Brondizio 2008)
8. Sacha manguales	Forest where the sub-canopy is dominated by the fruit species known as sacha mangua (Peters et al. 1989)

certainly remnants of intensively managed gardens that have now been largely abandoned, or of planted or protected wayside or campsite vegetation that has been periodically manipulated by seasonal trekkers, travellers, or migrants (Alexiades 2009; Anderson and Posey 1989; Kerr and Posey 1984; Rival 2002).

There is a great diversity of such remnants or patches in forests throughout Amazonia; their ages and those of the vegetation that surrounds them vary from the very old (and often believed to have been created by long-dead ancestors), to recently abandoned swiddens. They therefore are essentially ‘cultural forests.’ In Brazil and Peru most of these forests are named after their most abundant and valuable tree species (e.g., ‘siringal’ in Brazil to indicate a forest where rubber trees are abundant; ‘sacha mangual’ in Peru to indicate a forest rich in sacha mangua or *Grias peruviana).* In many parts of Amazonia these patches or remnants fall into the general category of ‘manchales,’ which locally differentiates them from unmanaged forests. Table 4.1 lists several kinds of manchales that are commonly found in the forests of lowland Peruvian Amazon and neighbouring areas. A similar naming system is found in Brazil: ‘bacabal’ *(Oenocarpus bacaba)* ‘buritizal’ *(Mauritia flexuosa),* ‘acaizal’ *(Euterpe oleracea)*, and ‘castanhal’ *(Bertholetta excelsa*), just to mention a few. Toponyms are also useful for indicating other aspects of the landscape that suggest historical occupation as well: ‘Piquia dos negros,’ ‘Kalunda,’ and ‘macumbinha’ all suggest historical Afro-Brazilian settlements, even if such sites today might not be inhabited.

Ribereños of the Ucayali River often consider zapotales (forests of zapote trees) to be especially ancient. The zapote (*Quararibea cordata*) is a tall emergent forest tree that reportedly can survive for hundreds of years. It yields a large, sweet fruit with bright orange pulp. Zapotales are most frequently found along paths that have been used for centuries by indigenous and non-indigenous people to collect forest resources or along varaderos, the important forest pathways that link one river system or watershed to another. These zapotales are believed to have originated centuries ago, but Amazonians today continue to manage them by either intentionally or accidentally dispersing the seeds (while eating or processing food), protecting the seedlings and juveniles in the forests through selective weeding, and occasionally by transplanting seedlings from forests to the edges of pathways, agricultural fields, or fallows or into house gardens. Amazonians tend to clear vines away from any zapote trees they encounter in forests. People not only value zapotes as fruit, but they also know that the fruits attract a variety of game animals, ranging from monkeys to tapirs. Since zapotales are known to be rich in wildlife, Amazonians will use them as preferred hunting sites. Zapote trees are believed to protect people during high winds and storms, because they do not easily break. Travellers therefore have yet another reason to choose zapotales as good places to spend the night when they are journeying through the forest and to contribute to their continual, informal management. Zapotales are particularly abundant in the forests of western Amazonia.

Numerous other fruit and multi-purpose tree species that are found in manchales can be considered indicators of past human residence or presence. The forest disturbances that shifting cultivators typically cause (such as creation of gaps, burning, selective weeding, and others) may also stimulate the growth and therefore creation of manchales of several valuable timber species. For instance, mahogany (*Swietenia macrophylla*), which is one of the most valuable Amazon timbers, is known to successfully reproduce only in clearings (Shono and Snook 2006; Snook and Negreros-Castillo 2004). Areas with dense stands of mahogany, such as some parts of the upper Purus River basin in Peru, may well have been cleared for agriculture in the past by indigenous farmers or during the active phase of the rubber period, creating ideal conditions for regeneration and managed recruitment of mahogany and other valuable species. Virola (*Virola surinamensis*), another highly valued timber species, also appears to thrive with human disturbance of forests. Scholars have suggested that abundant stands in areas such as the Rio Preto in Brazil's estuarine zone may show virola's positive response to fires. More specifically, the now well-known practice of managing swidden fallows or areas that were intensively farmed by slash-and-burn methods for a year or two and then managed as tree-dominated gardens of combined planted and spontaneous vegetation may well be the origin of many fruit as well as timber-rich forest plots (Coomes and Burt 1997; DeJong 1996; Denevan and Padoch 1987; Denevan et al. 1984; Freire 2007; Posey and Balick 2006; Posey and Plenderleith 2002). Amazonian swiddens are frequently interplanted with a great variety of crops that may include annuals such as maize and manioc, semi-perennials such as bananas and plantains, and trees including a great variety of fruits, palms, and other utilitarian species (Padoch et al. 1988; Coomes 2010) that develop over time into dense and diverse forest-gardens. As annual swidden cropping fades with time; mature swidden fallows typically feature an abundance of planted tree crops and managed natural regeneration. Some of the larger trees—such as fruits including Brazil nuts and zapote, or timbers such as tropical cedar (*Cedrela odorata)*—typically persist for many decades within the regrowing forest. The management of swidden fallows both by indigenous groups and by ribereños or caboclos have been described in a very large literature on New World tropical agricultures of which we cite only a few examples (Adams 2009; Balée 1994; Erickson and Balée 2006; Cormier 2006; Denevan 2001; Denevan and Padoch 1987; Denevan and Turner 1974; Domínguez and Gómez 1990; Erickson 2006; La Rotta Cuellar 1989; Pardo et al. 2004; Posey and Balée 1989).

Effects of human activity may be somewhat difficult to ascertain in some other unusual, low-diversity or 'oligarchic' (Peters et al. 1989) forests of the Amazon. For instance, the extensive forests dominated by various native bamboo species (*Guadua* spp.) that cover large areas especially in the state of Acre in the western Brazilian Amazon are believed by some experts to have originated from the clearing of the area by indigenous groups (Balée 2003), or to have specifically resulted from repeated burning. In cattle ranches in southern Para and Northern Mato Grosso, *Guadua* forests appeared in pastures that were repeatedly burned. These, however, could have reflected a soil seed stock derived from indigenous uses (for arrow and artisanal products). Under normal native uses, successional processes would suppress the rapid extension of *Guadua*, but the repeated burning and the cutting away of other successional species favoured *Guadua*, causing it to become a severe pasture pest that required abandonment of some pastures. A similar dynamic seems to be in play for babassu (*Orbignea phalerata*) invasions of pastures as well. However, some recent research has questioned those assumptions suggesting other mechanisms for the bamboos' dominance. It is, of course, difficult to determine with any certainty what initial disturbances might have put these forests first on the road to bamboo dominance.

On the other hand, the importance of human management is clearly evident in the estuarine forests that are dominated by the valuable açai (*Euterpe oleracea*) palm. The fruit of the açai has long been a staple of the caboclo diet in Amazonian Brazil. It has recently also become an important source of cash as the market, because açai has expanded to urban areas and into cities beyond Amazonia and now even overseas. Açaí palms are native to and abundant in the floodplain forests of the Amazon estuary. Both the density and the distribution of the palm in estuarine forests depend on environmental and anthropogenic factors (Brondizio et al. 2002). The application of a variety of management and planting strategies is increasingly transforming the varzea forests of the estuary and beyond into açaí agroforests or 'açaizais' in a process that has been called the açaization of the Amazon estuary (Hiraoka 1994; Brondizio 2008). Açai agroforests include stands under different types and intensities of management, with varying population densities, structures, species diversity and composition. Brondizio (2008) suggests that 'while at the plot level one may observe a decline in tree species diversity in the açaizais when compared to unmanaged floodplain forest, a broader landscape view including plots at different levels of management may show an increase of tree species diversity.'

From his research in the great estuarine island of Marajó, Brondizio (2008), describes three main methods of managing and/or creating açai agroforests: (1) management of native stands; (2) planting of açai stands following an annual cropping phase; and (3) combined management and planting in native stands (Table 4.2).

Table 4.2 Three management systems to produce açai fruits in house gardens, fallows, and forests

Management system	Techniques	Comments
1. Selective forest enrichment system	1. Seed gathering of best phenotypes 2. Seedlings production in jirau (raised beds) 3. Cleaning under trees and planting seedlings	This system is mainly used to manage açai in house gardens. Fruits are produced in 3 years.
2. Seed broadcasting forest management system	1. Broadcasting of seeds in newly open agricultural fields, jogo de semente 2. Select weeding, samear 3. Thinning, afastamento	This system is used to manage açai in fallows. Fruit are produced in 5 years.
3. Forest stand management system	1. Thinning, afastamento 2. Cleaning, limpieça das toras 3. Removal of vines and shrubs, roça	This system is used to manage açai in mature forests. Fruit production increases after 3 years of management.

Management of natural stands is done at both the stand and individual levels. As is typical in the management of other fruit-rich forest stands described above, açai agroforesters often make openings in the canopy and thin the understory to promote the growth of açai palms. They continue to thin and selectively weed the stands and may enrich them further by planting or transplanting additional seedlings. Managing at the individual level, açai producers prune their palms to achieve an optimal number of stems per multi-stemmed palm clump.

When an açaizal is created from swidden or agricultural field, many of the same techniques are used. Fields are first cleared from forest, usually using fire, and in the ashes some combination of annual and perennial crops are planted. As annuals are harvested and gradually eliminated from the farmed plot, açai seedlings (and other economic interesting plants like cacau and cupuassu) are planted in. Weeding and pruning are used to encourage the development of açai seedlings and to control the density of stems per clump. As the plot matures these techniques continue to be used. Brondizio et al. (2002, pages 74–75) report that 'in unmanaged floodplain forests, açai stems contribute less than 15% to total stand basal area, and represent less than 20% of total individuals. As management proceeds, this contribution tends to increase to a level of 50% of total biomass, and up to 90% of total number of individual in 5 years. It is interesting to note how the maintenance of basal area is at similar levels in both floodplain forests and açai agroforestry. Management does not radically change stand biomass but instead influences which species contribute to it. Forest inventory data shows that basal area ranges from 29 to 31 m^2/ha in different types of floodplain forests (Pinedo-Vasquez and Zarin 1995; Peters et al. 1989). In açai agroforestry, it ranges widely from 22 to 41 m^2/ha (Brondizio et al. 2002). It is important to emphasize that açai stands vary very broadly in the type and intensity of their management, so that no 'standard' açaizal can be described. In the estuarine

Fig. 4.5 A highly productive açai stand in a house garden in Foz de Mazagão, Amapá, Brazil (Photo: Christine Padoch)

floodplain of the state of Amapá, caboclo households are increasingly producing large amounts of açai fruits in the extensive gardens that surround their houses (Fig. 4.5).

With the recent extraordinary expansion of the international açai market, various, more conventional plantation approaches to the planting and management of the palm are being developed and tried in the estuary. These 'scientific' or 'modern' plantings, which typically feature far less diversity of plant species than do traditionally managed stands, still constitute only a very small portion of all açai production in the Amazon estuary. Brondizio has noted that with the increasing value of the açai market the adequacy of local caboclo methods of managing as well as of marketing their traditional resource have been questioned, and caboclo açai management techniques either ignored or disparaged (Brondizio 2008). The substitution of unproven but purportedly scientific approaches to açai planting and production undoubtedly reflect this trend.

The booming urban and export market appears also to have stimulated considerable innovation in the system by promoting the selection and promotion of particular varieties of açai, notably a 'white' (*Açai branco*) variety, perhaps signalling an incipient domestication of the palm and more intensive manipulation of açai on a population or genetic level.

4.7 Conventional Silviculture in Amazonia

Silviculture for timber in the way people think about it in the temperate zone hardly exists in Amazonia. However, there have been some large pulp plantations on savanna lands such as those in Amapá. In this Amazonian region, the Jari Project embarked upon by Daniel Ludwig was based largely on the Asian pulp species, *Gmelina arborea,* and was a spectacular failure at the end of the day. In the 1970s and 1980s, there were some demonstration or experimental forest management and timber processing projects in Peru, Bolivia, Colombia, and Ecuador. For instance, BOLFor a sustainable forestry project in Bolivia, was carried out with funding by USAID. Similarly, the Pichis-Palcazu forest project, also financed by USAID, has experimented with low-damage timber extraction systems in the Upper Peruvian Amazon. There have also been many small community forest projects that have had diverse and overall dubious social, silvicultural, and ecological outcomes (De Pourco et al. 2009; Hoch et al. 2009; Larson et al. 2007; McCarthy 2005; Medina et al. 2009; Menzies 2007; Pacheco et al. 2010; Stearman 2006). On the whole the sector remains compromised by extremely high levels of corruption everywhere in the basin, with the World Wildlife Fund (WWF) estimating that more than 80% of timber in commerce is illegally harvested (Tacconi 2009).

There is a vastly growing literature on management of Amazonian forests for fruit (Miller and Nair 2006) and other non-timber products, but very little attention has been paid to the methods and techniques of management of forests for timber or construction materials by local residents (Guariguata et. al. 2010). Furthermore, little has been recorded of the knowledge that they may have of the phenology, regeneration, seed dispersal, and growth characteristics of tree species used for construction. In the next Sect. 4.8 we outline the informal forestry practices that perhaps are responsible for much of the wood production in current commerce.

4.8 Informal Forestry

Both indigenous Amazonians and their caboclo or ribereño counterparts are known to use a great variety of technologies for producing timber, fruits, and other forest products in their fields, fallows, forests, and house gardens (e.g., Padoch and Pinedo-Vasquez 2006; Sears et al. 2007). Although the specifics of each system may well be different and each deserves detailed study, a number of generalizations could be made that describe most management systems that have been observed. One characteristic of Amazonian silvicultural systems is that they tend not to segregate agriculture, agroforestry, and forestry products or practices, and they do not separate planted from spontaneously occurring useful plants. Timber species are often managed in agricultural fields; many stands rich in timber originate as agricultural plots (Fig. 4.6).

Fig. 4.6 Amazonian indigenous and non-indigenous farmers use selected weeding techniques to protect natural regeneration of valuable timber species in their agriculture fields (Photo: Miguel Pinedo-Vasquez)

Timber is also managed in diverse, mature forests, and still other timber trees are planted in house gardens. A diversity of species, purpose, origin, and age characterizes most systems. Secondly and related to the above, all useful species—crops, 'wild' trees, planted trees, etc.—in a particular plot tend to be managed concurrently through a series of complex and complementary processes (Padoch and Pinedo-Vasquez 2006; Pinedo-Vasquez and Zarin 1995; Sears and Pinedo-Vasquez 2004). The management techniques used by Amazonian foresters are typically part of elaborate systems that use and build upon the natural dynamics of vegetation and stand development and use the favourable aspects of each stage of land use. When a field is first cleared for agriculture, typically trees of useful species are spared and even protected from any burning that is done. These often include palm species used for thatch (like Inaja) and other fire-resistant cultivars of crops such as manioc. Subsequently, when crops are planted and weeded, seedlings of economic species encountered in the field are again spared and protected. Crops that are due to be harvested within 3 months or so are managed together with spontaneously occurring trees that may not be harvested as timbers for another 30 years or more. In indigenous production systems, researchers have noted circular plantings with different cultivation zones within which different planting (and burning) strategies are carried out.

This permits more targeted approaches while still maintaining polycropping patterns and diversity in the types of cultivars (Hecht and Posey 1989).

After 2 years or so, intensive weeding tends to be reduced as annual crops are eliminated and semi-perennial and perennial crops come to predominate. At this point the farmers typically leave more natural vegetation to regenerate, which, among its other functions, helps recuperate fertility of the soil. The growth of timber and other useful woody species is encouraged during this transition from field to fallow, particularly during the final season of intensive cropping when farmers encourage or assist in the development of valuable tree seedlings that establish through natural regeneration or are planted, by weeding around the seedlings or freeing them from vines. Fallow management for timber production focuses on juveniles and on the removal of selected vines, shrubs, and trees to create the gradients of light and humidity necessary for the natural regeneration of a diversity of timber species.

Timber management in fields and house gardens also focuses on the protection of seed producer trees and seedlings. Selected seeds and seedlings from these trees are planted or transplanted into more hospitable environments. Seedlings are managed by weeding and are protected from insects, rodents, and floods. The house garden is also an important component of the system, serving as nursery and experimental plot where farmers test selected varieties and species of plants, including timber species. This function of dooryard gardens has been widely documented but very much underappreciated.

This process of fallow enrichment allows farmers to increase the utility and option value of their landholdings while allowing for the necessary recuperation of soil fertility. When one annual crop field is allowed to fallow, Amazonian farmers typically open another field, usually from an old fallow. A trend noted of late in some regions, including the açai-growing estuarine floodplain, however, is a decrease in the area dedicated to annual crops and an increase in area of production forest (Brondizio 1999).

The various smallholder traditional silvicultural systems for managing the seedlings, juveniles, and adult trees of valuable species vary significantly from species to species. Valuable species that are fast-growing are managed differently from the one ones that grow more slowly. Similarly, valuable species that are light-tolerant are managed differently from species that prefer shade. When managing fast-growing timber species, smallholders encourage competition among seedlings because a small number of seedlings (approximately 1 for every 100 seedlings) actually reach the juvenile stage. Amazonians actively thin stands of juveniles of fast-growing species by removing the bark around the stem. This technique is known in the Peruvian Amazon as anillado. The anillado technique helps to control gap formation and sunlight to avoid the establishment of vines and other weedy species. Smallholders manage adult individuals of valuable fast-growing species by repeatedly removing vines and termite nests; local farmer-foresters report that vines and termite nests are the main causes of damage to both wood and fruit production in fast-growing valuable species.

In managing slow-growing species, smallholders selectively weed to protect seedlings that have naturally regenerated or were transplanted in fields, fallows, or forests.

In most cases, the seedlings of slow-growing species cannot compete successfully with seedlings of fast-growing species; therefore, smallholders tend to remove all competing vegetation (including seedlings of fast-growing species) from around the seedlings of the slow growers. Since the natural regeneration of slow-growing species is far lower than that of fast-growing trees, Amazonian farmer-foresters tend to transplant seedlings of the slow growers to enrich their fields, fallows, and forests. Smallholders tend to weed around the juveniles of fast-growing species, especially to control the growth of vines and other fast-growing weedy species. On the whole, Amazonians tend to put much more effort into managing the juveniles of slow-growing timber species than those of fast-growing species. Smallholders annually selectively clear around adult trees of the slow-growing timbers, largely to reduce competition for the natural regeneration of the seedlings of these valuable species.

Amazonians encourage the regeneration of light-tolerant species in their forests by removing emergent trees with particular types of canopies, especially those that are umbrella-shaped; regeneration of those timber species that are not light-tolerant is promoted by leaving two or three seedlings of *Cecropia* or other pioneer species nearby to provide the requisite amount of shade. In some cases smallholders protect the seedlings of light-intolerant species by keeping banana or other perennial or semi-perennial crops in the field specifically for the shade that they provide.

We have observed that Amazonian smallholders encourage stand development by removing vines, opening gaps, and removing any individual trees that are misshapen or have large branches. In forest stands where species of fast-growing timber predominate, Amazonian farmer-foresters do the thinning by harvesting some individuals that can be used for any number of purposes, and/or by eliminating individuals that show any deformations or are not producing fruits. In forest stands where slow-growing species are dominant, smallholders tend to thin by eliminating any individual trees that are deformed or, in the case of fruit trees, those that have been less productive. In most cases stand management includes the simultaneous management of seedlings, juveniles, and adult trees of many species.

In the Peruvian Amazon, farmers manage seedlings in forest stands using two principal forest management techniques: huactapeo and jaloneo.

- Huactapeo is a technique that consists of three operations: selective weeding, cleaning (including the removal of the roots and stems of species that regenerate by sprouting), and controlled burning (including the elimination of regeneration materials such as the roots and stems of sprouting species by burning).
- Jaloneo is a thinning technique that includes the selection of healthy, well-formed seedlings, and uprooting of seedlings with any defects. By uprooting seedlings, managers reduce the probability of their resprouting.

Amazonians also manage the juveniles of valuable timber species along with any planted and protected fruit and other valuable species. While in Brazil smallholders use the afastamento system (enrichment), in Peru farmers use the manchal system (enrichment) to manage juveniles of timber and non-timber species.

The manchal system includes three specific techniques, termed huactapeo, raleo, and mocheado.

- Huactapeo is essentially selective weeding with a focus on removing vines, particularly woody vine species that are believed by farmer-foresters to be the main killers of juveniles.
- Raleo is a thinning technique that consists of removing deformed and diseased juveniles. In communities near urban centres farmers also use raleo to harvest some juveniles to sell as poles in urban markets.
- Mocheado is a pollarding technique that consists of cutting back the top branches of individuals of species that have umbrella-type branching, such as many *Inga* species. Mocheado is done to open the canopy of the stand and let more light into the stand and speed the development in height of juveniles of valuable species.

Overall the three techniques involve selection, marking, pollarding, pruning, liberation, and thinning activities; and they serve to remove undesirable individuals. By removing less desirable individuals from the stands, space and light are made available for growth in height and diameter of stems of the juveniles of valuable tree species. Farmers also use a technique called huahuancheo. This technique consists in cleaning and pruning of the best juveniles or adult trees that are then harvested to sell in the market.

In many cases, farmers begin harvesting fast-growing trees in 4 year fallows and again harvest in the 6th and 8th years. We have observed that in some cases, for instance in stands rich in capirona (*Calycophyllum spruceanum*) or bolaina (*Guazuma crinita*), two marketable fast-growing species, immediately after harvest farmers make new fields to plant agricultural crops, but also to encourage natural regeneration of the tree species (Fig. 4.7). This case is more common in regions where cheap poles and small boards are in high demand (Sears et al. 2007; Padoch et al. 2008).

Two management techniques commonly used to manage adult trees are anillado and desangrado. These techniques are applied on an average of once every 6–8 years.

- Anillado involves the killing of selected stems of competitor species using girdling and fire. Its application causes the tree to die rapidly and avoids resprouting from the roots or stem. Amazonians use it to kill stems of large species that are difficult to control.
- Desangrado is a commonly used girdling technique. Using desangrado, Amazonian farmers remove small stems of competitor species and individuals of stranglers and woody climbing vines. Desangrado involves two operations: selection, in which all individuals of vine and other species that are climbing or strangling the trunk and/or covering the canopy of valuable species are selected for removal; and girdling, which involves the removal of bark, cambium, and sapwood in a ring extending around the selected individual at the bottom of its trunk. From the ring fissure, sap, resins and water are lost. The abundance of resin or sap attracts ants, termites, and other insects that not only extract the sap or resin but also damage any new sprouts. The infestation of insects thus controls the sprouting of vines and helps kill them.

Fig. 4.7 Managed swidden fallows rich in fast-growing timbers (e.g. *Calycophyllum spruceanum* and *Guazuma crinita*) exist throughout Amazonia (Photo: Miguel Pinedo-Vasquez)

The suite of traditional management techniques outlined above is used to increase the value of forests. The application of these techniques results in a significant increase in the commercial volume per hectare of timber. For instance, the mean commercial volume of managed stands rich in capinuri (*Maquira coreacea*), known as capinurales, was 81 m^3/ha for areas that had been managed as mature capinural forests for 8 years, 89 m^3/ha for those managed for 16 years, and 85 m^3/ha for those managed for 24 years. All the above values were significantly higher than the estimated mean of 54 m^3/ha for unmanaged forests in the Peruvian Amazon (Pinedo-Vasquez 1995).

The management of forests for the production of both timber and non-timber products is cyclically linked to agricultural management. When the rate of growth of the timber trees begins to decline, the stand is slashed and a new agricultural phase begins. This cyclical characteristic of forestry practiced by indigenous and non-indigenous Amazonians, makes it particularly different from conventional forestry.

The combination or 'hybridization' of conventional forestry with Amazonian practices is little discussed and has been little explored in the literature. The example we described above (Sect. 4.4) of local farmers who successfully integrated exogenous technology and knowledge gained while working for the large-scale timber industry, with local knowledge of the environment and their silvicultural practices to develop a lucrative local industry in Amapá (Sears et al. 2007), is certainly not unique. The study of such examples, perhaps like the practices themselves, has been neglected because it falls between forestry research categories.

4.9 Forests, Forestry, and the Future of Amazonia

Forest types in Amazonia are a good deal more complex that the standard literature would suggest, and local knowledge systems show a much more elaborate set of classification systems that take in more environmental and ecological complexity than non-native classification systems. This complexity of forest types reflects the degree of understanding of forest histories. Recent studies in archaeology, pollen analysis, ethnography, environmental history, and soil science is leading to an understanding of Amazonian environmental history that views the region as having been substantively modified by human agency in Pre Colombian times and dramatically affected by different booms. In addition, a number of diasporas as well as economic pressures have shaped patterns of exploitation, production techniques, and resource strategies. What is emerging from the ethnographic approaches to resource uses is a sense of an array of techniques ranging from individual species to landscapes that has framed Amazonia's biota in ways that make it very difficult to untangle the 'wild' from the tame, and in many cases, these are not even useful categories. What is clear is that there are suites of management techniques that provide for income and resilience, and protect and enhance diversities, while maintaining biomass through successional processes at the landscape level. These knowledge systems certainly merit greater attention for the longer term, especially given the uncertainties about the impacts of climate change in tropical regions and their pivotal role in global climate mediation.

Outside observers often assume that local tropical people do not know how to manage forests and that the logs and veneers were harvested from 'wild trees' that presumably were in place from time immemorial. We have shown the diversity of knowledge about the management of trees and landscapes in Amazonia, and this huge library of vernacular knowledge could go far in improving forestry in Amazonia. The history of modern forestry with its emphasis on monocultures and rapid yields may yet be successful in some areas of Amazonia, but overall the successes of the formal forestry sector have been open to question. Local knowledge systems that are capable of producing timber and many other commodities, as well as environmental services, merit much more attention. The forms of knowledge and the capacity for innovation in vernacular science deserve to be viewed with a great deal of thoughtfulness rather than dismissing the complexity of such knowledge because it doesn't match the frameworks of conventional forestry, which for Amazonia has largely a history of failure.

Timber is without question the most valuable biotic commodity coming out of Amazonia at this time, and given the prevalence of local extinctions and expanding demand, rethinking forestry in Amazonia is overdue. The education of new foresters in the value of the current practices, along with analyses of the dynamics that produce economically diverse and ecologically complex forest systems, suggests a recasting of pedagogy as well as practice.

The process of integrating the principles, methods, and practices of traditional forest management into training a new generation of foresters is still fragmented despite the existing volume of technical information. Some Amazonian universities have integrated agroforestry, ecology, and other related training courses in their syllabi, but most of these courses are based on conventional principles, methods, and practices rather than on the plethora of knowledge and experiences of smallholder forestry practices. Lack of integration of traditional forest management practices is expressed by the use of conventional techniques in reforestation programmes, rather than the rich diversity of techniques that are equally practiced by indigenous and non-indigenous Amazonians. Similarly, forest management plans designed by smallholders are still not recognized as technical documents by the public forest sector in most Amazonian countries. The above examples are only two of the reasons why a new generation of foresters needs to be trained to use and apply traditional forest management principles, methods, and practices. An accumulating body of knowledge and emerging insights into Amazonian patterns of forest management should help foresters, in both Amazonia and elsewhere, to liberate their thinking and their training from long and complete domination by foreign, colonial ideas of what forestry means and how it needs to be done.

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