AMAZONIAN DARK EARTHS AND *CABOCLO* SUBSISTENCE ON THE MIDDLE MADEIRA RIVER, BRAZIL

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Summary

This thesis examines the relationship between Amazonian Dark Earths (ADE) and *Caboclo* subsistence on the Middle Madeira River, Brazil. ADE are fertile anthropogenic (man-made) soils formed through practices of burning and waste disposal by pre-Columbian Amerindian populations. "*Caboclo*" is a social category that refers to the people of diverse origins that form the majority of the contemporary rural population of Brazilian Amazonia. Bitter manioc fields (*roças*) and homegardens (*sítios*) are the principal forms of *Caboclo* subsistence cultivation on ADE on the Middle Madeira River. Multi-sited ethnography shows that differences in historical ecology at both local and regional scales either enable or constrain *Caboclo* subsistence cultivation on ADE. At communities located on long-term landholdings with a history of egalitarian land-tenure and multi-generational kinship there is a rich body of local knowledge and practice relating to the cultivation of ADE. Interviews with 249 farmers in six localities demonstrate that bitter manioc cultivation in fertile soils (floodplain and ADE) tends to be characterised by intensive swidden systems with smaller fields, shorter fallows, and a predominance of what locals refer to as "weak" (low starch fast maturing) landraces. Bitter manioc cultivation in infertile soils (Oxisols and Ultisols) is characterised by more extensive shifting cultivation systems with larger fields, longer fallows and a predominance of what locals refer to as "strong" (high starch slow maturing) landraces. Interviews with 63 households at 16 communities show that homegardens on ADE combine the most common species of homegardens on Oxisols and in the Floodplain, with other species that occur most frequently on ADE. Homegardens on ADE exhibit significantly higher culturally salient species diversity when compared to homegardens on the other types of soil. Collectively, bitter manioc fields and homegardens constitute cultivated landscapes that show diverging agrobiodiversity on different soils, the outcome of an interplay between soil affordances, *Caboclo* agency and plant responses over time. These findings provide a springboard for some conclusions concerning the relationship between ADE and agriculture in the pre-Columbian period, drawing on what is known from the historical and archaeological record.

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Glossary of Amazonian Portuguese Terms

Aviador — Someone who extends industrial goods on credit, in exchange for extractive goods

Aviamento — An Amazonian system of extending industrial goods on credit, in exchange for extractive goods, that began before the rubber boom, and still continues today

Barracão — Large or medium sized wooden building built during the rubber boom. These buildings functioned as hubs of *aviamento*; to house *fregueses*, store rubber, industrial goods and agricultural produce

Beijú — Manioc bread

Caboclo — The people of the Amazon, who pursue traditional ways of life (manioc cultivation, fishing, hunting, extractivism), and who have lived through the Amazon for generations, of diverse and heterogeneous ancestries

Cacaia — The backswamp area of the floodplain, where the high floodplain *restinga* grades into the lake behind it. Partially or wholly flooded each year, but highly variable, based on water flow between lake, main river course and tributaries

Capitão — One way that people on the Middle Madeira refer to manioc seedlings, owing to a tendancy in their morphology to grow straight upwards, with few branches, towering over the clonal manioc plants, and therefore being the "Captain" of the field

Capoeira	Fallow vegetation
Coivara	After a *roça* has been cleared and burnt, smaller branches remaining are gathered into piles and burnt. This creates patches of concentrated ash and charcoal in *roças*, which are sometimes used to plant yam, sweet potato, or banana
Farinha	Manioc flour
Feixes	Bundles of manioc stems
Freguese / Fregueses / Freguezia	Worker / Workers
Goma	Manioc starch
Macaxeira	Sweet Manioc
Mandioca	Bitter Manioc
Mandioca fraca	"Weak Manioc." Low Starch Fast Yielding (LSFY) Landraces that originate in the floodplain. Most planted on ADE and in the Floodplain
Manidoca forte	"Strong Manioc" High Starch Slow Yielding (HSSY) Landraces originating on the terra firme and most commonly planted in Oxisols and Ultisols
Maniva	Manioc stem, cut at harvesting and chopped into clonal shoots for planting
Maniva de Viado	"Manioc of the Deer." Local people observe that seedlings and deer footprints are both found in freshly planted *roças.* Some believe that the seedlings are planted by the deer, while others believe that the deer like to eat the seedlings
Massa	Manioc pulp left after soaking and removal of skin
Merenda	Snack

Multirão	Work group, normally of extended family kin on the Middle Madeira
Patrão / Patrões	Boss / Bosses
Rabeta	Motor used to power canoes
Regatão	River-bound trader
Restinga	High floodplain, where houses, homegardens and manioc fields are located. Floods only once every 10 years or so when there is an exceptionally high water level during the rainy season
Roça	Bitter Manioc Field
Puxirum	Work group, normally of extended family kin on the Middle Madeira
Saúva	Leaf cutter ants
Seringa	Rubber
Seringeiro	Rubber-tapper
Tapioca	Starchy granules derived from manioc
Tucupí	A sauce made from liquid squeezed from the *massa* mixed with hot chilli peppers
Vazante	Low levee floodplain located between channel and *restinga*, exposed and flooded yearly. The most fertile area of the floodplain owing to yearly nutrient wash from main channel

Chapter 1: Introduction






a) Sebastião with stone-axe head at Community Terra Preta, on the River Manicoré
b) Work group planting bitter manioc in Ultisols at Community Terra Preta
c) River Manicoré at low-water in October taken from bluff at Community Terra Preta
d) Children at Community Terra Preta
e) River Madeira floodplain at low-water in October taken from bluff at Community Água Azul
f) River Madeira floodplain at high water in February taken from bluff at Community Água Azul

This thesis examines the relationship between Amazonian Dark Earths (ADE) and *Caboclo* subsistence on the Middle Madeira River (the biggest whitewater tributary of the Amazon); in the municipality of Manicoré, Amazonas State, Brazil. ADE are fertile anthropogenic (man-made) soils, whose formation is a legacy of Amerindian settlement patterns, mostly during the late pre-Columbian period (2000-500BP) (Lehmann *et al.* 2003c; Glaser and Woods 2004; Woods *et al.* 2009). Today these soils, still highly fertile hundreds or several thousand years after formation, are found at archaeological sites throughout the Amazon basin (Petersen *et al.* 2001; Neves *et al.* n.d.). Contemporary populations in the region do produce analagous soils, albeit at more limited scales (Hecht 2003; Schmidt 2008; Schmidt and Heckenberger 2009; WinklerPrins 2009). The key process in the formation of the soils at ADE sites is known as "biochar" wherein charred organic material is added to soils (Lehmann and Joseph 2009). This initiates a set of biological and chemical processes that lead to increased soil organic matter, microbial activity, cation exchance capacity, pH and nutrient retention, all of which are beneficial for agriculture (Glaser *et al.* 2003; Lehmann *et al.* 2003a; Lehmann *et al.* 2003b). The benefits of biochar are most dramatic in the humid tropics, where soils are generally infertile Oxisols and Ultisols (Lehmann and Rondon 2006). Biochar has been lauded as a possible form of sustainable agricultural intensification for smallholders in the humid tropics. In such regions shifting cultivation (which has been a sustainable form of subsistence agriculture for thousands of years) has been rendered destructive by political, economic or demographic factors, especially in degraded or forested regions (Sillitoe 2006; Glaser 2007). ADE also provide a sustainable form of carbon sequestration (Sombroek *et al.* 2003). Despite these claims, only a handful of studies of the actual use of ADE for agriculture have been carried out. The primary users of ADE in the Amazon today are *Caboclos*, traditional Amazonian people of heterogeneous origins. The research that this thesis presents is intended to help increase our understanding of how ADE are used for subsistence cultivation by these Amazonian smallholders, and this allows us to draw some conclusions regarding the possible relationship between these anthrosols and agriculture in the late pre-Columbian period.

1.1 Amazon Research Sites: History and Ecology

In order to conduct fieldwork it was first necessary to identify an appropriate region and field sites within it. The Amazon is a world of rivers. Since the beginning of human occupation of this region, more than 15,000 years ago, its rivers have provided aquatic protein and a means of transport for people living there. Major variations in the chemical properties of different Amazonian rivers have shaped the historical ecologies of the regions that they flow through; including the size, distribution and contemporary use of ADE. Both Amazonian people and scientists typically split the rivers of the Amazon into three categories. The first is made up of *whitewater* rivers such as the Solimões-Amazonas (The River Amazon in Brazil), Madeira, Purús, Juruá and Caquetá-Japurá. These rivers' headwaters lie in the Andes, their water rich with sediment from these mountains, which is responsible for two characteristics that are of great utility for human inhabitation: fertile floodplains that can sustain intensive agriculture and abundant aquatic protein sources (fish and turtles). The second category is formed by *blackwater* rivers, such as the Negro, Uatumã, or Uaupés, whose dark waters are stained with humic acids from rotting vegetation. Their headwaters are located in nutrient poor regions of the Amazonian lowlands, and therefore these rivers lack cultivable floodplains, and aquatic protein is far scarcer than in whitewater rivers. Finally, there are *clearwater* rivers such as the Xingú and Tapajós, whose transparent waters drain from the ancient and heavily leached Guiana and Brazilian shields. The floodplains of these rivers are are not usually cultivable, and also contain less aquatic protein (Sioli 1984) (Figure 1).

Before research began it was assumed that ADE should hold most importance for *Caboclo* subsistence in blackwater regions. This because these regions lack the fertile floodplains that characterise white water regions, and therefore ADE - being the only fertile soils - should hold greatest importance for their inhabitants. Fieldwork began on the blackwater Uatumã and Negro rivers, to the North East and West of the city of Manaus. Owing to an intertwined set of environmental and historical factors that would only become fully apparent later, these regions are unsuitable for the study of the relationship between *Caboclo* subsistence and ADE (Fraser *et al.* 2009).

Figure 1 The Amazon Basin (the highlighted area) in northern South America. Major rivers mentioned in the text are indicated, along with the Middle Madeira River in the central Amazon region where fieldwork was carried out.

Firstly, while there are many ADE sites on the Uatumã and Lower Negro, they are of restricted size (most are 1-2 hectares [ha]). The proximate factor for the small sizes of ADE sites in these landscapes is the ecological limitation that was imposed on population growth in the late pre-Columbian period by lower availability of aquatic protein in blackwater rivers, and lack of fertile floodplain soils. More recently, the wide dispersal of extractive resources, and inferior quality of rubber in these regions has precluded the formation of long-term communities through which collective subsistence is made manifest. Rather, the families on the Lower Negro and Uatumã are recent migrants of diverse origins who live in individual homesteads on separate landholdings. Kinship relations are only beginning to emerge this generation. This lack of multi-generational kinship makes it harder to mobilise work group labour, which in turn makes it more difficult to practice agriculture. With the exception of Amerindian families who are migrants from the Upper Negro living on the Cuieiras tributary of the North bank on the lower Negro (Cardoso 2008), families who have grown up on the Negro are primarily extractivists, whose livelihoods revolve around commercial and subsistence fishing, illegal timber extraction and gathering forest products such as lianas. While all cultivate some bitter manioc, many of them have to buy manioc flour during some months of the year. Many families have little or no agricultural experience because past generations have pursued extractivist livelihoods. Hence, the possibility of cultivating ADE is unimportant to the subsistence of such families. Those who do cultivate ADE sites tend to be migrants from more agricultural regions, either whitewater regions (such as the Solimões) or peri-urban areas such as Iranduba. On the lower Negro, several of the few individuals for whom agriculture was the primary form of subsistence, stated that agriculture was much more prevalent in whitewater regions, and that ADE was more heavily cultivated in these regions (for a more complete discussion of ADE on the Negro, see Fraser *et al*. 2009). It gradually became clear that - in the blackwater landscapes of the River Uatumã and both sides of the Lower Negro - while ADE clearly played an important role in the subsistence of the few families interested in cultivating them, not enough agriculture was being practiced in the region for these soils to be of great importance for *Caboclo* subsistence. Those who do practice agriculture on the Negro today are usually discrete un-related families, who are recent migrants from subsistence trajectories located in landscapes with more situated agricultural knowledge. In short, there is no widespread “culture of agriculture” in these regions, which is necessary for ADE to be important for *Caboclo* subsistence.

The recognition of the likelihood that whitewater rivers held the most suitable locations for fieldwork on *Caboclo* subsistence and ADE led to a visit to the Middle Madeira River, which turned out to be perfectly suited to research questions. In the region there are many ADE sites[1], a good number of which are large (20-50ha). These sites today are frequently the site of long-term communities, where all the inhabitants are related to one another and subsistence is therefore usually a collective endeavour. The human geography of the region is characterised by such historic communities; that have their roots in small-scale extractive operations on landholdings that were established during the rubber boom. The region, a whitewater river basin, has far larger ADE sites than those of the Negro because the combination of a superabundance of aquatic protein, 5-15 times more than that of blackwater regions (Ohly and Junk 1999; Oliver 2001), and fertile floodplain soils that supported large and settled pre-Colombian Amerindian populations. These regional characteristics have allowed the development of situated agro-ecological trajectories that have resulted in a "culture of agriculture," among local inhabitants with widespread cultivation both in infertile Oxisols and Ultisols of the *terra firme*, fertile ADE and floodplain soils. Chapter two and three examine historical and contemporary *Caboclo* subsistence on the Middle Madeira in greater detail.

1.2 The Origins of Amazonian Dark Earths: *Terra Preta* and *Terra Mulata*

Amazonian Dark Earths (ADE) are generally found on stretches of *terra firme* bluffs that overlook rivers or lakes, but have also been encountered in interfluvial areas, and in the floodplain (Sombroek 1966; Smith 1980; Lehmann *et al.* 2003c; Glaser and Woods 2004; Teixeira *et al.* 2006; Woods *et al.* 2009). Two major classes of ADE are recognised, *terras pretas* and *terras mulatas. Terra pretas* are the outcome of certain kinds of sustained human occupation in a circumscribed locale. More specifically, they are the emergent properties of the soil A-horizon at sites of human inhabitation subject to domestic refuse management, involving different practices of waste disposal across the space of inhabitation, the burning of diverse organic materials including fish, turtle

[1] During the course of research on the Middle Madeira, 193 composite soil samples along with GPS locations were taken at 10 ADE sites in the region. Chemical properties (Ph,P,Ca,Mg,Al,Fe,Zn,Mn) of the samples were analysed at INPA and EMRAPA in Manaus Brazil. Principal Components Analysis and Soil fertility mapping (using ARCGIS 9.3) were used to investigate 6 of the ADE sites. For reasons of space and relevance, these results are not included in this thesis. However, they are presented in an as yet unpublished paper, available from the author at james.angus.fraser@gmail.com.

and animal bones, palm fronds and weeds. Over time, dark brown or black anthropogenic soils form, nutrient rich and frequently replete with broken ceramics. This has been termed the “midden model” of dark earth formation, and is now the standard scientific explanation for the origin of these soils (Sombroek 1966; Smith 1980; Kämpf *et al.* 2003). *Terras Mulatas*, less well documented and therefore more contentious, are thought to have formed through intensive agriculture involving “cool” burning and mulching (Hecht 2003; Schmidt 2008). This is the “agricultural model” of dark earth formation (Sombroek 1966; Andrade 1986; Woods and McCann 1999). These soils are less nutrient rich, light brown or greyish in colour are found adjacent to some terra preta sites. The term Amazonian Dark Earths (ADE) is now standard in the literature and encompasses both of these categories, and the diversity within and between them. Studies have shown that these soils are generally much richer in pyrogenic carbon, (now known to be the key element in the sustainable fertility of these soils); Phosphorus (P), Calcium (Ca), Magnesium (M), Manganese (Mn), Zinc (Zn) and other nutrients important for plant growth (Sombroek 1966; Smith 1980; Falcão *et al.* 2003; Texeira and Martins 2003). Plant trials have demonstrated huge increases in yield for a variety of crops (Lehmann *et al.* 2003a; Steiner 2007). The fertility of ADE is anomalous for a *terra firme* soil in the Amazon region. The soils of the *terra firme* in the Amazon basin are generally infertile Oxisols and Ultisols, renowned for their low nutrient levels and the limitations they present for agriculture, including toxicity caused by acidity and a high iron and aluminium content. Naturally occurring fertile soils in the Amazon are usually found only in the floodplains of whitewater rivers, and very limited patches of fertile “*terra roxa*” on the *terra firme*. Well aware of the fertility of ADE, local inhabitants throughout Amazonia value these soils for agriculture (German 2001; Hiraoka *et al.* 2003; Kawa 2008).

1.3 *Caboclo* Subsistence

The regions with the greatest areas of ADE are the major whitewater rivers of the Brazilian Amazon (the Solimões and Madeira, and their lakes and tributaries) (c.f. Petersen *et al.* 2001). This is because these regions are the richest environments of the Amazon, the most capable of sustaining large populations. Today these areas are mainly inhabited by the Amazonian peasantry known as "*Caboclos*" and so it is these people who are the most common users of this resource, and among whom knowledge and practice of ADE cultivation is well developed. The people living in the Brazilian Amazon today are often distinguished as belonging to three different groups, Indians, *Caboclos* and Colonists (Adams *et al.* 2009a). In reality the two former groups are not mutually exclusive, though both academic literature and the identity politics surrounding distribution of resources by the state for "indigenous" people often renders them so (see Chapter 2). Indians are the remnants of the original Indigenous population of South America. *Caboclos* are of multiple and heterogeneous origins, who are found living traditional lifeways in the rural areas of Amazonia today. Colonists are migrants from southern and North-Western Brazil[2]. The majority of *traditional* inhabitants of the Amazon are *Caboclos*, not Indians, who constitute less than 5% of modern Amazonians (Harris 1998). *Caboclos* are syncretic in that while their modes of subsistence are derived from Amerindian practices established in pre-Columbian times, their standard religion is a folk Catholicism of Iberian origin (though the influence of Evangelical churches is growing). The social category *Caboclo* in reality encompasses a wide spectrum of ethnic origins, cultural forms and cosmologies, ranging from people of entirely Indigenous ancestry that do not formally identify themselves as such, to people who identify both grandparents as originating in North Eastern Brazil, other countries of south America, or even Europe (see Chapter Two).

While they are not *direct* heirs to pre-Columbian knowledge, *Caboclos* have appropriated the major pre-Colombian modes of subsistence, and some of the skills associated with them, that were practiced by Amerindian peoples. It is in such *subsistence activities*: primarily the cultivation of bitter manioc[3] and the practice of fishing, but also in the cultivation of agroforests and kitchen gardens, and the extraction of forest products, that there is most continuity between post and pre-Columbian

[2] Colonists, who move with the frontier (with the roads) are generally poor rural dwellers from different parts of Brazil, Rondonia, Mato Grosso and southern Brazil. They come seeking land and a better life, but with a very different vision of good living than that of *Caboclos*, invariably involving cattle ranching, commercial agriculture, gold mining or timber. There are no colonists as yet on the Middle Madeira, because there are no roads connecting it to the rest of Brazil.

[3] While the term 'cassava' is often used in English, 'manioc' is a more suitable name, as it is closer both to the scientific term *Manihot* and the Brazilian term *mandioca*. Its roots lie in the Tupi word *maniot*. The term 'cassava' comes from *casaba*, an Arawak word that refers to manioc bread, rather than the plant itself (Gade 2002).

lifeways. In engaging in these modes of subsistence *Caboclos* respond creatively to diverse environments. It is this creativity that *Caboclos* manifest in achieving aspects of their subsistence through the cultivation of ADE that is the subject matter for this thesis.

Caboclo people *came into being* in the context of social relations between people of diverse origins involved in colonial and post-colonial trade surrounding the extraction of forest products; many of them historically subsisted through trade and market relations such as *aviamento* (see Chapter 2). For this reason, it is useful to note that Caboclo subsistence has always been achieved through some engagement in market relations, though usually at a minimal level, not normally generating surplus for trade. Therefore the expression "*Caboclo* subsistence," if it is to be historically accurate, must encompass both subsistence agriculture and the practice of extractivism to meet subsistence needs (this would include *fregueses* (workers) and small-scale landholders, but not the owners of large extractive operations, or riverbound *patrões* (bosses)).

Understanding the relationship between *Caboclo* subsistence and ADE is fundamental in evaluating the importance of ADE for smallholder agriculture, since *Caboclos* are the primary users of this resource in Amazonia. Yet few have commented on the apparent paradox in the conclusion drawn by existing studies of *Caboclo* agriculture and ADE: that the most important subsistence crop of both post-Columbian *Caboclos* and pre-Columbian Amerindians, bitter manioc, does not yield well on ADE (German 2001; 2003a; 2003b; 2004; Hiraoka *et al.* 2003; McCann 2004). The question of the relationship between bitter manioc and ADE is examined in more detail later in this chapter, and is the subject of chapters three, four and five.

1.4 The Middle Madeira River

The river Madeira is the longest tributary of the Amazon River and the sixth biggest river in the world. It measures some 3350km (2082 miles) and contributes around 15% of the total volume of water of the Amazon River. The Madeira is classified as a whitewater river because of the fertile alluvium brought down from the mountains that give the turbulent waters their colour (Junk and Furch 1985; Sioli 1984). The Madeira basin covers around 20% of the whole Amazon basin, some 138 million km² (Goulding 2003). On either side of the main river channel is an extensive floodplain, which covers an area of around 60,000 km². The main channel and its floodplain cut through a mosaic of *terra firme* and floodplain lakes (both seasonally flooded and oxbow) and blackwater[4] tributaries such as the River Manicoré, River Atininga and River Mataurá. Satellite photos and ethnohistorical evidence reveal river movement within the floodplain, in the form of oxbow lakes, channels and bluffs with ADE that now lie far from the river. Whilst the headwaters of the river and some of its tributaries lie in the Andes and are therefore whitewater, many of its tributaries are either clearwater or blackwater, draining geologically old regions of the Brazilian landscape. This diversity of river origins has shaped a great heterogeneity in riverine and lacustrine environments and an extremely high biodiversity index (Rapp Py-Daniel 2007). The climate of the region today is in the transition from tropical and super humid to tropical and humid, the average temperature is 27.6° C and average annual precipitation is 2.523mm. The dry season typically falls between June and September and, the rainy season occurs from October to May. The river is at its fullest between March and April and reaches its lowest level between September and October. The upland *terra firme* soils are typically Red and Yellow Oxisols, Oxisols and dark brown, grey and black Ultisols, renowned for their low nutrient levels and the problems they present for agriculture including toxicity caused by their acidity and a high iron and aluminium content[5]. Floodplain soils are Haplic Gleysoils, typical of whitewater floodplains. Regional vegetation is composed primarily of dense lowland evergreen broadleaf rainforest, comprising some 64% of total natural vegetation. Submontane dense lowland rainforest is also present in smaller patches. Along the floodplain of the Madeira occur open alluvial rainforests and dense alluvial rainforests. Open patches of savannah known locally as *campinas* are also encountered inland (Silva 2005).

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[4] These rivers are not blackwater in the same sense that the Negro and its upper tributaries are blackwater. The Manicoré changes in colour from black to green when the Madeira fills and floods into the Manicoré through channels that connect the rivers. Sioli's tripartite division of black white and clear waters is useful for purposes of simple categorization, but the reality is more complex.

[5] The Middle Madeira lies along the boundary of two great soil formations. The eastern bank marks the edge of the Solimões Formation, a region of comparatively better soils. The western bank forms the edge of the Central Brazilian formation characterised by less fertile soils.

1.5 Human inhabitation during the pre-Columbian period

In the late pre-Columbian period the whitewater environments of the Central Amazon such as the Middle Madeira were some of the most heavily populated regions in the entire Amazon basin (Petersen *et al.* 2001; Neves and Petersen 2006). The Madeira floodplain is one of the most eutrophic[6] environments in Amazonia, and this makes it able to sustain such high population densities. The floodplains of whitewater rivers are enriched by sediments in the yearly flood, and those of the Madeira are particularly extensive. The floodplains offer various areas suitable for cultivation along the low (flooding each year) and high (flooding only once every five to ten years or so) levees. Aquatic protein (fish and in the past, turtles) is abundant in all aquatic zones. It has been estimated that there is between five and fifteen times as much aquatic protein in whitewater lakes and rivers than in blackwater ones (Ohly and Junk 1999; Oliver 2001).

The Upper Madeira River passes through the region where the most important Amazonian staple crop, Manioc (*Manihot Esculenta* Crantz) and the only fully domesticated palm species; Peach Palm (*Bactris Gasipaes* Kunth) were both domesticated (Clement *et al.* 2010). This region has the oldest known evidence for sedentary occupations, dating back to 3,500 BP. This evidence is supported by the ADE of that age at archaeological sites. The oldest currently known ADE sites (from semi-sedentary occupations up to 5000 years old) are located on the River Jamari, a tributary of the Upper Madeira. The Jamari sites present the longest known archaeological sequence in Amazonia. These are is also the locations of the oldest known Polychrome pottery (Miller 1992a; 1992b; Meggers and Miller 2006). The Tupi language family originates between the eastern tributaries of the upper Madeira River and the upper Xingu River. Part of the Arawak trunk also originates in south central Peru (Migliazza 1982; Urban 1996). The ancestors of either or both groups may have been directly responsible for the domestication of Manioc and Peach Palm. This combination of languages, ceramics and crop origins, with some of the oldest evidence of sedentary occupation suggests that Tupi speaking people – who cultivated manioc and peach palm and used polychrome ceramics – descended the Madeira from their cultural homelands

[6] Eutropic is used here in its literal sense (from the Greek Eutrophia; well nourished) referring to a body of water rich in nutrients and aquatic fauna.

and expanded through the Amazon starting 2500 B.P. (Neves 2008). The Madeira was an important trade route in the pre-Columbian period, and was certainly integrated into macro-regional trade networks with associated social formations (Heckenberger 2008).

By the late pre-Columbian era (500-1500AD) this rich environment supported large and settled Amerindian populations (Menédez 1992). Broad geographical language maps designate the Middle Madeira as a region inhabited by groups belonging to the Tupi language family (Hornborg 2005). Some languages of the region such as the Mura-Piranhã are of independent origins (Everett 2005). Ethnohistorical evidence points to occupation by independent language groups such as the Mura- Piranhã and the Tupi groups Mundurucu, Parintintin, Arara, and Tora (Horton 1948; Nimuendajú 1948a; 1948b; Amoroso 1992; Menédez 1992).

Recent population estimates put pre-European Indigenous populations in the year 1492 at around 5 to 6 Million for Greater Amazonia and at least 3 to 4 Million for the Amazon Basin (Denevan 2003). Owing to a combination of disease, warfare, slavery and associated social upheaval, these populations were decimated, reaching a nadir by the mid 17th Century (Sweet 1974; Hemming 1978; 1987). Many forests both along the major watercourses and elsewhere in the Amazon are only a few hundred years old, having regenerated following the massive depopulation caused by European conquest (Raffles 2003).

The first description of ADE sites on the Middle Madeira, was by Curt Nimuendajú, who travelled down the Madeira in the 1800's (2004 :159). The only published archaeological survey that has been conducted on the Middle Madeira located many sites (Simões 1987). During the course of the research described here, 22 ADE sites were visited, and many more reported by informants on the *terra firme* bluffs of the main channel of the Middle Madeira, the lakes Capanã Grande, Matupiri, Atininga and Genipapo, and tributaries Manicoré, Atininga, and Mataurá. The presence of such an abundance of, large and deep ADE sites - as much as 2 metres at the community Boca do Rio - and the wider anthropogenic forests, including stands of useful species such as Brazil-nut are evidence of the major landscape domestication that these populations engaged in. ADE are one of the most durable legacies of these inhabitants.

Figure 2 The Middle Madeira River. Communities in white are sites of qualitative and quantitative research, communities in grey sites of land use survey and brief ethnography. *Map drawn by Victoria Frausin*.

1.6 Study Area: The Municipality of Manicoré

The municipality of Manicoré is located in the south of Amazonas state and covers an area of 48.282,48 km²; which makes it a little larger than the Netherlands (Figure 2). The population is 44,327; around 25,000 in the interior and 19,327 in the city (IBGE 2007). This is an anomaly in contemporary Amazonia in that there are more people living in the interior that the city. This goes against the rural-urban migration trend that has seen an emptying out of the interior in recent decades (Becker 1995; Parry 2009). The urban population is highly integrated with the interior population through kinship relations, and rural dwellers support a great many dependants in the city with money (for children in school, other dependants) and agricultural produce (especially manioc flour, which is also the carbohydrate staple in the city). Much employment in the city of

Manicoré is dependent on the local government. There are some micro-businesses selling imported goods, and agricultural produce. Today the Madeira is one of the most heavily populated rivers in the whole of Amazonia. In Brazilian territory it includes the cities of Autazes, Borba, Novo Aripuanã, Manicoré and Porto Velho. The total population is well over 400,000 people in the cities and their rural hinterlands (IBGE 2007).

On the Middle Madeira *all* transport is waterborne, as it always has been in the Amazon, until relatively recently. Manicoré is linked by track to two communities either side of it, but after that, all transport is effectively by river[7]. Families and individuals often have private transport in the form of a *rabeta* motor (5 hp or more) and wooden canoe. There are various small to medium sized local ferries and river-bound traders (locally and historically known as *regatão*) who service passengers and trade with different localities in the interior. Large-scale commerce is done by large ferries that travel (several every day) up and down the Madeira transporting passengers and goods to the major urban centres of Manaus and Porto Velho[8].

1.7 *Caboclo* Subsistence and ADE on the Middle Madeira: The Manioc Paradox

On arrival in the region, the river Manicoré was identified as a good potential research area, owing to the presence of large ADE sites occupied by long established communities. All the communities on the lower reaches of the River Manicoré were visited in order to select a village that would provide the most suitable research site. Selection criteria were guided by the original methodology of the research project, which had been informed by the literature on ADE available at the time of planning. According to this literature, bitter manioc, the crop from which *Caboclos* derive their carbohydrate staple *farinha* (manioc flour), does not yield well on ADE. Farmers

[7] There are footpaths between the villages, maintained in the course of hunting and extractive activities, between many of the communities. They are only used by a minority of the population, and not to transport goods.
[8] These river-bound traders form strong lasting relationships with the communities along their route, often with exclusive sale of produce to one favoured trader. With an eye to the future, sweets and other small gifts are sometimes distributed by the ferry owners to children at these communities.

reportedly found that while stems and foliage grew vigorously, tuber growth was poor. Furthermore, farmers were said to use ADE to plant nutrient demanding "dark earth crops" such as watermelon, maize, beans, West Indian Gherkin and squash (German 2001; 2003a; 2003b; 2004; Hiraoka *et al.* 2003; McCann 2004). If ADE farmers regularly plant a wider range of crops than those who have no access to these soils, one would expect there to be significant differences in subsistence cultivation and livelihoods between those with and those without access to these soils. The idea therefore was to compare the subsistence cultivation of families farming Amazonian Dark Earths (ADE), and families farming Oxisols and/or Ultisols. The Middle Madeira is a region with an abundance of ADE sites, and so it was expected that *Caboclo* communities would be found to be cultivating watermelon, maize, beans, squash, West Indian gherkin on the ADE sites they inhabited. The communities on the lower reaches of the river Manicoré frustrated these expectations however, just as most other communities on the Middle Madeira River would on later occasions. At Boca do Rio in the mouth of the River Manicoré, only a little sweet and bitter manioc was being grown on ADE. Most of the site was covered in homegardens and secondary forest. At Estirão, a similar pattern, a few small fields of maize, bitter manioc, sweet manioc and another with papaya and tomato. Most of the ADE was occupied by the village site, homegardens and secondary forest. At Barro Alto, a much larger community - even more unexpectedly - most of the ADE was covered in bitter manioc fields. At the community of Terra Preta, the pattern of farming most closely resembled that described in the literature. There were at least a few ADE fields with maize, beans and watermelon at the time of visiting (September 2006), see Table 1. The Terra Preta Community was selected because it came the closest to fitting with the pattern of ADE agriculture that was expected from the literature available at the time. Later it became apparent that this cropping pattern was a recent, relatively ephemeral development, owing to the influence that the encouragement of the head of the agricultural cooperative had over his extended family, stretching across two landholdings of the community. As fieldwork progressed it became apparent that the cultivation of these crops on ADE was relatively unimportant in the subsistence of the families living at the Terra Preta Community. During several months spent at the community, time as a participant observer was invariably spent planting bitter manioc fields with the community work group, then weeding those same fields, interspersed with harvesting mature manioc, carrying it to the river to soak, and processing it into manioc flour in *casas de farinha* (manioc flour houses). As time passed, it was observed that Bitter Manioc was planted in ADE, as some fields and homegardens in ADE. Residents stated that bitter manioc yielded well in ADE, and that in the past when the community was larger, it had been heavily cultivated there.

At this point, other communities were visited in order to gain a broader understanding of *Caboclo* subsistence cultivation on ADE. The North Bank of the Madeira was selected as many ADE sites and large communities were reported in the region. On the North Bank of the Madeira the communities Água Azul, Monte Orebe, Monte Sião and Barreira do Capanã were visited. At these communities, bitter manioc was planted at most of the ADE sites. At Barreira do Capanã, farmers said that bitter manioc yielded very well in ADE; it was a case of planting the right varieties. At Água Azul, farmers there explained that there were two kinds of bitter manioc, weak and strong. Weak manioc was fast maturing, had its origins in the floodplain, and yielded well in ADE. Strong manioc on the other hand, was from the *terra firme* and grew best in Oxisols and Ultisols. As research continued, it became apparent that that bitter manioc and ADE were fundamentally interconnected aspects of *Caboclo* subsistence. This is because subsistence can be, and is, achieved through the cultivation of manioc on ADE, but also in a deeper, cosmological sense; because both ADE and manioc are aspects of anthropogenic landscapes that some *Caboclos* recognise have their origins in Amerindian modes of subsistence (See Chapter 3).

1.8 *Caboclo* subsistence cultivation on ADE: Roças and Sítios

A regional survey confirmed the initial observations that *roças* and *sítios* are the predominant forms of *Caboclo* subsistence cultivation in ADE (Table 1, Figure 1). For this reason they became the major focus of research. At the different localities on the Middle Madeira, *Roças* and *Sítios* on ADE are aspects of the cultivation portfolios of many families.

Sítios are literally the “places” that *Caboclos* inhabit. Their most common and spatially extensive element is an agroforest, comprised of diverse useful tree species. Close to the homestead, spatially restricted but intensively managed kitchen gardens are often found. *Sítios* correspond to what are commonly known as homegardens, a form of sustainable agroforestry found throughout the tropical world (Kumar and Nair 2006), and thought to be the sites of the earliest forms of cultivation (Lathrap 1977). *Sítios* are normally the sites of long term inhabitation. This means they are comprised of diverse perennial tree and crop species that were useful to different generations of inhabitants. On the Middle Madeira *sítios* are located on historical landholdings, usually much older than the communities into which they have more recently been incorporated. Sítios are frequently located on ADE sites, because ADE sites are often situated in the most attractive locations for inhabitation (e.g. river access, fresh water access) and successive generations have found the soils advantageous for planting bitter manioc and other secondary food crops and fruit trees. *Sítios* are usually comprised of one or more households, the “clusters” described in Chapter 2, containing several family generations. As I travelled to other communities, it was most common to find *sítios* on ADE sites. Unlike bitter manioc fields, homegardens on ADE have been recognised in the literature as important aspects of *Caboclo* subsistence on ADE (Hiraoka *et al.* 2003). Chapter six presents the findings of a crop inventory of 63 sitios in ADE, Oxisols and in the Floodplain.

Roça (pronounced ‘ho-sa’) literally means “bitter manioc field[9].” *Roças* are cultivated on diverse soil types (Oxisols and Ultisols, ADE and Floodplain soils). On the Middle Madeira, *roças* are cleared from either young or old fallow, and sometimes from mature forest. Firstly, the vegetation is cleared and left to dry out before being burnt. This means that when clearing in old fallow or mature forest, *roças* can only be established during the summer months from May-September, when wood can dry out enough to be burnt. With young fallow, vegetation only needs a couple of dry days to dry, and therefore *roças* can be established throughout the year. Workgroups then plant bitter manioc. The field will require weeding, and manioc tubers are harvested from as little as 5 months after planting up to 3 years afterwards. After all the manioc has been

[9] While fields with other crops are also sometimes referred to as *roças*; they are always qualified as being *roça-of-something*: a field of another crop. The word *Roça* alone always means bitter manioc field.

harvested, the field is usually fallowed, or fruit trees are sometimes planted in order to form a *sítio*.

Manioc varieties are classified as either bitter or sweet, depending on cyanogenic glycoside content. Bitter varieties require detoxification for consumption, but yield well in poor, acid soils, have a high starch content, and are more resistant to pests and pathogens (McKey and Beckerman 1993). Sweet varieties can be eaten roasted or boiled with no need for detoxification, but they are vulnerable to pests, yield less starch and require better soils. It has been argued that sweet manioc is more appropriate for smaller, more mobile groups and bitter manioc is more suited to larger, sedentary populations (McKey and Beckerman 1993). Recent research has confirmed that both sweet and bitter manioc evolved from a single domestication event of the wild species *Manihot esculenta* spp. *Flabellifolia* (said to be of intermediate toxicity) in Southwestern Amazonia (Olsen 2002; Olsen and Schaal 2006). The majority of Amazonian people today are sedentary and are culturally inclined to consume manioc in the processed form as *farinha* (manioc flour) which, when combined with fish, forms their staple diet (Adams *et al.* 2009c). Because bitter manioc is a more productive and versatile crop, and processing is necessary anyway in order to produce the staple foodstuff *farinha*, sweet manioc is of minor importance for subsistence in the areas where bitter manioc is predominant.

The forms of agricultural system under which *roças* are established are known as swidden, or shifting cultivation. The term "Swidden" refers to burned field, or slash and burn agriculture. In this thesis, "Swidden" is used to mean short-cropping (harvesting from 6 months to 1 year after planting), short fallowing *intensive* cultivation. Fallows can be as little as 1-5 years. "Shifting cultivation" on the other hand, is used here to refer to longer cropping (harvesting from one to three years after planting), long fallow (normally above 15 years) *extensive* cultivation, where the field remains in fallow for longer than it is cropped.

The essential difference between *roças* and *sítios* is that the former are cleared from fallow or forest, most commonly cultivated with bitter manioc as an annual, and left to fallow after harvesting. Management of the agroforestry component of sitios does not follow the fallow-cultivatation-abondonment cycles of swidden or shifting cultivation, because most species are perennial. The kitchen garden however, is essentially a swidden, with the important difference that nutrients are added both unintentionally (waste and chicken manure deposition) and intentionally (creation of ADE-like soils in raised beds) by people, and management is more intense owing to proximity to dwellings. We return to this question in the final chapter.

In this thesis "agriculture" is used as a catch-all term, and is employed in conjunction with more specific terms for types of cultivation system such as swidden, shifting cultivation, homegarden etc. While some commentators prefer to avoid using the word "agriculture" (Terrell *et al.* 2003), authors of the recent *Rethinking Agriculture* volume argue that while its root and meaning are inevitably Eurocentric; it has become widely used in academic and public discourse around the world, and changing it would just shift the debate onto the next word and categories used to replace it (Denham *et al.* 2007).

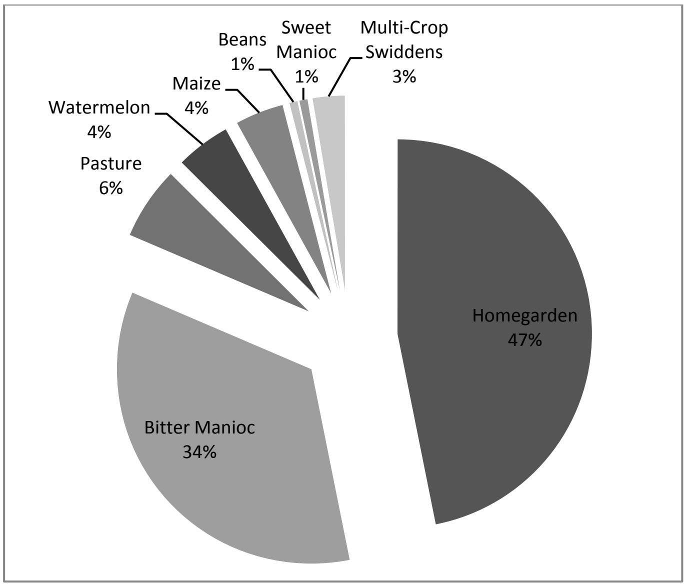

Figure 3 Land-Use on 150 hectares of ADE under cultivation in 13 Communities on the Middle Madeira River in the Municipality of Manicoré, Amazonas State, Brazil.

Table 1 Land Use on ADE at 13 Communities on the Middle Madeira River

Community	**Homegarden**	**Bitter Manioc**	**Pasture**	**Watermelon**	**Maize**	**Beans**	**Sweet Manioc**	**Multi Crop**	**Total Hectares**
Água Azul	2	2.25							**4.25**
Barreira do Capanã	10.5	7.45	2		0.5				**20.45**
Barro Alto	3.5	21.25		0.25		0.5		2	**27.5**
Boa Vista	8	3.25		0.5					**11.75**
Boca do Rio	12	1					0.25		**13.25**
Estirão	6	1			0.75	0.25	0.75	0.25	**9**
Itapinima	2		7						**9**
Monte Sião	4	4.5		0.5	1				**10**
Parana de Urua	8	1			1				**10**
Santa Helena	7	1		0.5	1				**9.5**
Terra Preta	5	1.75		1.25	0.75	0.25		1	**10**
Terra Preta do Atininga	1				1				**2**
Vista Alegre	1	7.25		3.75				1	**13**
Total Hectares	**70**	**51.7**	**9**	**6.75**	**6**	**1**	**1**	**4.25**	**149.7**

Figure 3 and Table 1 give us an idea of family decision making in terms of which investments in different forms of land use on ADE. Comparing table one and table two, we see that the communities where most bitter manioc is planted in ADE are also communities with larger populations. This is the case at Barro Alto, Água Azul and Vista Alegre where locals themselves explain intensification of bitter manioc cultivation (swidden-short fallow) on ADE as an outcome of population pressure. At these communities larger populations live on and cultivate smaller areas of land, and because of this there were only a few large *sítios* at these locations. Most *sítios* at these communities have only a very small number of remaining trees after clearance for houses, and are small because *roças* are located close behind dwellings. This shows that when space is at a premium, bitter manioc cultivation in *roças* takes precedence over *sítios*. At other communities such as Barreira do Capanã, Boa Vista, Monte Sião populations are dispersed throughout larger areas of land (owing to family clusters occupying large separate historic landholdings). People therefore have more land at their disposal, and owing to this, on these landholdings *sítios* are large. Most of the *sítios* included in the quantitative phase come from communities such as these, characterised by large landholdings with relatively few inhabitants (1-4 households).

Table 2 Basic Community Information for study sites on the Middle Madeira River in the Municipality of Manicoré, Amazonas State, Brazil. The *sítios* and *roças* columns show the number of each that were included in the study at each community.

Community	Households	Population	ADE (ha)	Soils	Market Access	Sítios	Roças
Estirão	12	80	30	ADE, OX, UL	Good	3	-
Barro Alto	110	588	30	ADE, OX, UL	Good	3	94
Terra Preta	24	80	20	ADE, OX, UL	Good	5	-
Esperança	39	166	8	ADE, OX, UL	Good	8	-
Boca do Rio	?	?	40	ADE, OX, UL	Good	-	-
Vista Alegre	55	294	30	ADE, OX, UL, FL	Good	-	32
Água Azul	42	207	14	ADE, OX, UL, FL	Good	1	21
Monte Orebe	12	60	6	ADE, OX, UL, FL	Good	-	5
Monte Sião	8	35	25	ADE, OX, UL, FL	Medium	2	5
Boa Vista	4	16	20	ADE, OX, UL,	Poor	2	6
B. do Capanã	38	190	50	ADE, OX, UL,	Poor	9	34
Capanãzinho	36	477	-	OX, UL,	Medium	3	-
Forteleza	21	90	-	FL	Good	-	11
Paú Quemado	33	134	-	FL	Good	-	6
Porto Seguro	20	90	-	FL	Good	3	-
Genipapo	27	120	-	FL	Good	8	-
Delicia	24	100	-	FL	Good	4	12
Amparo	20	80		FL	Good	1	11
Verdum	43	171	-	FL	Good	5	12
Braço Grande	26	149	10	ADE, OX, UL	Poor	4	-
Repartimento	29	151	10	ADE, OX, UL	Poor	2	-

More bitter manioc is planted in ADE on the North Bank of the Madeira, than on the River Manicoré (where only at Barro Alto is manioc heavily cultivated on ADE, the other communities only have a few *roças* each on ADE, though according to elders much greater quantities were planted in the past), Table 2. This is also outcome of population pressure, because the North Bank of the Madeira is more heavily populated than the River Manicore.[10]

[10] Another reason could be because on the North Bank of the Madeira the low levee floodplain (*vazante*) is used for 3 month cycled crops (maize, watermelon, beans), because these soils are the most fertile, and the flood does not impinge on their cultivation because they need to be harvested after three months anyway. Planting bitter manioc in the low floodplain imposes great demands on labour, for all tubers need to be be harvested and immediately processed into manioc flour before the waters rise. For this reason only small amounts of bitter manioc are planted in the low levee floodplain. Hence ADE is more attractive than the vazante for manioc because it can be harvested at leisure.

1.8.1 Bitter Manioc, ADE and *Caboclo* subsistence

Bitter Manioc (Manihot Esculenta Crantz) is the primary staple source of carbohydrates for *Caboclos* living traditionally in rural areas of Amazonia, and the sale of manioc flour (*farinha*) is often an important source of income for them (Adams *et al.* 2009b). The cultivation, processing, sale and consumption of this crop and associated knowledge are therefore fundamental aspects of *Caboclo* subsistence. Bitter Manioc was also a staple crop of the pre-Columbian Amerindian peoples whose settlement patterns led to the formation of ADE (Arroyo-Kalin 2010). Given these facts, it would seem logical to expect bitter manioc cultivation in ADE. Yet most of the literature on agriculture and ADE in the Amazon claims that bitter manioc does not yield well on ADE (German 2001; 2003a; 2003b; 2004; Hiraoka *et al.* 2003; McCann 2004; Sillitoe 2006). These authors state that while *Caboclo* farmers find that while stems and foliage grow vigorously, tuber development is poor. German cited agronomic reasons to explain this inability of bitter manioc to yield well in fertile ADE. This exuberant foliage coupled with small tuber growth might be an adverse reaction of the crop (that is well adapted to the infertile soils of the Amazonian *terra firme*) to cultivation in fertile soils, or to the lack of potassium in ADE, she suggests (2003b:318-319). Roosevelt deployed similar arguments over 20 years earlier in claiming that bitter manioc is unsuitable for floodplain cultivation and best suited to long fallow cultivation on poor soils (1980:119-139).

German, McCann and Hiraoka *et al*. also claim that it is logical for *Caboclo* farmers to plant more nutrient demanding "dark earth crops" such as watermelon, maize, beans, West Indian Gherkin and squash, rather than bitter manioc (German 2001; 2003a; 2003b; 2004; Hiraoka *et al.* 2003; McCann 2004) in ADE. They assert that because manioc yields well enough in poor soils, it makes no sense to plant this crop in better soils, when there are other crops (the "dark earth crops") that *only* yield well in better soils. This is because they assume that reserving better soils for more nutrient demanding crops is the rational decision: underestimating by far the importance of bitter manioc. German and McCann reproduce a wider "invisibility of bitter manioc" in their conclusion that these secondary crops; that are unimportant to *Caboclo* subsistence; are the proper focus of ADE subsistence cultivation (see below). Vegetables and greens are insignificant aspects of *Caboclo* diet, considered as seasonings, not real food (Murrieta 2001). In the Amazon, fruit takes the place of vegetables as a source of vitamins and fibre. Maize is eaten as a snack when still fresh, but mainly is used as animal feed. Beans are only eaten to accompany meat, and a meal with beans as the only source of protein would be considered very poor fare indeed.[11] Watermelon is sometimes planted on ADE for the market, but is considered by many *Caboclos* as troublesome to cultivate. Reasons include vulnerability to pests, and the consequent need to buy and frequently apply pesticide, the timing of planting rendered difficult to by unpredictable rainfall, which may also lead to meagre harvests, and the difficulty of securing a buyer and transport. Tenuous links to the market are probably the overriding factor in the decisions of farmers on the Middle Madeira to plant bitter manioc rather than market crops. With crops such as watermelon or papaya, farmers need very good links to the market, e.g. someone who will both pick up produce and have a market outlet ready for it at the moment when it is ripe. The Middle Madeira is distant from large regional markets, and all transport is water-borne. With bitter manioc, good market links are not necessary; it is the staple crop and therefore always needed in the household and wider community, and there is always a market, at local and regional levels, while no fertilizers or pesticides are required for its cultivation. The municipality of Borba, on the lower Madeira River, illustrates this point. In this region agriculture on ADE tends to be more commercially oriented with production of market crops like watermelon and papaya. This greater market orientation is the outcome of the relatively close proximity of the lower Madeira region to the cities of Manaus and Itacoatiara. *Caboclo* communities in this region have a long history of integration into regional market networks centred on these cities (Nick Kawa Pers. comm.).

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[11] While Watermelon is cultivated on ADE sites on the lower Negro (German 2001), on the lower Madeira River around Borba (Kawa 2008; Fraser, fieldnotes) and on the River Mauhes (Parry, pers. comm.); this is generally by entrepreurial, market-oriented farmers practicing commercial agriculture. Manioc cultivation on ADE has been observed at Caixiuana in Para (Kern and Ruivo, pers. comms.), on lake Tefe, and at communities upriver and downriver from Tefe along the West Bank of the Solimões (Fraser, fieldnotes), On the Middle Amazon (Smith 1999), and on the lower Negro (Cardoso 2008).

The conclusions of German and Hiraoka *et al*. are also in part a product of the historical ecology of the arenas (the lower Negro River and Central Amazon near Manaus respectively) where their research took place. In the case of the lower Negro, as already noted, the historical ecology of the region (the predominance of extractivism, few long term communities, no widespread local tradition of agriculture) is responsible for the lack of agriculture and therefore the lack of knowledge of bitter manioc cultivation on ADE among inhabitants today (Fraser *et al.* 2009). Hiroaka *et al*.'s research took place in the Central Amazonas river region to the east of Manaus. Many of their research sites were in peri-urban areas with roads connecting them to municipal centers (see Hiraoka *et al.* 2003). This is why most of the ADE agriculture that they observed was commercially oriented. McCann's research was conducted on the Arapiuns River in Pará. There are many ADE sites on the Arapiuns, where long-term residents of the river cultivate bitter manioc. In fact, virtually no one plants anything other than bitter manioc on the Arapiuns (Jos Barlow, pers. comm.). McCann also reported bitter manioc cultivation on ADE on the Arapiuns but curiously, he reached the same conclusion as the other authors. On the Middle Madeira, bitter manioc is widely cultivated on ADE, and a rich body of local knowledge surrounding ADE agriculture has developed over the last few generations. We examine this in detail in Chapters two and three.

The consensus that bitter manioc does not yield on/is not cultivated on ADE is also related to a general "invisibility" of manioc in the literature on Amazonia (Adams *et al.* 2009c). A classical debate exists around the most limiting factors for human inhabitation in the Amazon: which is more scarce; protein or carbohydrate? (Beckerman 1979; 1994; Gross 1975; 1983; Meggers 1954; 1971; Carneiro 1970; see discussion in Adams *et al.* 2009c). In the richest environments of the central Amazon - whitewater floodplain regions - the superabundance of aquatic protein means that calorie sources, of which bitter manioc is the staple, are the most critical factor in achieving human subsistence (Meggers 1971; Murrieta and Dufour 2004; Adams *et al.* 2009c). As Adams *et al*. recently put it:

"despite the socio-economic invisibility of the manioc grown and consumed by traditional populations in the Amazon, the combination of this tuber and its derivates with fish ... forms the nucleus of the riverine adaptive strategy, at least partially explaining the impressive historical resilience of these communities on the Amazon floodplains and, perhaps, other landscapes of the region too...It is beyond question that manioc and fish constitute the staple diet of various indigenous communities along the major watercourses (rivers and shores) of the Amazon ... far from being a retrograde diet, manioc must have always been the core cultivar in the Caboclo subsistence system." (2009c: 298)

Adams *et al*. go on to argue that bitter manioc has remained fundamental to *Caboclo* substance because, a) it is genetically most well suited to the cultivation in the tropics (and it is well suited to slash and burn agriculture, having evolved in the forest-savannah interface) b) of the astuteness of *Caboclos* in maintaining for their subsistence a crop whose genetic diversity, cultivation, and processing is in their hands, and not at all controlled by external actors, which is at least partly the case with many other tropical crops such as maize or rice. c) Finally, to *Caboclos*, bitter manioc is more than just a staple source of calories, its consumption and central position in subsistence activity is deeply embedded in social relations, memory and place. The adoption of the "manioc/fish binomial," as the subsistence base, may have initially for practical reasons of survival, but through its endurance for over 200 years its importance is reflected in symbolic values that its role in subsistence have generated and continue to generate among *Caboclo* societies. In this thesis, I argue that this importance of bitter manioc to Caboclo subsistence is the driving force behind the emergence of different manioc cultivation systems in different soil types, including ADE, and the knowledge associated with them (Chapters three, four and five).

On the Middle Madeira, the cultivation, processing and consumption of bitter manioc are deeply embedded in *Caboclo* subsistence and cosmology. In the interior, real food (*comida*) is manioc flour with fish or bushmeat. In the city, beef or chicken may substitute fish and bushmeat as the protein source accompanying farinha. *Caboclos* remark that exotic foodstuffs, such as pizza, available in Manicoré, *não e comida* (is not food). The importance of manioc is also shown in the way that the derogatory expression "*elles estão comprando farinha!*" (they are buying manioc flour!) works as an idiom for destitution. If people in the interior are buying *farinha* they are seen to be destitute, not only because they are incapable of producing their own food, and/or mobilising the labour necessary to do it, but they are obviously bereft of relatives and friends capable of giving or loaning them *farinha*. Elders recall how in more remote regions of the Amazon during the rubber boom, more exploitative *patrões* forbid their workers to plant bitter manioc, thus forcing them to buy *farinha* from their own *patrão* at high mark-ups. This is remembered as a particularly cruel and exploitative form of domination, as it prevented people from achieving their own subsistence. Manioc cultivation is therefore fundamental in achieving food security and the existential well being that comes with it.

Manioc cultivation is usually practiced in anthropogenic landscapes, elements of which -namely ADE, old fallows and the manioc seedlings that sprout when they are cleared - are interpreted by some *Caboclos* as indices of ancestral or Indian agency (Chapter 3, section 3.9). Manioc is planted by way of cuttings from the stems (*maniva*). When planted, these clonal shoots grow into manioc plants that are genetically identical to the mature plants they were cut from. Manioc retains its ability to reproduce sexually, and produces seeds that lie dormant in fallow vegetation, to sprout when land is cleared and burnt anew. Many *Caboclos* believe that the seedlings that appear in newly burnt manioc fields cleared from very old fallow do so because these landscapes were once cultivated by ancestral inhabitants, the Indians. Furthermore, some *Caboclos* are aware of the processes through which ADE form, and recognise that ADE are the outcome of old Indian settlements (Chapter 3). These two elements are combined in the observation that manioc fields cleared from old fallow on ADE produce lots of seedlings. In the presence of seedlings in *roças* on ADE they recognise that manioc was also cultivated in ADE, both by recent inhabitants, and older ones; depending on the age of fallow cleared. This means that bitter manioc, old fallows, and ADE have a cosmological significance *vis-a-vis Caboclo* subsistence; they are manifest elements of the landscapes in which they cultivate, connecting them to the ancestral inhabitants of their land (See Chapter 3).

1.9 Methodology and Thesis Outline

This section outlines permissions and ethical considerations, describes how ethnography was carried out, outlines the quantative methods used, and how individuals and communities were chosen for sampling during the quantitative phase. The final outline of the thesis summarises the content of each chapter, also discussing key methods and findings.

1.9.1 Permissions and Ethical Considerations

Fieldwork was conducted under the auspices of a Scientific Expedition [Art.2º da RN nº 65/2005 Portaria MCT nº 858/05] granted by the Brazilian National Research Council (CNPq). The ethics of the proposed research were evaluated and permission granted by the Ethical Committee of the National Amazonian Research Institute (INPA). During the qualitative phase, periods of weeks and months were spent at different communities, and this provided ample time to gain the confidence of, residents and to fully explain the purposes of research. Informants were assured of the independent nature of research, that information they divulged would not be shared with institutions such as IBAMA (Federal Environmental Agency). Research findings were constantly and openly discussed and critiqued with participants. On arrival in communities the president of the community was approached, the purposes of research were explained, and permission was asked to conduct research in the community. Every informant was assured that interviews were for the purpose of research that was independent of institutions such as IBAMA (Brazillian Institute of the Environment and Natural Resources).

1.9.2 Phase One: Qualitative Research

As described in section 1.8., during initial visit to various communities in the Middle Madeira region, I realised that *Caboclo* subsistence on ADE was influenced by the diverse local histories and geographies. Focussing on only one or even two communities, would yield only a parochial representation of *Caboclo* subsistence on ADE. In order to be able to take up a broader perspective on *Caboclo* subsistence on ADE, I adopted multi-sited ethnography and participant observation in communities where ADE was significant to *Caboclo* subsistence. The results of thie research are presented in chapters two and three. The central locations during long-term fieldwork were the communities where most agriculture was practiced on ADE: Terra Preta, Barro Alto and Barreira do Capanã and Boa Vista. I spent several months at each of these communities, split into one or two week intervals, between September 2006 and March 2008. I also spent several weeks at other communities cultivating ADE. These were Estirão, the Água Azul region and Vista Alegre. While I stayed at these communities I participated in daily activities, mostly planting, weeding, harvesting and processing bitter manioc, weeding homegardens and collecting and consuming fruit, and fishing. During these activities, and during periods of rest and at mealtimes, I conducted unstructured and open ended interviews on different aspects of *Caboclo* subsistence, focussing especially on: local and regional culture and history, manioc cultivation in different kinds of soil, different fallows, landraces, local knowledge of landraces and successional processes in the use of categories weak and strong, local knowledge of manioc sexual reproduction, management and incorporation of seedlings, perception of new clones from seedlings, local conceptualisations of degrees of bitterness and sweetness of manioc, local environmental knowledge and homegarden species and their uses. During this research I identified the localities where most bitter manioc cultivation was taking place on ADE, Barro Alto, Barrierã do Capana and Boa Vista, the Água Azul region, and Vista Alegre. Ethnography of manioc cultivation then focussed on these areas especially (see Chapter 3), and these communities were selected for quantitive research.

1.9.3 Phase Two: Quantitative Research

In the context of the qualitative research described above, a novel set of quantitative methods were generated in order to compare *roças* and *sítios* on ADE with *roças* and *sítios* on different soils; at different locations on the Middle Madeira River. This section describes the process through which individuals were selected for inclusion in the study, while actual methods are presented immediately before data is presented in Chapter 4 and Chapter 6. In communities where I was already familiar with many inhabitants, quantitative data was gathered in the context of ongoing qualitative work. In those communities visited only for quantitative work, contact with people was made through a total population approach, where all individuals willing to participate were included.A total population approach was chosen because there have been few studies of ADE agriculture and none comparing ADE homegardens and bitter manioc fields with those located in different types of soil. Therefore, for findings to be robust it was necessary to include as many informants as possible. On the second and subsequent visits, attempts were made to include all members of the community in the study. This involved visiting every single household in each community. Some people were not present during any of the visits, while a few others were not willing to be interviewed. The study is therefore based on *the closest approximation to the total population* in research communities, given the constraints imposed by time and some individuals not wishing to participate. The quantitative methods used to gather data are described below and in further detail in relevant chapters.

1.9.3.1 Bitter Manioc Quantification

The four localities that had the greatest numbers of people cultivating this bitter manioc on ADE were selected for semi-structured quantitative interviews: Barro Alto, Barrierã do Capana and Boa Vista, the Água Azul region, and Vista Alegre. In order to be able to compare bitter manioc cultivation on ADE with the background soils of the *terra firme*, equivalent numbers of farmers cultivating Oxisols and Ultisols were interviewed at these locations (see Table 2). This so called "blocked design" (comparing similar numbers of farmers in each kind of soil at the same location) was selected in order to minimise the confounding effects of differences between different communities on manioc farming (Bernard 2006) . Comparing an equivalent number of farmers cultivating on each soil type at each location is the best way to examine farming in different soils, because it minimises the effects of differences in human and physical geography on manioc farming between different locations/ communities. For this reason, quantitative data from manioc farmers at other locations was not included.

In order to investigate bitter manioc cultivation in the floodplain, it it was necessary to include floodplain communities.This is because *Caboclos* who live on the *terra firme* usually only cultivate on the *terra firme*. In order to incorporate floodplain farmers two localities were selected. The first, the Água Azul Floodplain (comprised of farmers resident in the floodplain communities Forteleza, Paú Quemado, and a few farmers at Água Azul and Monte Sião who had fields in the floodplain), was selected because the researcher was already acquainted with farmers at all of these communities. To complement this, the communities Verdum, Amparo and Delicia, four hours downstream from Manicoré were selected. These communities were of particular interest as they are among the longest established floodplain communities on the Middle Madeira and this is where the most popular bitter manioc landrace in ADE, Tartaruga, is widely planted in the floodplain. The quantitative methods used to gather data are outlined in section 4.2., and described in detail in the relevant chapters.

1.9.3.2 Homegarden Quantification

In the central research communities, all of the homegardens on ADE were included in the study. These communities were; Terra Preta, Barro Alto and Estirão on the River Manicoré, and Água Azul, Monte Sião, Boa Vista and Barreira do Capanã on the North Bank of the Madeira (Vista Alegre and Monte Orebe had no homegardens on ADE). All homegardens of comparable size on Oxisols/Ultisols in these communities, whose inhabitants were willing to participate, were included. Because of the fact that at many of these communities, almost all homegardens are on ADE, it was necessary to include other communties in order to obtain a sample size comparable to the sample of homegardens on ADE (see Table 2). Because of the fact that the homegardens of most communities are located on only one or at the most two kinds of soil, it was not possible to achieve a blocked design (e.g. compare equal numbers of homegardens on each kind of soil at every community). This brings up the issue of the effects of factors such as market access on homegardens on the different kinds of soils. This, and other aspects of methods and data collection are described fully in sections 6.2-6.4. All homegardens at the community Esperança on the River Manicoré were included, as were three at the community of Capanazinho, neighbouring Barreira do Capanã, with informants who the researcher knew from time spent at Barreira do Capanã. Finally, floodplain homegardens at Verdum, Amparo, Delicia, Genipapo and Porto Seguro were included. These communities were selected because they contain many large homegardens, comparable in size to those on the *terra firme.* At other locations in the floodplain, such as the Água Azul Floodplain, homegardens were non-existent or very small (<0.25ha).

1.9.4 Outline of the Thesis

Chapter two introduces the reader to *Caboclo* subsistence on the Middle Madeira River from a historical perspective. It draws on ethnography, especially oral histories and the historical literature of the Amazon. It opens with an examination of exactly what a "*Caboclo*" is, discussing representations of them in the literature and by the Brazilian state. A history of *Caboclo* subsistence is then presented, followed by a discussion of kinship relations. This is illustrated with the case of one *Caboclo* community, Terra Preta. We then examine the subsistence trajectories of four different regions of the Middle Madeira. This demonstrates how contemporary relationship between *Caboclo* subsistence and ADE has been shaped by divergent agro-ecological trajectories in different regions. A major thread running through the entire chapter is the importance of access to land in enabling *Caboclo* subsistence cultivation. The chapter demonstrates how a conjunction of historical and ecological factors have combined to make ADE important to *Caboclo* subsistence in several localities on the Middle Madeira River, where egalitarian land tenure has allowed agriculture to be practiced for generations. While by constrast in other localities, ADE was unimportant to subsistence as settlement patterns became disrupted in the context of struggles over land tenure, patron-client relationships and caboclo/Amerindian identity. The former locations with situated agricultural trajectories on ADE were therefore selected for further research.

Chapter Three presents the findings of an extended ethnography of bitter manioc cultivation on ADE on the Middle Madeira. It describes the local categories of "weak" and "strong" which people use to describe sets of traits associated with low starch, fast maturing manioc landraces, and high starch, slow maturing landraces respectively. The categories "weak" and "strong" are also use by locals to describe the land; where strength is determined by the age of fallows: weak land is covered by young fallow, whilst strong land is covered with old fallow or mature forest. Locals claim that weak manioc is suited to weak soils, whilst strong manioc is suited to strong soils. The four localities where manioc is most cultivated in ADE are described, and narratives from farmers there are presented and analysed. In the context of the primacy of bitter manioc and the relative unimportance of sweet manioc the question of bitter and sweet manioc is reframed as one of "how bitter?" Evidence is also presented of local understandings and widespread management of manioc seedlings, which shows the process through which genetic diversity is generated and amplified. This led to the hypothesis that given that farmers select different landraces when planting in different kinds of soil, the seedlings they incorporate will exhibit genetic traits derived from the landrace assemblages the predominate in different types of soil. This should lead to divergent co-evolutionary dynamics in manioc cultivation in different soil types.

Chapter Four presents and analyses quantitative data on bitter manioc cultivation in four kinds of soil at six locations on the Middle Madeira. It presents several novel indicies that are used to quantify aspects of bitter manioc cultivation. *Landrace area per hectare* represents the proportion of each field occupied by a certain landrace. *Performance Ranking Index* ranks farmer perceptions of the performance of particular landraces in different soils of the *terra firme* (this index is based on the propensity of farmers to claim that different landraces perform better or worse in different soils). The *Strength Index* comprised of asking farmers to rank the landraces they know well from weakest to strongest (this index is based on farmer's use of categories weak and strong to refer to the rate of maturation and starch content of different landraces). This chapter demonstrates that in each locality there are differences between the cultivation of bitter manioc in different types of soil. Patterns identified include the similarities in the cultivation of bitter manioc in ADE and the Floodplain (swidden cultivation: shorter fallows, more weak landraces, shorter cropping periods), and in Oxisols and Ultisols (long fallow cultivation: longer fallows, more strong landraces, longer cropping periods). Farmers select landraces because they perform well in particular soil-successional scenarios. Seedlings from sexual reproduction that appear in manioc fields as volunteers are then already more likely to exhibit genetic traits that make them well adapted to particular cultivation systems. A survey of farmers showed that a percentage of individuals at all localities select them for incorporation into the planting stock of clones, this will generate genetic diversity that is adaptive to such cultivation systems. Because the genetic traits of seedlings in these different cultivation systems on different soils reflect the predominant genetic traits of different landrace assemblages, when seedlings are incorporated as new clones, divergent co-evolutionary dynamics emerge in different agricultural systems on different soils over time.

While anthropological studies of bitter manioc cultivation in the Amazon have almost exclusively focused on long-fallow shifting cultivation in marginal areas of low soil fertility, a large proportion of bitter manioc cultivation has taken place in the rich whitewater landscapes of the Central Amazon. Chapter Five examines the full Madeira dataset for manioc cultivation in four environments, two nutrient rich (ADE and the Floodplain) and two nutrient poor (Oxisols and Ultisols). It presents the combined data for landrace area per hectare, performance ranking index and strength index from the six localities described in the previous chapter, along with data on seasonality, field sizes, and yields. This chapter demonstrates that bitter manioc agriculture on the Middle Madeira River tends to be characterised by *intensive* swidden systems with smaller fields, shorter fallows, and a predominance of “weak” landraces. The genetic traits of weak landraces make them well adapted to swidden cultivation in richer landscapes: they are fast maturing and yield well in fertile soils. Bitter manioc agriculture in infertile soils (Oxisols and Ultisols) is characterised by more *extensive* shifting cultivation systems with larger fields, longer fallows and a predominance of “strong” landraces. The genetic traits of strong landraces similarly make them well adapted to long fallow shifting cultivation, they are slow maturing and yield well in the highly leached acid soils of low fertility that are typical of the *terra firme* in the Neotropical lowlands. These different bitter manioc cultivation systems manifest diverging loci of bitter manioc agrobiodiversity, each featuring a predominance of certain genetic traits; selected because they are adaptive to particular soil conditions.

Chapter six compares the culturally salient agrobiodiversity of 63 homegardens in ADE (n 21), Oxisols (n 20) and in the floodplain (n 22). The families living in these homegardens were interviewed in order to find out numbers of species and individuals of those species that they consider to be part of their homegarden. The results of these species inventories were used to construct three indicies of culturally salient species richness (number of species), density (number of individuals) and area coverage per hectare (density divided by size of homegarden then multiplied by species crown size).

These three indicies are used to represent aspects of agrobiodiversity. They are analysed with several kinds of statistical analysis (non-Metric multi-dimensional scaling, Shannon Index, Anova and SIMPER) and this demonstrates that there is a greater culturally salient species agrobiodiversity in homegardens on ADE.

Chapter seven concludes the thesis by synthesizing its major findings. ADE and *Caboclo* subsistence are shaped by regional and local historical ecology. The two major forms of *Caboclo* subsistence cultivation on ADE, bitter manioc fields (*roças*) and homegardens (*sítios*), when looked at together, constitute cultivated landscapes. Chapters four to seven demonstrated that cultivated landscapes in different soils feature both different patterns of landraces and species. This constitutes divergent patterns of bitter manioc landraces and homegarden species, and associated knowledge and practice in their cultivation in different soils. *Caboclos* generate this agrobiodiversity through the creativity of their subsistence in relation to different environments. These findings are used as a springboard for some conclusions about the relationship between pre-Colombian agriculture and anthrosols in Central Amazonia, in the context of a discussion of historical and archaeological material.

Chapter 2: *Caboclo* Subsistence on the Middle Madeira: A History





a) Maria Magdalena peeling bitter manioc skins after soaking in river. Community Terra Preta
b) Maria Magdalena carrying manioc pulp up the river bank. Community Terra Preta
c) Rubber (*Hevea Brasiliensis*) trees at the ADE site at Community Santa Helena, River Mataurá
d) Brazil-nut (*Bertholletia exelsa*) tree at Community Estirão, River Manicoré
e) Emilton Carneiro, founder of Community Estirão

In order to understand "*Caboclo* subsistence" it is necessary to address the question of what each of these terms mean in the historical context of the Middle Madeira River. Here I use material from ethnography and the literature to situate "*Caboclo*" and "subsistence" within the historical ecology of the Middle Madeira. I begin by asserting that the heterogeneity of *Caboclo* subsistence on the Middle Madeira problematises aspects of the academic literature on *Caboclos*; and the indigenous policies of the Brazilian state. This is followed by a general history of *Caboclo* subsistence and its relationship to ADE on the Middle Madeira River. This reveals a trajectory stretching from the primacy of extractive activity in achieving *Caboclo* subsistence, with cultivation always practiced to a certain extent, through the decline of extractivism to the emergence of the more general culture of agriculture found in the region today. The history and geography of kinship on the Middle Madeira is presented, drawing on regional and general literature. I argue that kinship as history on the Middle Madeira is of key importance in creating and maintaining this culture of agriculture. Aspects of this are illustrated through the presentation of a Case Study of the Terra Preta Community, on the River Manicoré on the Middle Madeira. Finally, different subsistence trajectories in different localities within the Middle Madeira region are presented in order to show how ADE will only be an important aspect of *Caboclo* subsistence if certain conditions are met. These include access to land, secure ownership/stewardship, and the existence of long established communities. These elements provide both the *necessity* to use ADE to meet the subsistence needs (for manioc flour, and a variety of homegarden species for diverse uses) and the kinship relations that have formed through multi-generational residence, in order to maintain the labour necessary to engage in the subsistence activity required to meet these needs. The importance of ADE for *Caboclo* subsistence is therefore shaped at multiple scales: from local agro-ecological trajectories (see section 2.5) to regional historical ecologies (Fraser *et al.* 2009).

2.1 What is a *Caboclo*?

The word *Caboclo* may originate from the Tupi *caa'boc*, meaning "who came from forest," or *kari'boca* "son of the white man." Today this term is used in Brazil is to refer to the Amazonian peasantry, whom we have already noted, are a diverse and heterogeneous group of multiple origins: Amerindian, North-eastern Brazillian and European (mostly Iberian). The term "*Caboclo*" is an ambiguous one, both in the literature and amongst the people living throughout the Amazon. This term is problematic because it has pejorative connotations , and is not usually used by the peasantry of the Amazon to refer to themselves (Pace 1997). Its use has continued despite this because there is no obvious alternative. This thesis uses the term, because it is now standard in the academic literature on the subject of the Amazonian peasantry (Nugent 1993; Adams *et al.* 2006; Adams *et al.* 2009b).

The first studies of *Caboclo* people and their culture tended to be characterised by functionalist and ecological determinist perspectives popular at the time, and therefore tended to portray these Amazonian people as being ahistorical and homogenous, whose traditional subsistence practices were determined by the harsh environment they lived in. (Meggers 1950; Moran 1974; Parker 1985; 1987; Ross 1978). These approaches have been extensively critiqued in more recent work, which emphasizes both the historical identity of *Caboclo* societies and the diversity of origins and social realities of these people (Nugent 1993; Nugent and Harris 2004; Adams *et al.* 2009b). The ability of *Caboclos* to engage in large scale landscape transformation has also recently been demonstrated (Raffles 1999; 2003; Raffles and WinklerPrins 2003). Despite these advances, these newer studies have not adequately addressed the diversity of *Caboclos* and their subsistence trajectories at the local level. This is probably because most of the research that they draw on usually focuses on a single community, and/or a restricted area, and therefore do not recognise the significant differences between *Caboclo* communities at different locations within the same region (e.g. Lima 1992; Harris 2000; Raffles 2003).

During the course of fieldwork, it became apparent that *Caboclo* subsistence knowledge and practices are highly variable both within and between regions. This diversity is produced through the interaction of the diverse agro-ecological trajectories with the exigencies of subsistence in different environments at different scales. These scales are regional (e.g. whitewater Madeira, blackwater Negro), and local (e.g. within regions; inhabiting a blackwater tributary, or living on bluffs on the whitewater main channel) and these processes differentiate *Caboclo* communities both within and between regions (Fraser *et al.* 2009). The Middle Madeira today is therefore characterised by diverse *Caboclo* subsistence trajectories and this shapes contemporary knowledge and practice of subsistence cultivation, and its relationship to ADE. We return to this subject in section 2.5, after a general history of caboclo subsistence and kinship has been presented. The remainder of this section emphasizes how the diversity of social realities on the Middle Madeira problematises any firm boundary between "*Caboclos*" and "Indians."

The Middle Madeira "*Caboclo*" population is made up of people from diverse origins. These range from those with predominant Amerindian ancestry (the communities Barreira do Capanã, Monte Sião and Amparo), to those with some Amerindian relatives (the communities of Rio Manicoré) to communities where most people are of European appearance and can remember that both great grandparents migrated from the Northeast, such as the Community of Genipapo in the floodplain at the mouth of the river Mataurá. The communities of Barreira do Capanã, Monte Sião and Amparo (in the process of becoming a Mundurucu reserve) in particular, could be said to be more "Indian" than others. Many of the inhabitants of these communities are clearly of Indian ancestry, this was notable both in their appearance and different ways of being; more reserved upon first meeting, saying that their relatives were "from here" rather than from the north-eastern Brazil, and their being referred to being or being like Indians and Mura (an Amerindian people who lived and live on the Madeira) by *Caboclos* from neighbouring communities. More subtle differences in behaviour and knowledge emerged through time. Certain elders who were responsible for the foundation of other communities, such as Maria Magdelena at Terra Preta, and Emilton Carneiro at Estirão, have one or more Indian parents, grandparents and/or other kin. Given this undeniable indigenous influence on *Caboclo* society on the Middle Madeira, it seems possible that some of the practices and knowledge associated with manioc cultivation, and more specifically, bitter manioc cultivation on ADE, have their origins not only in recent *Caboclo* creativity, but also connect them to deeper histories on the Middle Madeira. Hence, current knowledge and practice are also syncretic, in that they manifest current creative responses to changing circumstances, but also some elements of knowledge and practices may have older origins (Chapter 3).

On the Middle Madeira, Indians and *Caboclos* have until recently lived relatively harmoniously, with intermarriage cementing social ties into kinship relations. The extension of state resources to "indigenous people" requiring the drawing of sharp lines along previously blurred social boundaries is now causing a considerable amount of resentment and conflict however. In this context of ambiguous ethnicity the creation of Indigenous reserves has been the source of great controversy and conflict in the River Manicoré, River Mataurá, the community of Amparo on the floodplain of Lake Genipapo and on Lake Capanã Grande (see the examples in sections 2.5.3-2.5.5). Tension has been caused by the drawing of sharp ethnic distinctions between "Indians" and "*Caboclos*" which before had been blurred through intermarriage and many years of cohabitation. The inclusion / exclusion of people according to often arbitrary and politically motivated creation of Indigenous reserves has created considerable ethnic tension between those residents choosing to identify themselves as "Indigenous," and those who have chosen not to. In many cases some people identify themselves as Indians while other members of the same family do not (see example in section 2.4). There are several cases of false claims of indigenous ancestry in attempt to create and control access to huge swaths of land. In a recent case recounted along the whole of the River Manicoré; a family from the Lago de Remedios (a small lakeside community on the River) tried to claim Indigenous status, laying claim to the entire lower portion of the river, which would have meant that all of the communities of the river (all long term inhabitants themselves) would have been made to leave the river. Another example is provided by a family living close outside Vista Alegre (at another community called "Terra Preta" on the old access road linking the Manaus-Porto Velho highway to Manicoré). This family is claiming indigenous status, and also laying claim to a large tract of land, provoking the scorn of locals.

The result of these processes is that a sharp ethnic division is being drawn between two groups that had before intermingled and lived alongside one another relatively peacefully. This has led to the not uncommon belief among *Caboclos* that

Indians are lazy, and reliant on government handouts. This belief has been influenced by the effects of inclusion in reserves on Indians, where the resources they receive can, according to *Caboclos*, lead to their giving up cultivation, buying *farinha*, and becoming alcoholic. The murder in late 2007 of the head of FUNAI (The National Indigenous Foundation) Manicoré in Manaus, allegedly related to land disputes at the community of Amparo, underscores the conflict this is causing. The essentialising and paternalistic conception of the "indigenous" implicit in these decisions is a major cause of these problems, and is wholly inadequate to conceive of the complex and ambiguous nature of *Caboclo*-Indian relations that have emerged in the wake of the rubber boom. Today, many *Caboclos* are loath to recognise Indian ancestry. Ever since the Europeans arrived, to be an *Indío* is to be at the bottom of the social scale. Up until very recently people would rarely self-identify as Indian, even when they state that one, several or all parents or grandparents are Indian. It is ironic that what is changing this is not the valorisation of Indigenous identity and culture *per se*, but the politicisation of ethnicity in the context of the extension of state resources to "Indigenous" people.

2.2 *Caboclo* Subsistence on the Middle Madeira

As with many regions of the lower Amazon, the Middle Madeira was heavily re-populated during the Rubber Boom (from 1840-1920) and current *Caboclo* subsistence, social relations and kinship are a legacy of the local manifestations of region-wide social and economic transformations occurring during this period. By 1865 the rubber stands of the lower Amazon River and Marajó Island were being over-exploited. The Madeira had by then become the new destination of migration, to the extent that possession of the rubber stands there was being contested and the most recent migrants were moving on to settle the Purús River (Tocantins 1982). The image of life often re-presented in the literature of the Amazon during the Rubber Boom usually centres on the *Barracão*[12]. The *Barracão* was a large wooden building owned by a *patrão* (boss). He was the boss and held the workers in a state of semi-slavery. He achieved this through monopolising the supply of manufactured goods with which the workers were

12 See for example Ferrante (1972); one of the main sources for the Globo miniseries 'Amazonia' screened recently on Brazilian television.

paid for their work on the rubber (*Hevea brasiliensis*) trails in the high-levee floodplain and *terra firme*. The boss advanced goods to workers at highly inflated prices, ensuring their continued indebtedness and his control over them. In extreme situations, normally more remote regions, the boss would even forbid the workers from planting bitter manioc, thus increasing his hold over them. This system of exchange of manufactured goods for extractive products is known as *aviamento*. The boss himself was linked to bigger suppliers who worked for the big rubber exporting houses of Manaus and Belém, and who supplied him with manufactured goods in exchange for rubber. This system of exchanging manufactured goods for forest products has its roots in the earliest European colonial forays into the Amazon where tools and other goods were exchanged for turtle oil, spices, hardwoods, vegetable oils and cacao (*Theobroma cacao*) beans gathered by Indian groups (Aubertin 2000; Sweet 1974). The rubber boom then was but a new and intensified phase of this established Amazonian mode of production based on extractivism, which stands in sharp contrast to the plantation agriculture that characterised other regions in Brazil (Weinstein 1983).

The purpose here is not to question the historical accuracy of this representation of the *Barracão*, but rather to point out that it only tells part of the story. At one extreme, slavery, abuse, rape and murder of Indians was commonplace in more remote operations in Peru and Colombia (Taussig 1987; Davis 1997). At the other, on parts of the Middle Madeira and other areas of central Amazon, the social relations of extractive production were comparatively benign, with some exceptions. There existed a multiplicity of other social forms around the Patron-client and *aviamento* relationships, for the production of rubber and other products, such as Brazil nut (*Bertholletia excelsa*), rosewood (*Aniba roseiodora*), *sorva* (*Couma utilis*), jute (*Corchorus capsularis*), and balata (*Manilkara* spp.), which have experienced boom periods over the last one and a half centuries. No one arrangement could be seen as typical (Weinstein, 1993:20). Alongside the big operations there existed many smaller family-oriented enterprises. Weinstein notes that,

'Many tappers were actually small-scale *seringalistas* [rubber stand owners] who legally owned four or five trails, along with enough land to feed themselves and their families on a diet of manioc, fish and game. The propertied tapper would still have informal patron-client ties with a small town merchant or a wealthier neighbour, but the relationship would be more flexible and less susceptible to coercion than that between the propertyless tapper and the *seringalista*' (Weinstein 1983:20)

Dean adds that

"By 1910, a more sedentary form of *Hevea* exploitation was beginning to appear…the *seringeiros* [rubber gatherers] devoted part of their efforts to planting and tending their own farm plots, lessening their dependence on the stores of the patron. In these plots they were able to engage to some extent in raising crops for cash, even export crops like cacao, and they planted rubber as well." (Dean 1982:41)

As Susanna Hecht argues, the image of the lonely and marginalized tapper trapped in debt-peonage may have been accurate in more remote regions, but this narrative hides the thriving yeomen communities, with well tended orchards and prudent husbandry who also tapped rubber, described by the early regional scholar Euclides da Cunha on the Purus River in the early 1990s (2004:61/62).

What emerges from oral histories then is that in the region of the Middle Madeira the relative autonomy of many families has enabled them to practice agriculture for generations on high and low levee floodplain, and the ADE and other soils of the *terra firme*. Many middle-aged informants state that it was their great-grandparents who first occupied (and often legally registered) the land where they now live. Seventy and eighty-year-olds recall the ships that arrived laden with migrants from Ceará, Pernambuco and Paraíba in North-eastern Brazil. Thus, contemporary *Caboclo* subsistence is emergent from agro-ecological trajectories that stretch back for several generations.

On the Middle Madeira the concentration of extractive resources in areas of relatively easy access to people settling in riparian areas contributed to the sedentism that has characterised the lifeways of these rural folk until the present day. This in turn has allowed for the development of kinship relations and the widespread practice of agriculture. The most important crop in terms of subsistence was bitter manioc, as it is today. Smallholders also produced manioc flour for sale to river borne traders who supplied the more remote regions where this staple foodstuff was not produced. The production of manioc flour probably fluctuated along with extractive cycles (Pinton 2000). Older informants do recall times of hunger during their childhood, when they were forced to subsist on Urucuri (*Attalea phalerata*, an ADE indicator species) when there was not enough *farinha*. This implies that at times extractive activity took precedent over the production of *farinha*. Additionally beans (*Phaseolus* spp.), squash (*Cucurbita* spp.) and watermelon (*Citrullus lanatus*) Tobacco (*Nicotiana tabacum*), Sugar cane (*Saccharum officinarum*) were planted on the floodplain and on ADE for subsistence, sale and barter. Homegardens and agroforests were also productive, featuring various citrus species, cacao, coffee (*Coffea* spp.) and rubber grown for subsistence and market. Such a pattern was also characteristic of other Amazonian regions at the time (Miller *et al.* 2006)

The contemporary reality of life on the Middle Madeira has been shaped by post-Colonial extractive cycles, especially the rubber boom. While it is difficult to precisely gauge the chronology of cultivation and extractivism over the last hundred years, owing to the vagueness of many oral histories, we can be sure that as rubber and other extractive products decreased in value, agriculture increased in importance. Residents throughout the region agree that it was around thirty years ago that agriculture became the principal livelihood activity in the municipality. Here then we see a shift in *Caboclo* subsistence, from a mixture of the cultivation of bitter manioc and extractivism, to a greater reliance on the former for both household consumption and exchange or sale.

2.3 Kinship is Geography and History[13]

The contemporary pattern of rural settlement and agro-ecological practice can be traced to the social and economic trajectories outlined above. Kinship on the Middle Madeira has also emerged within these historical processes. Communities in the region claim to be *tudo parente* (all kin), as most members are related. This history of residence and kinship means that people are strongly tied to one another and the land on which they were raised. Most private landholdings have ended up (at least *de facto*) in the hands of the community, even if they had one owner before, as after a hundred years of cohabitation residents are all related to each other. Many large landholdings (i.e., the

[13] The work of Gow, Ingold, and Leach (1991; 2000; 2003) have been influential in the development of the ideas in this section.

site of large *barracões*) have also ended up in the hands of the community (usually the people who worked there historically), although not always without a fight with the *patrões* or their descendents, which in some places is still going on (such as the Atininga River). An important function of kinship in such a context is to mediate access to resources, principally land (Harris 2000).

When thinking about kinship and residence in rural Amazonia the idea of the "cluster" is useful as a conceptual tool; this is defined as a "dense network of multi-family houses, organised around a parental couple" (Harris, 2000:84). The concept was first presented by Lima in her doctoral thesis concerning rural dwellers of the Middle Solimões River (Lima 1992). These clusters of households are closely related through kinship, and are the "matrix of social organisation and reproduction…the primary units in which economic and social life are acted out" (Harris, 2000:87). Clusters are often tied to one another through "re-linking marriages," creating a dense network of consanguineous and affinal ties. Harris highlights the developmental cycle of the cluster, which commences when an elementary cluster forms as a couple take up residence together in a nuclear family. It becomes a complex cluster as new generations of co-resident kinsfolk emerge. A complex cluster is formed from three to four vertically related generations and at least two sibling sets (Harris, 2000:95). Communities then are usually formed from two or more intermarried complex clusters. With around 150 years or more of existence, many complex clusters have formed on the Middle Madeira, and these form the basis of most communities in the region (see the example of community Terra Preta in section 2.4, a typical small community formed of two complex clusters).

The existence of such communities formed from complex clusters on long-term landholdings engenders their inhabitants with a collective agency. This locus of consanguinal and affinitive ties makes it relatively easy to organise the workgroups that are crucial for agricultural labour. It is through the cluster that access to land for residence and agriculture is mediated, and fishing rights in local waters distributed. There is an intensive sharing and co-dependency in the affective space within and between clusters, ranging from the daily exchange of objects such as food (fish and bush meat in particular), manioc cuttings and other plant seeds, labouring for one another and bringing up (*criando*) each other's plants, animals and children.

Additionally, and most important for our discussion, the cluster is the nexus for the creation and transmission of agro-ecological knowledge and technique. It is in the social and ecological context of the cluster and its activities that children are brought into the world. Relatives are those who provide an 'education of attention' for young children during the activities of life in the houses, *sítios*, *roças*, rivers and forests of the landscape (c.f. Ingold 2000). In this way, the way children come to perceive and engage with their environment is mediated by their situatedness in the agro-ecological trajectory of the cluster and it is through them that its *habitus* is reproduced through time (c.f. Robertson 1996). Through this process, the *habitus* of the cluster is in constant (re-)creation as well as transmission; the 'lived world' of each new generation emerging as a reinvention of the previous one (c.f. Gow 2001; Harris 2007). Kinship and the corporeality (or embodied knowledge) through which it is made manifest represent a kind of 'cultural memory' (c.f. Toren 1999).

2.4 Case Study: The Community of Terra Preta

This case study illustrates many of the points made in this chapter, showing how the lives of the inhabitants of a community on the River Manicoré are shaped by the historical ecology of the region. The community of Terra Preta is located on a large ADE site at an outer bend of the River Manicoré. The site is split into three historic landholdings, Santa Rita, at the western side, Renovado where the center of the community lies today, and São Francisco to the eastern side. Only the latter two are part of the community Terra Preta. This is because the family that owns Santa Rita are commercial fishermen, and only occupy the site for certain periods of the year, and conflict between the members of this family and community members over fishing rights has prevented their joining the community. The Renovado and Santa Rita landholdings are each occupied by a large extended family, 3 marriages, and the children bourne by them link the two extended familes.

The oldest family member at Renovado is Maria Magdalena da Silva, 85 years old. Her grandfather was a migrant from North-Eastern Brazil. After going to fight for Brazil in the war with Paraguay in the 1860's he arrived on the Middle Madeira River and married a local woman. Her other set of grandparents were Indians from Mauhes. Maria Magdelena was born on the Renovado site, but when she was young her family moved to Cantão, a rubber landholding with 15 *estradas* and a *barracão* which was owned by Dega Mendez, their *patrão* and the owner of Redencáo a short way upriver when she was young. She was the firstborn, with 6 brothers and 3 sisters. They worked as *Seringeiros*, but also planted bitter manioc, and produced *farinha* for subsistence and sale. Once, when asked "who are *Caboclos*?" She responded "*Yo soy cabocla*." (I am *cabocla*). This is rare because people do not usually self-identify as *Caboclo*. Yet, she is sister and *mai de creacão* (adoptive mother) to Antonio da Silva Borges, the president of the Maloca Community upriver, a Mura Indian reserve. She is greatgrandmother, grandmother, and mother to all of the family apart from the spouses. She has 10 *filhos* (children), 60 *netos* (grandchildren), and 73 *bis-netos* (great-grandchildren) (not all of whom live at the community), and hopes to live to see her first *tartara-neto* (great-great-grandchild). This creates some interesting situations, there are some grandchildren that are younger than great-grandchildren, i.e. Francisca (15) has a 5 yr old aunt. Maria Magdalena had four children with a man called Manuel Campos dos Reis: Deco, Pleiboy, Sebastião and Francisco. While the children were still young, Manuel left to work on a boat, and never returned. Maria Magdalena brought them up herself, working hard cutting rubber and planting bitter manioc for her family to subsist. While they lived and cut rubber at Cantão, they planted bitter manioc on ADE at the Redencão site. Maria Magdalena's son Sebastião used to be a viador, he bought farinha, Brazil-nut and rubber in their house at Cantão, he used to have a 6hp motorised canoe, and take people down to Manicoré. With another man, Magdalena had a daughter, Marisilda. She had her two last children, including Aruldo, the current President of the agricultural cooperative, with Raul, the owner of São Francisco. The first owner of Redencão was Dega Mendez, who didn't live on the site, but rather at his *seringal*. Subsequent owners, Manuel Reis, Antonio Cutinha and Chico Logueira all lived at the Redencão. All the owners let people cultivate there for free. Maria Magdelena's daughter , Marisilda de Silva Francosa went to work as a maid in Porto Velho. While she was there she met a rich man called Carlos, and then they started going out and eventually were married. 25 years ago Carlos bought the Redencão site, and the whole family moved onto it.

According to Maria Magdelena there were more than 8 *patrões* that used to frequent the river to collect extractive goods in exchange for industrial merchandise. Did the *patrões* exploit them? "*Nois enganava elles, e eles nois enganava*" (We deceived them, and they deceived us). These examples show that there were diverse relationships around the institution of *aviamento*, there were many *aviadores* and *patrões*; no one had a monopoly, therefore relations were more egalitarian. This meant that the families could freely cultivate the ADE at the site (see below).

Manuel Jose Ferreira Viera 72, is the head of the family living at São Francisco,the other landholding making up the community of Terra Preta was born in Manicore. Four of his sons live with their families in several households on the landholding. Manuel's mother and father were born in Manicore, but their parents were from the state of Ceara in North-Eastern Brazil. His father worked on River Matuará, River Atininga extracting Balata, coquirana, solva, copaíba and Brazil-nut, and after lived in Manicoré. Then he settled on the River Manicore, in the community Boa Fé and planted manioc. In the summer he cleared and burnt fields and planted bitter manioc, and also cut rubber. In the winter he worked extracting Brazil-nuts. Manuel used to work and live in Boa fe with his father, but 18 years ago he moved to São Francisco because it was closer to the Brazil-nut grove where they gathered every winter. São Francisco has 6 *estradas* and a Brazil-nut grove. The historical owner of San Francisco was Raul, and he also let people cultivate there. He was the patrao and he had merchandise. Both him and his fregueses were born on the River. There were many more people living at the site historically, people would come from a long way away to plant. There were more than 20 families living there including Rauls family, *arrendatarios* (tenants) and fregueses (workers). It was almost the size of Barro Alto there. Raul had a barracao there. The fregueses lived with their *patrão* or aviador and cut rubber and gathered Brazil-nuts. Their boss always let them plant. There were also *arrendatarios* (tenants), who could sell to anyone, but had to pay their *patrão* 10 kilos of liquid rubber a month.

Since moving to the site, Manuel's sons and their families joined them from Boa Fe, a nearby community on Oxisols. One of them, João Delgado Viera remarked on the difference between sitios on ADE and sitios on Oxisols.

"There is a big difference now we've moved here and have terra preta to plant in. In the *sítio* we can plant banana and avocado which grow much better than in clay. Other things, like Peach Palm, do well in both soils, but in ADE it only one year after being planted, and in clay after four years. Plants develop better in terra preta. We can plant beans and maize. We have more food and we use the maize to keep chickens."

The ADE site at Community Terra Preta is occupied mainly by *sítios*, combining kitchen gardens and agroforests, with some small rocas where watermelon, beans and maize are planted (see Table 1). At the Redencão site, surplus oranges, avocados and bananas from sitios are sold in Manicore, and the cultivation of these species broadens the base of subsistence consumption. The majority of land-use on ADE at the community today is for sitios, not manioc fields. This would appear to be because the population is small, less than 100 people. Small patches of bitter manioc are planted in the kitchen gardens of ADE *sítios*, along with some sweet manioc, rather than in *roças* as at other communities. While there is little bitter manioc planted in ADE today at Terra preta, it was heavily cultivated in the past. Evidence for this is provided in the fact that farmers find that more seedlings appear in fields on ADE than they do on the Oxisols and Ultisols futher behind the village. This appears to be true not just for this community, but various others, as people often remarked "*terra preta da mutio capitão*" (lots of manioc seedlings appear in ADE). People remember that there were many families who used to plate at the site; as a result, there was only fallow from the riverside for half an hour's walk until the edge of the mature forest. The ADE there is said to be tired from all this, compared to the ADE at maloca, a nearby indian village, which is said to be *novinha* (new).

2.4.1 Religion and Beliefs

Each community, unless Evangelical, has a saint, *santa*. At Terra Preta the santa is *nossa senora de Fatima,* who is the saint of fishermen. People might make a prayer to her if they want something and make an offering if it comes true. Fisherman (when fishing nearby) pray to her for luck in fishing, if they get a good catch they might repay her by buying something made by the community (cake/chicken etc) at the yearly religious *festa*. At this event a girl is made *boneca viva* (living doll), and people make offerings to the saint via her.The church and saint have only been present for 15 years. Historically only Boa Fé and Barro Alto had church /santas, they are the oldest communities on the River Manicoré. Each community has a yearly party for its saint. The saint travels to the community from a neighbouring community. Each community also has a harvest festival, choosing a particular produce as its focus. At Terra Preta this is the *festa da Jaturana*, a fish that is abundant around May-June each year. People make requests to different saints depending on the problems they face. A granddaughter of Maria Magdalena nearly died of Pneumonia, so her mother Maria made a prayer to the saint of Barro Alto. The girl survived and so she was made *boneca viva* at the next saint's party there. On another occasion, a man named João at the Santa Rita landholding adjacent to Community Terra Preta was having problems with leaf cutter ants in his *roça*. He arranged a prayer to the Saint of Santa Luzia, who protects *roças*.

While communities such as Terra Preta belong to catholic or evangelical parishes, *Caboclos* believe in sprits of the forest such as the *Curupira*, a little being with back to front feet, who must be appeased with offerings of cigarettes or food. This being is often conceived of as a guardian of the forest, protecting it against those who would damage it unnecessarily. If this creature becomes annoyed, it entrances people and causes them to lose their way. Another creature of the forest is the *Juma*, a fearsome beast with an eye in its chest.

Certain menstruation taboos also exist. Dolphins are said to attack menstruating women on the river. A Mura girl from the Maloca community was apparently drowned by a dolphin because of paddling a canoe whilst menstruating. People are not supposed to go to the *beira* (riverside) at midday. Maria Magdelena scolds her great grandchildren when they go to swim in the river at midday. According to her, once two children went to the *olho da agua* (riverside spring, also said to harbour spirits) at midday, disappeared, and were never seen again. The water is said to harbour beings, such as the *princesa do mar*, a serpent, that can enchant people, causing them to leave the land to live in the river[14]. Up until recently each settlement would have an associated *curador/benzador* (curer/blesser), a kind of magician healer. This traditional knowledge has been displaced with the appointment of a resident in each village as a health officer by the state.

This section has briefly shown how *Caboclo* cosmology is syncretic, fusing folk Catholicism of Iberian origin, with Amazonian beliefs. It also demonstrated how historically, relations at Community Terra Preta were egalitarian and people were allowed to cultivate. This has allowed the small but thriving community we find today to emerge. The kinship relations found at Community Terra Preta are typical of the Middle Madeira, the community is comprised of two large intermarried complex clusters, who are all descendents of people who lived within the locality and were historically associated with the landholdings there, both as workers or owners. While Community Terra Preta is an interesting case, in order to gain a broader understanding of Caboclo subsistence and its relationship with ADE it was necessary to visit other areas. The remainder of this chapter describes how the historical ecology of several regions on the Middle Madeira has shaped the current relationship between Caboclo subsistence and ADE.

[14] The Legend of Sapucaia-Oroco: There was a man who was enchanted and transformed into a big snake. One day went he went to a party and danced with a menstruating woman. He was very angry because of this and sunk the whole village. Now it is a whirlpool, ships avoid it and you can ever hear gallos canting there. People have reported being unable to spend the night there owning to racket eminating from the depths.The community is located 6hrs above the town of Borba on the lower Maderia, you can see the mark in the bank where community collapsed. According to the account by the German explorer Franz Keller, Sapucaia-Oroco was a Mura Village downstream from Borba (Keller 1874). Slater (1994) has done the most detailed work on such enchanted beings.

2.5 Caboclo Subsistence Trajectories at four different locations on the Middle Madeira

Contemporary *Caboclo* subsistence is emergent from diverse historical ecologies situated in Amazonian landscapes. Land tenure is a critical factor in allowing *Caboclos* to cultivate *roças* and *sítios*: principal forms of subsistence cultivation. To be able to study *Caboclo* subsistence and ADE it was important to find localities in which *Caboclos* were able to establish *roças* and *sítios* on ADE, and preferably, where they had been doing so for a good deal of time. Each subsection looks at a different area of the Middle Madeira. The River Manicoré and the North Bank of the Madeira are shown to be areas where ADE agriculture has long been established, whereas the River Atininga and the River Matraurá are shown to be areas where agriculture has been seriously disrupted by conflicts over land tenure.

2.5.1 The River Manicoré

The River Manicoré is a blackwater affluent of the Madeira, with its mouth on the east bank of the Madeira just above the city of Manicoré (Figure 4). Migrants entered the river from the mid-1800's onwards, settling and participating in extractive ventures. They engaged in agriculture and established or renovated homegardens on the *terra firme* of the east bank of the river, while working cutting rubber in the *Hevea*-rich high-levee floodplain forming the west bank of the river. On the river Manicoré, rubber and Brazil-nut extraction took place in under both small-scale operations, characterised by more egalitarian relations. There were no large operations with exploitative bosses. Instead the River was characterised by individual landholdings, upon which communities eventually developed. During this period, both landholders and river borne traders engaged in relations of *aviamento* with inhabitants of the river and migrant workers. Extractive activity was more prevalent than it is today, but agriculture was always practiced. Many of the sites occupied were abandoned Amerindian settlements, with fertile ADE in domesticated landscapes. Seven of the ten communities of the Manicoré River are located on ADE sites. During the rubber boom, the rubber of these villages and the river in general was produced by a series of smaller, more family-oriented enterprises, each with between one and ten rubber trails. The workers of each *barracão* were formed from people who lived with their families on the river, and seasonal workers who lived at the *barracões* during the summer rubber season. This allowed the people working rubber and brazil nut stands and extracting other forest products greater autonomy than a typical *aviamento* relationship. The existence of many smaller bosses, and even smallholders engaging in relationships of *aviamento* among themselves, meant that people had more choice in who they worked for, and the reality of their relationships was far more complex than the slave-like exploitation typified in the popular representation of the *barracão* outlined in section 2.2 above. The river was inhabited by people who had their own plots of land (or had access to the land of others) and, while working seasonally gathering rubber and other extractive products, also engaged in subsistence agriculture. After the Second World War the bosses abandoned their *barracões* (owing to the drastic reduction in the value of rubber), thus ending their reign as middlemen and allowing the long-term residents of the river to start to deal directly with the river traders. The communities along the river today can be characterised as extended family clusters (like those at Community Terra Preta) with collective landownership and agricultural trajectories with their roots in the rubber boom period or even earlier, especially when inter-marrying with local indigenous peoples occurred. This has emerged from several generations of cohabitation, during which kinship relations among all residents were established, and so the original landowner usually ended up being related to the whole community, conferring collective land rights onto them. Generations of agricultural practice also established land rights, and generated a repertoire of local knowledge and practice.

Ethnohistorical data from interviews with village elders indicate that ADE were used for subsistence production of various subsistence items such as sugar, tobacco, rice, and coffee that are today more commonly bought, owing to the growth in availability of cheap industrial goods. While surplus manioc flour was always sold, during the rubber boom agriculture was more subsistence focussed. Since the end of the boom and the appearance of cheap industrial foodstuffs, agriculture has become more focussed on the production of manioc flour for the market. Farmers are unable to compete with industrial sugar, coffee, rice and maize but most of the manioc flour consumed in Amazonas state is still produced artisanally by local farmers.

Oral histories show that the communities Terra Preta, Estirão and Boca Do Rio, used to have hundreds of residents, and therefore bitter manioc was widely cultivated on ADE. Owing to population decline at these communities, much less bitter manioc is cultivated on ADE today. At Barro Alto, which has experienced population growth, bitter manioc is widely cultivated on ADE (Table 2).

Figure 4 The Upriver Area of Study. ADE sites are either represented on the map by dark areas corresponding with communities, or the question mark symbol, which indicates the presence of sites that were reported by informants but either visited only briefly, or not visited at all in the course of research. *Map drawn by Victoria Frausin.*

2.5.2 The North Bank of the Madeira

The North Bank of the Madeira refers to the Communities west of Manicoré on the main channel of the river Madeira (Figure 4). These are Vista Alegre, the Água Azul Coast (Água Azul, Monte Orebe and Monte Sião) and Barreira do Capanã, Boa Vista and Capanãzinho. All of these are situated on or close to ADE sites. The major difference between this locality and the Manicoré River is that the communities are situated along the main channel of the Madeira. This means that locals can simultaneously exploit rich floodplain soils and fish stocks, as well as terra firme soils, tributaries and lakes. Historically, the extractivism along the coast from Vista Alegre to Água Azul was controlled by three bosses, Aristide Rosario (the resident boss at Democracia, who also controlled trade at nearby Vista Alegre), Lucas Teixeira Pinto (owner of Água Azul), Joaquim Gualdinho (owner of the land from Monte Sião to Fazenda Jacaretinga). The Barreira do Capanã and Capanãzinho region is the location of a historic cooperative, set up in the early 1900's. A Jewish migrant named Izaac Belelo was responsible for its formation. When he arrived in the region he found all the people working individually, inhabiting discrete historical landholdings. He settled and married a local woman. He acquired a large farm at the mouth of the Capanã Grande and two other *barracões*. He reared animals and started to buy up people's produce: Brazil-nut, Rubber, and Wood to feed the engines of boats, and other extractive products such as *sorva*, Rosewood and *massaranduba*. Izaac became the *aviador* of the people there, and treated them well. He was instrumental in setting up a cooperative called the *Associacion de Novo Aliança* that includes the communities Barrera do Capanã, Nazare, Santa Ana, Terra Preta, São Francisco. The cooperative still functions today, and mediates in the relations of its occupants and the state and other insitutions. The Association recently rejected attempts to incorporate its lands into extractive reserves by the Brazilian state. Most of the people in the communities are related, first cousin marriage is frequent, and if someone wanted to marry a person that was from outside, the prospective candidate first had to be judged by the cooperative. While the sphere of influence of each of these bosses was wider than on the Manicoré River, oral histories of elders in the region indicate that the people who worked for them were not subject to coercion and were relatively autonomous, even when they lived on land owned by one of the bosses.

Along the North Bank of the Madeira, smallholders used to live along the high floodplain (*restinga*), which was the site of extensive homegardens rich in rubber and cacao groves. Others settled on the *terra firme*, some on ADE sites. People made a living from harvesting rubber and Brazil nut, along with other extractive products including *balata* and *sorva*. They also planted bitter manioc in the floodplain and on the *terra firme*. There were various smaller *barracões* in the region, some with a small number of resident workers; as elsewhere, inhabitants obtained manufactured goods in exchange for their produce at the *barracões*. The various ADE sites situated along the north bank of the Madeira were also cultivated. Manioc, maize, watermelon, tobacco and other crops were planted. Some of the sites have been under cultivation for a very long time, at Vista Alegre, Fazenda Boa Vista and Barreira do Capanã, bitter manioc and other crops have been planted in ADE for over a hundred years. Thirty years ago a dramatic shift in the course of the Madeira led to the rapid erosion of the high floodplain, and residents of all the communities of the North Bank shifted onto the terra firme. Up until this time, residents of the communities Água Azul, Monte Orebe, Monte Sião and Vista Alegre lived on the high levee floodplain, which formed part of an S bend in the river, locally renowned as forming the biggest curve in the course of the Madeira. People noticed that the river was to change its course as pressure on the middle of the bend was causing the land to erode away. In 1970, 18 local men cut a channel (*furo*) through the middle of the S bend. The high levee upon which people had built their homes began to be swept away and so residents were forced to relocate to the terra firme. A low-levee floodplain has emerged as the previous high levee was gradually swept away, and is now being cultivated by locals. Such manipulations of waterways by local people are common throughout Amazonia (Raffles 2003; Raffles and WinklerPrins 2003).

In this section we have seen how the agricultural history of the River Manicoré, and the North Bank of the Madeira (Vista Alegre-Água Azul Coast, Barreira do Capanã) was shaped by more egalitarian relations of land tenure and *aviamento*, which allowed the development of long term communities and enabled the development of agricultural knowledge and practice on ADE. As an outcome of these historical processes the Middle Madeira is characterised by many small family-landholdings occupied by people with continuous agro-extractivist histories stretching back for up to 150 years. This has allowed the development of a repertoire of manioc landraces, selected for different soil types (Floodplain, ADE, Oxisol, Ultisol) and different cropping systems (short-fallow, long-fallow), as well as the agro-ecological knowledge associated with manioc cultivation. Although oral histories do not stretch back far enough to recall settlers' preferences for where to live, the pattern of settlement today (i.e., many communities located on ADE sites) suggests that ADE and the wider domesticated landscapes within which they are embedded were particularly attractive to settlers because of the greater abundance of useful species and fertile soils. For instance, the plam Urucuri must have attracted rubber tappers as its fruit (a woody endocarp) was thought to provide the most suitable material for smoking rubber (S. Hecht, pers. comm., 2007). Homegardens with existing concentrations of cacao and Brazil nut were augmented with the establishment of citrus and rubber groves. The age of the rubber, citrus and mango (*Mangifera indica*) trees growing in many ADE homegardens testify to this. Both oral histories and the presence of such old homegarden species reveal that many such sites have then been continuously inhabited and cultivated since the mid-Nineteenth century or earlier.

2.5.3 River Mataurá[15]

By contrast, downstream from Manicoré on the two other major tributaries of the Middle Madeira, Atininga and Mataurá (Figure 5) we find examples of much more exploitative relations, which ultimately inhibited the development of ADE agriculture and long-term communities. Carlos Martinez Lindoso or "Coronel Vencedor" was one of the many Colonels in the Army that settled along the Madeira and set up large extractive operations during the nineteenth century (Keller 1874). His landholding, still known as "Vencedor" and today the site of a community of the same name, is located on a major bend in the Madeira, just below the mouth of the River Mataurá, opposite the Parana de Urua. He controlled a swathe of extractive locales in the region[16]. The owner of a large Barracão of 180-200 men on the Vencedor landholding, a large rubber estate with 180 rubber trails, he was famed for his cruelty; apparently a favored punishment was tying up a worker and throwing him into the middle of the river from a canoe. He

[15] While it is impossible to verify all the details of the story of Carlos Vencedor and the later creation of the Indigenous reserve, the same details of the story as written here (with minor variations) were given by four unrelated individuals living in different communities. (Parana de Urua, Santa Elena, Barro Alto, Estirão). The opinion that the creation of the Indigenous reserve on the Mataurá was a sham is widely held among locals in the department of Manicoré.

[16] The Rubber Estates; Vencedor, São Tome, Jurarua Compsaso, São Jose, and the Brazil nut estates Santa Maria, Boa Vista, Mirití and São Pedro, Igarapé-Acú, Preguiça and Saúva.

was similar to the bosses of more remote areas, ruling through fear and imposing debt-bondage on workers.

Colonel Vencedor had three barracões in the Mataurá River where he exchanged industrial goods for Brazil-nuts and Rubber. The three barracões were “Tracaja”, run by Eduardo Rosa, “Santa Maria” by João Lindoso, and in the river mouth “Jacare”, which was run by Carlos Lindoso Vencedor himself. He was not owner of the land in Mataurá as he was in other locales, but coveted its rich *castanhais,* rosewood and other extractive resources. He started trying to obtain the rights for its historic landholdings from their long term inhabitants, apparently by falsely promising to help people register their property, only to do it in his own name, then claiming the land as his. This was the cause of a rebellion by the *Caboclos* and Indians of the Mataurá[17].

Once Vencedor had been deposed the Mataurá became at thriving and free river much like the River Manicoré was. An informant now living at Boa Vista who grew up on the Mataurá during this time reported large homegardens and bitter manioc swiddening on ADE, much like the pattern found on the River Manicoré and North Bank of the Madeira. This was not to last. The river is now an Indigenous territory and much of its long term inhabitants have been removed. While accounts differ, they all converge on the actions of one man, Jose Leles, as being instrumental in the setting up of the reserve by FUNAI (The National Indian Foundation). By all accounts not an Indian himself, Leles married an Indian woman from the river, and hit on the idea of creating a reserve. He got in touch with FUNAI and a “study” was carried out, people were asked whether they were Indians or not. The implications of the reserve were not explained to the people. Many who were of Indian ancestry chose not to identify themselves as Indigenous. When the reserve was created, those who had landholdings

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[17] A group of young men assembled and burnt down the two barracões that were deeper inside the river. They then approached Jacare, where Carlos Lindoso was. It was a two story barracão. One man stepped forward, the rest hidden in the darkness. He asked for something from the shop. The old Coronel, sensing something was wrong, said he had “nothing for *Caboclos*” and tried to send the man on his way. The man pulled a gun though and shot the Coronel in the leg. The men then set fire to the Barracão. Lindoso managed to escape through the back but was caught and then the men “castrated him, cut his ears off and stabbed him so many times you couldn’t see the space between the holes”. This was on the 25th of December, 1930. When word of this rebellion reached Manaus, influential relatives and friends of the deceased sent a boat full of police to reclaim the river and “*meter fogo nos Caboclos de Mataurá*” [set the Caboclos of *Mataurá* on fire]. The young men of the river had set an ambush in the mouth, and the invading boat was damaged and forced to retreat.

were indemnified for their land and its natural resources, but young men with no landholdings who worked seasonally for others received nothing. They were taken by the police to a site on the floodplain opposite Manicoré called Sururu. Ironically many of those relocated were of entirely Indian descent and some of those who self identified as “Indians” of the Mataurá had blond hair and blue eyes. The whole lower area of the river was given to a small group of people who self-identified as Indians. What once had been series of historic communities located on large ADE sites (the lower course of the Mataurá was once the bank of the Madeira) analogous to Manicoré is now practically deserted. As one local put it:

“Jose Leles bought some land within Mataurá. He went to Manaus and discovered that if he created an Indigenous reserve there he would be able to gain control of its resources. So he went to Funai and made an indigenous reserve and Funai entered and said to everyone you have to sign as Indians to stay…. Before, 70 years ago it was just patrões and fregueses and then the fregueses killed the patrões….. *Antes não teve negocio de indio no Mataurá* [Before there was no Indian question in Mataurá]. It was just *nordestinos* (migrants from North-east Brazil) and Indians all working together”

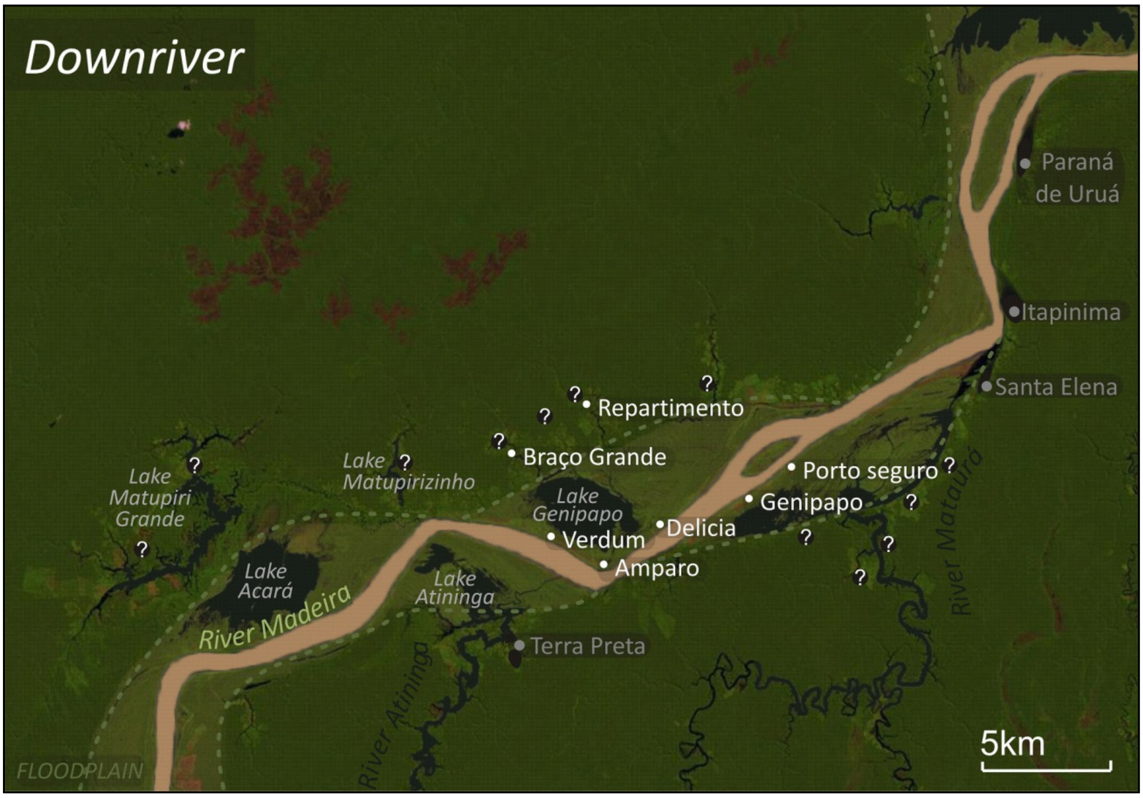

Figure 5 The Downriver Area of Study. ADE sites are either represented on the map by dark areas corresponding with communities, or the question mark symbol, which indicates the presence of sites that were reported by informants but either visited only briefly, or not visited at all in the course of research. The communities in white are core areas of research, while the communities in grey were only included in the land-use survey. *Map by Victoria Frausin.*

2.5.4 Atininga

The community "Terra Preta da Atininga," is located on large ADE site overlooking lake Atininga (Figure 5) and was established when a boss arrived from Maranhão (a state neighbouring Pará in the Brazillian Northeast) bringing his workers with him. The head of the family was also a Coronel, and the freguezia worked extracting Brazil nut, Rubber and Wood. On the 10th of July 1955 two important events occured. At 5 am, Getulio Nascimento, a man who would go on to become a Chico Mendez-esque community organiser, and set up a Brazil nut cooperative was born. At 10 am a boat arrived with bosses and Police and a shootout occured between them and some of the workers who had been trying to claim some of the land as their own. It was election day and the people had supported a man called Paulo Neves, who had promised to address their land issue if elected. The bosses supported Plinio Coelho, who had promised to look after their interests. Plinio won the elections, and the shootout began. Those workers who had rebelled were jailed and new workers were put in their place. The land has since changed hands, but until recently the long term residents had no legal claim to it. Residents continued to be paid a pittance for the yearly Brazil nut harvest, this was one of their main grevances. Until recently the old *patrão* was alive, and he allowed people to plant crops provided they did not plant "*bem de raiz*" that is to say perennial fruit and nut trees of the homegarden. But when he died, his son and granchildren (the Curica family) started to claim 25% of any production. As a result of this all agriculture on ADE halted, and people planted bitter manioc in more distant fields not claimed by the bosses. Many people left, and in September 2006 only a few farmers were cultivating ADE. Thanks to the efforts of Getulio Nascimento, this situation is now being resolved. Getulio has been instrumental in setting up the Brazil-Nut association of Manicoré. The people of Terra Preta da Atininga, instead of selling Brazil nut to the patron and receiving about £1.50 per tin of nuts now sell to the cooperative and receive £4 per tin.

2.5.5 Amparo

The community of Amparo is located on the high floodplain that separates Lake Genipapo from the main channel of the Madeira (Figure 5). The community is currently in the process of becoming a Mundurucú Indigenous territory (*terra indigena*). While residents are clearly of Indian descent, the impetus for creation of the reserve again seems to be land conflict. Historically the locality was dominated by Dico and Antonio Velino who controlled the extraction of Rubber and Brazil Nut in the area. Dico's son Ze Curica inherited ownership of the locality. Conflict recently flared over the land-use rights of the long term residents of the land. Curica was demanding that residents ask permission to plant there. In the context of growing awareness of the power of asserting Indigenous rights, the community organized itself and was granted Indigenous status in

2007. Locals claim that the murder of the head of FUNAI in Manaus was Curica's response to the loss of his land.

2.5.6 ADE and Caboclo Subsistence on the Manicoré Atininga and Mataurá Rivers, and the North Bank of the Madeira

These four localities were visited in the search for *Caboclo* subsistence agriculture on ADE during the initial phase of research, but only the River Manicoré and North Bank of the Madeira were selected for continuing fieldwork. The Atininga and Mataurá Rivers were not suitable for further research owing to a lack of agriculture on ADE. On the Mataurá, the agro-ecological trajectories and associated local knowledge of ADE cultivation ended with the creation of the indigenous reserve when most of the population was forced to leave. On Lake Atininga, people were simply never allowed to fully exploit the ADE, as they were forbidden from establishing homegardens, and in the end were charged a 25% tax on all agricultural produce, which effectively ended all cultivation. Recent changes in land-rights should improve this situation on the Atininga. The Matuará remains a highly contentious issue on the Middle Madeira, with rumours of an expansion of the indigenous reserve to include the entire river, and threats of a revolt and invasion by former inhabitants.

These examples demonstrate how the history of land-rights in the context of the patron-client relationship (Atininga, Mataurá and Amparo) *and* more recently in the creation of Indigenous reserves (Mataurá, Amparo and also Capanã Grande) powerfully mediate the relationship between Caboclo subsistence and ADE. Here we have seen how, as a result of conflict over land, there are not significant traditions of ADE agriculture on River Mataurá or Lake Atininga. This contrasts with the River Manicoré and the North Bank of the Madeira, where owing to peaceful co-existence of a series of long term communities on old landholdings. As a result of this situated agro-ecological trajectories associated with significant local knowledge of the use of ADE in Caboclo subsistence - in the form of *sítios* and *roças* - emerged in the communities in these areas.

2.6 Conclusions

This chapter has presented the reader with a history of *Caboclo* subsistence on the Middle Madeira. Its major findings are the following:

a) On the Middle Madeira, the social category "*Caboclo*" is extremely heterogeneous; some of its number have entirely or partially Amerindian ancestry, and therefore it is not inconceivable that some *Caboclo* knowledge and practice of cultivation on ADE has indigenous aspects.
b) *Caboclo* subsistence on the Middle Madeira was profoundly shaped by the rubber boom, though the relations of rubber production were different in different areas.
c) Some areas (River Manicoré, North Bank of the Madeira) were relatively egalitarian in some areas, and this enabled the formation of long term, kinship based, communities with generations of experience cultivating *roças* and *sítios* on ADE.
d) Other areas (River Atininga, River Mataurá) were more exploitative, and as a result conflict over land-tenure has disrupted the formation of long term communities and associated situated local knowledge and practice of ADE cultivation.
e) Owing to these factors, the river Manicoré and the North Bank of the Madeira were selected as the most suitable areas for the study of the relationship between *Caboclo* subsistence and ADE.

Chapter 3: *Caboclo* Subsistence Cultivation and Amazonian Dark Earths: An Ethnography

a) Josefa Guimarache, weeding a bitter manioc field in ADE at Community Barreira do Capanã
b) Antonio Pinto, a farmer of bitter manioc in ADE at Community Barro Alto
c) Saba Batista, standing in front of a variety of bitter manioc he selected from a seedling, in an ADE field at Barro Alto
d) Tivi, a ADE bitter manioc farmer toasting white farinha from the landrace *Pirarucu Branco* at Barreira do Capanã
e) A bitter manioc seedling, recognised by its many leaves, in a new bitter manioc field in ADE at Barreira do Capanã
f) Weeding a bitter manioc field in ADE at Barreira do Capanã, the palms in the field are Caiaué (*Elaeis oleifera*), an ADE indicator species that is fire resistant

Bitter manioc is the primary staple source of calories for *Caboclos* on the Middle Madeira River (Chapter 1), and the sale of *farinha* is often an important source of income for families. Its cultivation, processing, sale and consumption are therefore fundamental aspects of their subsistence. This means that *Caboclos* devote a great deal of time to preparing the landscape (clearing fallow, burning), planting, weeding, harvesting and processing bitter manioc. The environments that *Caboclos* of the Middle Madeira inhabit are diverse, in locations that are differentially positioned within floodplain-*terra firme* landscape mosaics: characterised by different soils, rivers and lakes, and forests with a variety of different fallow ages. The outcome of generations of bitter manioc cultivation in these landscapes has been the development of a significant body of knowledge relating to bitter manioc cultivation in different soil types (Oxisols, Ultisols, ADE, and Floodplain), and different successional stages has developed in the *Caboclo* communities of Middle Madeira.

This chapter focuses on how *Caboclos* use and manage ADE (and, for the purposes of comparison, other soils of the *terra firme*) in diverse and creative ways in the process of achieving their subsistence. It focuses on multi-sited fieldwork at the four localities on the Middle Madeira where ADE is most widely cultivated: Barro Alto, on the River Manicoré, and Barreira do Capanã and Boa Vista, The Água Azul Region and Vista Alegre, all located along the North Bank of the Madeira. It also includes interviews with some of the more knowledgable bitter manioc farmers from other communities. This allows us to take a broader perspective, and examine which certain practices and or knowledge are unique to a single locality, and which are found in more than one place. The knowledge and practice of manioc cultivation in diverse environments involves a set of skills and perceptions that are at once continually emergent and informed by situated agro-ecological trajectories in different localities. As the previous chapter demonstrated, differences in historical ecology of different regions of the Madeira have either enabled or constrained the development of local knowledge of manioc cultivation in ADE. The localities investigated in this chapter are all characterised by a historical ecology enabling of agriculture; long-term communities, on historically egalitarian landholdings.

I analyse narratives from bitter manioc farmers at each of these communities that reveal local understandings in relation to characteristics of bitter manioc landraces (weakness/strength, degrees of bitterness or sweetness); the performance of different landraces in different soils; the "strength" of fallows as an indicator of soil fertility, and how this relates to weak and strong landraces. *Caboclo* perception and management of seedlings is also explored. Some aspects of the cultivation of *sítios* on ADE are discussed, including how agroforests and kitchen gardens can be planted with a wider range of species, and how bitter manioc is sometimes intensively cultivated in the kitchen garden in a manner analogous to intensive swidden cultivation. I also present evidence that farmers are aware of the anthropogenic origins of ADE, and that these soils formed at the sites of Amerindian settlements. This data is presented in the form of quotes because it allows us to use the farmers own voices to show how that there are various similarities between individual understandings of manioc cultivation in different soils between farmers at inhabiting disparate locations.

3.1 Bitter Manioc Cultivation along the Middle Madeira

Bitter manioc is planted both on the *terra firme*, on Oxisols, Ultisols and ADE, and in the floodplain. On the Middle Madeira, bitter manioc fields are usually cleared and planted by a work group locally known as a *pushirum* or *mutirão.* Fields on Oxisols or Ultisols are usually cleared for planting at the beginning of the dry season. This work is done by men only. In these soils, fields are usually located in old fallow. Firstly, trees are felled and must be left to dry out for several months, before being burnt. The work of planting is done by men, women and children. Early in the morning the owner of the field cuts the long manioc stems into 10-15 cm clonal shoots. He or she must also provide a snack (*merenda*), usually coffee and crackers, and lunch for the work party. The men move forward, opening up shallow holes in the ground with their hoes. The women and children follow behind with the clonal shoots in baskets, dropping them into the holes and then covering them with earth using their feet. Fields on ADE are generally smaller, located in younger fallow, and are planted throughout the year. This is because young fallow can be dried out and burnt with only a few rainless days, whereas old fallow requires weeks of dry weather to dry out properly.

Manioc processing (which is essential in order to remove cyanogenic glycosides) activity centres on *casas de farinha* (manioc flour houses): a thatched roof held up by four poles, sheltering a round clay oven topped by large metal pan for toasting; to squeeze the water from the *massa* (manioc pulp) either a *prensa* (a wooden press) or a *tipití*, a long tube woven from lianas. *Farinha* made from *massa* from tubers soaked in water (*farinha da agua*) is regarded as the best quality. Sometimes a motor is attached to a grater to grate up raw tubers as an alternative to soaking them. *Farinha* is sometimes made from grated tubers because of lack of time to soak them (i.e. an urgent need for manioc flour to eat or sell), or because some weak varieties do not soften in water after being left for too long in the ground. Sometimes, these two practices are combined, where *massa* from soaked tubers is mixed with dry grated manioc to bulk up *farinha*. This practice is known as *Tapurá*.

The characteristics of its cultivation in different soils, fallow ages, and the traits and performance associated with different manioc landraces, are of great interest to *Caboclo* farmers on the Middle Madeira. In the regions we examine below, this has been the case for a long time, and because of this there is a substantial body of local knowledge of manioc cultivation amongst *Caboclos* on the Middle Madeira. This is the subject of this chapter. We begin with two important categories by which manioc is categorised, as either *fraca* (weak) or *forte* (strong).

3.2 "Strong" and "Weak" Bitter Manioc

On the Middle Madeira, people categorize different Bitter Manioc landraces as being either weak (*fraca*) or strong (*forte*) (Table 3). These categories express the rate of maturation and the suitability to different soils and different fallow ages associated with different bitter manioc landraces. Weak landraces often have a directly traceable origin in the floodplain and are fast maturing; harvestable as little as five months after planting, but tend to have a higher water content which results in less starch production. They are also more likely to rot, or no longer soften in water if left in the ground for longer than a certain period of time. The characteristics exhibited by weak landraces strongly suggest a floodplain origin (fast maturing, fast seeding but not long lasting in the ground), as they are traits which serve well in the floodplain. It is possible that having come from the floodplain these landraces are more capable of taking advantage of the greater nutrient levels in ADE. These landraces are also associated with short fallowing and short cropping cultivation. They are said to be more suited to intensive cultivation in more fertile soils (ADE / Floodplain). Strong landraces are slow maturing, but produce more starch and less water, and therefore yield greater amounts of manioc flour when processed. Strong landraces resist rotting for longer periods and are the most durable in the land (lasting up to four years in some cases). They are said to be better suited to longer cropping cycles, long fallow cultivation in less fertile soils (Oxisols / Ultisols). Rather than a landrace being either weak or strong, farmers describe certain landraces as being more or less weak or strong than another landrace.

Table 3 Local Categories: *Mandioca Fraca* (Weak Bitter Manioc) and *Mandioca Forte* (Strong Bitter Manioc), used to describe different manioc landraces by farmers on the Middle Madeira River, in the municipality of Manicoré, Amazonas state, Brazil.

Characteristic	**Weak Manioc** *Low Starch Fast Maturing*	**Strong Manioc** *High Starch Slow Maturing*
Maturation	Faster	Slower
Starch Production	Less (more water)	More (less water)
Resistance to Rotting	Lower (6 months to 1.5 years)	Higher (up to 3 or 4 years in the ground)
Softening in Water	Only in earlier stages	Softens even after years
Suitability to Fallow Age (*terra firme* only)	Earlier Successional stages	Later Successional Stages
Lengths of cropping-fallowing cycles	Shorter Fallowing, Shorter cropping	Longer fallowing, longer cropping
Soil Associations	ADE / Floodplain	Oxisol / Ultisol

3.3 Weak and strong land and fallows

Bitter manioc landraces and their degrees of strength or weakness are not associated just with different soil types, but also as being suited to agricultural systems characterised by either short fallowing (swidden) or long fallowing (shifting cultivation). On the *terra* *firme*, farmers often stated that weak manioc is suited to "weak soils", strong manioc is suited to "strong soils." The strength of a soil is determined by the age of fallow growing on it. Therefore, weak manioc is said to be best suited to cultivation in young fallow, which indicates weak soil. Bitter manioc is only normally cultivated in young fallows on ADE, because young fallows in other soils do not yield well. Still, if young fallow is cleared in Oxisols and Ultisols (normally owing to population pressure, see the example of Barro Alto below), farmers claim that it is best to plant weak manioc. Strong varieties are said to be best suited to planting in fields cleared from old fallow or primary forest, which are indicators of "strong land."

Farmers state that different bitter manioc landraces are suited to different stages in the successional process: For example, it was often claimed that: "*Arroz* (a strong landrace) *é bom para mata*" (Arroz is good for the forest [soils]) they say, or "*Arroz só dá bem na terra forte*" (Arroz only does well in strong soil). The categories weak and strong, applying to both bitter manioc landraces and soil fertility, and are combined when people state "*mandioca fraca na capoeira fraca, mandioca forte na capoeira forte*" (weak manioc in weak fallow, strong manioc in strong fallow). On the Middle Madeira River local people therefore deduce soil *fertility* from the stage that successional processes have reached at any given point in time. People say that "*Terra fraca é terra com capoeira baixa, terra forte é terra com capoeira alta*" (Weak land is land with low second growth, while strong land is land with tall second growth). Soil is said to be *cansado* (tired) from having been cultivated too much, and the resultant *capoeira fina* (thin secondary growth) provides an indicator of this. Pat Stocker (2006:143), in her doctoral research in Pará and Bahia, also found that people had varieties that they said performed better in weaker soils, as did Thiago Cardoso on the Cuieiras River on the lower Negro (2008:101). Cardoso (2008:73) also found that farmers in this region use the expressions "weak" and "strong" for young and mature successional growth.

Farmers obviously do not understand soil fertility in terms of nutrients as soil scientists do, but in terms of their location in anthropogenic successional processes and their known history of use. This perception of soil fertility as being determined by age of fallow and known history of use might have something to do with several generations of history of bitter manioc farming under long fallow shifting cultivation. Soil fertility is expressed in a schema that makes sense for non-anthropogenic soils under long fallow shifting cultivation, but falters when it is used to explain the fertility of ADE. ADE is called *terra fraca* when it has been intensively cultivated (but still yields bitter manioc, maize and watermelon) and an old fallow on Oxisols is *terra forte* (even though it will not yield maize or watermelon). The following quote shows how understandings of soil fertility are influenced by the practice of long fallow shifting cultivation of bitter manioc. In this instance, an informant assumed that since there was old fallow, which he characterised as strong land which would be good for manioc; it would be good for Guarana. "I planted a hectare of Guarana, but it didn't grow! I don't understand why, it was *capoeira alta, terra forte*! (high fallow, strong earth)." On Oxisols, Ultisols and ADE, fallow is therefore an indicator of the strength of a land, as old fallow indicates that the land has had time to recuperate from the last time manioc was planted there, whereas young fallow indicates that the land has recently been cultivated and is likely to be weak. ADE transcends these categories however, as while it is often described as weak when covered in young fallow, bitter manioc can be successfully cultivated in it.

3.4 Case Study: Barro Alto

Barro Alto is the largest community in the interior of the municipality of Manicoré. Forty years ago the community was comprised of only eight families, numbering some sixty two people. In 2007 there were nearly 600 people living in the community. The village is situated on a high *terra firme* bluff at a bend in the river Manicoré. The landholding on which the centre of the community now located was owned by a man named Juvenal Lopes Vas. He was the *patrão* (boss) and owned of four rubber trails (known as *estradas*). One *estrada* is located on the island in front of the community, two in the forested high floodplain on the opposite side of the river, and the other to the south of the community on *terra firme.* More rubber trees were planted throughout the community. Juvenal himself had become the owner through marriage to the daughter of the previous owner, a man named Pinel. Four other families were resident on the land, along with a few temporary seasonal workers, and they cut the rubber trails for Juvenal. He paid them for the rubber they brought him with industrial goods (*mercadoria*) such as sugar, coffee, salt, milk and butter that he received in exchange for the rubber from ships which traded rubber and other extractive products along the Madeira to Manaus. Another riverbourne *commerciante* called Amadeo Alecrim exchanged manioc flour (*farinha*) produced by residents for industrial goods. Men also worked in nearby Brazil nut groves, and went on expeditions lasting for months to gather sorva, Balata and Rosewood near the headwaters of the river. By all accounts Juvenal treated the residents well, allowing them to plant *roças* and establish *sítios*. Today's community spans four long-term landholdings, Barro Alto, Raimiro, Parintintin and Liberdade. For political and administrative purposes Barro Alto is a single community. However the recent arrival of two evangelical churches (Assemblea and Adventista) has created religious divides and conflict within the community.

At Barro Alto the 35 ha of ADE on which the community is located has been the site of increasingly intensive cultivation as the population expanded over the last fifty years. As population increased, the *sítios* of the community have thinned out, and have been replaced by homesteads and bitter manioc fields. The population is seven times that of Terra Preta and Estirão (Table 2) and most of the community households are crammed into a single square kilometre; hence there is much less space for *sítios* and houses are closer together. Directly behind the community, farmers cultivate bitter manioc on ADE under a short cropping - short-fallow system. Fallow periods are very short, from 1 to 4 years. The most predominant landrace is called Tartaruga, and at Barro Alto when cultivated in ADE it is harvested between 5 months and 1 year after planting. Tartaruga is a weak landrace that is widely cultivated in the floodplain in the communities Verdum, Amaro and Delicia downstream from Manicoré. It arrived on the River Manicoré a long time ago, it is difficult to ascertain when, or who brought it, several elders recall its arriving from completely different places.

Behind the ADE are sandy Ultisols that, owing to population pressure, are also fairly heavily cultivated, with shorter fallows of 5-15 years. These soils are planted with a mixture of Tartaruga and a stronger landrace Roxinha-RM [River Manicoré kind]). In the clayey Oxisols further behind the community, bitter manioc is planted in a longer-fallow, longer-cropping system. Slow maturing varieties of manioc (Arroz and Roxinha-RM are planted and harvested 1-2 years after planting. These fields are fallowed for 15 or more years, and a rapidly growing population is causing agriculture to push into the primary forest further inland. While landownership is ostensibly collective, in reality once a *roça* is cut, burnt and planted it becomes property of the family. All fallows therefore have owners. It could be argued that distance to market may explain why there is more bitter manioc agriculture on remote ADE sites in Manicoré, but Barro Alto has good market access and bitter manioc is *still* the main swidden crop on ADE (Table 1).

From the preceeding discussion and following narratives we can conclude that:

a) Bitter manioc farming on ADE at Barro Alto has intensified as population has grown, because of this ADE is referred to as "weak land." Sitios on ADE are restricted owing to clearing for houses and manioc fields.
b) Historically, a greater diversity of crops were cultivated on ADE, today only bitter manioc is cultivated. This is because of economic changes (greater availability of industrial products means that people no longer need to cultivate sugar cane, tobacco and coffee for subsistence, greater market for manioc flour).
c) Bitter manioc is said to mature more quickly in ADE.
d) The weak landrace Tartaruga is seen as the most suited to cultivation in ADE, while the stronger landraces Arroz and Roxinha-RM are seen as more suited to Oxisols.
e) Weak manioc is seen to yield better in ADE and young fallow, strong manioc is seen to yield best in Oxisols and Ultisols with old fallow.

"When I was young there was still old fallow behind the village. As the community grew bigger and bigger we cleared more and more fields and now the forest is far away. When I was younger we planted beans, tobacco, maize and bitter manioc in the *terra preta*. It was around twenty years ago when people started planting bitter manioc constantly there. I remember when we started planting I once harvested 80 sacks of *farinha* from half a hectare. Since then because people hardly even leave the land to fallow, the land has got weaker, but still yields well: around 50 sacks per half hectare. We plant Tartaruga in terra preta as it yields more, and it is well suited to *terra fraca.* After 10 months it flowers and seeds; the plant matures. In clay this only happens after 12 months....When we plant in the clayey soils of the *centro*, Arroz [the landrace] yields best."

Antonio Pinto da Souza, Barro Alto

“Tartaruga yields well in Terra Preta. In the clayey soils Roxinha or Arroz is better. For me *terra preta* is better than clay, because while it needs to be weeded more, bitter manioc grows quicker. We began to harvest after six months, in the clay it is only after a year.’ In *terra preta* and any other soil, Roxinha only yields well if the land has been fallowed for eight years or more. Tartaruga is appropriate for capoeira fina. If you put *mandioca forte* in *capoeira fina* it will not yield. If you put *mandioca fraca*, like Tartargua in the *capoeira forte* is doesn’t yield well either.”

Sebastião Pinto Batista, Barro Alto

“I didn’t plant Roxinha in the first field because it was young fallow, but it yielded well in the second, because the second field was cleared from old fallow. Tartaruga is suited to weak fallow, if you put strong manioc in weak fallow it doesn’t yield.”

Selmo Batista, Barro Alto

“I only fallow a maximum of 2 years in terra preta. After 10 months, Tartaruga is mature and yields a seed. This only happens after 12 months when we plant in clay. The maniva [stem] becomes ash coloured after 7 months in terra preta, but only after a year in clay. If you plant Roxinha in weak terra preta, it matures more quickly, gives many tubers but they don’t thicken. Tartaruga is best suited to terra preta when it is fraca. When terra preta is forte, Roxinha yields well.”

Antonio Pinto da Souza, Barro Alto

“In clay[ey soils] Tartaruga “*da muito pão*” [meaning bits of the tuber will not soften in water]… *Mandioca fraca* is from the varzea, it yields well in *terra preta* but after a year in the ground it won’t soften any more in the water. In the winter the tubers are more watery, in the summer they are drier.”

Elderlei Pasos, Barro Alto

“In *Capoeira grossa* everything yields, but in *capoeira fina* only Tartaruga or Jiju yield. If you have to plant in *capoeira nova*, it is better to plant in *terra preta* as the yield is better than capoeira nova on barro or areia, which hardly yields anything.”

Raimundo Nonato de Araujo Caietano, Barro Alto

"Terra preta is weak land because lots of bitter manioc has been planted there. In terra preta, bitter manioc yields quickly, Tartaruga is the right manioc for terra preta. In strong clay, roxinha, arroz and jabuti. Weak land is land with low fallow, strong land is land with high fallow."

Aldo Pinto de Souza, Barro Alto

3.5 Case Study: Barreira do Capanã and Boa Vista

Barreira do Capanã and Boa Vista are quite different from Barro Alto in several ways, geographically, demographically and culturally. The locality is formed from a series of old landholdings strung along what was once the largest bend of the River Madeira. The river course shifted dramatically around 30 years ago and the bluffs on which the community is located have been left overlooking a floodplain lake during the rainy season, and trapped behind the old dry river course during the dry season (June to October). During the dry season access is reduced to a journey of several kilometres by foot across the dry lake, making market access difficult during this period. Locals have begun to plant watermelon, maize, beans, squash, banana and bitter and sweet manioc on the newly emerged floodplain, principally in June and July. Given that households and clusters occupy a relatively long stretch of bluffs (5.6 kilometres); the locality is less heavily populated that Barro Alto. Culturally the community is also distinct from Barro Alto. Many of the people of Barreira do Capanã (particularly the eastern half) are of Amerindian descent.

Barreira do Capanã features the largest ADE site identified during the course of the research, some 50ha in size. It is divided up into several large and historic landholdings. Agricultural land-use on ADE is a mixture of homegardens and manioc swiddens. Some farmers also plant small amounts of maize. Unlike Barro Alto, where population growth has restricted the size of *sítios*, most families with ADE at Barreira do Capanã also have large *sítios* producing fruit for subsistence and market. Historically, ADE was planted with a greater variety more crops that today. An elderly couple, Luis Menes de Castro and Juliana de Maranch Menezes recall planting maize, watermelon, squash, beans, sugar cane, yams, as well as Bitter and Sweet Manioc in ADE. The first time they planted bitter manioc in ADE, one tuber weighed 10 kilos. At neighbouring

Fazenda Boa Vista there is another large ADE site with a single landowner, inhabited by 3 families. The ADE site has a farm with 4 cows and a large citrus orchard with 700 orange (*Citrus sinensis*), tangerine (*Citrus. reticulata*) and lime (*Citrus. aurantifolia*) trees. Farmers there also plant bitter manioc on ADE, with a little maize and watermelon.

In contrast to residents of Terra Preta and Barro Alto, who identify one or both grandparents as economic migrants from North-Eastern Brazil, the people of Barreira do Capanã say are *gente daqui, gente da terra* (people from here, people of the land). The elders of the community state that the ADE site where they live used to be an *aldeia dos indíos* (Indian Village). Some of the younger men, who were more frank, said that they *were* Indians. A man named Tivi, for example, once said "*quando eu era pequenho, cada dia que foi na escuela, pase na capeoira e teve medo, porque as pessoas dizeron que habia Indios alla. So depois di conta que os indios somos nois*." (when I was young I walked to school every day past the old fallow on the terra preta, and I was scared, because people said that Indians lived there. It was only later that I realised that we were the Indians).

People at Barreira do Capanã and Boa Vista, like those at Barro Alto, believe certain varieties of bitter manioc do well in ADE, in particular a variety called Pirarucu Branco. Pirarucu Branco is famed for yielding huge tubers in ADE. It has been cultivated in ADE at Barreira do Capanã for decades. Tivi, remembers his grandmother, an Indian woman, planting Pirarucu Branco over and over again (without fallowing) in her homegarden ADE for decades. Tivi also remembers his grandmother planting a variety of Sweet Manioc in ADE called "Macaxeira Pão." The roots of one plant filled half a *Tipití.* Pirarucu Branco was probably more important before the sale of manioc flour became such a major livelihood activity, because it yields white manioc flour, which does not sell as well as yellow manioc flour. Other informants similarly remember it being cultivated for decades. Farmers at Barreira do Capanã and Boa Vista also believe that weak manioc yields better in ADE and strong manioc yields better in clayey soils. It is difficult to ascertain when Pirarucu Branco arrived at Barreira do Capanã. The practice of planting it in ADE appears to have begun with the arrival of a woman from an Indigenous (Mura) community called Castañeira Piraoka on the upper Capanã Grande River. This community is situated on an ADE site, and the woman who brought it told people at Barreira do Capanã that Pirarucu Branco yields particularly well on ADE. This landrace is widely planted in the floodplain community of Forteleza, close to Barreira do Capanã; and older members of this community recall it being planted up and down the Middle Madeira floodplain during their childhood. It is most likely therefore that this landrace originates in the floodplain.

On Oxiols and Ultisols, the most predominant landrace is called Jabuti, which by oral accounts is the oldest at Barreira do Capanã and Boa Vista, in the Água Azul region and at Vista Alegre. When most old people were questioned, it was the landrace they remembered most being planted in their childhoods. Jabuti is often described as the strongest of all landraces. People say that it does not *quebrar* (diminish in volume when processed) at all, and is the most durable in the land of all the landraces, and yields very yellow manioc flour. It takes a long time to mature and is only good in strong land (land with old fallow). Locals note that it does not yield well in ADE. Tartaruga has arrived relatively recently in the locality and has quickly become established as a favourite variety on ADE. It was brought over to Boa Vista from the River Manicoré and then quickly spread to Barreira and also into the Água Azul region, though it has been renamed as Cosha Branca.

From the discussion above and the following narratives we can determine that:

a) Weak manioc is seen as better suited to ADE, strong manioc to clayey soils (like Barro Alto).
b) A greater diversity of crops were historically planted in ADE than are today (like Barro Alto).
c) At these communities, because they are based on large, sparsely populated landholdings, *sítios* are of greater importance to *Caboclo* subsistence than at Barro Alto.
d) Bitter Manioc and Sweet Manioc are said to perform well in ADE, especially the landrace Pirarucu Branco, which could be a bitter-sweet cross (see section 3.8).
e) The strong landrace Jabuti, is said to be best suited to Oxisols and Ultisols, but does not yield well in ADE.

f) In *sítios* on ADE, which receive nutrient additions in the form of organic waste, ash and charcoal, and chicken manure, bitter and sweet manioc have been cultivated continuously for decades, and still yield well enough to make planting worthwhile. Citrus trees, which do not yield well in Oxisols and Ultisols, are also cultivated successfully in ADE.
g) Some locals recognise an anthropogenic origin for ADE, including processes of formation.
h) As with Barro Alto, fallows have owners, ownership rests within the family, and are therefore often cultivated by several generations of the same family.

“Some people say that manioc doesn't do well in *terra preta*? But it depends which variety you plant. If you plant the right kind of manioc you get a good yield.”

Veronica Gualdinho, Barreira do Capanã

“Jabuti [a strong landrace] only yields small tubers if you plant it in terra preta... Weak manioc is better suited to *terra preta*. Jabuti is better suited to clay.”

Maria, Barreira do Capanã

“Bitter manioc yields better in terra preta. Weak manioc is better in *terra preta*, strong manioc yields better in clay.”

Bibi, Barreira do Capanã

“When I was young all everyone planted in Terra preta was Pirarucu Branco. I always planted Pirarucu Branco. It used to yield loads and loads.”

Manuel 'Pele,' Barreira do Capanã

“Jabuti is for red earth (clay). Weak manioc like Pirarucu Branco and Aruari are for *terra preta*. Sweet Manioc also yields better in *terra preta.*”

“Parts of the top-soil of this *roça* have become *terra preta*, from being burnt so many times. I cleared this field from a fallow of my grandfather.”

Jose Arifani Mendes Trindade, Barreira do Capanã

"Pirarucu Branco is the king of *terra preta.*"

Janilson, Barreira do Capanã

"Not everyone likes planting manioc in terra preta, because it weeds up so much. But for the tubers that it yields, it's worth it. There's no comparison with clay. Both bitter and sweet manioc yield much better in Terra Preta. The roots develop better and grow larger in terra preta. My parents' homegarden is constantly planted with bitter and sweet manioc every year, and it keeps yielding."

Raimundo Nonato Soares Barros (Pindu), Boa Vista

"We have many *plantas de raiz* planted in the terra preta. Orange, Lime, Tanjarine, Avocado. We make good money selling oranges, tanjarines, Limes and Lima in Manicoré. All these plants don't yield well in Clay."

Raimundo Nonato Soares Barros (Pindu), Boa Vista

'There was an old man who said *terra preta* was made by Indians. Burning, planting manioc and maize the Indians made *terra preta*. These are the things that grow best in *terra preta*, no? If you wanted to make *terra preta* you could; we just don't because we already have plenty. We'd just make a *roça* with lots of *coivaras*, burn and it forms 3 fingers of *terra preta* [holding up 3 fingers horizontally]. It's like women do in the *sítio* when they make *terra queimada*; its *terra preta*. Some parts of *terra preta* are darker because they were burnt more. I think in the *terra preta* where there are pottery fragments is where the Indians lived and where there are no fragments is where they planted...There is a field over there which is becoming terra preta. We did it by accident. We cut down the fallow and burnt it, but it didn't burn well and we didn't plant it, it just regrew. The we cut it down and burnt it again, but didn't plant it. The soil of this field has become *terra preta*."

Raimundo Nonato Soares Barros (Pindu), Boa Vista

3.6 Case Study: The Água Azul Region

The Água Azul region is an artificial construction spanning several physically neighbouring communities (Boa Esperança, Água Azul, Monte Orebe and Monte Sião). These are further divded into the former two as opposed to the latter two, each pair linked by geography and kinship. Boa Esperança and Água Azul were until recently a single community, and were split up for political reasons, and Monte Orebe and Monte

Sião are two small neighbouring evangelical communities. For simplicities sake, Boa Esperança and Água Azul are both referred to here as Água Azul. Until 30 years previously the majority of the population of these communities lived along a high floodplain that used to be located in front of the *terra firme* bluffs that people now inhabit. They occupied historic landholdings featuring rubber and cacao groves. When the river changed its course 30 years ago, the high floodplain was washed away and people relocated to the *terra firme*.

Água Azul today is a large community occupying a relatively small area of land. Becasue of this, most *sítios* were much smaller than those at Barreira do Capana and Boa vista. The ADE site at Água Azul is relatively small, around 15ha, and owing to this restricted size, its cultivation is limited to a handful of families. They have intensified bitter manioc production - with a short-cropping short fallow system planted with fast maturing floodplain manioc, a weak landrace called Pirarucu Amerelo, This intensive cultivation system is reminiscent of that found at Barro Alto. This seems to be a function of population pressure; the families in question cite lack of available land as the reason for their intensification. Most people plant bitter manioc in Oxisols and Ultisols, where the most predominant variety of bitter manioc is the strong landrace Jabuti. Many other people are involved in the cultivation of banana in the high levee floodplain on the east bank of the Madeira, opposite the community. The low floodplain *vazante* is planted with watermelon, maize, manioc and beans.

Farmers at Monte Orebe use the ADE site inland from the bluff to plant bitter manioc, though maize and watermelon have been cultivated there before. Farmers of the community Monte Sião plant *roças* and have *sítios* on two ADE sites (each around 10 ha), which form part of the single landholding on which the community is situated. These ADE sites are located close to Monte Orebe, away from the houses of most of the Monte Siao community members. In recent history the ADE sites were occupied but were abandoned by the families residing there owing to a land dispute. Two families from the community have recently reoccupied them and established new homegardens on the sites. Land-use has been less intensive for these reasons and because the population of the community is small.

The preceeding discussion and following quotes show that:

a) As with farmers at Barro Alto and Barreira, farmers in the Água Azul region believe that weak manioc, such as Pirarucu Amerelo yields well in ADE and strong manioc, such as Jabuti and Arroz, yields well in Oxisols.
b) The floodplain landrace Pirarucu Amerelo was brought to the *terra firme* found to yield well in ADE.
c) The landraces Tartargua and Pirarucu Branco are also present in the region, and farmers have similarly found that they yield well in ADE.
d) Locals recognise a floodplain origin for weak manioc, and a *terra firme* origin for strong manioc.
e) Some people recognise that ADE was made by Indians, and that bitter manioc yields better in soils as they become ADE.
f) People claim that bitter manioc can be planted in ADE for long periods of time, with short fallows or none at all, and still yield adequately.
g) Other advantages of bitter manioc cultivation in ADE were mentioned: faster maturing, straight growing tubers, large tubers, and better, yellower manioc flour.

"Everyone used to live on the floodplain before it started to wash away about 30 years ago. The floodplain was full of rubber trees and cacao groves. We used to plant bitter manioc in the floodplain and here on the *terra firme*. *Mandioca fraca* like Pirarucu Amarelo comes from the floodplain, and when we brought it up here we found it yields really well in terra preta. We've been planting it in the terra preta for 30 years now, only ever fallowing for 1 or 2 years before planting again, as we have so little land, and it still yields really well..... Mandioca forte like Jabuti and Arroz yield better in the clayey soils."

Raimundo Teixeira de Souza, Água Azul

"We planted bitter manioc each time in the same place in the terra preta, the soil is tired but it always yields alot."

Enimilia Morais Pinto

"Weak manioc are Pirarucu Amarelo and Tartaruga, they come from the floodplain. Strong manioc is Jabuti and Arroz, they come from *the terra firme*....In terra preta, manioc grows straighter, yields quicker, and the *farinha* is better, its yellower. In clay manioc grows crookedly."

Autevir Morais Arcangel, Água Azul

"Pirarucu Branco and Tartaruga yield the best in *terra preta*. Their tubers can grow up to a meter long, with the width of a 2 litre coca-cola bottle. Jabuti and Arroz are best in clayey and sandy soils. In the *terra preta* I only fallow for 2 years, and replant up to 3 times [replant is the practice of instantly replanting manioc in the same spot as it is harvested]. When I plant in clay, I only plant after five years or more fallow, and I only replant once, if you replant more than once, *so da miúdo* [it only yields small]."

Junior, Monte Sião

"*Mandioca fraca* yields better in *terra preta*, *mandioca forte* yields better in clay[ey] and sand[ey soils]."

Manuel Galdinho Cavalcante, Monte Sião

"The old people told us how *terra preta* forms where there was an Indian village. Millions of them burning, making pottery, cooking, *roçando*. In this way the land became *terra preta* from burning. It's the same way when we burn a *roça* and do *coivara*, it makes *terra preta*, the soil goes black, any plant will grow better. Manioc planted in the *coivara* always grows better…when you burn the *coivara* like this it changes the soil forever, we sometimes find these places in the forest which have been burnt, these places are better to plant *roça* than places which have never been burnt."

Manuel Galdino Cavalcante, Monte Sião

"It was the Indians that made *terra preta*. We always find their ceramics in the *terra preta*. *Terra preta* was formed by the Indians' burning. There are different types of *terra preta*, here it is really dark, further behind it is less dark...When we make a *roça* and burn, the soil becomes dark. Every *capoeira* has a little *terra preta* underneath, because it was burnt. The [non-ADE] *capoeira* is always better to plant manioc than when it was primary forest, the replant in the *capoeira* is better than the first in [non-ADE] primary forest. All the vegetation burns, rots and becomes *estrumo* [fertiliser]. When the earth burns it stays like that forever, the more times it is burnt the better it will yield bitter manioc. It's because we transform the earth, digging, mixing. The more times the earth is burnt, the deeper the *terra preta* goes. When I began to cultivate the *roça* behind my house [on Oxisol] it was hard clay. When the earth is burnt it becomes sandier. As it becomes *terra preta* the soil becomes looser and sandier. I have cut and burnt there 8 times, now there is 10-15 cm of *terra preta*. Where the earth is darker, manioc yields better. In the *coivara* bitter manioc grows beautifully and yields well. Manioc yields better now in that *roça* than before. Only the top of the soil is *terra preta*, but the manioc is also planted at the top of the soil, it grows bigger and faster now."

Raimundo Ipês dos Santos, 'Dico'
Água Azul

3.7 Case Study: Vista Alegre

Historically Vista Alegre was a series of large, independently owned landholdings, whose owners cut rubber, collected Brazil-nut, planted Jute in the floodplain, and cultivated bitter manioc. They sold production to the *patrão* Aristide do Rosario, who lived at and owned the landholding known as Democracia, which today is the site of a community of the same name. During this period, people planted bitter manioc, tobacco, watermelon and maize and a little beans and vegetables on ADE. Bitter manioc yielded very well during this period. As in the nearby Água Azul region many people in the community used to live in the floodplain. The site of the community Vista Alegre was until around thirty years ago fairly sparsely inhabited until many relatives moved on to the *terra firme* when the high floodplain they lived on began to be washed away after the Madeira changed its course. Vista Alegre is today a relatively large community and this is reflected in the more intensive cultivation of ADE. Today, the ADE where bitter manioc, maize, watermelon, and a little West Indian Gherkin and squash are grown is also considered *terra fraca,* because of its young successional vegetation and known history of heavy use.

The ADE site at Vista Alegre is around 20 ha in size. Interestingly, it is not located right on the bluff, as with most other sites, rather it begins between 10 and 50 meters inland depending on the location. The upshot of this is that there are less homegardens on ADE, as most houses are located on the bluff edge which is mostly Oxisols. Cultivation of watermelon became increasingly intensive from the early 1980's, with the community producing 40,000 fruits per year on ADE. In 1997, ADE cultivation was largely abandoned owing to invasion of *limorana (Gynerium sagittatum)*. Short-cycled crops such as watermelon are still viable, as they can be harvested before the *limorana* takes over. Farmers began to plant watermelon again in

2005. As the cropping cycle is short (3 months) and plant growth is on the surface this is seen as viable, as produce can be harvested before the *limorana* takes hold again. Before *limorana* invasion bitter manioc cultivation was also more widespread in ADE, but today it is restricted to areas of ADE not taken over by *limorana*. Many people now plant bitter manioc on the Ultisols and Oxisols behind the ADE. A major new livelihood practice is cultivating plantain (*pacovão*) in the floodplain on the opposite bank of the Madeira.

The following quotes show that:

a) As with Água Azul, when residents moved to the *terra firme* they found that one of their weak floodplain landraces, Roxinha Branca, performs best in ADE.
b) As with the other three localities, they found strong landraces Jabuti[18] and Arroz that are predominant in fields on Oxisols and Ultisols in old fallow, don't yield very well in ADE.
c) Some recognise that Indians used to live in the locality and were responsible for that formation of ADE. Some also recognise processes through which ADE formation occurs.
d) As at Barro Alto, a land is considered "weak," if it has young fallow, and strong if it has mature fallow.
e) Like Barro Alto, people used the maxim "weak manioc in the weak land" to explain why they plant weak landraces in the ADE, which is covered in young fallow. They also claim that strong manioc yields better in strong land
f) Locals have found that ADE can withstand intensive (short fallow) manioc cultivation.
g) Watermelon has been intensively farmed on the site.

[18] In addition to agroecological reasons to plant Jabuti, the fact that people in Vista Alegre cultivate banana and watermelon in the floodplain of the opposite side of the Madeira probably influences their choice of planting almost exclusively this forte landrace. This is because they are making money from growing other crops and therefore are not selling very much of the manioc flour they produce. Durability in the ground, which allows greater labour flexibility is more attractive than fast maturing landraces that while being ready for harvest quicker, would place heavier demands on labour on account of having to be harvested and processed in a smaller time frame.

“The Roxinha Branca we plant here is from the floodplain. I remember that people used to plant it in the floodplain. There used to be an island above Pandegal. There was a big flood and the seven families that lived there left and came here had land titles at Vista Alegre. They brought Roxinha Branca with them from the floodplain. They found that the strong landraces Jabuti and Arroz didn't yield well in the terra preta, but Roxinha Branca did yield really well, and still does.”

Abel Fernando de Oliveira, Vista Alegre.

“In the olden times there were many Indians that used to work in these lands. The old people told us that terra preta was made by the Indians... My grandparents were Indians...”

Abel Fernando de Oliveira, Vista Alegre.

“Here used to be a Mura (an Indian tribe) village. We know because the old people told us that when the first outsiders invaded these lands, the Mura fled to Capana Grande. They made the terra preta here and we find pieces of their pottery... How do you make terra preta? You gather together rubbish in the *sítio*, burn it and then you can plant what you like.”

Antonio Trajado Dias, Vista Alegre

“My grandfather planted like I do in the terra preta, 3 times one after the other, harvesting tubers and replanting manioc straight away.”

Junivaldo Dantas, **Vista Alegre**

“About 15 years ago Roxinha Branca arrived here and everyone began planting it in terra preta because it yielded so well.”

Francisco Ferreira Maselo, Vista Alegre

“weak manioc yields well here at the front [on ADE] because the land is tired, the strong manioc yields well there [in old fallow on Oxisols and Ultisols]. For example, roxinha branca, yields really thin tubers there in the center [in old fallow on Oxisols and Ultisols], here [on ADE] it yields larger tubers. Jaboti here on terra preta doesn’t yield well, but there in the center [in old fallow on Oxisols and Ultisols], it yield well.”

Manoel Bittencourt Dantes, Vista Alegre

"When we first arrived here after we bought this piece of land twenty years ago, we planted a *roça* in the terra preta. We planted Jabuti, Arroz, Pirarucu Amarelo, Pirarucu Branco and Tartaruga. We thought that they'd all grow well, everything grows well in *terra preta*, no? But Jabuti and Arroz didn't grow very large potatoes. But Pirarucu Amarelo, Pirarucu Branco and Tartargua grew really well. Better than they do in any other soil [of the *terra firme*]."

Zenil Monteiro Ipi, Vista Alegre

3.8 Local Understandings of the relationship between Bitter Manioc (*Mandioca*) and Sweet Manioc (*Macaxeira*)

Bitter and sweet manioc are perhaps better thought of as two ends of a continuum, ranging from little or no cyanogenic glycoside content to very high content (Table 4). Where then, does the boundary between "bitter" and "sweet" manioc lie? This section shows that *Caboclos* recognise that there is an ambiguous "intermediate" area, of sweeter bitter varieties.

Table 4 Levels of cyanogenic glycosides (CN) in manioc, adapted from McKey and Beckerman (1993)

Kind	Local	CNP	HCN
Sweet Manioc	*Macaxeira*	Innoculous	<50 mg CG
Bitter Manioc	*Mandioca*	Moderately	50-100 mg CG
Bitter Manioc	*Mandioca*	Dangerously	>100mg CG

It is interesting to speculate on the relationship between bitter and sweet manioc and strong and weak manioc. While locals recognised that bitter manioc landraces are more or less bitter, the relative bitterness of bitter manioc landraces was not of great importance to them, as this does not effect processing to a great degree. The "weakness" or "strength" of landraces *was* of great importance, since from local perspectives these categories determine when a landrace will mature, what kind of soils it yields best in, and what kind of *terra firme* fallow it is best suited to. Bitterness is neither easy for people to measure; nor are its degrees of bitterness of primary importance; what is *most* important is whether a landrace is dangerously bitter (*mandioca*) or not (*macaxiera*). Though as we shall see below they do recognise different degrees of bitterness. For these reasons, degrees of bitterness were not quantified (as are other aspects of manioc cultivation in Chapters 4 and 5), but rather accessed through narratives presented in this section. Therefore, determining whether or not there is a link between cyanide content and rate of maturation awaits genetic studies. Local people do suggest however, that the strongest landraces are usually the most bitter (see below).

On the Middle Madeira today, and in the central Amazon during the late pre-Columbian period, the majority of manioc cultivated is "bitter." The bitter-sweet question can then be reframed as one of *how bitter*? This section looks at how locals on the Middle Madeira distinguish the degree of bitterness of bitter landraces, and how bitterness and other traits shape the use of different landraces. If the content of cyanogenic glycosides is associated with other genetic traits (fast, slow maturing, floodplain, *terra firme*, root colour, dry matter content etc.), then selection for different traits by farmers might affect the bitterness or sweetness, and therefore use, of a landrace. There is some evidence that slow maturing varieties are more likely to be bitter (Jones 1959). Piroa Indians from southern Venezuela claim that slow maturing landraces are the most bitter and have the most resistance to rotting (Heckler and Zent 2008). On the Middle Madeira, while bitter and sweet manioc are not always planted seperately, and farmers do observe the capacity of Bitter Manioc and Sweet Manioc to interact and reproduce (see narratives below). Furthermore, on farmers on the Middle Madeira and in other regions commonly sub-differentiate bitter landraces as being more or less bitter. Heckler and Zent also find that Piroa Manioc Farmers recognise four grades of bitterness: very bitter, slightly bitter, not bitter and sweet". The parameter of bitterness was perceived as a continuous variable. The Piroa frequently compared the of landraces with the adjectives such as "more" or "less" and "a lot" or "a little" (Heckler and Zent 2008). In the following narratives, we see different indicators of bitterness during the processing of bitter manioc into *farinha*. Firstly, some locals note that less bitter varieties need to be soaked for less time, and float rather than sink in the water. During later stages of processes they notice that intermediate varieties yield "less *tucupi*" and "more goma." *Tucupi* is a yellow liquid extracted from the manioc tuber. The tuber is soaked, has its skin removed (before or after soaking), is drained (using a *tipipí,* or prensa). The resulting pulp is left to settle, where the starch (*goma*) is separated from the liquid (*tucupi*). Initially poisonous owing to the presence of cyanide, the liquid is cooked (to eliminate the poison) for hours, and then chillies are added to make it into a sauce.

The following quotes show local understandings of the degrees of sweetness and bitterness of landraces. The main themes that emerge are as follows:

a) Bitter manioc and sweet manioc cross pollinate, and local people recognise that bitter manioc is "stronger" in the sense that the seedlings from cross pollination between *mandioca* and *macaxeira* will be bitter.

b) Pirarucu Branco is considered to be like Sweet Manioc because it has a white tuber, yields sweet *farinha* and does not to be soaked for as long as more bitter varieties. This raises the intriguing possibility that such "intermediate" varieties originate from bitter and sweet manioc cross-pollination.

c) There are several other bitter manioc landraces that are considered to be like sweet manioc, because they exhibit traits (white tuber, farinha taste, weak tucupi, lots of goma, good for tapioca) that remind people of sweet manioc.

d) Arara is considered to be dangerously bitter.

e) One quote also mentions a slightly *bitter* variety of sweet manioc.

"Bitter Manioc mixes, when Sweet Manioc is planted close to Bitter manioc it goes bitter….. We have various types of Bitter Manioc which are like Sweet Manioc. Pirarucu Branco is like Sweet Manioc because the tuber is white and it is not very bitter. Arroz is not like Sweet Manioc because the tuber is yellow and very bitter. Roxona comes from a seed in my mother's field, its white too like Sweet Manioc. Bonitinha from Doraci is also whitish and looks like Sweet Manioc. These three [Pirarucu Branco, Roxona and Bonitinha] are all like Sweet Manioc. Cutias (Agoutis) like Pirarucu Branco, it is white and sweet...."

"Pirarucu Branco yields so well in ADE that it used to be the only landrace I planted. Its *tucupi* is weak the farinha is almost sweet and it yields lots of *goma*. I like the *farinha* we make from it much more than the *farinha* of Jabuti, which is bitter. Now I mix it with other landraces so the farinha mix will be yellower and it will sell better. Arroz gives a powerful *tucupi*: all kinds of yellow manioc give strong *tucupi,* we only use them for tapioca if we are doing a mixture and serra a little [grate up with electric motor]."

Tivi, Barreira do Capanã

Pirarucu Branco is almost Sweet Manioc, it has a white tuber. The tuber of Sweet manioc is always white. When we soak it floats in the water, it doesn't sink to the bottom. The root is really watery. I stopped planting it. I prefer Roxinha which has a purple skin and purple guia, it yields lots of tubers. We plant sweet manioc in the floodplain. If we plant it in the terra firme it crosses with bitter manioc and goes bitter. Roxinha is more bitter, we need to soak it for five days. Pirarucu Branco only needs to be soaked for 3 days**.**

Manuel Doce, Barreira do Capanã

The variety "Bonitinha" comes from a seedling that appeared in my field. It was born when sweet manioc crossed with bitter manioc. I believe this because it grew where sweet manioc had been planted. I took a cutting and planted it. Then it spread out.

Doraci, Barreira do Capanã

"The old people said that when bitter manioc and sweet manioc marry, the bitter manioc is stronger... the sweet manioc will become bitter manioc."

Emilton Carneiro, Estirão

"Pirarucu Branco and Castanha are Bitter Manioc but look like Sweet Manioc, the tubers are white and they yield less *tucupi.*"

Elderlei Pasos, Barro Alto

"Ituki, Castanha and Pirarucu Branco are all Bitter Manioc that are like Sweet Manioc**.** My mother used to like them to make *ped de muleki*.... We also have a kind of Sweet Manioc that is a little bitter. If I boiled it for you to eat, you wouldn't like it! It's good for making beijú though."

"The most bitter landrace I know of is Arara. It is so bitter that even the *sauva* [leaf cutter ants] stay away. They could clear a whole field of manioc, but would leave the Arara plants alone. My father planted Arara in the part of the field where *sauva* [leaf cutter ants] always passed, and they left it alone"

João Viera, Terra Preta

"When you plant Arara you need to know what you are doing because it is very bitter. When you harvest you need to leave it to soak for more than five days. Once a family I know didn't and they made *beijú* from it and then got sick and threw all the *beijú* in the bushes"

George Borges Soares, Barro Alto

3.9 Generating Diversity: Local Management and Selection of Landraces

"Normally traditional populations are cast as merely maintainers of geneticdiversity. In fact, their agricultural systems function as gene banks. Owing to this, their role is much more important, as they *generate and amplify* this [genetic] variability in a continual processes.' (Martins 2005: 218, my emphasis)

This section examines how farmers select landraces for planting in fields in different soils and fallow ages on the basis of their different agronomic and aesthetic characteristics, which are the phenotypic expressions of different genetic traits. This generates different concentratations of agrobiodiversity in different manioc fields which in turn shapes the genetic content of seedling volunteers. When these volunteers are incorporated into the stock of planting clones, the genetic diversity of manioc landraces is increased.

3.9.1 Landrace Selection

Farmer selection of certain landraces means that each field has a particular genetic population. This means that the genetic makeup of seeds produced by any one field is influenced by farmer selection for certain landraces. Therefore, farmers directly influence manioc evolution. This chapter has demonstrated how farmer selection of landraces is contingent on their perceptions of different types of soil (Floodplain/ADE/Oxisol/Ultisol) and vegetation, especially successional (young, middling, old fallow and primary forest). Landraces emerge from local people's agricultural practices, but people select to get a good yield, or fulfil other economic, subsistence or aesthetic requirements, and *not* to create a landrace. In explaining how current patterns in geographic distribution of landraces have come about, it is important therefore to focus on the processes of perception and management that maintain the existing existing stock of clones and generate manioc genetic diversity through the incorporation of seedlings. The *longe duree* of planting decisions also shapes contemporary landrace configurations. Indeed the presence of divergent landrace assemblages on ADE fields today (the prominence of Pirarucu Branco at Barreira do Capanã and of Tartaruga at Barro Alto) is cumulative and embodies years of experimentation and experience. The decisions of groups of farmers, both from previous generations, up to those of the last few years, conditions both the availability and the genetic content of landraces. Old landraces disappear, mostly because their characteristics are no longer suited to the changing farming context. Conversely, new landraces appear, and if their traits fit current farmer preferences, they are quickly adopted. Other factors include farmer preference for certain agronomic, economic and aesthetic criteria but also are affected by constraints such as the availability of landraces in a particular planting season (Table 5).

Table 5 Farmer Perception of Manioc Traits on the Middle Madeira: Matrix of Commonly mentioned agronomic characteristics of different manioc landraces on the Middle Madeira, and their scientific equivalents. The effect on practices that these traits have is suggested, and also on the wider agricultural system

Local Expressions	Scientific Trait	Effect on practices	Effect on Agricultural System
Da ligeiro	Fast Maturation Early Seeding	Can be harvest from 5/6 months after planting	Faster cropping cycles
Demorar / Cuesta madurar	Slow Maturation	Can only be harvested after 1 year, only reaches full size after 1.5/2 years	Slower Cropping cycles
Aguenta	Long lasting in the ground	Left in the ground (associated with slow maturation, and most bitter landraces)	Facilitates below ground storage
Não Aguenta	Susceptibility to rotting	Root is liable to rot if left in the ground for longer that a certain time (usually a year)	Means manioc must be harvested
Não Quebra	Higher Dry Matter Content	More farinha per root mass after processing (drier root) (Associated with slow maturing, durable landraces)	Increase Production
Não amolesce mas	Becomes unsuitable for water processing after a certain amount of time in the ground	Necessitates either earlier harvesting, or dry processing using a motor powered grater	Places demands on labour at different times
Quebra	Lower Dry Matter Content	Less farinha per root mass after processing (more water content in root, associated with fast maturing, floodplain landraces that não aguenta, and não amolesce mas)	Decrease Production
Da miúdo	Yields little		People may stop planting it
Carrega Pouco	Yields fewer roots		People may stop planting it
Carrega Bem	Yields lots of roots		People may plant more of it
Bom para mistura		Good to be used to make farinha from various different manioc varieties mixed together	
Yellow Root	Yellower farinha		If production of farinha is more market oriented, yellowness is an important factor, as yellower farinha can be sold for more
White Root		People plant whiter rooted manioc when they value strongly other qualities, such as quality of farinha, yield etc.	People plant combined with another variety that yields yellow farinha in order to mix. White roots produce more tapioca, goma
Mas dolce	Sweeter Farinha	Several informants said they preferred the farinha from sweeter bitter manioc. These landraces do not have to be soaked in water for as long as more bitter landraces	More individuals in population with lower HCN. This will influence the HCN content of seedlings, and if they are incorporated, of the population as a whole
Mas amarga	More bitter root	Defence against predation Has to be left in water for a longer period of time before processing	More individuals in population with higher HCN. This will influence the HCN content of seedlings, and if they are incorporated, of the population as a whole
Da graudo		More farinha	More production (depending on starch content)
Da bem in X soil	Well adapted to a certain soil type	People plant more of this variety in X soil type	Divergent Co-evolutionary Dynamics if Seedlings are incorporated
Da bem na terra forte / da bem no mato	Well adapted to soil with old succession, or forest	People plant more of this variety in old fallow or mature forest	Divergent Co-evolutionary Dynamics if Seedlings are incorporated
Da em terra fraca	Well adapted to soil with young successional vegetation	People plant more of this variety in young fallow	Divergent Co-evolutionary Dynamics if Seedlings are incorporated

3.9.2 The management of seedling volunteers

Recent scientific work by Pujol, Elias, McKey and colleagues demonstrated how the incorporation of volunteer seedlings by manioc farmers increases genetic diversity and is responsible for the adaptation of manioc cultivation systems to particular environments. In the process of a field being cut and burnt anew from fallow where manioc has previously been cultivated, seeds germinate (stimulated by the high temperatures) and appear as seedling 'volunteers' in the fields about a week or so later, often before the clones have been planted. These seedlings grow from new genetic material, often different from the clones planted into the new field. Many farmers allow these seedlings to grow and later, intentionally or unintentionally, they are incorporated into landraces to which they bear a phenotypic resemblance. This process serves to bring new genetic material into landraces and maintain their vigour over time. The outcome of the practice of selective incorporation of volunteer seedlings is that landraces come to be formed of various clones that are morphologically similar but with distinct genotypes. n a recent study in French Guiana, Elias and colleagues demonstrated that 72% of landraces were not monoclonal[19] (Elias *et al.* 2001b). The germination ecology of manioc is thought to be pre-adapted to slash and burn systems, owing to its having evolved in transitional forest-savannah ecosystems predominant in Amazonia in the pre-Holocene period (Pujol *et al.* 2002). Seeds are capable of surviving 50 years or more in fallows and shifting cultivation creates a mosaic of seedbanks lying dormant in successional vegetation . Seedlings recruited from seedbanks and incorporated into landraces transform pure clonality into a mixed clonal-sexual reproductive system. Seedbanks and how farmers use them play a crucial role in maintaining genetic diversity in landrace populations. (Pujol *et al.* 2007).

In modern manioc cultivation in the Neotropics the extent to which volunteers are incorporated (the generation of genetic diversity) is greatly variable. studies in French Guiana found a relatively high level of incorporation (Elias et al 2001b). Pat Stocker found only a small amount of incorporation of seedlings in Para. (Stocker 2006: 162/163). On the Middle Madeira all farmers recognised the morphological differences of seedlings, stating that the seedlings grow straight up without growing branches, and that the seedling grows only one tuber that goes straight down (people often represented

[19] Rather, landraces were made up of more than one clone, which when compared had very similar phenotypes but different genotypes. The clonal propagation of manioc serves to reproduce and conserve the desired characteristics of these few exceptional clones, most of which are quite heterozygous and may exhibit greater vigour and resistance to pests and diseases because of this. The problem with clonal reproduction is that only a fraction of the original population is reproduced, and this leads to a genetic 'bottleneck' resulting in a steady loss of diversity However, because manioc has retained its ability to reproduce sexually - it is through incorporation of new clones, which appear as volunteers, that genetic diversity is maintained (Elias et al., 2001a, 2001b)

this with their index finger pointed down mimicking the single tuber), and is considered difficult to pull up. Some people on the Manicoré River call seedlings '*capitão*' (captain) because of their tendency to tower over the other manioc plants, as if commanding them. Other people call them *maniva de viado* (maniva of the deer), explaining that this is because the deer often come in and eat the seedlings as they appear in the field, or, as others claim, because the deer plant the seedlings. Some people snap the stems of seedlings, which they claim causes them to *desgalhar* (branch out) like normal manioc plants, and also yield multiple tubers, rather than just one.

Interviews revealed farmers who purposefully use cuttings from volunteers to plant, others who do unintentionally, and others who purposefully exclude volunteers. The first category is formed of the people who intentionally take cuttings from those volunteers they consider to be most healthy or attractive,[20] or "bonito" and plant them separately to see 'what kind of manioc it is', 'if it yields really big tubers' or 'if it has a really yellow tuber'. People in this intentional category differ in how they name the resulting variety of manioc. From a scientific perspective, it appears that what farmers perceive as "bonito" are heterozygous seedlings (Pujol *et al.* 2005). The second category is that of unintentional incorporation. During the course of fieldwork it became apparent that many people, while not intentionally selecting and planting from seedlings, did not remove (some or all of) them during weeding. Rather these people simply harvest them together with the rest. In most instances they do not separate the *maniva* of the seedlings from the rest of the clones. This leads to the unintentional incorporation of clones from the seedlings. The perplexing (for the farmer) result of this is that unknown types of manioc appear in the middle of what they thought were blocks of one kind of manioc only. The third category is formed from those who purposefully remove the seedlings during weeding. When asked why they do this, they often state that the seedlings '*não presta*' (they are no good) because they only yield a single tuber, and are hard to remove from the ground.

[20] This suggests parallels to Pujol, David and McKey (2005), who demonstrated how Amerindian farmers in French Guiana both maintain heterozygosity (through clonal reproduction) *and* genetic diversity (through incorporation of only the healthiest seedlings). This selection may have something to do with size asymmetry between heterozygous and inbred seedlings (Pujol and McKey, 2006).

3.9.3 Local Understandings of Manioc Seedlings

Caboclos recognise that these seedlings that appear in new fields are distinct from planted manioc. Some simply ignore or weed out the seedlings. Others recognise that if they take cuttings from mature seedlings and plant them, new varieties of bitter manioc are born. This is critical in maintaining and amplifying the genetic diversity of manioc varieties. *Caboclos* refer to seedlings them by various different names such as *capitão* (captain), because they tower over *roças*, or *maniva de viado*, because they are said to be planted by deer, or eaten by deer, as deer footprints are observed in freshly planted *roças*. Sebastião and Zenilda of Community Terra Preta once commented that "*Os antigos contaron que de maniva de viado foi gerado mandioca verdadera pelos indíos.*" (The old people told us that it was from the seedlings that real manioc was generated by the Indians). This is fascinating in that it both correctly identifies the domestication event (a cutting taken from a naturally propagated manioc plant), and that it was Indians who performed it. Similarly, Joana, an 85 year old woman at Barreira do Capanã, a community with many individuals of Indian heritage, said "*cuando nasce a semente não arranca ele que eles foram planto pelos antiguos*" (when the seeds are born, don't pull them up, for they were planted by the old ones). Emilton Carneiro, the 82 year old founder of the community of Esitrão, said that "*as vezes fazemos roça na matona e nasce la, são os antigos que fizeron roça la*" (sometimes we plant a roça in the big mature forest, and the seedlings appear there; it was the old ones that made a roça there). Emilton calls bitter manioc varieties that come from seedlings "*mandioca nativa.*" (native bitter manioc). His grandfather, an Indian, taught him this. Miguel Pasos from Boca do Rio, said that "*Capitao são differente das outros, da outro tipo de mandioca que ninguem conhece. Meus avos dizeron que esas mandiocas nasce porque foi os indíos que os plantaron*" (The seedlings are different from the others, they give a different type of bitter manioc that nobody recognises, my grandparents said that these [kinds of] bitter manioc appear because it was the Indians that planted them).

Local understandings of manioc sexual reproduction vary between individuals, families and communities, and appear to be based on personal experiences. The discussion above, and the following narratives show that some *Caboclos*:

a) Believe that seedlings come from manioc varieties that were planted by Indians, or ancestors. Seedlings are therefore indicators of the agency of past generations that anthropogenic landscapes (fallows and ADE) are used for manioc cultivation.

b) Recognise that volunteers come from sexual reproduction, in that they notice that they exhibit traits of two existing varieties.

c) Intentionally let these volunteers grow.

d) Manage them by:

i) breaking their branches so they grow outwards rather than upwards,

ii) loosening the soil around the roots so they grow outwards rather than downwards,

e) When harvesting, some people select certain attractive volunteers, and save then for vegetative propagation when planting a new manioc field.

f) When mature, and if the farmer likes certain attributes, these manioc plants planted from cuttings from volunteers are either:

i) incorporated into an existing variety,

ii) incorporated as a sub-variety of an existing variety (such as Jaboti-Preto), or even a combination of two varieties (such as Jaboti-Arroz), or

iii) established as new variety. Naming new varieties usually takes place when they pass from the person who brought them into cultivation to their neighbours and relatives. Sometimes the variety simply ends up with the name of the person who it spread from, as in the case of Glaí.

"My mother and grandmother called the seedlings 'mai *da roça*,' [mother of the field] When we clear and burn a roça, seedlings appear, before the maniva we plant has appeared. I keep watching the seedlings, they grow straight up (they don't desgalha [branch out]). I look at the colour, the branches and the height of the seedling. I let them all grow to see which will grow the biggest tuber. If the plant is beautiful, if the tuber is really yellow, or very big, I will take a cutting and plant it in the next *roça*..... We plant many varieties because we are always experimenting....My mother did the same....."

Josefa Rodrigues Guimarache, Barreira do Capanã

"I leave some seedlings in the fields. The tuber grows straight down. New types of manioc come from the seedling because they are mixed. I leave them grow and look to see if it yields more, or [the tuber] is white or yellow. I plant and experiment to see if it gives a good tuber. This is why we've got so many varieties of manioc. The seedlings are always different, the leaves change, the bush changes, the tuber changes. If we plant a field of the variety Arroz, various types of manioc grow."

Tivi, Barreira do Capanã

"We call the seedlings *filho de mandioca* [children of manioc] they come from the seeds which appear when the plant matures. We let them grow together with the others (perhaps snapping them in the middle if they grow too high). We pay attention to the tuber, the ones which are the most beautiful; I take the maniva and plant it in the next *roça*."

Nai Cunha da Silva, Esperança

"We take the maniva from the seedlings when they are mature and plant them. One day when we are harvesting bitter manioc, we see a seedling with a beautiful tuber, decide to leave it, then harvest it and plant it in the next field. The seedlings are different, the colour changes, the colour of the guias and the leaves. The tuber changes too."

Dioneseo Pinto and Estivão da Silva, Barro Alto

"It's because one variety marries or *trensar* (has sex) with another. For example, one appeared that has the tuber of Pirarucu Branco, the bush of Pirarucu Branco, but the leaves of Glaí. Pirarucu Branco had sex with Glaí; and the variety that appeared looked like a mixture of both."

Paulo, Barreira do Capanã

"I planted Tartaruga and Roxinha all mixed up, and the seedlings which appear look like a mixture of the two. I have two types of bitter manioc that come from seedlings in my fields. One I called Bonitinha, it seeds really early….."

Sabastião Pinto Batista, Barro Alto

"We plant the manivas that come from seedlings, because they are born with more vigour. I always know the variety of the seedlings that grow… I leave all of the seedlings grow, I learnt this from my grandfather. He said 'look my son, these manivas here are those that are born from the seeds, the seeds fall, stay in the ground and when we burn they are born. They grow with more vigour…"

Junivaldo Dantas, **Vista Alegre**

"We call the seedlings *capitão*, lots of *capitão* appear in *terra preta*. You have to loosen the soil around the roots, if not the tuber will grow straight down. We leave those that we think are most beautiful. Seven days after planting a roça, the *capitão* are born. I go around choosing, those with thick stems, with lots of branches. Usually more than 100 capitão are born in each field. I only leave between 10 and 20. *Capitão* mature first...Its difficult to know which variety they are, the leaves are different, the tuber is different. I named a landrace "*manivão*" that comes from *capitão*, it yields long tubers."

Amilton Guimarache, Boca do Rio

"We call bitter manioc that comes from the seedlings "Mandioca Nativa." We call the sweet manioc that comes from seedlings "Macaxeira Nativa." There are many kinds, but we only *batisar* [to name, or to baptize] them when we give them to other people. "*Camarão*" [Prawn] and "*Castanha*" [Brazil-nut] were both *mandioca nativa* that were named by my parents. We gave them to other people and they spread out…."

Emilton Carneiro, Estirão

"We call the seedlings "*capitão*," [captain] they come from the fruits of the manioc plant. When a *capitão* is really beautiful and gives a yellow tuber we take a cutting to plant in another field. My mother in law taught me how to recognise the different types of bitter manioc. If it looks exactly the same as Roxinha or Jabuti for example, then we call them that. I know Roxinha *legitmima* [legitimate] for example, because the *entrecasca* [the second layer of skin on the stem] of the maniva is purple, and the *entrecasca* of the tuber is also purple. But if they look a little different we call them Roxinha *achada* [found] or Jabuti achada. Sometimes I give these ones other names. One I call, "Jabuti de dedo", because the leaves are like fingers. Another I call "*Roxinha rabo de tatu*," because the tubers look like the tail of an armadillo. If the *capitão* doesn't look like anything I recognise I just call it *maniva achada*"

Luciclea Dias Danta, Vista Alegre

"I plant plant all my varieties mixed together. I let the seedlings grow, and harvest them together with the rest... But when I plant the next year, something strange happens, varieties that I have never seen before appear in the middle of the ones I know.... My father used to say that bitter manioc plants marry each other. The one that is strongest takes control of the other. If you plant Jabuti with Sara, Sara will become Jabuti."

Casimiro Dantas Bittencourt, Vista Alegre

"I plant with the cuttings from seedlings, sometimes they yield a type I know, other times they don't. One seedling that I started to plant with but didn't know, I called Azulona. Because it was big and the leaves were blue. Another seedling which appeared I did know because I had seen it in other people's fields, it was a kind called Jararaca. So that's what I called it when I planted it."

Paulo, Barreira do Capanã

"I know the variety of the majority of seedlings, just looking at the stems, we know. Sometimes a seedling appears which I don't know the name of.... Recently I named one Tucumã, because the stem is yellow......A seedling recently appeared in my field. It was attractive and so when I was harvesting bitter manioc I took cuttings from the mature seedling and planted them. The manioc plants that grew were peculiar in that they had thin, elongated leaves, like fingers. I was at a loss as to which type of manioc it was. But then, when I was in Manicoré I described the appearance of the plant to a woman from Boca do rio. 'Ah,' the woman exclaimed, 'that must be Oirana.' Then I had found the correct name for the bitter manioc variety, and brought it to my new field here to see how it yields on *terra preta*"

Josefa Rodrigues Guimarache, Barreira do Capanã

"A seedling from manioc is born as another variety. It happens because we plant a field of some varieties, harvest and then fallow grows. When we cut down the fallow, new varieties appear as seedlings that we have never seen. We don't give them names straight away. Its only when we give them to someone that we give them a nickname."

Doraci, Barreirã do Capana

Locals recognise hereditary traits, because the traits which are present in the predominant landraces are most likely to be exhibited by seedling volunteers which appear in new fields, a legacy of the sexual reproduction taking place the last time the field was cultivated. For example, at Barro Alto the farmer Sebastião Pinto Batista noticed that the bitter manioc plants which grew from cutting from a seedling that he had planted, which grew in a field which had been planted with Tartaruga, displayed the same fast-maturing, fast seeding traits as Tartaruga does. As seedlings are incorporated over time divergent co-evolutionary processes are emergent, as the genetic material underwriting landraces is transformed and morphed, by the different selective pressure imposed by configurations of landraces, and other cultivation practices: people's behaviour is also affected in this process. The most obvious change is the labour requirements and seasonality when fields are planted and harvested in different month.

Seedlings are not usually assigned to a landrace straight away. Normally people say that they can only tell the variety once the plant approaches maturity. A greater proportion of people believe that the seedlings always yield clones of an existing variety (this was also the finding of Marianne Elias and colleagues (2001), who state that 67% of seedlings were found to be close enough to known landraces to be assigned to them). If it does not closely resemble a type present in their community, they will try to find the name with relatives or friends from other communities. Other people recognise that clones taken from the seedling are always different from existing varieties of bitter manioc. They often seem loath to name them, calling them a ‘kind from seed’, ‘found manioc, or ‘native manioc’. Naming may also occur when the new clone is passed from one farmer to another. Often the original name may be forgotten, and the name of the person who gave the type of manioc is used (for example *Glai* and *Capão*). Once a seedling is clonally propagated, sometimes the clone can be clearly recognised as an existing or known landrace, other times they are completely different. Sub-specific naming are relatively common for the most popular landraces. Jabuti (also known as Jabutzinho) for example has sub-specific names such as Jabuti-Preto at Repartimento, Jabuti-Grande at Barro Alto and Jaboti-Arroz at Capanazinho. At Barro Alto, Tartaruga is subdivided into Tartarug*inha* (little Tartargua) and Tartarug*ona* (big Tartaruga). The former is much more prevalent, because it yields bigger tubers. The latter grows tall, but yields smaller tubers. Many people have the idea that landraces are pre-existent in nature, and when cutting from a seedling is planted, it is up to them to work out which landrace it is. This gives seedlings a certain ambiguity, and this comes through in the narratives above.

3.10 Conclusions

The ethnographic research that this chapter presents shows that:

a) Farmers claim that there are certain advantages to the cultivation of manioc in ADE (e.g. faster maturing, bigger yields).
b) Farmers in different localities categorise the same landraces as either weak (low starch-fast maturing), or strong (high starch-slow maturing).
c) Weak landraces are seen to originate in the floodplain, and are suited to cultivation there and in ADE and young fallow in Oxisols /Ultisols. They are associated with various traits (e.g. fast maturing, lower starch, earlier seeding, spoiling if left too long in the ground).
d) Strong landraces are from the *terra firme*, and suited to cultivation in Oxisols/Ultisols in old fallow. They are associated with various traits (e.g. slow maturing, high starch, durable in the land).
e) Farmers recognise that sweet and bitter landraces cross-pollinate, raising the possibility that some landraces cultivated today are the outcome of this process.
f) Seedlings in different soils will exhibit the predominant traits of landrace assemblages planted in them; their incorporation as cuttings into stock of clones for planting could lead to divergent co-evolutionary dynamics in different kinds of soil.
g) ADE and Manioc Seedlings are interpreted as indicators of the effects of Amerindian agency in shaping anthropogenic landscapes.

This is strongly suggestive of differentially adapted manioc cultivation systems in kinds of soil. In order to test this hypothesis, a novel set of quantitative methods were generated in order to be able to statistically compare manioc cultivation in different kinds of soil. Chapter four examines bitter manioc cultivation in three kinds of soil at the four terra firme localities, Barro Alto, Barreira do Capanã and Boa Vista, The Água Azul Region and Vista Alegre, that were described in this chapter. It examines bitter manioc cultivation in the Floodplain at two localities, the Água Azul Floodplain and the Genipapo Floodplain.

Chapter 4: The Cultivation of Bitter Manioc in four soil types at six localities on the Middle Madeira River

a) Bitter Manioc field in the floodplain at Community Forteleza
b) Bitter Manioc swidden in ADE with plants of 3 different ages owing to continuous replanting, Community Barro Alto
c) Chopping up manioc stems for planting in Ultisols at Barreira do Capanã
d) Opening up the ground with hoes in order to plant bitter manioc in ADE at Barreira do Capanã
e) José Trindade in his Oxisol bitter manioc field, which was planted in old fallow at Barreira do Capanã
f) Weeding a bitter manioc field in Ultisols at Community Terra Preta

This chapter investigates the hypothesis, developed through ethnography presented in the previous chapter, that bitter manioc cultivation systems (varieties, fallow lengths, farmer knowledge, seasonality) will be different in different soils because of local adaptations to the chemical properties and other characteristics (e.g. flood regime) of the environment. On the Middle Madeira River, bitter manioc is cultivated on Oxisols, Ultisols and Amazonian Dark Earths on the *terra firme*. It is also in cultivated in a variety of floodplain zones, a little in on the annual flooding low levees (*vazante*), but most in the high floodplain (*restinga*), and the backswamp (*cacaia*) zones, all three enriched to varying degrees by rich sediment carried down from the Andes. This chapter presents local understandings of different soils and their cultivation drawn from ethnography and quantitative data on various aspects of bitter manioc cultivation in six different localities, four in the terra firme, and two in the floodplain, in order to determine whether there are differences in its cultivation in different kinds of soil. Quantitative categories were generated in the context of ethnography. They quantify:

- The Bitter manioc landraces or varieties present in fields on different soils.
- *Caboclo* perceptions of the performance of the same bitter manioc landraces in different terra firme soils.
- *Caboclo* perceptions of the degrees of strength or weakness of particular landraces.
- Fallow lengths.
- The incorporation of seedling volunteers.

4.1 Shifting and Swidden Cultivation

Shifting and Swidden Cultivation have been major forms of agriculture in lowland South America, humid Africa and parts of Asia for thousands of years, becoming widespread from the beginning of the Neolithic period (Conklin 1961; Eden and Andrade 1987; Kleinman *et al.* 1995; Denevan 2001; Cairns 2007). Today, shifting cultivation is the most widely practiced form of smallholder agriculture found in the humid tropics, practiced by some 300-500 million people on between 300-500 million hectares of land (Giardina 2000; Goldammer 1993). Traditional agriculture is associated with folk-varieties of crops and associated knowledge and genetic diversity, the outcome of generations of situated agricultural practice. (Nabhan 1983; Altieri 1987; Cleveland 1994; Altieri 1995).While shifting/swidden cultivation has been widely studied, insufficient attention has been paid to how local systems are adapted to the affordances of local agro-ecological conditions. Like all forms of traditional agriculture, shifting/swidden cultivation is extremely variable in form; its character in a given locality is shaped by an interplay of factors including the extent of available land, labour and capital, patterns of local settlement, agronomic variables such as kinds of crops (grains, root crops etc.) types of crop assemblages and succession, crop-fallow time ratios, swidden dispersal, soil management, climate, and soil conditions, amongst others (Conklin 1961).

There are thousands of varieties of *Manihot esculenta*, each with unique characteristics. They differ in the colour, form and size of leaves and stem; and the size, number, colour and cyanide content of roots, and the rate of growth. This phenotypic variability is determined by genetic differences amongst distinct varieties or landraces. Landraces are the result of generations of farmer selection in a local environment, and are therefore often considered to be adapted to local growing conditions as a result (Carneiro 1983; Boster 1984; Chernela 1987; Salick *et al.* 1997; Elias *et al.* 2000; Desmoulière 2001; Emperaire and Peroni 2007).

4.2 Methods and Data Collection

The quantitative data presented here was gathered during interviews conducted during long-term ethnography that took place between September 2006 and March 2008. During the ethnography, a novel set of quantitative methods were generated. In order to measure the relative presence of different landraces in different soil types, farmers were asked which proportion of their field was occupied by each landrace. Farmers plant bundles (*feixes*) of uncut bitter manioc stems of each landrace, and normally recalled landrace proportions in terms of numbers of feshas and so were asked how many *feixes* of each landrace they had planted in their field. From these figures, proportions of each landrace in a total field of 100% were calculated[21]. In order to account for different field sizes, the landrace area for each field was then multiplied by the size of the field in fractions of a hectare. Fields range from 0.25 ha up to 2 hectares. The sum of the areas for each landrace in each soil type was then divided by the total area of fields in that soil type, to give the landrace area per hectare of that type of soil. Hence,

$$lah = \frac{\sum la \times fsi}{tfa}$$

Where *la* is landrace area, *fsi* is field size and *tfa* is total field area in soil x (the sum of the area of all the fields in a particular soil type).

Local farmers categorise bitter manioc landraces in terms of their being being stronger [*forte*] or weaker [*fraca*] (see Chapter 3). In order to quantify this, farmers were asked to rank the landraces they plant starting with the weakest and ending with the strongest. This data was then quantified by placing their answers along an ordinal scale (from 1, the weakest, up to the strongest).

The ethnography presented in the previous chapter revealed that farmers claimed that certain landraces performed better in particular soils. In order to quantify this a Performance Ranking Index (*pri*) was developed by asking farmers to rank landraces in order of performance for each soil type (*terra firme* only), starting with the best, then second best, third etc. A score was assigned to each ranking by numbering the ranks. The top ranked landrace was equal to 1, the 2nd, 0.9, the 3rd, 0.8, the 4th 0.7 etc. This method was selected because it incorporates the order of ranking, without giving the order of landraces too much weight in the construction of the rank index .The rankings for each landrace in each soil type were summed and then divided by the number of farmers citing the landrace performance in each soil type. The Performance Ranking Index (*pri*) allows us to see whether landraces perceived to perform best in different soils fit with planting behaviour that is measured by the Landrace area per hectare (*lah*). It also allows us to capture the knowledge of people who had fields in one soil type, but had experience in planting in other soils and the knowledge of individuals who have much experience with bitter manioc farming but for some reason (old age being a

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[21]For example, if a farmer said he had planted 2 bundles of Jabuti, 4 of Aruari, 1 of Tartaruga and 1 of Arroz in his field, the landrace Areas would be 0.25 Jabuti, 0.5 Aruari, 0.125 Tartaruga and 0.125 Arroz

primary one) did not have a bitter manioc field planted at the time of research. The ranking shows how well known landraces are, and the soil types that people associate them with the most. People were not asked to rank landraces they were not familiar with; including those they were currently planting but did not have prior experience with. The *pri* was not applied in the floodplain, because most floodplain bitter manioc farmers only plant in the floodplain, and therefore only have experience of planting their landraces in one type of soil.

The lah and pri for different soils were then compared using Analysis of Variance (ANOVA) (Iversen and Norpoth 1987; Field 2005). ANOVA is a group of statistical models and procedures, which are used to determine whether the observed variance in different groups renders them "significantly different" from one another or not. ANOVA gives a statistical test of whether the means of several groups are different or not. In order to determine whether two groups are significantly different, we examine the F and p (probability) outputs. The p-value is the probability of obtaining a test statistic by chance: the lower the p-value, the less likely: so the more "significant" the result. Usually, p values need to be <0.5 for a result to be considered significant. F values are measurement of distance between individual distributions. As F goes up, p goes down (i.e., more confidence in there being a difference between two means). Therefore highly significant differences between groups are indicated by a combination of very low p scores with very high F scores. One-way ANOVA is used in this chapter to test for differences among the *pri* and *lah* for different landraces in different soils.

The incorporation of seedlings was measured by asking farmers if they a) *intentionally* incorporated seedlings; that is took cuttings from seedlings and planted them apart to see how they did, b) *unintentionally* incorporated seedlings; where they do plant cuttings of seedlings volunteers, but mixed up with the others, or c) *removed* them, cutting the volunteers out as weeds when they appeared in the field. These categories, based on ethnography, are more elaborated in the previous chapter (section 3.9.2). The following additional data were collected for each field, its size, the month that it was planted, and the age of the fallow that it had been cleared from. In the floodplain, the zone in which the field was located was recorded (either *vazante*, *cacaia* or *restinga*).

Data was collected in six locations, four in the *terra firme*, and two in the floodplain. The *terra firme* locations were selected from an overall number of twenty or so communities visited in the initial period of research. The four localities 1) Barro Alto, 2) Barreira do Capanã and Boa Vista, 3) Monte Sião, Monte Orebe and Água Azul were selected because they had the most manioc being planted in ADE, and therefore provided the best locations in which to compare cultivation in different kinds of soil. At these locations all farmers with manioc fields in ADE were interviewed, along with equivalent numbers of other farmers planting manioc in Oxisols and Ultisols, including those who had fields in more than one kind of soil. At the floodplain communities, all farmers who had fields at the time of the research were interviewed. This provided the raw data for the Landrace area per hectare Index. During these interviews, farmers were also asked about the age of fallow, field size, incorporation of seedlings and yields. Data for the landrace strength index was gathered during the same interviews. Data for the perception ranking index was gathered during interviews with *terra firme* farmers, but also was gathered among retired farmers who no longer had fields, and people who for some reason did not have fields at the time of research.

Ideally, floodplain farmers resident in the same communities as *terra firme* farmers would have been selected for comparison. This was not possible, because (at least in all the 24 communities visited) most farmers resident in communities located on upland bluffs invariably plant manioc on *terra firme*, preferring to plant other crops in the floodplain if they have access to it. The sample of floodplain farmers were then selected from two localities, each spanning several communities. The first, known as the Água Azul Floodplain is formed from members of the floodplain of communities of Paú Quemado (6 individuals) and Fortaleza (11 individuals), directly in front of Barreira do Capanã and Boa Vista, and members of the terra firme Água Azul Coast Communities (7 individuals) who plant in the floodplain. The second locality is formed from members of three neighbouring communities (Verdum, Amparo and Delicia) located on the high floodplain below Manicoré which lies between lake Genipapo and the Madeira, opposite the mouth of the River Atininga. These communities were selected also because they are among the longest established and most well populated floodplain areas of the municipality of Manicoré and are the site of the extensive floodplain homegardens which facilitated other areas of the study. The same methodology as *terra firme* was employed, minus the perception of performance index, as it is only of use when comparing the performance of the same landraces in different types of soil. Table 6 shows the number of informants for each index in each locality analysed in the following section.

Table 6 Bitter Manioc Dataset. Communities, Number of informants (n) that contributed to strength index, fields and performance ranking index. Total Field Areas by soil type (area) in hectares, and mean field size in soil type (mean) in hectares.

Community		**Fields**												**PRI**		
	Str	**Ultisols**			**Oxisols**			**ADE**			**Floodplain**			**UL**	**OX**	**ADE**
	n	*Area*	*Mean*	*n*	*Area*	*Mean*	*n*	*Area*	*Mean*	*n*	*Area*	*Mean*	*n*	*n*	*n*	*n*
Barro Alto	35	18	0.71	25	38	1.2	33	21	0.58	36				14	23	24
Barreira	24	11	0.92	12	10	0.9	11	9.7	0.57	17				7	14	14
Agua Azul	9	6.5	0.81	8	7.25	0.9	8	6.3	0.78	8				7	11	7
Vista Alegre	19	9.3	0.93	10	10.5	0.9	12	6.3	0.63	10				11	17	11
AA Floodplain	22										13	0.5	24			
Genipapo	30										24.3	0.7	35			
Total	139	45	0.81	55	65.75	1	64	43	0.6	71	37.3	0.6	59	25	42	32

Data from each of the six localities are analysed in turn in the two following sections, firstly four in the terra firme, secondly, two in the floodplain. Each section is preceeded by a brief discussion of local understandings of soils.

4.3 Bitter Manioc cultivation on *terra firme*

Residents of the Middle Madeira classify soils according to their colour and texture, the stage of successional vegetation that covers them, and their known history of use. Soils of the *terra firme* are divided into two encompassing substances, *barro* (clay) equivalent to Oxisols and *areia* (sand), equivalent to Ultisols. Clayey soils are easily recognised, and called *barro amarelo*, *barro vermelho*, or *barro branco/tabatinga* depending on yellow, red or grey colouring. The residents also recognize that soils may be a mixture of these types, such as *areia misturado com barro*.

Terra Preta is also unmistakable owing to its very dark colouring, ceramics, different successional processes and the distinct suite of volunteers associated with it. Texturally they are designated as either *solto* (loose) or *duro* (hard), or somewhere in between. Some volunteers, such as the caiaué oil palm (*Elaeis oleifera*) or a weed locally known as Maria preta or Rabo de gato (*Acalypha brasiliensis*, Euphorbiaceae) are so ubiquitous on *terra preta* that they could be designated signature species rather than merely indicators. Certainly, local people strongly associate them with *terra preta*.

Terra mulata and sandy Ultisols are more ambiguous however. In terms of soil colour and texture, they are easily confused, not only by over enthusiastic researchers, but also by locals. This ambiguity is reflected in the diversity of terms that were recorded as referring to them: *terra preta*, *terra preta misturado com areia*, *areia misturado com barro*, *areia preta* and *areião* (black earth, black earth mixed with sand, sand mixed with clay, black sand, and big sand). Ultisols are sometimes confused with ADE because of their dark colouring. *Terra mulata* are less often confused with Ultisols because of their obvious higher fertility. They yield maize and also exhibit some of the same kinds of weeds as *terra preta*. Thus it is through differences in fertility and successional processes that *terra mulata* can be differentiated from Ultisols.

4.3.1 Case One: Barro Alto

Barro Alto is the largest rural community in the municipality of Manicoré and produces the most manioc flour of all the communities in the region. Farmers plant manioc on three soil types: in ADE, located closest to the community, Ultisols, behind the ADE, and Oxisols, further behind, where mature forest is located. The large and growing population has had the effect of reducing fallow periods on the ADE and Ultisols closest behind the village.

The quantitative data show that practice of bitter manioc cultivation on ADE is characterized the dominance of a floodplain landrace Tartaruga, Table 7. Bitter manioc is cultivated under more intensive, shorter cropping cycles on the ADE at Barro Alto than when cultivated on non-ADE soils, Table 9 , Figure 6. Farmers explain that Tartaruga is the most prevalent landrace on ADE because it both yields well on ADE, and is suited to weak land (young fallows, not infertile *per se*). Farmers consider Tartaruga to be the most weak landrace (Table 7) with most people beginning to harvest only six months after planting. Furthermore, they claim that manioc matures quicker on ADE.

On Oxisols, most fields were cut from older successional vegetation and mature forest or in young fallow from mature forest that had only been cultivated once previously (Figure 6, Table 9). The most prevalent landraces are Roxinha-RM and Arroz. These landraces are harvested later and are slower maturing than Tartargua. The strength index shows that farmers consider Roxinha-RM to be an intermediate landrace in terms of strength, and Arroz to be a strong landrace (Table 7). The older fallows and slower maturing landraces make for a less intensive cultivation system. Ultisol cultivation seems to be somewhere in-between ADE and Oxisols. This is true both in the mix of landraces , Roxinha and Tartaruga (Table 7, Table 8) and the length of fallowing, which is shorter than Oxisols, but longer than ADE (Figure 6, Table 9).

The Analysis of Variance of the means of the three most popular landraces in each soil type, presented in Table 8, shows that there is a significant difference between the areas of Tartaruga in each soil type. Roxinha-RM areas are significantly different in Dark Earths from the other types of soil, but Oxisols and Ultisols did not show a significant difference. Arroz areas were significantly different in Oxisols when compared to the other two types of soil, but it did not exhibit a significantly different Area in ADE when compared to Ultisols.

The performance ranking index, shown in Table 7, confirms that people's perceptions of performance vis-à-vis soil type are reflected in their planting decisions, with an interesting exception. Note how Arroz is said to be the best yielding landrace in Oxisols, but Roxinha-RM is the most frequently planted. This is probably because Roxinha-RM produces very yellow manioc flour, and given that the sale of manioc flour is of fundamental importance in livelihoods this probably explains the fact that it is the most predominant landrace in this kind of soil.

Table 7 Landrace strength (STR; based on 35 informants), Landrace area per hectare and Performance Ranking Index for 12 local varieties of manioc in 25 Ultisol (UL), 33 Oxisol (OX) and 36 ADE fields at the Barro Alto community on the Manicoré River, in the Municipality of Manicoré, Amazonas State, Brazil. The n column shows the number of informants that contributed to the index for each landrace. Roxinha-RM refers to the Roxinha landrace found on the River Manicoré, to differentiate it from other landraces with the same name found in communities on the North Bank of the Madeira River. Bonitinha-BA is the Bonitinha landrace planted at Barro Alto, while Bonitinha-Sb is a different landrace taken from a seedling by one farmer. Sara(nzal) refers to one landrace sometimes called Saranzal, and sometimes Sara.

			Landrace Area per Hectare									**Performance Ranking Index**					
Landraces	*STR*	*n*	*UL*	*n*	*OX*	*n*	*ADE*	*n*	***Total***	***n***	*UL*	*n*	*OX*	*n*	*ADE*	*n*
Roxinha-RM	3.00	23	0.563	20	0.417	33	0.29	15	1.27	68	0.81	13	0.80	21	0.50	14
Tartaruga	1.24	26	0.292	21	0.067	15	0.656	35	1.02	71	0.73	12	0.37	12	0.98	24
Arroz	4.30	24	0.062	7	0.209	25	0.024	4	0.30	36	0.30	5	0.88	22	0.04	1
Aruari	2.83	13	0.024	4	0.143	17	0.023	2	0.19	23	0.35	6	0.47	14	0.12	4
Jiju	1.77	14	0.042	5	0.08	11	0.003	2	0.13	18	0.38	6	0.22	7	0.19	6
Jabuti	4.70	11	0.002	1	0.054	6	0	1	0.06	8	0.06	1	0.37	11	0.04	1
Pirarucu Amerelo	2.00	2	0.008	1	0.011	2	0	0	0.02	3	0.06	1	0.00	0	0.05	2
Manaus	3.00	2	0.004	2	0	0	0.007	3	0.01	5	0.00	0	0.00	0	0.02	1
Sara(nzal)	3.00	2	0	0	0.007	1	0	0	0.01	1	0.07	1	0.10	4	0.10	4
Jab Grande	4.00	2	0	0	0.005	1	0	0	0.01	1	0.01	0	0.04	1	0.00	0
Bonitinha-BA	--	0	0	0	0	0	0.003	2	0.00	2	0.01	4	0.00	0	0.00	0
Bonitinha de Saba	1.00	2	0	0	0	0	0.001	1	0.00	1	0.00	2	0.00	0	0.00	0

Table 8 Analysis of variance for the mean landrace area of Tartargua, Roxinha-RM and Arroz for 25 Ultisol, 33 Oxisol and 36 ADE fields at the Barro Alto community on the Manicoré River, in the Municipality of Manicoré, Amazonas State, Brazil

	Tartaruga		**Roxinha-RM**		**Arroz**	
	F	*P*	*F*	*P*	*F*	*P*
Oxisol-Ultisol	11.826	0.001	0.00169	0.967	6.445	0.014
Oxisol-ADE	31.991	<0.001	6.152	0.016	14.372	<0.001
Ultisol-ADE	6.238	0.015	7.32	0.009	1.5	0.226

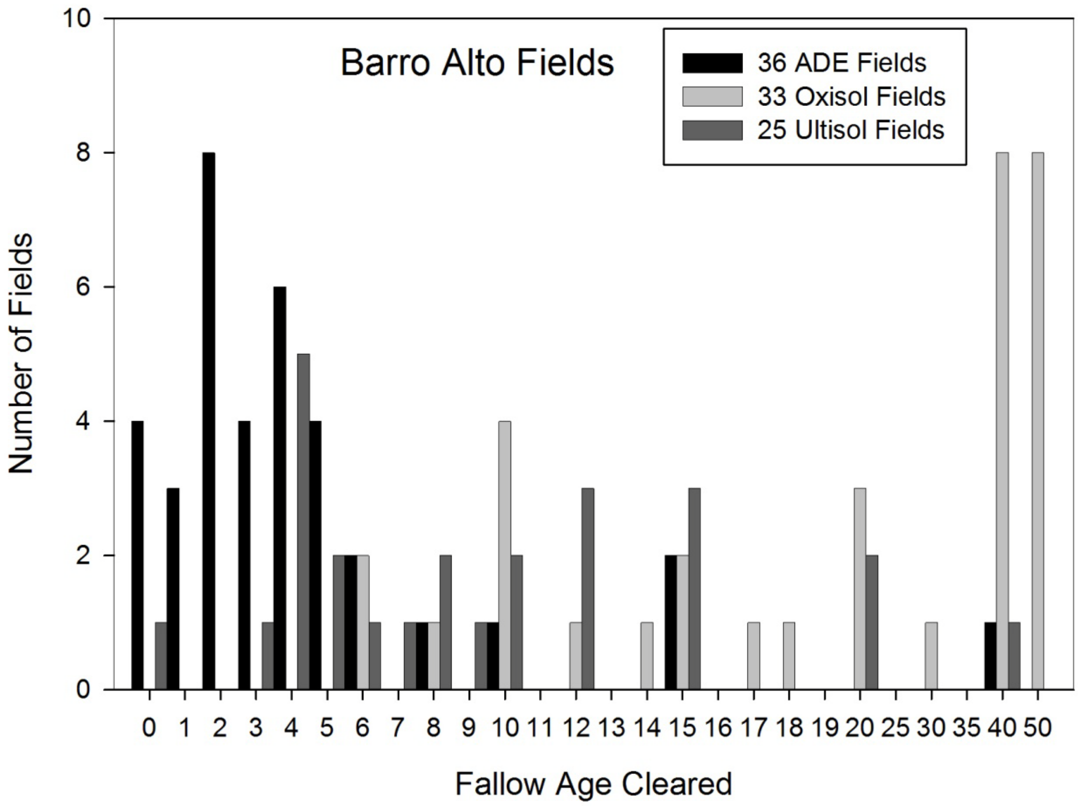

Figure 6 Fallow ages for 94 fields on 3 soil types at the Barro Alto community on the Manicoré River, in the Municipality of Manicoré, Amazonas State, Brazil. MF means a field cleared from mature forest, and MF 2nd means the second time a field cleared from mature forest is cultivated.

Figure 6 shows that the cultivation of ADE at Barro Alto is characterised by an *intensive* short fallow swidden system with most fields cleared from 0-6 year old fallow. Ultisol cultivation is also reasonably intensive, with most fields cleared from fallow of 4-15 years. Oxisol cultivation is the most extensive, characterised by longer fallows, with fields cleared from fallow aged 10 years right up to mature forest. Table 9 shows us there is a significant difference in mean fallow lengths in the different soils between the different soils. It shows that ADE is cultivated most intensively, with a mean fallow period of less than five years, significantly less than both Ultisols and Oxisols.

Table 9 Descriptive statistics and Analysis of variance for the Mean Fallow Age for 25 Ultisol, 33 Oxisol and 36 ADE fields at the Barro Alto community on the Manicoré River, in the Municipality of Manicoré,Amazonas State, Brazil. For these calculations, the categories mature forest (MF) and Young Fallow from recently cleared mature forest (MF 2nd) were arbitrarily assigned the ages 50 and 40 years respectively.

Soil	Mean	StdDev	Std. Error	Median	ANOVA	F	P
Ultisol	10.08	8.165	1.633	8	*Oxisol-Ultisol*	27.628	<0.001
Oxisol	29.121	16.633	2.896	30	*Oxisol-ADE*	64.267	<0.001
ADE	4.875	6.967	1.161	3	*Ultisol-ADE*	7.15	0.001

4.3.2 Barreira do Capanã and Boa Vista

Bitter Manioc cultivation at Barreira do Capanã and Boa Vista shows both similarities and differences with those of Barro Alto. The similarities are that landraces considered weaker, with their origins in the floodplain, Pirarucu Branco, Tartaruga, Glaí, are more predominant on ADE, and landraces considered strong, Jabuti, Arroz, Roxinha-BC are more predominant on Oxisols and Ultisols, see Table 10. The Perfomance Ranking Index shows a strong preference for Pirarucu Branco in ADE, and an equally strong preference for Jabuti and Arroz in Oxisols. The most popular landrace in ADE, Pirarucu Branco, is intermediate on the strength continuum (strength = 3.06), Table 10. In the floodplain community of Fortaleza directly in front of Barreira it is considered one of the strong floodplain varieties. The greater presence of strong landraces on ADE at Barreira (e.g Arroz) is probably an outcome of a greater perceived "strength" of the ADE which has not been as heavily cultivated as at Barro Alto and Vista Alegre (Figure 7, Table 12).

At Barreira do Capanã, ADE was not considered "weak land" as it is at Barro Alto and Vista Alegre. This is because it has been cultivated much less intensively owing to lower population pressure. Consequently, fallow lengths are much more similar across the three soil types, with the exception of a few more intensively cultivated ADE fields, Table 12. This could be the reason why there is a considerable amount of the strong landrace Arroz being planted in the ADE at Barreira, and also more Jabuti, two landraces which are virtually absent from ADE at the other communities, Table 10.

The analysis of variance of the landrace area per hectares in different soil types shows that there are differences between them, but there is not such a high level of significance as at Barro Alto, Table 11. Pirarucu Branco is present with almost significantly greater densities in ADE when compared to Ultisols (p = 0.068). The most significant differences are with Jabuti. This confirms that what people say with regard to this landrace not yielding well in ADE effects their planting decisions; there is a significantly greater amount of Jabuti planted in both Oxisols and Ultisols when compared to ADE, Table 11.

Table 10 Strength, Performance Ranking Index, and Landrace area per hectares for 12 Ultisol, 11 Oxisol and 16 ADE fields in the communities of Barreira do Capanã and Boa Vista on the Middle Madeira River, in the Municipality of Manicoré, Amazonas State, Brazil.

			Landrace Area per Hectare								**Performance Ranking Index**					
Landraces	*STR*	*n*	*UL*	*n*	*OX*	*n*	*ADE*	*n*	***Total***	***n***	*UL*	*n*	*OX*	*n*	*ADE*	*n*
Jabuti	5.67	19	0.303	8	0.346	9	0.088	7	0.737	24	0.37	3	0.96	7	0.16	3
Pirarucu Branco	3.06	18	0.042	4	0.088	8	0.277	10	0.407	22	0.40	3	0.32	2	0.97	14
Arroz	5.36	12	0.014	2	0.198	8	0.128	9	0.34	19	0.23	2	0.71	7	0.29	5
Tartaruga	1.60	11	0.1	1	0.048	4	0.18	9	0.328	14	0.00	0	0.21	2	0.32	5
Roxinha-BC	4.88	9	0.259	8	0.041	4	0.012	2	0.312	14	0.41	3	0.31	4	0.32	6
Aruari	3.00	12	0.2	8	0.08	5	0.031	4	0.311	17	0.23	2	0.49	5	0.37	7
Amarelinha	2.00	3	0.107	6	0.005	1	0	0	0.112	7	0.10	1	0.00	0	0.05	1
Glai	2.50	7	0	0	0.032	2	0.054	5	0.086	7	0.00	0	0.10	1	0.29	5
Piraiba	1.80	6	0	0	0.032	3	0.052	3	0.084	6	0.00	0	0.04	0	0.18	3
Pirarucu Amerelo	2.00	2	0	0	0.001	1	0.062	2	0.063	3	0.00	0	0.00	0	0.10	2
Guia Roxa	3.60	6	0	0	0.005	1	0.053	2	0.058	3	0.00	0	0.00	0	0.21	3
Roxona-BC	3.67	4	0	0	0	0	0.028	4	0.028	4	0.00	0	0.00	0		
Roxinha Branca	3.00	2	0	0	0	0	0.026	1	0.026	1	0.00	0	0.00	0	0.00	0
Sara(nzal)	9.00	2	0	0	0	0	0.012	2	0.012	2	0.00	0	0.02	0	0.00	0
Pashubao	--	0	0	0	0	0	0.012	1	0.012	1	0.00	0	0.00	0	0.00	0
Oirana	--	0	0	0	0	0	0.012	1	0.012	1	0.00	0	0.00	0	0.00	0
Azolao	8.00	2	0	0	0.002	1	0	0	0.002	1	0.00	0	0.11	1	0.00	0
Bonitinha	3.00	4	0	0	0.001	1	0	1	0.001	2	0.00	0	0.10	0	0.05	1

Table 11 Analysis of Variance for the mean landrace area per hectare of the most predominant landraces in 12 Ultisol, 11 Oxisol and 16 ADE fields at the communities of Barreira do Capanã and Boa Vista on the Middle Madeira River, in the Municipality of Manicoré, Amazonas State, Brazil.

	Pirarucu Branco		**Arroz**		**Jaboti**	
	F	*P*	*F*	*P*	*F*	*p*
Oxisol-Ultisol	2.077	0.164	9.817	0.005	0.316	0.58
Oxisol-ADE	1.045	0.346	4.49	0.044	17.301	<0.001
Ultisol-ADE	3.615	0.068	3.391	0.077	8.309	0.008

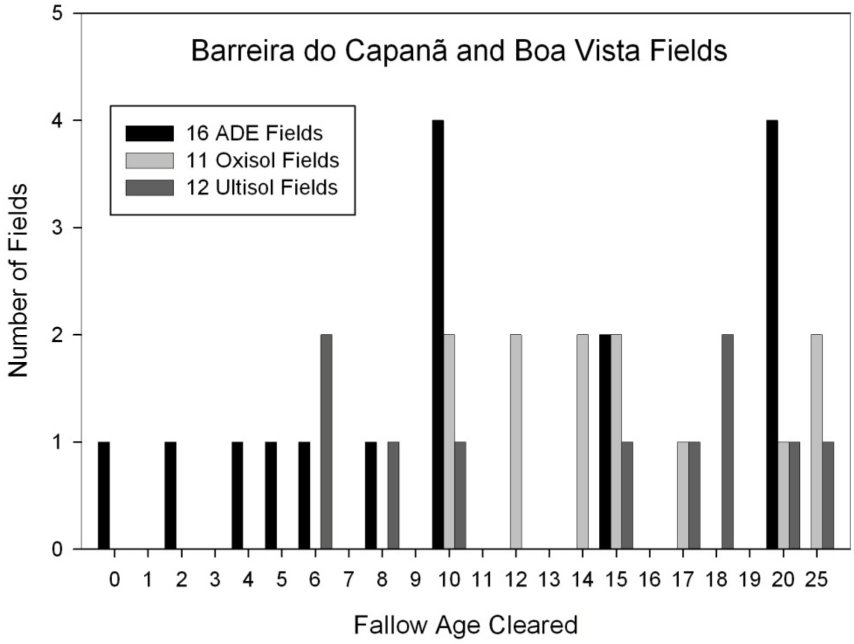

Figure 7 Fallow ages for 39 Fields on 3 soil types at the communities of Barreira do Capanã and Boa Vista on the Middle Madeira River, in the Municipality of Manicoré, Amazonas State, Brazil.

Figure 7 shows that cultivation is less intensive than at Barro Alto, but it all takes place in fallow, there were no fields being cut in mature forest. There is a tendency for fields to be cleared from younger fallow in ADE, but much less pronounced than that observed at Barro Alto. Table 12 shows that there is a significant difference between mean fallow ages in ADE and Ultisols, but no significant difference when Ultisols were compared to Oxisols, nor when ADE were compared to Oxisols.

Table 12 Descriptive statistics and Analysis of variance of the mean fallow age in each soil type for 12 Ultisol, 11 Oxisol and 16 ADE fields in the communities of Barreira do Capanã and Boa Vista on the Middle Madeira River, in the Municipality of Manicoré, Amazonas State, Brazil.

Soil	Mean	StdDev	Std. Error	Median	ANOVA	F	P
Ultisol	18.25	8.379	2.419	15	*Oxisol-Ultisol*	0.0259	0.874
Oxisol	17.545	12.396	3.738	17	*Oxisol-ADE*	2.848	0.104
ADE	11.438	6.314	1.578	10	*Ultisol-ADE*	6.039	0.021

4.3.3 The Água Azul Region

The main ADE site at the Community Água Azul has been very intensively cultivated under a short fallow-swidden system by one extended family (cluster) for the past thirty years. Lacking sufficient land for long fallowing, the family have developed an intensive system reminiscent of that at Barro Alto, with another floodplain landrace (Pirarucu Amarelo) as its focus, Table 13, and very short fallows (2-3 years, Table 15, Figure 8). They have been intensively farming the site for more than thirty years. The Ultisol and Oxisol fields, while located in older fallow than ADE, are still located in relatively young succession (10-20 year) owing to population pressure. The primary forest directly inland is now distant and land-tenure restricts access to other areas of easier access.

The ADE site at Monte Sião (actually much closer to Monte Orebe) is a large site that was abandoned over a land dispute but has recently been re-occupied by two families. They were found to be planting Pirarucu Branco and Tartaruga in their ADE, which was interesting as the same landraces are being selected at different ADE sites, suggesting that if a landrace works well in one ADE site, it may well do so in others. There are two other smaller patches of ADE, one on the bluff overlooking Igarapé Água Azul and another behind the village at Monte Orebe. Both had bitter manioc swiddens on them at the time of research. The swiddens at the main Água Azul ADE site and some of those at Monte Sião were located in young fallow, whereas those on the other ADE were located in older fallow.

In the Água Azul region we see a broadly similar pattern to Barro Alto and Barreira / Boa Vista. There is a significantly greater presence of the most popular strong landraces Jabuti and Arroz in Oxisols and Ultisols when compared to ADE. Pirarucu Amarelo is the most popular in ADE, but also planted in the other soils. Pirarucu Branco and Tartaruga have recently arrived and are becoming popular on the ADE sites at Monte Sião and Monte Orebe. This demonstrates how farmers quickly adopt new landraces that they believe yield well on ADE. The strength index shows that people consider Pirarucu Amarelo, Tartargua and Pirarucu Branco to be weak landraces, and Jaboti and Arroz to be strong, Table 13, as people in other communities do. The performance ranking index shows that people believe that Pirarucu Amarelo yields best in ADE, Jabuti yields best in Oxisols, and Arroz yields best in Ultisols. This broadly mirrors planting behaviour indexed by the landrace area per hectare. The ANOVA does not show a significant difference between Pirarucu Amarelo in Oxisols and Ultisols and ADE because it is popular in all three types of soil, is thought to perform well in all and not least because it yields very yellow manioc flour, Table 14. The most popular landraces are the strong Jabuti and Arroz, and the ANOVA shows they are significantly more present in Oxisols and Ultisols than ADE, Table 13.

Table 13 Strength, Perception Ranking Index, and Landrace area per hectares for 8 Ultisol, 8 Oxisol and 8 ADE fields in the Água Azul Region of the Middle Madeira River, in the Municipality of Manicoré, Amazonas State, Brazil.

			Landrace Area per Hectare								**Performance Ranking Index**					
Landraces	*STR*	*n*	*UL*	*n*	*OX*	*n*	*ADE*	*n*	***Total***	***n***	*UL*	*n*	*OX*	*n*	*ADE*	*n*
Jabuti	4.13	8	0.231	4	0.513	8	0.06	3	0.804	15	0.54	4	0.89	10	0.24	3
Arroz	3.00	9	0.421	8	0.173	5	0.118	6	0.712	19	0.81	6	0.67	8	0.44	4
Tartaruga	1.25	4	0.054	3	0	0	0.365	5	0.419	8	0.26	2	0.00	0	0.39	3
Pirarucu Amerelo	1.14	7	0.135	3	0.077	4	0.174	4	0.386	11	0.40	3	0.20	3	0.69	5
Aruari	3.00	3	0.094	5	0.113	4	0.061	2	0.268	11	0.31	3	0.36	5	0.21	2
Pirarucu Branco	2.00	2	0	2	0	0	0.157	3	0.157	5	0.23	2	0.00	0	0.56	4
Roxinha-BC	--	0	0	1	0.067	2	0	0	0.067	3			0.25	3	0.00	0
Sara(nzal)	3.50	2	0.008	1	0	0	0	3	0.008	4			0.00	0	0.31	3

Table 14 Analysis of variance comparing the means of the most predominant manioc landraces in 8 Ultisol, 8 Oxisol and 8 ADE fields in the Água Azul Region of the Middle Madeira River, in the Municipality of Manicoré, Amazonas State, Brazil.

	Arroz		**Jabuti**		**Pirarucu Amarelo**	
	F	*P*	*F*	*P*	*F*	*P*
Oxisol-Ultisol	7.772	0.015	3.693	0.075	0.423	0.526
Oxisol-ADE	0.386	0.544	11.697	0.004	1.047	0.318
Ultisol-ADE	16.474	0.001	2.967	0.107	0.0869	0.772

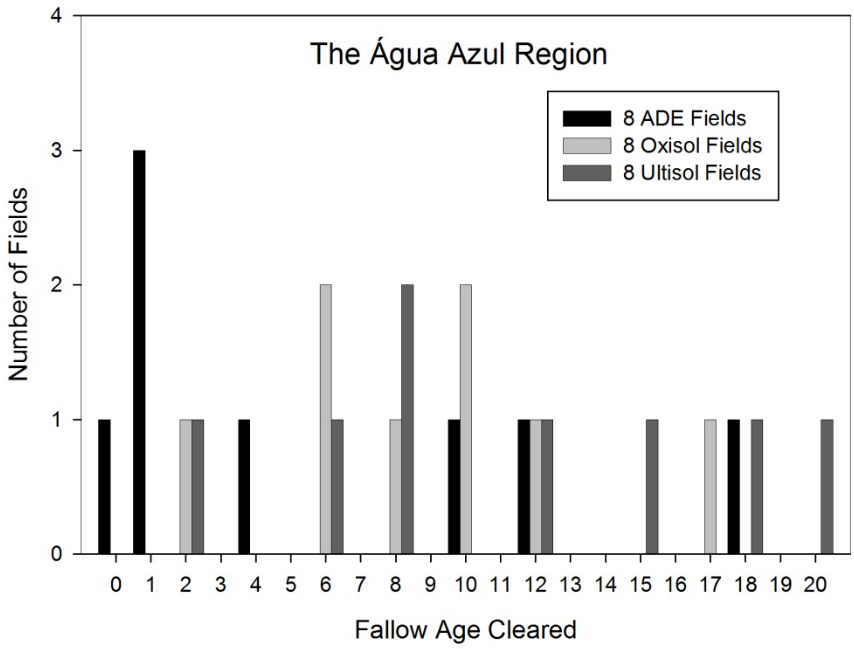

Figure 8 Fallow ages for 24 fields on 3 soil types in the Água Azul Region of the Middle Madeira River, in the Municipality of Manicoré, Amazonas State, Brazil.

Table 15 and Figure 8 show that while more ADE fields are located in young fallow, this tendency is not pronounced enough to mean that there is a significant difference between the ages of fallow in which fields are located in different kinds of soil.

Table 15 Descriptive statistics and Analysis of variance for the mean fallow age in each soil type in the Água Azul Region of the Middle Madeira River, in the Municipality of Manicoré, Amazonas State, Brazil.

Soil	Mean	StdDev	Std. Error	Median	ANOVA	F	P
Ultisols	11.125	6.221	2.199	10	*Oxisol-Ultisol*	0.331	0.574
Oxisols	9.5	5.014	1.773	9	*Oxisol-ADE*	1.511	0.239
ADE	5.875	6.664	2.356	2.5	*Ultisol-ADE*	2.653	0.126

4.3.4 Vista Alegre

At Vista Alegre the most predominant landrace in ADE is Roxinha Branca while the most predominant in Oxisols and Ultisols is Jabuti, Table 16. The performance ranking index shows that people perceive that Roxinha branca performs better in ADE, and Jabuti in Oxisols and Ultisols. This implies that these perceptions influence planting behaviour. The strength index shows that people consider Jabuti to be a strong landrace, and Roxinha Branca to be a weak landrace.The Analysis of variance show that Jabuti has a significantly greater presence in Oxisols and Ultisols, when compared to ADE, Table 17. At Vista Alegre, like Barro Alto, farmers associate weak manioc not just with ADE, but as being the manioc best suited to planting in weak land that which has a young fallow on it. This reflects the perception that weak manioc is more suitable for planting in intensive systems (short cropping, short fallowing).

Interestingly, people do not plant in weak successional vegetation on Oxisols and Ultisols. Figure 9 and Table 18 show that people are not planting in “weak” fallows in soils other than ADE. Most manioc fields in Oxisols and Ultisols are cut from fallows over ten years of age. In one example, an unfortunate farmer planted in weak fallow on Ultisols behind the community at Vista Alegre. The family harvested only 12 sacks of manioc flour from half a hectare. The combination of more weak manioc and shorter fallows in ADE means that like Barro Alto there are more intensive systems in these soils. More strong manioc and longer fallows in Oxisols and Ultisols mean that the bitter manioc cultivation is more extensive in these types of soil, Figure 9 and Table 18.

Table 16 Strength, Performance Ranking Index, and Landrace area per hectares for 10 Ultisol, 12 Oxisol and 10 ADE fields at the Vista Alegre Community on the Middle Madeira River, in the Municipality of Manicoré, Amazonas State, Brazil.

			Landrace Area per Hectare								Performance Ranking Index					
Landraces	*STR*	*n*	*UL*	*n*	*OX*	*n*	*ADE*	*n*	***Total***	***n***	*UL*	*n*	*OX*	*n*	*ADE*	*n*
Jabuti	5.36	12	0.727	10	0.543	11	0.104	4	1.374	25	0.77	9	0.92	16	0.00	0
Roxinha Branca	1.50	13	0.028	5	0.071	5	0.228	6	0.327	16	0.58	7	0.15	3	0.87	10
Arroz	5.00	6	0.015	2	0.145	5	0.064	3	0.224	10	0.25	3	0.38	7	0.15	2
Roxinha-RM	3.86	8	0.084	7	0.014	2	0.052	3	0.15	12	0.45	6	0.09	2	0.24	3
Sara(nzal)	5.00	4	0.011	2	0.095	5	0.034	3	0.14	10	0.00	0	0.19	4	0.13	2
Tartaruga	2.09	12	0.031	4	0	0	0.098	4	0.129	8	0.21	3	0.03	1	0.39	5
Glai	1.71	8	0.027	3	0.029	2	0.058	3	0.114	8	0.38	5	0.04	1	0.29	4
Roxona-VA	3.50	3	0.046	2	0	0	0.064	3	0.11	5	0.00	0	0.00	0	0.00	0
Amarelinha-VA	3.00	3	0.008	2	0.093	4	0.003	2	0.104	8	0.00	0	0.00	0	0.00	0
Pirarucu Amerelo	2.00	4	0.006	2	0	0	0.083	4	0.089	6	0.00	0	0.00	0	0.16	2
Caraulho	--	0	0	0	0.019	1	0.04	1	0.059	2	0.00	0	0.00	0	0.00	0
Aruari	3.00	2	0.015	3	0.019	1	0.003	1	0.037	5	0.17	2	0.09	2	0.00	0
Roxona-BC	--	0	0.032	1	0	0	0	0	0.032	1	0.00	0	0.05	1	0.08	1
Jab Grande	--	0	0.008	1	0	0	0.012	1	0.02	2	0.00	0	0.11	2	0.00	0
Amerelona	2.00	2	0	0	0	0	0.02	1	0.02	1	0.00	0	0.00	0	0.00	0
Pirarucu Branco	3.00	2	0	0	0	0	0.016	1	0.016	1	0.00	0	0.04	1	0.15	2
Julio da Varzea	--	0	0	0	0	0	0.016	1	0.016	1	0.00	0	0.00	0	0.00	0
Expomani	--	0	0.011	1	0	0	0	0	0.011	1	0.00	0	0.00	0	0.00	0
Azolao	--	0	0	0	0	0	0.01	1	0.01	1	0.00	0	0.00	0	0.00	0
Amarelinha	--	0	0.005	1	0	0	0	0	0.005	1	0.00	0	0.00	0	0.08	1
Nameless	--	0	0.001	1	0	0	0.002	1	0.003	2	0.07	1	0.13	3	0.12	2

Table 17 Analysis of variance for the mean landrace Area for the Roxinha Branca and Jabuti landraces in 10 Ultisol, 12 Oxisol and 10 ADE fields at the Vista Alegre Community on the Middle Madeira River, in the Municipality of Manicoré, Amazonas State, Brazil.

	Roxinha Branca		**Jabuti**	
	F	*P*	*F*	*P*
Oxisol-Ultisol	1.511	0.233	1.456	0.242
Oxisol-ADE	2.095	0.163	22.738	<0.001
Ultisol-ADE	4.732	0.043	14.343	0.001

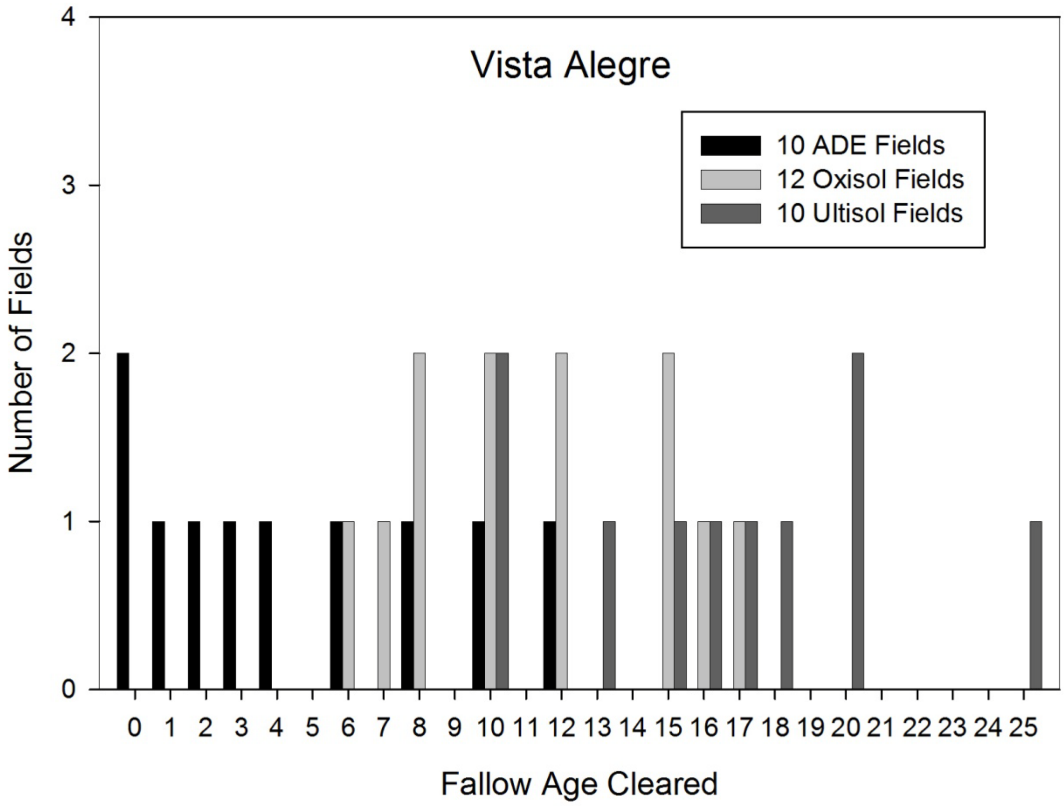

Figure 9 Fallow ages for 32 fields on 3 soil Types at Vista Alegre community on the Middle Madeira River, in the Municipality of Manicoré, Amazonas State, Brazil.

Figure 9 shows that manioc is planted in younger fallow in ADE than in Oxisols and Ultisols, and this difference is significant, Table 18.

Table 18 Descriptive statistics and Analysis of variance for the mean fallow age of 10 Ultisol, 12 Oxisol and 10 ADE fields at the Vista Alegre Community on the Middle Madeira River, in the Municipality of Manicoré, Amazonas State, Brazil.

Soils	**Mean**	**StdDev**	**Std. Error**	**Median**	**ANOVA**	**F**	**P**
Ultisols	16.4	4.695	1.485	16.5	*Oxisol-Ultisol*	7.932	0.011
Oxisols	11.3	3.75	1.082	11	*Oxisol-ADE*	15.599	<0.001
ADE	4.6	4.248	1.343	3.5	*Ultisol-ADE*	34.733	<0.001

4.4 Bitter Manioc cultivation in the Floodplain

In the literature on bitter manioc cultivation in Amazonia, the existence of fast maturing floodplain varieties, as opposed to slow maturing terra firme varieties is well recognised (Smith 1999; Adams *et al.* 2009b). However, bitter manioc cultivation in the floodplain is much less well studied than bitter manioc cultivation in the *terra firme*, and this has allowed the persistence of several misunderstandings. Floodplain manioc has been wrongly characterised as exhibiting reduced genetic diversity and not yielding well. Ohly (1999:88) stated that "Although there are cassava varieties in use with a short growing period, floodplain grown cassava cannot compete in quality and yield with cassava grown on *terra firme* (Gutjahr 1995)". Roosevelt (1980) also claimed that bitter manioc is not suited to floodplain cultivation.

Today bitter manioc is cultivated with great success in the floodplain on the the Solimões and Madeira Rivers by *Caboclo* farmers. It is also cultivated by the Shipbo Indians on the Ucayali floodplain in Peru (Ron Weber Pers. Comm.). A recent Embrapa (The Brazilian Agricultural Research Institute) study[22] found an 80% increase in yield in the floodplain compared to *terra firme* average production of 12.5 tonnes per hectare, using long-cycled (e.g. strong) landraces. Two recent studies in the Mamirauá floodplain reserve in the mouth of the River Japurá found no evidence that there is less genetic diversity of floodplain varieties than those of the *terra firme*, or that their yield is inferior. These studies show the wide distribution of high yielding, floodplain adapted varieties (Schmidt 2003; Pereira 2008).

Bitter manioc is widely cultivated in the floodplain upstream and downstream from Manicoré. The floodplain is not homogenous, but rather contains various different zones within it. Locals recognised three broad categories in the floodplain the *vazante*, *restinga* and *cacaia*. These zones differ in flooding regime and fertility. The *Vazante* is the low levee floodplain of the main channel which floods every year. These soils exhibits the highest natural fertility of all tropical soils, because they receive a flush of nutrients every year from the rich sediments carried down the Madeira from the Andes in the annual flood. Manioc is cultivated in the vazante, but in smaller quantities, as having to harvest it all in a very short time and make *farinha* immediately places great

[22] http://www.cpatu.embrapa.br/noticias/2007/agosto/2a-semana/mandioca-tem-cultivar-precoce-para-varzea Last accessed on 09/06/09

demands on labour. These zones are preferred for the cultivation of watermelon, maize and beans, which mature rapidly and require the most fertile soils.

The high floodplain itself, locally known as the *restinga*, only floods once in ten years or so. Being the highest and least frequently inundated land in the floodplain, it is the location of households, and is also a mosaic of young and old fallow, homegardens and fields[23]. The high floodplain varies considerably in width, from under 100 metres up to 500 or more. Behind the *restinga* is the land backing onto the lake behind the floodplain. This zone is known as the *cacaia* and also yearly flooded, though it becomes a swamp rather than part of a major river, as with the *vazante*. In some lakes such as Lake Genipapo, Atininga and Matupiri the water which inundates this zone is not as fertile as that of the main channel, as much of it comes can come from the blackwater affluents which fill lakes. Whitewater does enter these lakes though, as the main channel rises and spills into them. Inundated soils therefore receive some nutrient replenishment. Other lakes are located directly within the floodplain in the form of oxbow lakes and other remnants of old river courses, such as those in front of Barreira do Capanã, Boa Vista and Monte Sião, and Lake Acara downstream from Manicoré.

Table 19 Location of 59 bitter manioc fields in the floodplain along the Middle Madeira River

Floodplain Zone	Flooding Regime	Fertility	Fields
Vazante	Yearly (main channel)	Highest	7
Restinga	One in ten years	Lowest	9
Cacaia	Yearly (lake)	Lower	43

Bitter manioc cultivation in the floodplain has some advantages when compared cultivation on the *terra firme*. Soil fertility is not a constraint and therefore fallows can be very short, more to control weed invasion that to counter declining soil fertility. This is reflected in the fact that the perception of successional stages in the high floodplain

[23] This land use is broadly similar to that of that of the Shipibo, one of the few surviving Indian floodplain cultures on the Ucayali, a whitewater tributary of the Amazon located in Peru (Denevan 2001:90-97). The Shipbo plant fast-cycled crops in the main floodplain playas (vazante). Their settlements and homegardens are on the high floodplain, with shifting cultivation of maize, manioc and watermelon on the “higher backswamp” which is the equivalent of the *cacaia* (see map in 2001:94).

contrasts strongly with that of the *terra firme*. What locals refer to as an "old" fallow in the high floodplain may be as little as two years of age.

Soil fertility then is not understood as a function of successional processes as it is in the terra firme. Farmers in the floodplain often distinguished between new land and old land New land is land that has recently appeared from the river and refers to both the *vazante* that is revealed with the flood regime each year, and new areas of *restinga* that appear periodically as the river course shifts. This land is said to be the most fertile having recently emerged. Conversely, old land refers to areas of the high floodplain that have not been flooded for a long time and therefore are said to be of lower fertility. While most floodplain soils are said to be clayey, locals note that there are also more restricted patches of sandy soils in the floodplain.

The main challenge with manioc cultivation in the floodplain is the flood regime. While most bitter manioc is planted in the higher floodplain, both the unpredictable flood regime and heavy rainfall still threatens these plantations. With most fields located in the *cacaia*, flooding demands that all bitter manioc is harvested before the fields flood in March and April. This places high demands on labour. Low areas of ground also tend to become waterlogged after heavy rain, and this can cause manioc tubers to rot.

Farmers in the floodplain also used the terms weak and strong to describe the landraces they plant there. This is interesting because the literature tends to assume that all floodplain landraces are necessarily low starch fast yielding. This research found however that there are a number of landraces that are considered to be "strong" or high starch slow yielding. These do not appear to have evolved on the *terra firme*, but are said come from the floodplain itself. When farmers plant bitter manioc in the *vazante*, for obvious reasons they plant more weak landraces. In the *restinga* and *cacaia* they plant a mixture of the two. In the *cacaia*, the lowest areas that flood first are usually planted with more weak landraces. A tendency was therefore observed to plant weak landraces in the lower areas of higher fertility that flooded years, and strong landraces in higher areas that flood less frequently.

In addition to this, farmers recognise traits in floodplain bitter manioc landraces that would appear to uniquely adaptations to this environment. Farmers stated that some landraces are more able to resist water-logging than others. The tubers of certain landraces, it is said, can remain underwater for several days without rotting in times of flooding. Interestingly, some farmers said weak manioc is more able to resist water-logging, because the root itself is more humid. Some farmers at the Community Genipapo when planting in the *vazante* planted the weakest landrace (Sempre Serve) closest to the main channel (which is both the most humid and first place to flood), with a strong landrace (Maria Dias) higher up. They said that they did this for two reasons. The first being that the area closest to the river would flood first and therefore need to be harvested first, hence planting the fast maturing landraces. Secondly, these fast maturing landraces were said to be most able to resist the greater humidity of these soils.

In Verdum, people said that strong manioc is best planted "*em cima da terra*" (at the top of the land), in the restinga and in the higher ground of the cacaia. Weak manioc is better suited to lower areas of the cacaia and in the vazante. It would seem then that in the floodplain *mandioca fraca* and *forte*, rather than being associated with different soil types and capoeira stages, are understood as being best suited to different floodplain zones, and associated differences in flood-regime and soil fertility.

The fact that the lower soils are generally more fertile as they receive a wash of nutrients from floodwater, and that these are the ones where weak manioc are seen to be more suitable, provides an interesting parallel with their association with ADE on the terra firme. Likewise, the association of forte landraces in the floodplain with the less fertile "high ground" provides an interesting parallel with the perceived suitability of forte landraces with soils of lesser fertility in the *terra firme*. A key similarity then between the floodplain and terra firme is the perception that weak and strong landraces are suited to different agro-ecological conditions. The key difference is the flood regime, and the selective pressure in it must exert for fast maturing landraces, and the ability to resist water-logging.

4.4.1 Case Five: Água Azul Floodplain (Água Azul, Pau Quemado, Fortaleza)

The Água Azul Floodplain is an artificial construction of floodplain farmers from three neighbouring localities, the community of Água Azul on the terra firme, and the floodplain communities of Forteleza and Pau Quemado. Looking at Table 20, we see that most of the landraces planted in the floodplain are different to those planted in the terra firme, with a few major exceptions. We see that Pirarucu Amarelo and Pirarucu Branco, widely planted on the *terra firme*, are 1st and 5th most predominant landraces in the floodplain. This confirms local claims of a floodplain origin for these landraces. In terms of their strength, the former is considered weak (1.3), the latter, intermediate (3). Further down the list we also note the landrace Manaus, probably originating in the floodplain but also planted in the *terra firme* along River Manicoré. Up until now we have only considered that floodplain manioc may be taken and planted in the terra firme, but the presence of Jabuti and Aruari in the floodplain shows that *terra firme* landraces are sometimes taken and planted in the floodplain. The social history of some landraces shows considerable mobility, and some may even move from the floodplain, into the *terra firme*, and then back into the floodplain. This is the case with the Glaí landrace. It was taken from a floodplain community called Pandegal by a woman named Glaí from Vista Alegre. The landrace became established there, before moving along the *terra firme* to Barreira do Capanã. It appropriated the woman's name without her permission, something she was quite annoyed about. It then moved back into the floodplain at the community Forteleza, becoming Glaí Braco (white) and Glaí Amarelo (yellow) in the process.

Table 20 Landrace area per hectare, Strength and number of informants (n) for 24 fields in the floodplain at the Água Azul, Forteleza and Paú Quemado communities on the Middle Madeira River in the Municipality of Manicoré, Amazonas State, Brazil.

	Strength		**Landrace Area per Hectare**	
Landrace	*Str*	*n*	*lah*	*n*
Pirarucu Amarelo	1.33	9	0.218	9
Mae Joana	2.87	15	0.184	12
Olho Roxo	2.2	5	0.149	9
Juvenal	3.23	13	0.138	12
Pirarucu Branco	3	12	0.125	9
Manaus	--	0	0.087	1
Jararaca Branca	1.75	4	0.087	1
Direitinha	1.4	10	0.073	9
Maria Dias	--	0	0.012	1
Vermelinha	2.5	2	0.01	2
Glaí Branco	3	2	0.008	3
Boliviano	--	0	0.001	1

In terms of the ages of vegetation cleared, we see that the floodplain is the most intensively cultivated of all soil types. The soil type most like it on the terra firme in terms of intensivity of cultivation (e.g. shortest fallows) is ADE, Figure 6.

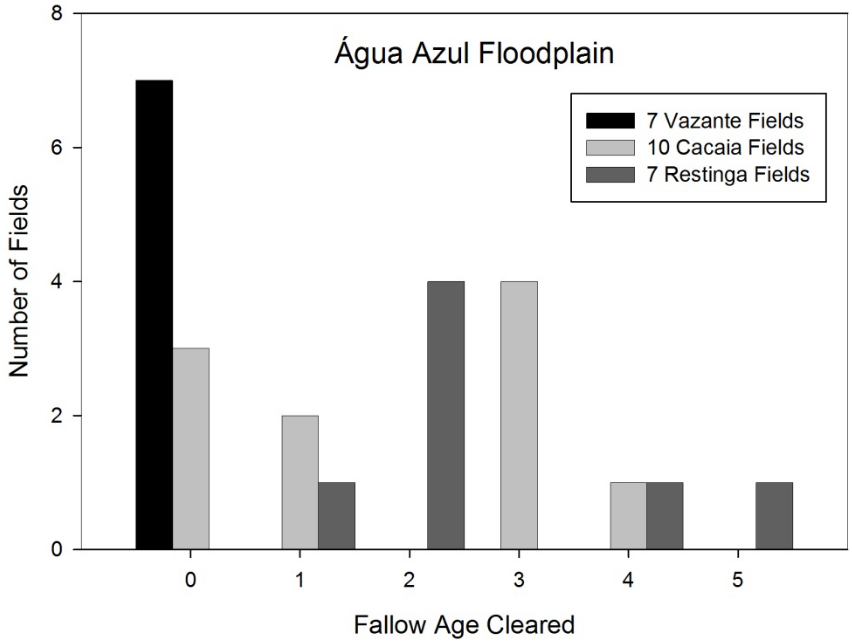

Figure 10 Fallow age for 24 fields in 3 zones of the Água Azul Floodplain on the Middle Madeira River in the Municipality of Manicoré, Amazonas State, Brazil.

4.4.2 Case Six: The Lake Genipapo Floodplain

The communities of the high floodplain in front of the lake Genipapo; Delicia, Amparo and Verdum comprise the final case. On the floodplain of the Lake Genipapo Coast, farmers in all three communities reside on the high floodplain and plant manioc in the *cacaia* and *restinga*. The limited *vazante* is reserved for watermelon, beans and maize. Tartaruga is the most predominant landrace in these communities, Table 21. This confirms the claim of farmers at Barro Alto and other communities that this landrace originates in the floodplain. Furthermore, Tartaruga is also considered relatively weak (2) by floodplain farmers. It is phenotypically identical to the landrace found in *terra firme* communities, but this does not rule out genetic differences.

Table 21 Landrace area per hectare, Strength and number of informants (n) for 35 floodplain fields at the communities of Verdum, Delicia and Amparo on the floodplain of lake Genipapo on the Middle Madeira River in the Municipality of Manicoré, Amazonas State, Brazil.

	Strength		**Landrace Area per Hectare**	
Landrace	*Str*	*n*	*lah*	*n*
Tartaruga	2	31	0.331	32
Sempre Serve	1.27	26	0.229	26
Curuca	3.37	27	0.229	27
Maria Dias	3	3	0.182	3
Abidaozinho	1.67	9	0.052	9
Toazinha	1.25	2	0.046	2
Vermelinha			0.041	1
Beleza	3.5	4	0.035	5
Japim	2	1	0.03	1
Jararaca Branca	1	1	0.012	1
Vermelao	3	1	0.007	1
Pirarucu Amarelo	2	1	0.006	1
Galhadinha	4	1	0.005	1
Manauense	1	1	0.003	1

The fallow lengths again show that the floodplain is the most intensively farmed of all soil types; ADE is the second most intensively farmed (Figure 11).

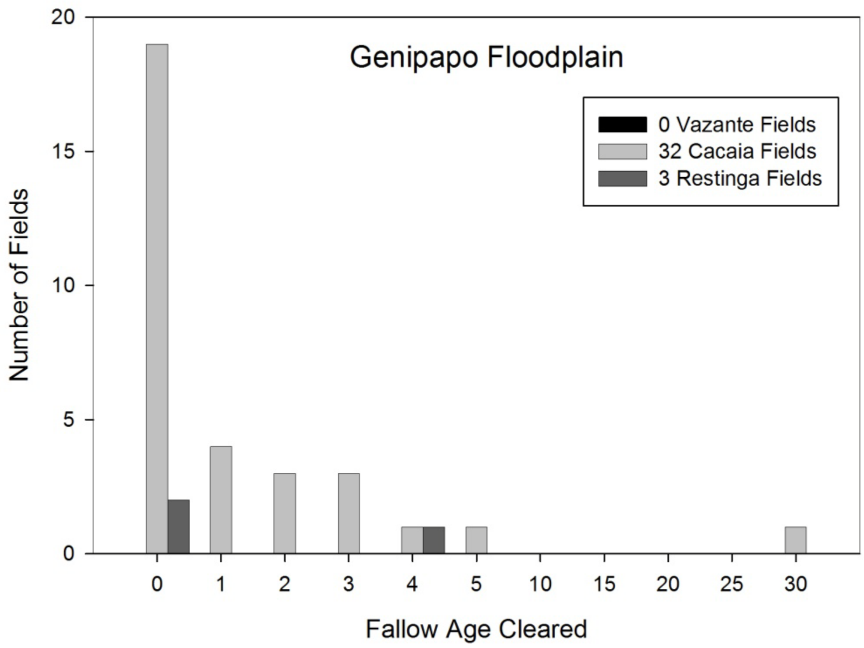

Figure 11 Fallow age for 35 fields in 3 zones of the lake Genipapo Floodplain on the Middle Madeira River in the Municipality of Manicoré, Amazonas State, Brazil.

4.5 The management of seedling volunteers

In modern bitter manioc cultivation in the Neotropics the extent to which volunteers are incorporated (the generation of genetic diversity) is greatly variable. Studies in French Guiana found a relatively high level of incorporation (Elias *et al.* 2001a). Pat Stocker found only a small amount of seedling incorporation amongst farmers in Pará, in the eastern Brazilian Amazon. (Stocker 2006: 162/163). On the Middle Madeira interviews revealed farmers who purposefully use cuttings from volunteers to plant, others who do unintentionally, and others who purposefully exclude volunteers (Chapter 3). Once these three categories were established, quantitative data was gathered.

Table 22 Proportions of people that intentionally, unintentionally or purposefully avoid plant cuttings from seedlings at six localities, four on the *terra firme*, two in the floodplain on the Middle Madeira River in the municipality of Manicoré, Amazonas State, Brazil.

Incorporation	Barro Alto	Barreira and Boa Vista	Água Azul	Vista Alegre	Água Azul Floodplain	Genipapo Floodplain
Intentional	32%	17%	23%	27%	11%	26%
Unintentional	14%	14%	31%	9%	33%	20%
Remove	54%	66%	46%	55%	55%	53%
Informants	*37*	*29*	*13*	*11*	*9*	*15*

Table 22 shows that there is significant incorporation of seedlings in all communities. It indicates therefore that the distinct genetic traits of volunteers emerging from different configurations of landraces planted in different soil types are being incorporated into the stock of planting clones to some extent, supporting the notion that over time divergent co-evolutionary dynamics are emergent from the practice of planting more of certain landraces in certain kinds of soil. Following Cleveland and Soleri (2007), Table 23 represents the process of the generation of genetic diversity in manioc cultivation.

Table 23 Processes in Manioc Evolution (Adapted from Cleveland and Soleri 2007)

Phenotypical selection >	***Populational Changes*** >	***Genetic response*** >	***Cumulative directional response over generations, e.g. evolution***
This refers to farmer selection for certain landraces which exhibit particular characteristics (see Table 4) which can in turn be interpreted as manifesting different genetic traits. We have seen that farmers plant more of certain manioc landraces in certain soil types	This refers to the divergent landrace assemblages which emerge from farmer selection for certain landraces in certain kinds of soil. This means that there are patterns in the distribution of populations of clones in different kinds of soil (table one)	This refers to the certainty that seedling volunteers will be made-up of the genetic material of the population of clones planted in a field. Therefore farmer selection for certain traits will be reflected in the seedling volunteers	This refers to divergent co-evolutionary dynamics which probably explain the emergence of traits that characterise weak and strong landraces. This is likely to occur over generations as the same landraces are planted in the same kinds of soil, and seedlings with the prevalent traits are incorporated

According to Cleveland and Soleri (2007), the clearest evidence for contemporary farmer selection is in clonally propagated species such as manioc, Table 23. Incorporation of seedlings into recognised varieties increases intra-landrace heterogeneity. Famers also tend to select the largest and healthiest volunteers, because it is these that they perceive to be the most vigourous, and this results in increased heterozygosity[24] (Elias *et al.* 2001a; Pujol *et al.* 2005).

4.6 Conclusions

This chapter has presented data on manioc cultivation in four soil types at six localities. While the contingencies of local history and environment shape cultivation to an extent, we have shown that there are patterns in the cultivation of the same soil types at different localities (similar landraces, landrace strengths, perception ranking indicies and fallow lengths). This implies that there are some commonalities to cultivation on

[24] Heterozygosity means an individual having two alleles of a particular gene or genes and so giving rise to varying offspring. More simply put, it means genetic vigour, resulting from the sexual reproduction of two genetically different manioc plants

different soils that can be attributed to similar adaptations to the affordances of those soils, and the history of knowledge and practice in relation to them in a given locale.

Looking at the Landrace area per hectare and Analysis of Variance, we see that the Landrace area per hectare is often significantly different for different landraces in different soils. The first case, Barro Alto, is characterised by swidden cultivation (short cropping periods, short fallowing) on ADE with a predominance of a weak, fast maturing landrace Tartargua. The proximate cause of the intensive farming is population pressure, there are now around 600 people resident at Barro Alto. Roxinha-RM, a stronger landrace, was most common on Ultisols and Oxisols. The Ultisols and Oxisols were located in two different areas, which affected their cultivation. The Ultisols, close behind the community were more intensively farmed while the Oxisols, further away were less intensively farmed. This was shown to affect the landrace assemblages planted in these soils, namely more Tartaruga in the former and more Arroz in the latter. This is explained by the fact that farmers also associate certain landraces as performing better in younger and older fallow respectively. More Tartaruga is planted in Ultisols because these soils are considered weaker owing to the younger fallow found on them, and therefore are seen as being more suited to planting with weaker landraces. Conversely, Oxisols are far behind the community, and are covered with old fallow and mature forest. For this reason, they are planted with more of the strong landrace Arroz, as people believe that strong landraces are suited to strong land (land with old fallow or mature forest).

At Barreira do Capanã, the population pressure is slight, and therefore fallowing is longer. The shortest fallows were observed on ADE, farmers claim ADE recuperates quicker, and ADE are also located closer to the community. As with Barro Alto, different landraces were predominant in different soil types. In Ultisols and Oxisols, the strong landrace Jabuti was the most predominant. In ADE the weaker landraces Pirarucu Branco and Tartaruga were the most predominant. In the Água Azul region, one of the ADE site at Community Agua Azul was intensively cultivated, but not enough for fallow ages in ADE to be significantly different from Ultisols and Oxisols overall. The strong landrace Arroz was most predominant on Ultisols, Jabuti on Oxisols and on ADE the weak landraces Pirarucu Amarelo and Tartaruga were most predominant. At Vista Alegre ADE tended to be cultivated under intensive short fallow, short cropping swidden cultivation. The most predominant landrace was the weak

Roxinha Branca, along with Tartaruga, Roxona, and Amerelinha. This contrasts with the more extensive cultivation with longer fallows on Oxisols and Ultisols found at Vista Alegre. The stronger landrace Jabuti was most predominant in these soils. Some of the landraces that are most predominant in ADE are widely planted in the floodplain: on the Genipapo coast: Tartaruga, and in the Água Azul floodplain: Pirarucu Branco and Pirarucu Amarelo. These landraces probably originate in the floodplain given that several older informants remember planting them being planted in the floodplain when they were children. Floodplain agriculture is the most intensive, with fields located in 1-5 year old.

Bitter manioc cultivation on ADE shows some strong similarities in different localities. In all localities there are differences in landrace assemblages between ADE and background soils. The Analysis of variance showed that in some cases these differences are strongly significant, while in other cases weakly so. Furthermore, certain landraces (e.g. Tartaruga) are consistently defined as weak by unrelated farmers at different localities, and planted more in ADE. The high perception ranking index for Tartargua in ADE at different communities confirms that it is widely perceived as performing very well in ADE. Other landraces such as Jabuti and Arroz; were both consistently defined as strong, and planted more in Oxisols and Ultisols, by unrelated farmers in different locations. Farmers at different locations also perceived that these landraces perform better in Oxisols and Ultisols and worse in ADE. ADE tends to be cultivated more intensively, but fallow length is not always significantly different to cultivation in other soils. Factors driving intensification differ among localities, but include population pressure at Barro Alto, Água Azul and Vista Alegre. The higher fertility of ADE and its proximity to the communities contributed to intensification at all communities.

On the Middle Madeira farmers were found to plant different configurations of landraces in different soils. One of the factors conditioning this was their perception of the suitability of particular landraces and their agronomic characteristics (expressed in the local cateogories strong and weak) to certain soil types and successional processes (also expressed in terms of strength and weakness). This chapter has demonstrated the local knowledge underwriting these perceptions, and the role that farmer selection for specific traits - which they believe render a landrace as being more suitable to planting in certain soil-successional scenarios - plays in creating and amplifying manioc genetic diversity. This chapter demonstrated how discrete landrace assemblages in different soils are shaped by farmer knowledge of manioc cultivation, presented in qualitative form in the previous chapter, and quantified in the form of *pri* in this chapter. Farmers incorporate of seedling volunteers, and this suggests that divergent co-evolutionary dynamics are emergent from different selective trajectories in each soil type.

This Chapter has shown that manioc is successfully cultivated on the Middle Madeira in more fertile soils; and as part of this farmers have landraces appropriate to those soils. This shows that claims that bitter manioc is not suited to cultivation in better soils, whether anthropogenic (German 2001; 2003a; 2003b; 2004; Hiraoka *et al.* 2003; McCann 2004) or in the floodplain (Roosevelt 1980) were premature. This chapter has demonstrated that there are enough similarities in cultivation of bitter manioc in the same types of soil at different locations, for us to consider there to be distinctly adapted cultivation systems on different soils. The knowledge, practice and landraces associated Middle Madeira manioc cultivation systems are unique adaptive outcomes of regional historical ecology: local people responding creatively to the affordances of different soil types.

Chapter 5: Bitter manioc cultivation systems in one of the richest landscapes of Amazonia

a) Pirarucu Branco tuber, 18 months old, harvested from ADE at Community Barreira do Capanã
b) A press, used to squeeze water from manioc pulp after soaking. Community Barro Alto
c) A tipití, used to squeeze water from manioc pulp after soaking. Community Terra Preta
d) Manuel Galdinho shows Tartaruga tubers, 7.5 months after planting in ADE at Community Monte Sião
e) The Barroso family scrape the peel off bitter manioc at Community Barreira do Capanã
f) A motor attached to a grater is used to grind up dry bitter manioc at Community Água Azul

Bitter manioc (*Manihot Esculenta* Crantz) has provided the single most important staple carbohydrate energy source for Amazonian peoples for several thousand years (Heckenberger 1998; Oliver 2001; Lathrap 1970b; Arroyo-Kalin 2010; Clement *et al.* 2010). It is grown in many parts of the Amazon basin; along the courses of the major rivers in Eastern, Central and Northwestern Amazonia and in the wider Neotropical lowlands (the Orinoco basin, the Guinanas). There are some exceptions to this pattern; in parts of Western Amazonia and on the Southern periphery; sweet manioc is more predominant (Arroyo-Kalin 2010; Clement *et al.* 2010). These widely dispersed regions in which bitter manioc is cultivated are characterised by different environments, ranging from the fertile (the whitewater floodplains of the Madeira and Solimões Rivers) to the infertile (the Upper Negro). This has generated considerable diversity in bitter manioc cultivation; both at *genetic* (the variety and variability of landraces) and *systemic* (e.g. fallow lengths, cropping periods and associated knowledge and practice) levels. This diversity in bitter manioc cultivation systems is the outcome of the agency and creativity of Amazonian peoples in relation to the affordances of different soil types and the historical ecology of landscapes in which they are situated (Fraser *et al.* 2009).

Anthropological studies of bitter manioc agriculture in the Amazon have not adequately addressed the diversity of cultivation systems, because they have almost exclusively focused on long-fallow shifting cultivation in the poor soils of marginal upland inter-fluvial environments, by surviving Amerindian populations (Carneiro 1983; Boster 1984; Chernela 1987; Elias *et al.* 2000; Wilson and Dufour 2002). This is because social and cultural anthropologists tend to study Indians, who today usually live in peripheral areas where they have avoided most destructive effects of European contact. These environments are located on the *periphery* of Amazonia (the Guianas, the Orinoco, the Upper Xingú and the Upper Negro). This research bias is largely owing to the fact that most extant Amerindian people have survived by virtue of their migration to remote interfluvial regions (Balée 1992), or because they are trekking populations who have always kept to the uplands (Rival 2002). This research focus has given rise to certain assumptions in the literature on bitter manioc agriculture in Amazonia. It has been argued that bitter manioc does not yield well on fertile soils (German 2001; Ohly and Junk 1999); and that bitter manioc is best adapted to extensive, long fallow, longer cropping (1-3 yr) systems on *terra firme* (Moran 1989; Roosevelt 1980).

Contrary to the impression given by this literature however, the greater proportion of bitter manioc cultivation takes place in the *rich* environments of major white-water rivers such as the Solimões and Madeira located in central Amazonia. This is the case both today and for the late pre-Columbian period (Meggers 1971; Desmoulière 2001; Oliver 2001). These landscapes are among the most densely populated environments in the Amazon, because they combine fertile floodplain soils and abundant aquatic protein (fish and turtles). These rich environments are consequentially the areas with the largest and most abundant Amazonian Dark Earth (ADE) sites (Petersen *et al.* 2001; Fraser *et al.* 2009).

Despite the central importance of whitewater landscapes to present and pre-Columbian human subsistence in the Amazon, there have been no anthropological studies of bitter manioc agriculture in these regions. Few Amerindian groups today are found planting on fertile soils, though there are several exceptions, such as the Shipibo and Conibo who plant manioc in the floodplain of the river Ucayali of Peru Ron Weber Personal Communication. Today, neo-Amazonian peasantries often cultivate manioc on fertile floodplain soils in whitewater regions (Schmidt 2003; Pereira 2008; Balée 1992; Padoch 1996; Padoch and de Jong 1991; Pinedo-Vasquez and Padoch 1996; Pinedo-Vasquez 1995). Some regional commentators on traditional agriculture have ignored the forms of cultivation practiced by these people however. For example, Deborah Pearsall, quoting Emilio Moran, recently claimed that "few observations can be made of traditional farming on better soils, such as river floodplain habitats, which potentially yield for extended periods, since such lands are *rarely cropped using traditional methods* (Moran 1993)." (Pearsall 2007:212). Similarly, the lack of studies of agriculture on ADE today is probably also related to the fact that the majority of these soils are cultivated by *Caboclos*, because these people inhabit the regions of the central Amazon where these soils are most abundant. Laura German's work is a noteworthy exception to this. She studied the cultivation of crop assemblages - of which bitter manioc formed a part - on ADE, but she concluded that these soils are unsuitable for bitter manioc cultivation (German 2001; German 2003b; German 2003a; German 2004). *Caboclos* remain understudied because of an "invisibility" attributed to them owing to the fact that they sit uneasily with notions of indigeneity and authenticity in Western preconceptions of what Amazonian people should be like (Nugent 1993; Adams *et al.*

2009b). Because of this, William Denevan has stated "evidence for intensive agriculture [on ADE] is largely inferential" (Denevan 2001:113).

5.1 Bitter Manioc Cultivation Systems along the Middle Madeira River

This chapter provides evidence for intensive agriculture on ADE along the Middle Madeira. The previous chapter demonstrated that there are similarities in bitter manioc cultivation in the same soil environments at different locations on the Middle Madeira. These localities were examined in turn, and it was found that there were similarities in bitter manioc cultivation in the same soils at different localities. This chapter therefore focuses on the aggregated data for bitter manioc cultivation in four environments, two nutrient rich (ADE and the Floodplain) and two nutrient poor (Oxisols and Ultisols). It presents the combined data for landrace area per hectare, performance ranking index and strength index from the six localities described in the previous chapter, along with data on seasonality, yields and field sizes. The number of informants and the kind of data they contributed at each of the six localities that participated in research are displayed in Table 6, on page 122.

This chapter demonstrates that bitter manioc cultivation in fertile soils (Floodplain and ADE) by people along the Middle Madeira tends to be characterised by *intensive* swidden systems with smaller fields, shorter fallows, and a predominance of what they refer to as "weak" landraces. The genetic traits of weak landraces make them well adapted to swidden cultivation in richer landscapes: they are fast maturing and yield well in fertile soils, though they exhibit a lower starch content. Bitter manioc agriculture in infertile soils (Oxisols and Ultisols) along the Middle Madeira is characterised by more *extensive* shifting cultivation systems with larger fields, longer fallows and a predominance of what locals refer to as "strong" landraces. The genetic traits of strong landraces similarly make them well adapted to long fallow shifting cultivation, they are slow maturing with a high starch content and yield well in the highly leached acid soils of low fertility that are typical of the *terra firme* in the Neotropical lowlands.

5.1.1 Smaller Fields, Higher Yields

The more intensive nature of bitter manioc cultivation in more fertile soils is first demonstrated when we compare field sizes and yields in ADE and the Floodplain with those in Oxisols and Ultisols. There were significant differences between the total field area and average field sizes in different soil types (Table 6). Mean field sizes in Oxisols and Ultisols are closer to a hectare, while those in the Floodplain and ADE are closer to half a hectare in size. Median yields are the same on ADE and in the Floodplain, higher than those recorded on Oxisols and Ultisols (Table 24). In terms of caloric production therefore, bitter manioc cultivation on ADE can theoretically support larger populations on smaller areas of land.

Table 24 Bitter Manioc Yields in four types of soil. An average sack is equivalent to 60 kilos. Median is used rather than mean because of some large outliers. Figures do not take into account starch production of individual landraces, nor do they take into account the age of the fallow vegetation planted in (which affects the yield). Figures taken from farmers who had accurately recorded (written down) *farinha* production.

Soil Type	No. Of Farmers	Manioc Flour sacks per ha (Median)	Median Manioc Flour Production per ha
Oxisol	10	37.5 Sacks	2,250 kg/ha
Ultisol	6	35 Sacks	2,100 kg/ha
ADE	12	50 Sacks	3,000 kg/ha
Floodplain	6	50 Sacks	3,000 kg/ha

5.1.2 Landrace Diversity in Intensive and Extensive Cultivation Systems

Table 25 presents the distribution of landraces in the form of landrace area per hectare (*lah*), and local people's perceptions of landrace strengths and performance in four kinds of soil at six locations on the Middle Madeira. The landraces are ordered by the sum of *lah* across all soils. The most predominant landraces are present in different quantities in different soil types. The weak landrace Tartaruga is most predominant in ADE and in the Floodplain. Local people at all locations recognized this landrace as being most suited to ADE. They also claim that other floodplain landraces Pirarucu Branco, Pirarucu Amerelo and Roxinha Branca yield well in ADE. The performance ranking indexes for these landraces reflect this belief. Conversely, the stronger landraces Jabuti, Arroz and Roxinha-RM are most predominant in Oxisols and Ultisols, and this is also reflected in the performance ranking indexes for these landraces.

Figures 12-15 show the landrace area per hectare and strengths for 15 most predominant landraces in each kind of soil. Note the tendency for the most predominant landraces to be strong in the Oxisol and Ultisol charts, and for the most predominant landraces to be weak in ADE and Floodplain charts. This demonstrates that there is an overall tendency towards a greater predominance of weak varieties in ADE and in the floodplain, and a greater predominance of strong varieties in Oxisols and Ultisols, as we saw in Chapters 3 and 4. Observe that the field sizes (Table 6) correspond with both the predominance of weak or strong manioc, Figures 12-15, and the fallow ages, Figure 16, Table 28, That is to say that decreasing field sizes corresponds with more weak landraces and shorter fallows.

This shows that the swidden cultivation practiced in ADE and in the Floodplain is characterised by a predominance of *weak* landraces that are faster maturing, and so fit a *intensive* shorter fallowing, shorter cropping sceanario. Conversely, long fallow shifting cultivation in Oxisols and Ultisols is characterised by a predominance of strong landraces that are slower maturing, and so fit into a *more extensive* longer cropping, long fallow sceanarios. Table 26 shows the results of Analysis of Variance that demonstrates there are significant differences between the lah of the most predominant weak and strong landraces in the four soil types. Table 27 presents regressions that show that there is a strong correlation between the perception of performance of landraces (*pri*) in different terra firme soils, and the actual presence of landraces in these different soils (*lah*). This shows that perception of performance of landraces in certain soils by *Caboclos* plays an important role in their selection for planting, which explains the predominance of different landraces in different soil types.

Table 25 Strength, Landrace Area per Hectare and Performance Ranking Index for 4 soil types.

			Landrace Area per Hectare										Performance Ranking Index					
Landraces	*Str*	*n*	*UL*	*n*	*OX*	*n*	*ADE*	*n*	*FP*	*n*	***Total***	**n**	*UL*	*n*	*OX*	*n*	*ADE*	*n*
Tartaruga	1.6	81	0.155	30	0.046	19	0.419	53	0.215	32	0.835	204	0.37	17	0.18	18	0.63	37
RoxinhaRM	3.2	29	0.243	28	0.241	35	0.148	18			0.632	149	0.42	19	0.35	26	0.26	17
Jabuti	5.1	47	0.26	24	0.236	34	0.044	15			0.54	159	0.4	17	0.73	51	0.09	7
Arroz	4.4	48	0.093	19	0.195	43	0.067	22			0.355	138	0.36	16	0.68	49	0.17	12
Aruari	2.9	27	0.076	20	0.112	27	0.027	9			0.215	70	0.27	13	0.33	28	0.17	13
Pirarucu Amerelo	1.4	21	0.024	6	0.018	7	0.051	10	0.08	10	0.173	49	0.09	4	0.06	5	0.18	12
Pirarucu Branco	3	33	0.013	7	0.015	8	0.088	14	0.044	9	0.16	38	0.11	5	0.1	9	0.36	21
Sempre Serve	1.3	26							0.149	26	0.149	26						
Curuça	3.4	27							0.149	27	0.149	27						
Maria Dias	3	3							0.123	4	0.123	12						
Glai	2.1	13	0.006	3	0.01	4	0.021	8	0.04	6	0.077	33	0.11	5	0.03	4	0.14	10
RoxinhaBC	4.9	8	0.054	9	0.015	6	0.003	2			0.072	39	0.07	3	0.07	6	0.08	6
Jiju	1.9	14	0.017	5	0.047	11	0.003	3			0.067	19	0.14	6	0.08	8	0.09	7
Mae Joana	2.9	15							0.064	12	0.064	22						
Roxinha Branca	1.6	13	0.006	5	0.012	5	0.039	7			0.057	17	0.16	7	0.04	3	0.17	10
Olho Roxo	2.2	5							0.052	9	0.052	9						
Juvenal	3.2	13							0.048	12	0.048	20						
AmarelinhaVA	3	2	0.002	2	0.015	4	0.019	2			0.036	20	0	0	0.03	3	0.02	2
Sara(nzal)	4.9	7	0.003	3	0.019	6	0.012	8			0.034	17	0.03	1	0.09	9	0.11	9
Abidaozinho	1.7	9							0.034	9	0.034	9						
Vermelinha	2.5	2							0.03	3	0.03	3						
Manaus	--	0							0.03	1	0.03	1						
Jararaca Branca	1.8	4							0.03	1	0.03	1						
Toazinha	1.3	2							0.03	2	0.03	4						
AmarelinhaBC	2	2	0.028	7	0.001	1	0	0			0.029	8	0.02	1	0	0	0.03	2
Direitinha	1.4	10							0.026	9	0.026	9						
Beleza	3.5	4							0.023	5	0.023	5						
Japim	2	1							0.02	1	0.02	1						
RoxonaVA	3.5	2	0.01	2	0	0	0.009	3			0.019	11	0	0	0	0	0.01	1
Piraiba	1.8	5	0	0	0.005	3	0.012	3			0.017	8	0	0	0.01	1	0.04	3
Guia Roxa	3.6	5	0	0	0.001	1	0.012	2			0.013	3	0	0	0	0	0.05	3
Jararaca Branca	1	1							0.008	1	0.008	1						
RoxonaBC	3.7	3	0	1	0	0	0.006	4			0.006	5	0	0	0.01	1	0.03	2
Julio da Varzea	--	0	0	0	0	0	0.006	1			0.006	1	0	0	0	0	0.01	1
Manaus	3	1	0.002	2	0	0	0.003	3			0.005	7	0	0	0	0	0	0
Caraulho	--	0	0	0	0.003	1	0.002	1			0.005	2	0	0	0	0	0.03	2
Vermelão	3	1							0.004	1	0.004	1						
Galhadinha	4	1							0.003	1	0.003	1						
Amerelona	2	1	0	0	0	0	0.003	1			0.003	1	0	0	0	0	0	0
Expomani	--	0	0.002	1	0	0	0	0			0.002	1	0	0	0	0	0	0
Manauense	1	1							0.002	1	0.002	3						
Azolão	8	1	0	0	0	1	0.001	1			0.001	2	0	0	0.02	2	0	0
Pacu	4	1	0	0	0	0	0.001	1			0.001	1	0	0	0	0	0.02	2
BonitinhaBA	--	0	0	0	0	0	0.001	2			0.001	4	0	0	0	0	0.02	1

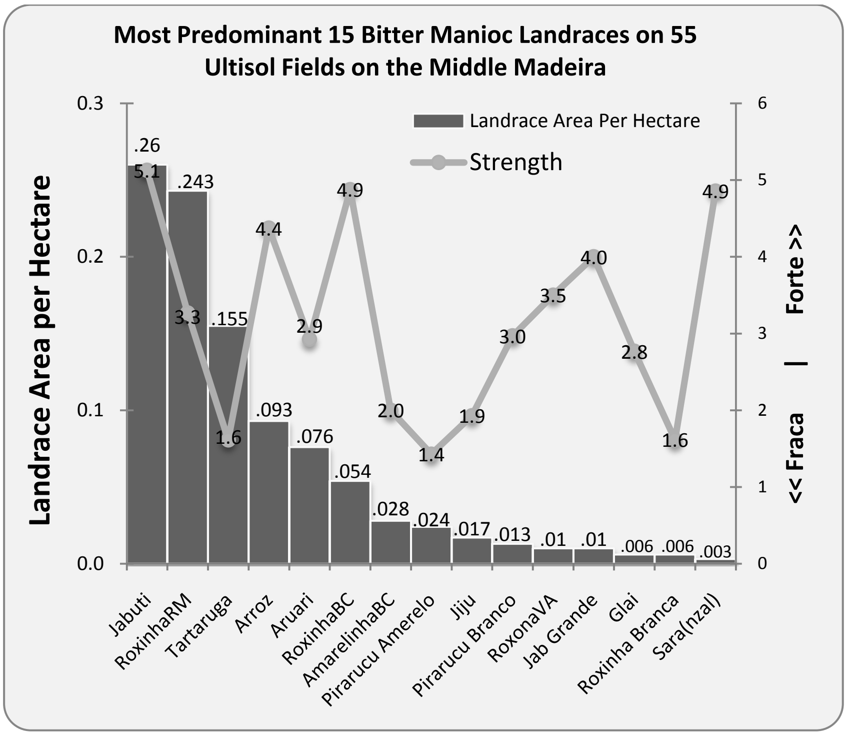

Figure 12 Total Landrace Areas and Strengths for 55 Ultisol fields on the Middle Madeira River, in the Municipality of Manicoré, Amazonas State, Brazil

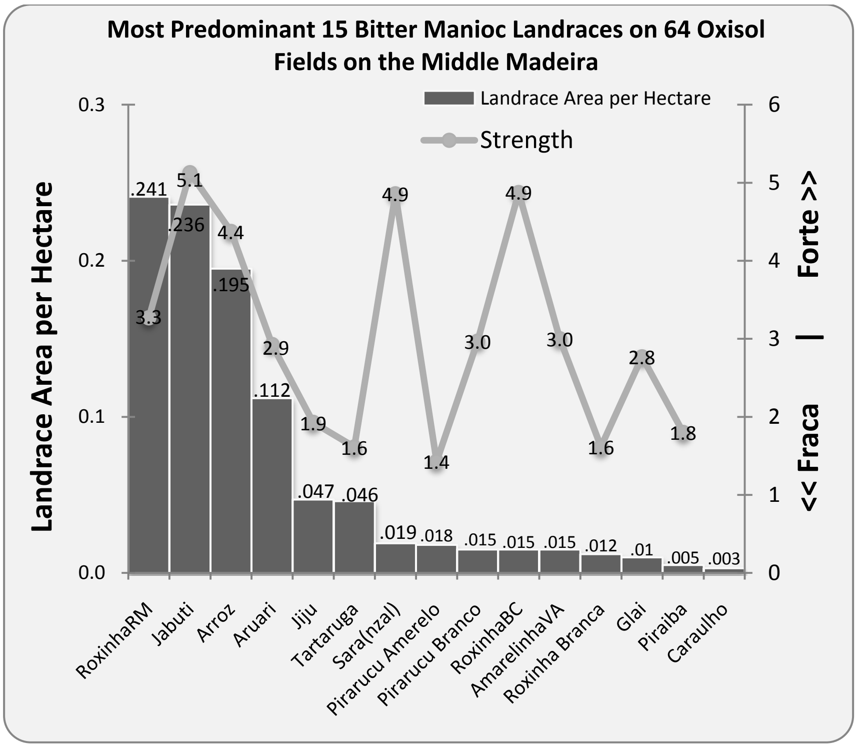

Figure 13 Total Landrace Areas and Strengths for 64 Oxisol fields on the Middle Madeira River, in the Municipality of Manicoré, Amazonas State, Brazil.

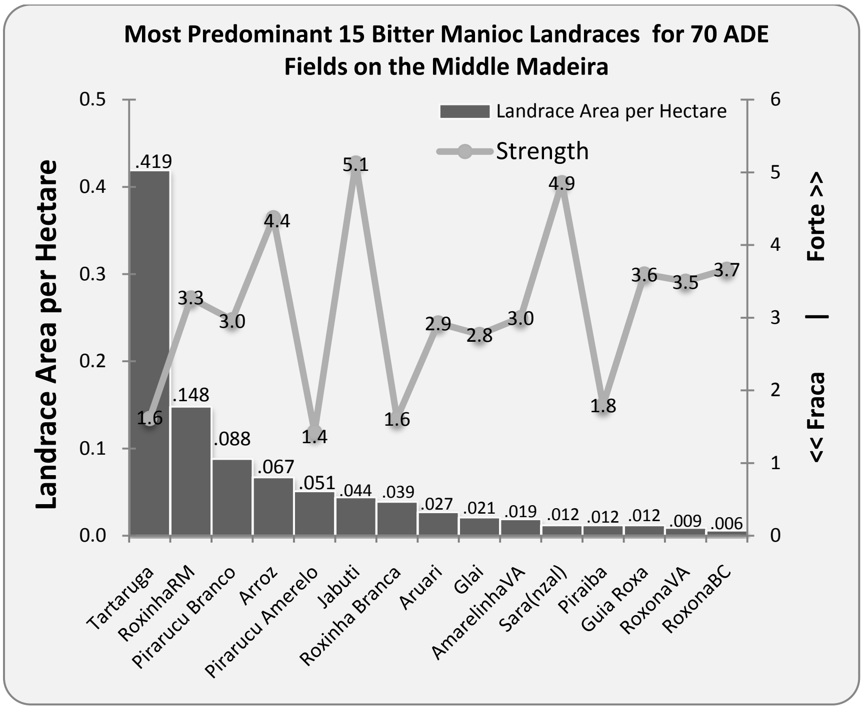

Figure 14 Total Landrace Areas and Strengths for 70 ADE fields on the Middle Madeira River, in the Municipality of Manicoré, Amazonas State, Brazil.

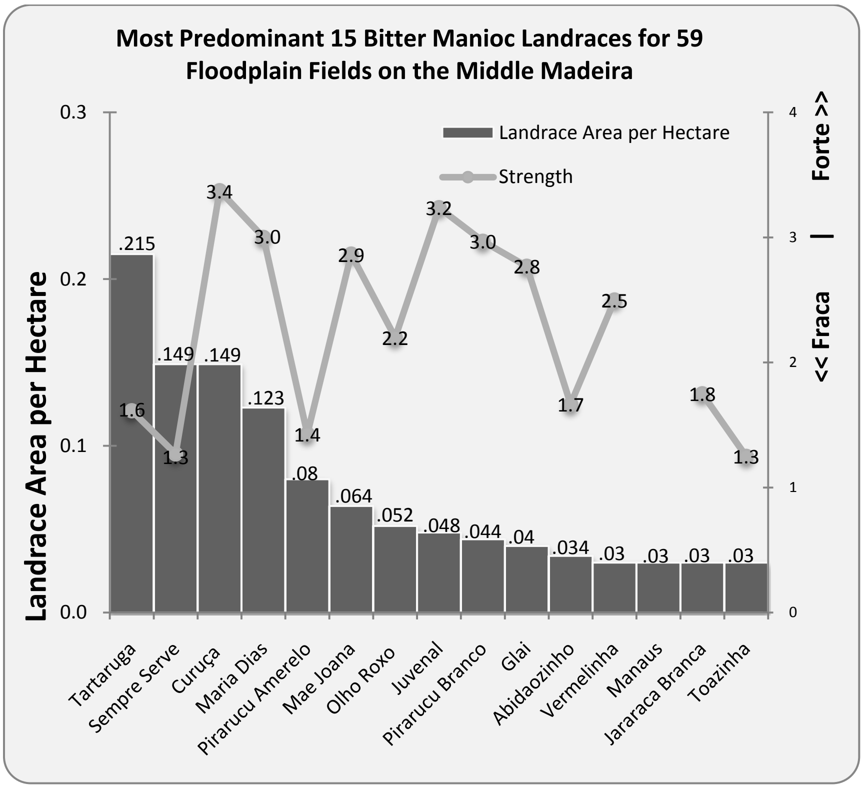

Figure 15 Total Landrace Areas and Strengths for 59 Floodplain fields on the Middle Madeira River, in the Municipality of Manicoré, Amazonas State, Brazil.

Most of the floodplain landraces were not present in the *terra firme*, but those that were (Tartaruga, Pirarucu Amerelo, Pirarucu Branco and Glai) are most predominant in ADE. Table 26 shows the results of Analysis of Variance comparing landrace area per hectare in four types of soil of key landraces along the Middle Madeira. Table 26 confirms the differences in *lah* and *pri* in Table 25, and the local narratives presented in Chapter 3. Tartaruga *lah* is significantly greater in ADE when compared to Oxisols and Ultisols. There is a significantly greater *lah* of Roxinha-RM, Jabuti and Arroz in Oxisols and Ultisols when compared to ADE. There is also a significantly greater lah of Pirarucu Branco in ADE when compared to Oxisols and Ultisols, but not when the same comparison is made with Pirarucu Amerelo (Table 26).

Table 26 Analysis of variance comparing landrace area per hectare for key landraces in four types of soil along the Middle Madeira River, Amazonas State, Brazil.

Landrace	**Tartaruga**		**Roxinha-RM**		**Jabuti**		**Arroz**		**Pirarucu Branco**		**Pirarucu Amarelo**	
ANOVA	*F=*	*p=*	*F=*	*p=*	*F=*	*p=*	*F=*	*p=*	*F=*	*p=*	*F=*	*p=*
Oxisol vs Ultisol	8.653	0.004	0.611	0.436	0.229	0.633	13.12	<0.001	0.286	0.594	0.01	0.92
ADE vs Ultisol	9.308	0.003	6.08	0.015	18.05	<0.001	2.892	0.092	4.279	0.041	0.537	0.465
Oxisol vs ADE	37.174	<0.001	9.825	0.002	36.74	<0.001	34.01	<0.001	4.976	0.028	0.867	0.354
ADE vs Floodplain	8.852	0.004							1.609	0.207	0.867	0.354
Floodplain vs Ultisol	0.0898	0.765							2.316	0.131	1.973	0.163
Floodplain vs Oxisol	13.524	<0.001							1.122	0.292	2.665	0.105

5.1.3 Perception Ranking and Landrace Area per Hectare

In order to determine the degree of correlation between two sets of variables, statistical tests knows as “regressions” are used (Schroeder *et al.* 1987; Field 2005). They model the relationship between a set of variables denoted *y* (in this case, perception ranking index, the indepenedent variable) and a set of variables denoted *x* (landrace area per hectare, or planting behaviour, the dependent variable.). Regressions are modelled as a scatterplot with *y* on the vertical axis and *x* on the horizontal axis, where a perfect linear relationship would see *x* and *y* increasing incrementally. Like ANOVA, we look at two outputs to determine the degree of significance of the relationship: to be significant a relationship requires a combination of a very low p (probability of relationship being down to chance) and a high r^2. R^2 is the coefficient of determination and it measures how well data conforms to the model, i.e., the regression equation. A good r^2 is at least 0.5, because it means that half of the dataset conforms to the model.

The results show that there is a highly significant relationship between people's perception of a landrace's performance in a particular soil type, and their behaviour in selecting landraces to plant in different soils (Table 27). The high R^2 values for each soil type indicate that in people's perception of a landrace's performance in a particular soil type strongly correlated with the landrace frequencies found planted in that kind of soil. This shows that the perception of how well a landrace performs in a particular soil correlates strongly with a high presence of that landrace in that soil. This suggests that people's perception of landrace performance affects their planting strategies, and perception of performance constitutes a key selective pressure on landraces in different soils. This implies that people's perception of performance in different soils has an effect on planting decisions. The corollary of this is that if one of the motivations to plant more of a certain landrace in a certain type of soil today is the perception that it yields better there, then it is perfectly possible that similar selective pressures were imposed on manic landraces in pre-Columbian agriculture

Table 27 Regressions between *pri* and *lah* for each *terra firme* soil type.

Soil	**Ultisol**	**Oxisol**	**ADE**
$n=$	14	18	19
$r^2 =$	0.771	0.851	0.849
$p =$	<0.001	<0.001	<0.001

Figure 16 displays all the fallow ages recorded for fields in all of the four soil types. It shows that most fields in the floodplain have been cleared from vegetation of 0-4 years growth. Most ADE fields were cleared from vegetation aged from 0-15 years. Most Ultisol fields were cleared from vegetation aged 4-20 years. Oxisol fields were cleared from vegetation aged from 6 years right up to mature forest. Table 28 shows the mean fallow ages of the different kinds of soil; the floodplain was the most intensively farmed with a mean fallow age of 2, followed by ADE, 6, Ultisol, 13, and Oxisol 20. The Analysis of Variance in Table 28 shows that there is a significant difference between these means, in all possible comparisons. The interesting this about this, is that this order of intensity of farming in terms of fallow lengths, corresponds exactly with the predominance of weak (fast maturing) and strong (slow maturing) in the different soil types. So the greatest proportion of weak manioc, corresponds with the lowest mean fallow age, in the floodplain, followed by ADE, Ultisols and finally Oxisols, with the longest fallows and greatest proportion of strong manioc in Oxisols. This shows that the prevalence of fast maturing or slow maturing landraces correlates with fallow ages, which provides more evidence for differentially adapted cultivation systems in the different soil types.

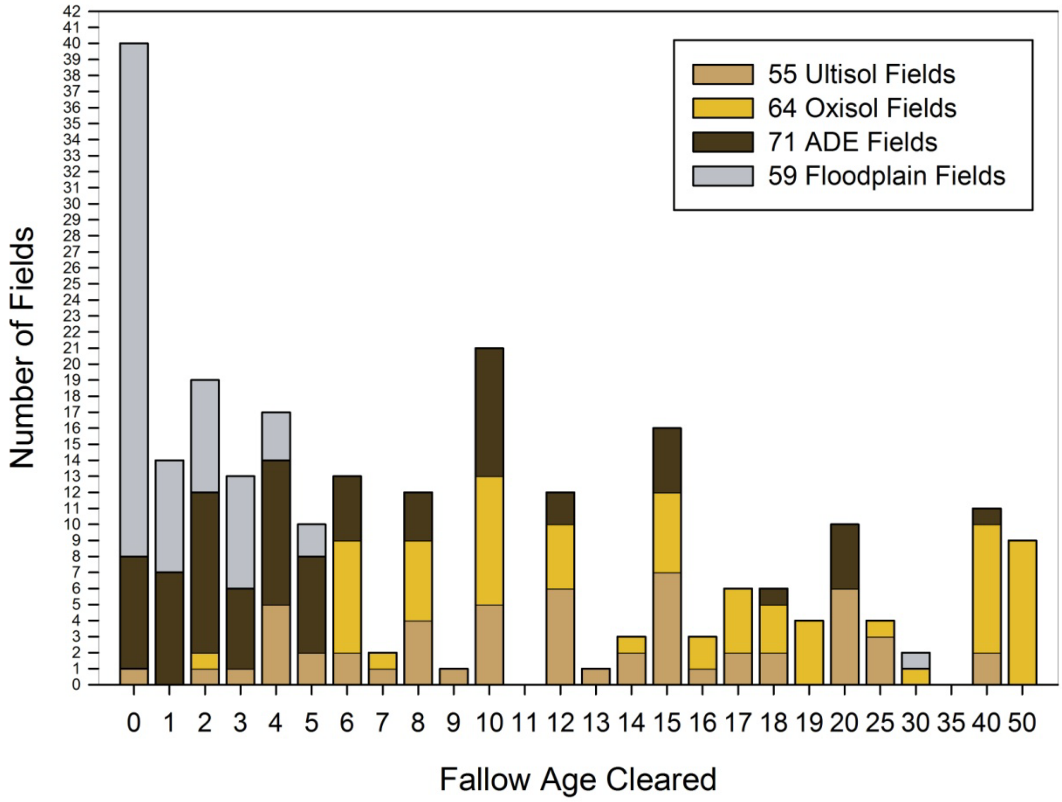

Figure 16 Fallow ages cleared (in years) for 59 Floodplain, 70 ADE, 64 Oxisol, 55 Ultisol fields on the Middle Madeira River in the Municipality of Manicoré, Amazonas State, Brazil.

Table 28 Descriptive statistics and Analysis of variance for ages of vegetation cleared in 59 Floodplain, 70 ADE, 64 Oxisol, 55 Ultisol fields fields on the Middle Madeira River in the Municipality of Manicoré, Amazonas State, Brazil.

Soil	Mean	SDev	SErr	Median	ANOVA	F	P
Ultisol	13.358	8.134	1.117	12	*Ultisol-Oxisol*	26.796	<0.001
Oxisol	20.797	15.153	1.973	15	*Oxisol-ADE*	134.695	<0.001
ADE	6.156	5.903	0.756	4	*ADE-Floodplain*	15.004	<0.001
Floodplain	2.1	5.608	0.724	0	*Ultisol-Floodplain*	74.768	<0.001
					Floodplain-Oxisol	80.186	<0.001
					Ultisol-ADE	29.793	<0.001

Figure 17 shows that months of planting vary between the different soil types. While in Oxisols and Ultisols all fields were planted between September and November, fields in the Floodplain tended to be planted from May to August, but ADE fields seem to be planted right through the year. This is probably related to differences in the affordances of different soil types. Oxisols and Ultisol fields need to be located in older fallow, becasuer these soils are nutrient poor and are therefore more reliant on the burn to clear to provide a nutrient flush. ADE are generally cleared from younger vegetation, and therefore are not so reliant on the burn to clear vegetation, or provide a nutrient flush. This is something that German noted on the Lower Negro (2001). The factors that constrain cultivation in Oxisols and Ultisols do not effect ADE as much, and some farmers explained how they capitalized on this, by planting manioc in January and February in order to harvest from July onwards to take advantage of the higher prices for manioc flour because of the lower production during this time precisely because much of the bitter manioc planted in Oxisols and Ultisols has been harvested by this point. Most bitter manioc is planted in the high floodplain *restinga* and back-swamp *cacaia* during the months of May to August as this is when the rainy season ends, floodwaters begin to recede.

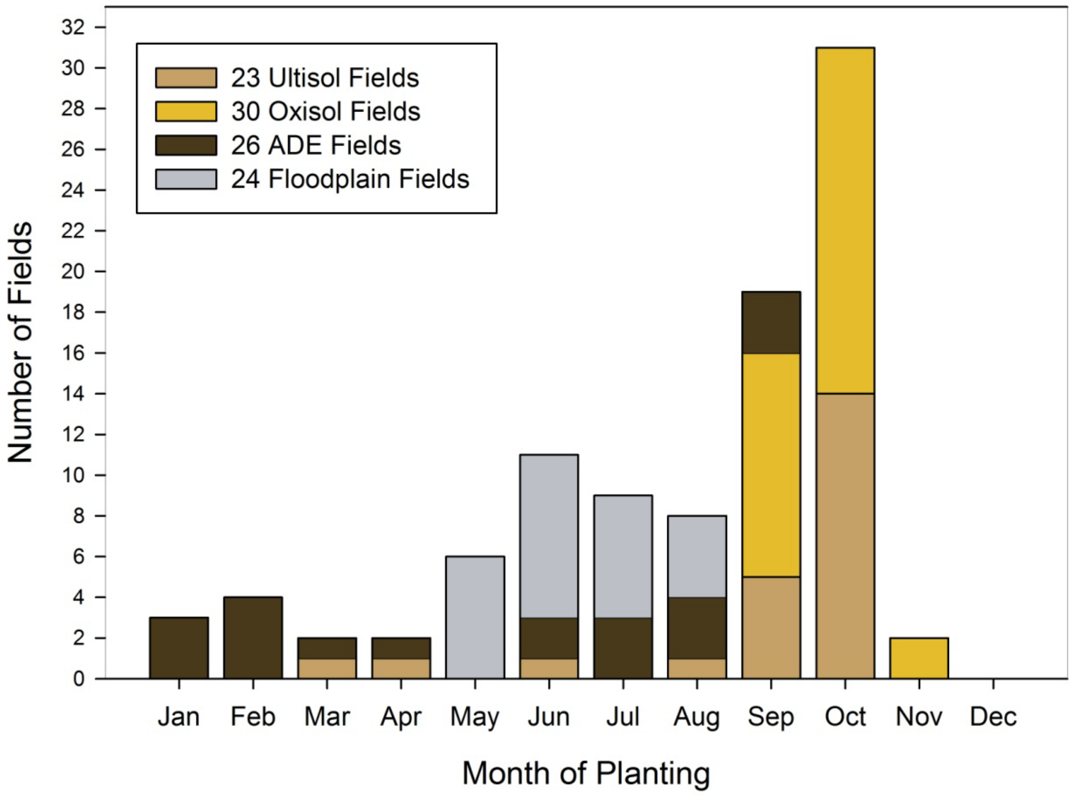

Figure 17 Month of Planting for 103 Bitter Manioc Fields in 4 types of soil on the Middle Madeira River in the Municipality of Manicoré, Amazonas State, Brazil.

5.1.4 Incorporation of Seedling Volunteers

114 Farmers on the *terra firme* and in the floodplain were asked if they incorporated seedlings and it was found that around 24% intentionally incorporate seedlings, 17% unintentionally incorporate them and 57% remove them (see Table 22). The seedlings that appear as volunteers in new fields in these different systems will incorporate the genetic traits of the weak or strong landraces that were planted there before. Owing to the fact that farmers have already selected landraces that perform well in particular soil-successional scenarios, seedlings are already more likely to exhibit genetic traits that make them well adapted to particular cultivation systems. When farmers select them for incorporation into the planting stock of clones, this will generate genetic diversity that is adaptive to such cultivation systems. Because the genetic traits of seedlings in these different cultivation systems on different soils reflect the predominant genetic traits of different landrace assemblages, when seedlings are incorporated as new clones,

divergent co-evolutionary dynamics emerge in different agricultural systems on different soils over time. Similar processes may ultimately explain the emergence of the constellations of weak (low starch fast yielding) and strong (high starch slow yielding) traits in pre-Columbian cultivation.

5.2 Discussion

The following section discusses the emergent properties of the systems of cultivation found in each kind of soil in turn.

5.2.1 Oxisols

Table 25 and Table 26 demonstrate that farmers cultivating these yellow-red clayey soils have the greatest preference for the strong landraces Jabuti and Arroz. These are the most popular landraces and are also those rated as the strongest by farmers. The predominance of strong manioc in this type of soil can be explained firstly by a farmer perception that strong landraces perform better in these soils. The Perception Ranking Index for Oxisols shows that the most predominant landraces in Oxisol fields – Jabuti, Arroz, Roxinha-RM (River Manicoré) and Aruari are also perceived to be those which perform best. This supports the contention that the pattern observed here is not down to chance, but rather the result of deliberate selection for particular landraces and their associated traits. The predominance of strong bitter manioc on these soils is also a function of the fact that the greater proportion of old fallow / mature forest being cleared is located on Oxisols, Table 28, Figure 16. There is a widespread perception that strong manioc is best suited to old fallow or mature forest, and weak bitter manioc is better suited to younger fallow. The seasonality table 2 shows that most Oxisol fields are planted in September and October. This is typical of long-fallow shifting cultivation, where fields are cut in June after the rains end, left for a few months to dry, to allow a hot burn which gives the clearest fields.

5.2.2 Ultisols

Ultisols are, in a certain way, more like ADE than Oxisols are. This is because, in the process of an Oxisol becoming ADE, it becomes more like an Ultisol because it becomes more friable. Table 25 and Table 26 demonstrate that farmers planting in these sandy soils prefer the stronger landraces Jabuti and Roxinha-RM. But the presence of Tartaruga in large quantities suggests that landrace assemblages which were quantified here do not contain as much strong manioc as Oxisols. This can be explained in part by the fact that some 25 (nearly half) of the 55 Ultisol fields are from the community Barro Alto, where the Ultisols lie close behind the community and are subject to more intensive cultivation that the more distant Oxisols . On non-anthropogenic soils of the *terra firme*, farmers will plant more weak bitter manioc if fallow vegetation is still young, as they believe that when soil is weak, weak manioc yields better than strong (see Chapter 3). Table 28 and Figure 16 show that Ultisol fields in the study are being located on younger fallow than Oxisols. This is an outcome of several communities being located on or close to large patches of Ultisols, rather than a general tendency for farmers to clear younger fallow on Ultisols, which was not observed. The perception of performance for this kind of soil suggests that as with Oxisols, Jabuti is the most favored landrace. The Total Landrace Area and Performance Ranking Index also correlate for the most predominant landraces. Despite these differences, the manioc bitter cultivation practices found in Ultisols and Oxisols are similar. The seasonality chart (figure 13) indicates that most of the Ultisol fields, like the Oxisol fields are planting in September and October.

5.2.3 ADE

On ADE fields we see a significant differences from the landrace assemblages that characterize Oxisols and Ultisols. The most predominant landrace, Tartaruga, is considered ‘weak’ by farmers, Table 25 and Table 26. Performance Ranking Index also diverges sharply from that of non anthropogenic soils, with Tartaruga, Pirarucu Branco , Pirarucu Amerelo and Roxinha Branca considered the best performing, and these are also among the most predominant landraces in ADE fields. The most important and interesting thing about these four landraces is that they all appear to originate in the floodplain; the first three have all been observed growing in the floodplain. Oral histories indicate a direct floodplain origin for Roxinha Branca.

Table 28 and Figure 16 show that ADE fields tend to be located in younger fallow, and interviews with farmers indicate that manioc is harvested earlier on ADE, beginning as little as five six months after planting. Fast maturing, 'weak' landraces would appear to better fit this short fallow swidden scenario. Having evolved in the floodplain these landraces are better able to take advantage of greater nutrient availability owing to the particular selective pressures imposed on them (Souza *et al.* 2006). Therefore, farmers experimenting with floodplain landraces in the *terra firme* found them to perform particularly well on ADE, and thus they become established as the predominant landraces on ADE. What we observe on ADE therefore is an emphasis on fast maturing landraces, in a more intensive short-cropping, short-fallow system, like that envisaged for pre-Columbian farming by William Denevan (2001; 2004; 2006). ADE soils also appear to give the highest yields of bitter manioc on *terra firme*, Table 24. While those farmers included in the yield estimates said they had kept a count of the number of sacks of manic flour harvested, these figures should be treated with caution, and certainly do not prove anything. What they *do* show is that bitter manioc planted in ADE does not yield less than other soil types as other commentators have claimed (German 2003; Hiraoka et al.2003). On the contrary, yields are probably improved. What is clear is that these soils can yield bitter manioc adequately under short fallow cultivation, which is impossible on Oxisols and Ultisols. Further research is needed in order to provide more accurate data on this.

5.2.4 Floodplain

The floodplain has its own set of landraces[25], and as with ADE, most of the popular landraces are considered weak, table 3. The most interesting thing for our purposes is that some of the most predominant landraces on ADE; Tartaruga, Pirarucu Branco and Pirarucu Amarelo are also amongst the most predominant found in the floodplain, Table 25. While the most predominant floodplain landraces are classified as weak, there are

[25] Although occasionally landraces from the terra firme are planted there, it is more common for floodplain landraces to be planted on the terra firme than vice versa. This is probably because traits selected for in the floodplain (fast matuing) are useful in short fallow systems on terra firme, but traits of the terra firme (Slow maturing, higher starch content) are not so advantageous in the floodplain.

also strong landraces in the floodplain. This is another interesting finding, while the literature assumes that all floodplain landraces are fast maturing, floodplain farmers in the Middle Madeira reported that they have slow maturing floodplain landraces. These tend to be planted in the highest areas of lower fertility, that do not flood yearly, whereas weak landraces tend to be planted in lower areas that flood, but are more fertile owing to nutrient washes from the river. Floodplain cultivation is the most intensive, with most fields located in fallow only 1-5 years of age, Table 28 and Figure 16. While the mean age of vegetation cleared is significantly different when every possible ANOVA comparison is made, the most similar were ADE-Floodplain, Table 26. Fields are smaller than in Oxisols and Ultisols, Table 1. Because of the flood regime and greater fertility, bitter manioc is harvested five or six months after planting. Median Yields are higher than in Oxisols or Ultisols, the same as ADE, Table 3. In at least five aspects: a) predominance of landraces that are considered weak, some of which are the same, b) shorter-cropping periods, c) shorter fallow, and d) higher yields, e) smaller fields, ADE and floodplain cultivation display considerable similarity. This is significant because it shows similar adaptations in bitter manioc cultivation in two fertile soils, whose fertility has radically different sources, one natural, fertile alluvium from the Andes, the other completely anthropogenic. One is completely natural, the other cultural. Yet cultivation systems with similar characteristics emerge on the two.

5.3 Conclusions

Until recently, scholarly consensus held that manioc does not perform well in ADE (Chapter 1). The research presented in the first five chapters of this thesis has demonstrated that this consensus was premature. The most common crop in ADE fields on the Middle Madeira today is bitter manioc, and historic locally sitatued body knowledge and practice surrounds its cultivation. On Floodplain and ADE soils along the Middle Madeira, bitter manioc is planted under intensive short fallow-swidden systems, with a greater emphasis on fast maturing-low starch landraces, shorter cropping periods (5-10 months) and shorter fallow periods (1-2 years)[26]. On Oxisol and

[26] Laura German (2003, p. 326) also observed more intensive agriculture on ADE. Farmers on the lower Negro and Urubu Rivers fallowed ADE fields for an average of 4.5 years, whereas Oxisol fields were fallowed for an average of 11 years. In her study ADE fields remained in production for an average of 10.8 months, whereas Oxisol fields remained in production for 28 months. Furthermore, while 72.7% of

Ultisols, manioc is cultivated under the traditional long fallow shifting cultivation systems, strong landraces predominate, with longer cropping periods (1-3 years) and longer fallowing (10 years or more). The fact that people continue to plant manioc in ADE and in the Floodplain in young fallow, but rarely do this in Oxisols and Ultisols shows that the perceived degradation thresholds for short fallowing and long cropping sequences differ across successional stages of secondary vegetation growth and soil types.

Bitter manioc landraces and their degree of strength or weakness are not associated just with different soil types, but with short fallow (swidden) or long fallow (shifting cultivation) in those soil types. Weak manioc on the terra firme is associated with short fallows on ADE and the same when planted on Oxisols and Ultisols. Weak manioc in the floodplain is planted in soils that flood yearly. Conversely on the *terra firme*, strong manioc is associated with longer fallows, not only on Oxisols and Ultisols, where it is said to perform best, but also on ADE when it is covered by old fallow. ADE fields are not often located in old fallow because these soils are usually covered in young fallow owing to their proximity to the communities that cultivate them.
The strong floodplain varieties are planted on the *restinga* and higher areas of the *cacaia*. Field Sizes were also different. The average Oxisol field was 1 ha, and the average Ultisol was 0.8ha. The average ADE field was 0.6ha while the average floodplain field is 0.6ha. The reason for the smaller field size in more fertile kinds of soil is the greater production and greater weed pressure. Median yields on ADE and in the floodplain are 50 sacks of manioc flour per hectare, compared to around 35 sacks on Oxisols and Ultisols. This shows that ADE manioc cultivation could support greater numbers of people on smaller areas of land. The seasonality chart (Figure 17) shows that seasonal constraints are removed on ADE, with fields being planted all year because young fallow can be cleared and burnt during a couple of rain free days. It shows how the constraints of planting in the dry season are effectively removed by the fertility of ADE, which allows planting in young fallow that would not normally be considered in Oxisols and Ultisols. This was also found by German (2001).

The seedlings that appear as volunteers in new fields in these different systems will incorporate the genetic traits of the weak or strong landraces that were planted there

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Oxisol fields in her sample were cut from mature forest only 25.6% of ADE fields were cut from old second growth forest.

before. These seedlings are sometimes incorporated into the stock of planting clones. Because the genetic traits of seedlings in these different cultivation systems on different soils reflect the predominant genetic traits of different landrace assemblages, so when seedlings are incorporated as new clones, divergent co-evolutionary dynamics emerge in different agricultural systems on different soils. Similar processes may ultimately explain the emergence of the constellations of weak (low starch fast yielding) and strong (high starch slow yielding) traits in pre-Columbian cultivation.

This chapter demonstrated the existence of swidden systems in fertile soils (Floodplain/ADE) on the Middle Madeira, featuring short fallows, cropping periods and a predominance of fast maturing “weak” landraces. Conversely, shifting cultivation characterises manioc farming in infertile Oxisols and Ultisols, with longer fallows, longer cropping periods and predominance of slower maturing “strong” landraces. The study of manioc cultivation in different soil types today provides data that, when situated in the context of archaeological and historical studies allows us to better imagine what pre-Columbian agriculture might have been like. This theme is developed further in the final chapter.

Chapter 6: Culturally Salient Agrobiodiversity in Homegardens on Amazonian Dark Earths

a) Samaúma (silk cotten) tree (*Ceiba pentandra* (L.) Gaertn.), A floodplain species that is also an ADE indicator
b) A sweet manioc landrace known as *Boliviano* in a homegarden on ADE at Community Monte Sião. Manioc plants phenotypically identical to this landrace have been observed by the author on a lake near Tefe on the Solimões River; in Florencia, Colombia; and at Puero Obaldia, Panama!
c) Cacao (*Theobroma Cacao*) in homegarden on ADE at Parana de Urua, Wild Cacao (*Theobroma Speciosum*) in homegarden on ADE at Community Terra Preta
d) Araticum (*Annona Montana*) in ADE homegarden at Community Terra Preta
e) Junior shows off the Plantain (Musa Spp.) growing in his homegarden on ADE at Community Monte Sião
f) The volunteer Papaya (*Carica Papaya*) and planted species Plantain (*Musa spp*) at homegarden in ADE at Community Terra Preta

Caboclos normally live in spaces that they refer to as *sítios*; the word *sítio* literally means "place." *Sítios* are equivalent to what are referred to in the literature as homegardens and agroforests. In the Amazon they are important both to *Caboclos* and Amerindians for the uses to which they put diverse species, subsistence consumption, food security, medicinal purposes and market production (Padoch and de Jong 1991; Lamont *et al.* 1999; Ban and Coomes 2004; Perrault-Archambault and Coomes 2008). Homegardens are found throughout the tropical world (Kumar and Nair 2006). The scientific community has recently become interested in homegardens, because of the agrobiodiversity that planted and managed homegarden species represent; and because of wider plant and animal biodiversity that they support (Bhagwat *et al.* 2008; Scales and Marsden 2008; Gardner *et al.* 2009; Pardini *et al.* 2009; Webb and Kabir 2009).

On the Middle Madeira River, *sítios* are located on historical landholdings, often much older than the communities into which they have more recently been incorporated. They are typically found adjacent to a riverside or lakeside, allowing easy access to canoes for fishing and transport and providing water for daily use. Given that certain geographical positions are preferred for sítios, the most suitable sites have long been occupied. Indeed, this is one reason why there are so many *sítios* coincide with ADE sites, because pre-Columbian Amerindian populations must have been attracted to the same sites for similar reasons. The arrival of Europeans sparked a massive exchange of crops to and from the Old World (Crosby 1972). In this period, colonists along the main Amazon River were establishing agroforests mixing native fruit trees and introduced species such as orange (*Citrus sinensis*) and mango (*Mangifera indica)* (Daniel 2004 [1776]; quoted in Miller *et al.* 2006; Bates 1988 [1863]; Amazonas 1984 [1852]). As a result of these historical processes of i) native domestication, ii) the introduction of exotic crops, and iii) different extractive phases (e.g., cacao, rubber), today's homegardens are a living legacy of these historical processes, composed of a mixture of native Amazonian (e.g., Brazil nut, rubber, açaí), Mesoamerican (papaya, avocado) and Old World (mango, orange, banana, coconut) trees and palms.

On the Middle Madeira *Sítios* are usually comprised of one or more households, the "clusters" described in Chapter 2, containing several family generations. Domestic animals such as chickens, ducks and pigs, live within the homestead space. In the immediate vicinity of this multi-dwelling homestead we sometimes (but not always) find a spatially restricted, but intensively managed kitchen garden. These gardens often feature raised beds, whose soils are the closest modern analogue to ADE (Steiner *et al.* 2009; WinklerPrins 2009). During the dry weather, the women of the homestead sweep dried leaves and other organic refuse into piles, that they set light to. These piles are often damp, and once lit may smoulder for up to two days. The resulting charred organic material, known as *terra quemada*, or burnt earth, is used to make raised beds, often mixed with rotten wood, lcoally known as *paú*[27]. Rasied beds are usually restricted to the planting of condiments. Kitchen gardens are most well developed on ADE, as a much wider spectrum of crops can be planted. Surrounding the kitchen garden is a spatially extensive, less intensively managed agroforest. Diverse mixtures of fruit and nut trees and plams are found in these spaces, Table 30. Agroforests are highly diverse, and range from highly managed orchards to lightly managed anthropogenic forest. Agroforests are shaped by the interaction between subsistence needs, soil affordances and plant response over time. *Sítios* are not always lived in. Sometimes, old *sítios* whose occupants have abandoned them continue to be visited and managed by their ex-occupants, or their relatives. These places are sometimes then re-occupied at a later date, years or decades after being abandoned.

Homegardens are the most common form of land-use on ADE among traditional inhabitants of Central Amazonia (Hiraoka *et al.* 2003). Clement *et al.*(2003) first highlighted the likely relationship between agrobiodiversity and ADE. A major interest in studying Homegardens on ADE is because they may contain patterns of agrobiodiversity or concentrations of certain species and landraces that are different from those found in other homegardens. But studies of agrobiodiversity and homegardens on ADE are limited, and the data they produced is insufficient to conclusively show that agrobiodiversity is different on ADE than on other soils (Major *et al.* 2005a; Kluppel 2006). Divergent agrobiodiversity in other systems of land use on ADE as opposed to other soils has been demonsrated for weeds (Major *et al.* 2005b), multicrop fields (German 2001) and fallows (Junqueira *et al.* 2010). The purpose of this chapter is therefore to test the hypothesis, based on these previous studies, that there

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[27] Some women are more elaborate in their soil mixtures. Zenilda, from the Community of Terra Preta, always tries to locate semi burnt, rotting roots of a dead samaúma (silk cotten) tree (*Ceiba pentandra* (L.) Gaertn.), (a floodplain tree that is also an ADE indicator species). These are found within or adjacent on the edges of *roças*, the flames of the burn apparently strong enough to cause the roots of trees to burn. If samaúma is not avaiable, rotting wood from Tucumã or Inga are used as a subsistitute, but according to her they are not as good, as they dry out quicker. She also adds rotting acaí seeds and blue worms to the mixture. People like Zenilda, who live on ADE sites, also mix in handfuls of ADE to their *canteiros.* Soil to raise seedlings (*muda*) of trees or plants also made in a similar way.

will be different patterns of agrobiodiversity in homegardens located on ADE when compared to those located on Oxisols and in the Floodplain.

6.1 Sítios and *Caboclo* Subsistence on different kinds of soil

During the course of research it became apparent that *sítios* on different soils tended to feature different species assemblages. *Caboclos* themselves were the first the point this out. *Sítios* in ADE, they said, have more Orange, Cacao, Avocado and Plantain than *sítios* on Oxisols. People with *sítios* on Oxisols, frequently complained that they were unable to plant more nutrient demanding species such as Orange and Plantain. People with *sítios* in the floodplain generally focus on plantain and cacao monocrops, given the high fertilty of these soils, coupled with prime market access confered by positioning of the *sítios* in communities located on the Madeira Floodplain (see Maps 1 and 3). The type of soil on which a *sítio* conditions the species that can be cultivated in it, the species assemblages which emerge in turn shapes different patterns of species use, and therefore different patterns of *Caboclo* subsistence.

Other influences on the species assemblages of *sítios* include market demands, and the availability of industrial goods. Trees and shrubs such as Rubber, Coffee and Cupuaçu were widely planted in homegardens during the periods in which there were market demands for them. Coffee was also planted for subsistence use, but this is now rare, owing to the availability of cheap industrial coffee. Similarly, sugar cane was once much more widely cultivated for subsistence use, the availability of cheap processed sugar has led to a reduction its subsistence cultivation. Therefore, species assemblages in *sítios* emerge from the interaction of soil affordances, plant responses and Caboclo agency or creativity with the exigencies of market and subsistence over time. They have been differentially shaped by the changing subsistence requirements of successive generations.

6.2 Communities and Homegardens included in the Study

Species inventories were elicited from the memories of the inhabitants of 63 homegardens (22 ADE, 21 Floodplain, 20 Oxisol/Ultisol) covering a total of 131 ha (ADE 38 ha, floodplain 54 ha, non-ADE 39 ha) in 16 communities. The homegardens included in this study were typically located in communities of low population density. This is because these were found to be the largest homegardens. In communities of high population density (such as Barro Alto), homegardens tended to be small, with many of the homegarden trees gradually being removed to make way for houses. Only homegardens over 1 hectare in size were included in the study. Relationships were developed with participants in this study over the course of two years of ethnography in the region. The quantitative phase came later, once trust had been established and once a general understanding of each community and its history had been attained. People were asked to list all the plants in their homegardens in a free listing exercise (see section 6.3.1.1).

While ideally homegardens on all the three soil types located at the same communities would have been included in the study, this was not possible. This was because at most *terra firme* communities, the majority of homegardens are located on either ADE or Oxisols, and while some communities have relatively equal numbers of homegardens on both of these soil types, no *terra firme* communities have inhabitants with homegardens in the floodplain. Because of this need to include different communities, efforts were made to minimise the effects of differential market access on homegardens. In the Amazon - a world of rivers - transport is entirely water-bound and distance to market takes on a different meaning to that of regions where transport is primarily by road. Seasonal fluctuations in water levels effects distance to market strongly in riverine and lacustrine landscapes. On the Middle Madeira River, the best placed communities in terms of ease of access are therefore the floodplain communities, located along the main channel. For *terra firme* communities located on tributaries and lakes, access can be difficult during the dry season, when water levels can be drastically reduced. The principal economic actors of the region are the large ferries that constantly travel up and down the Madeira, between the Cities of Manaus and Porto Velho, stopping along the way at Humaitá, Manicoré, Novo Aripuanã and Borba, and also at many of the floodplain communities along the Madeira. The majority of agricultural produce is bought by these traders, and sold in the urban markets of Manaus and Porto Velho. These ferries have lasting relationships with communities, engage in credit-debt relationships, and in turn community loyalty is expected. Therefore distance to market cannot be measured simply by distance to Manicoré. Manicoré itself is of much lesser importance as a market center than Manaus or Porto Velho. Its population of 20,000 cannot absorb much of the market produce of the region. In terms of market access it is much more important to the rural population because of its ferry port, where almost all ferries stop. Ferries only stop to trade at certain regular locations; usually (but not always) relatively large, long-term communities with good ports. The residents of these communities sell their produce collectively. People from communities close-by but located off the main channel invariably have relatives in the port of call, and take their produce there to be sold. As well as these larger ferries, smaller operators ferry people and goods to and from Manicoré, as well as further afield to other towns of the interior such as Humaitá[28]. The key variable of market access would therefore be *seasonality of access to major waterways.*

In order to compare the market access of each community, a simple ranking was devised. Firstly, based on interviews with locals at each community, market access was categorized as either good, medium or poor. Good market access was attributed to the communities in the floodplain, on the North Bank of the Madeira River, and on the lower Manicoré River, where seasonal changes in the levels of the river do not have a drastic effect on market access. Medium market access was attributed to communities removed from the main channel but still able to access it year round with water-borne craft (such as Capanãzinho), and those higher up the Manicoré River, where there are ferries, but not as regularly as on the main channel. Poor market access was attributed to communities (in this case Barreira do Capanã and Boa Vista) that for around four months per year have little or no access to river transport because of rivers and lakes drying up in the dry season. In order to compare the market access of each soil type, a simple calculation was performed where good market access scored 3, medium 2, and poor 1. When summed the total score for each kind of soil was as follows (the higher the score, the better the market access): Floodplain, 63, Oxisols 39 and ADE 43. From

[28] These are diverse operations, some of these are small traders of goods only, in the classic regatão sense, paying for local produce in cash or industrially produced goods, others are simply ferries, while many perform both tasks. Again, some traders have deep and even politically motivated relations with communities, such as Arlindo who operates on the River Manicoré. He is running for the position of town councilor on the strength of his community relationships.

this we can conclude that while the homegardens in communities located on Oxisols and ADE have a similar overall access, homegardens in the Floodplain have a significant advantage (Table 29).

On the Manicoré River, homegardens included in the study were located at Terra Preta (5 ADE), Barro Alto (3 ADE) and, Estirão (3 ADE). At these communities *all* homegardens were located on ADE, meaning no Oxisol homegardens could be included for comparison. At Esperança where most homegardens are located on Oxisols, 8 homegardens were included. Communities on the lower reaches of the river Manicoré (Estirão and Esperança) have good market access while those further up (Barro Alto and Terra Preta) have medium market access.

Table 29 The communities in which homegarden data were collected on the Middle Madeira River in the Municipality of Manicoré, Amazonas State, Brazil

Community	**Market Access**	**Number of Homegardens**		
		Floodplain	*Oxisols*	*ADE*
Terra Preta	Medium			5
Barro Alto	Medium			3
Estirão	Good			3
Esperança	Good		8	
Capanãzinho	Medium		3	
Barreira do Capanã	Poor		2	7
Boa Vista	Poor		1	1
Monte Sião	Good			2
Água Azul	Good			1
Braço Grande	Poor		4	
Repartimento	Poor		2	
Verdum	Good	5		
Amparo	Good	1		
La Delicia	Good	4		
Genipapo	Good	8		
Porto Seguro	Good	3		

On the North bank of the Madeira upstream from Manicoré, homegardens at the following communities were included: Água Azul (1 ADE), with good market access, Monte Sião (2 ADE) with good access to market. Boa Vista (2 ADE, 1 OX), Barreira do Capanã (7 ADE, 2 OX) with poor market access and Capanazinho (3 OX) with medium market access. Homegardens at Barreira do Capana and Boa Vista have poor access to market because while these communities used to be on the main channel of the Madeira, they are now located behind a seasonal lake owing to a change in the course of the main river channel 30 years ago. This lake dries up in the summer (from August to December) making access during this period difficult.

It was necessary to include several other communities in order to include more Oxisol and floodplain homegardens. This was because there were too few Oxisol homegardens of sufficient size in the communities located on ADE sites. The Oxisol homegardens included were Braço Grande (4) and Repartimento (2) on Lake Genipapo, with poor market access, because the lake dries up during the summer. These were included because they had large homegardens suitable for comparison with ADE homegardens, and relatives of informants in other communities lived there, facilitating access and trust. Downriver from Manicoré the homegardens of the Floodplain communities of Verdum (5), Amparo (1), Delicia (4), Genipapo (8), Porto Seguo (3), all with good market access were included. These localities were chosen because they are the oldest floodplain communities in the municipality, with large homegardens because the high floodplain is very wide at this point in the course of the River Madeira. Many of the floodplain communities upriver from Manicoré have very small or non-existent homegardens because of the limited extent of high floodplain.

6.3 Culturally Salient Biodiversity Indicies

In the biological sciences, biodiversity is measured through the use of transects, where all species within a circumscribed area are manually counted and measured by the researcher. This would give the most accurate information on species composition. However, given the time constraints of ethnographic field research, this was not possible. This chapter draws on two measures of culturally salient agrobiodiversity, that mimic the standard biodiversity indices species richness (number of species) and density data (number of individuals of each species). The information was gathered by asking participants which species they had in their homegarden, and how many of each. This in effect is richness and density of *culturally salient species*, and both measures therefore under-represent culturally unimportant species. This method will, of course, only reveal the species that *Caboclos* consider to be part of the homegarden, and not for instance those species that may fall inside the space of the homegarden, but are considered by them to be fallow species. While such data can never be as accurate as that yielded by transects, it is accurate enough to reveal the major patterns of species that predominate in homegardens on each kind of soil, which is our interest here. This data was validated by interviewing different residents of the same homegarden on different occasions, and/or by conducting interviews with several residents simultaneously; and checking the data against field observations in the homegardens themselves, against local narratives on which species usually predominated in homegardens on different soils, and agronomic information (whether or not certain species require fertile soils to grow and/or yield fruit). This validation revealed that people have remarkably accurate knowledge of the homegardens that they inhabit. This is because these are the spaces that they have grown up in, collected fruit from trees as children and adults, first for enjoyment, later for subsistence, barter or sale. They walk around these spaces daily, managing them, using certain individual trees to hunt animals that come in search of fruit. Furthermore, they are normally fully literate and are often required to know how many trees are in their homegarden in order to value their property.

6.3.1 Methods: Measuring culturally salient agrobiodiversity

The following quantitative measures of culturally salient agrobiodiversity are compared in this chapter: Species Richness, Density and Area Coverage per Hectare. Species Richness is the standard measure of biodiversity (Gaston and Spicer 2004) and is also the most widely used in homegarden studies (Padoch and de Jong 1991; Coomes and Ban 2004; Perrault-Archambault and Coomes 2008). It means simply how many different species there are in a circumscribed area. As noted above, the main limitation of species richness is that it does not account for the number of individuals of each species. When we count the number of individuals, we get a measure of the relative *dominance* of each species in the ecological community (in this case the homegarden) as a whole. In most ecological contexts, homegardens included, a small number of species are most numerous and/or form the bulk of biomass. These are known as "dominant species" (Tansley 2003; Begon *et al.* 2006; Chapman and Reiss 1999). Most ecological communities are defined by their dominant species, and homegardens are no exception. In order to identify whether there are patterns of agrobiodiversity, we need to focus on differences in species dominance of homegardens. Definitions of species dominance stress those species that are: a) most numerous, or b) form the bulk of the biomass. As a measurement of dominance, species density only takes account of the former, while the new measure presented here “species area per hectare” takes account of both. Species density constructs dominance only in terms of number of individuals and not biomass area. Species area per hectare factors in the biomass of the species and the homegarden area, taking the number of species in a homegarden, dividing by the size of the homegarden, before multiplying it by the estimated size of the inner crown of the species, to give the area coverage per hectare for each species.Why is species area per hectare a useful comparison to species density as a measure of dominance? Homegardens often feature diverse multi-strata combinations of plants of trees, encompassing a wide variety of species differing in size, life-cycle and uses and management practices as performed by homegarden inhabitants. Homegarden species vary greatly in size, ranging from very small, such as sugar cane (*Saccharum officinarum*), with a crown surface area of $0.2m^2$ right up to the very large Brazil-nut (*Bertholletia excelsa*) with a crown surface area of $78m^2$. Species Density as a measure of dominance does not take account of the size of individuals, and this has the effect of inflating the relative dominance of smaller species. Species with the highest density in ADE and Oxisols are coffee (crown surface 3.1 m^2) and açaí (crown surface 12.5 m^2) while the highest area per hectare is for Brazil nut (Table 35). This is because while there are more individuals of coffee and açaí, in homegardens, the individuals belonging to the species Brazil nut are far bigger than those of the species coffee and açaí. Smaller species tend to be planted in greater quantities, as their production tends to correlate to their size. To achieve the equivalent production to a single mature Brazil nut tree, a farmer needs to plant many more açaí or coffee plants. Species Area per Hectare factors this in, while species density does not. As a measure of homegarden agrobiodiversity therefore, Species Area per Hectare is superior, because it weighs species in terms of their size, giving larger species greater weight. This takes account of the greater production of larger species, and the fact that farmers need to plant and/or manage less individuals of these species to achieve a production equivalent to many more individuals of a smaller size. For instance, a few thousand sugar cane plants appears highly significant in terms of species density, but when their size is factored in, their species area per hectare is insignificant, which more realistically represents the fact that significant amounts of sugar cane are not planted in homegardens. Going on species density alone, it would appear that sugar cane is a significant element of homegardens, which it is not.This chapter incorporates the novel measure species area per hectare and compares it to the more traditional measures species richness and density.

6.3.1.1 Culturally Salient Homegarden Species Inventories

Inventories of culturally salient homegarden species were constructed using the following questions i) *Which plants are there in your homegarden? (Richness)*, ii) *How many are there of each?(Density)*[29].The area per hectare (Aha) for each species in each homegarden was calculated by summing the individuals of each species and then multiplying by the species' crown size, and then dividing by the area of the homegarden.

$$\text{Aha} = \frac{\text{sum si x CrSize}}{\text{Ahg}}$$

Where s_i are the individuals of species x, and Ahg is the homegarden area. Average crown size is estimated from plantation spacing recommendations: i.e, if recommended spacing is 4 x 4 m, the crown radius is 2 m, radius squared and multiplied by Pi yields the crown surface area of 12,56 m^2. Evidently, species Aha is a rough estimate, as individual crown sizes were not measured due to time constraints. Comparing the overall Aha in different soil types gives an indication of how dense or multilayered homegardens are.

The Shannon Biodiversity Index (H') was calculated for Culturally Salient Species Density and Area per Hectare for homegardens in each soil type. The advantage of the Shannon index is that it takes into account the number of species and the evenness of the species present. A homegarden that is rich in species, but only has a few individuals of most species, and large numbers of individuals of a only a few species will be uneaven and score low. The index is high for homegardens that exhibit larger (but roughly equivalent) numbers of individuals of many species, because species evenness

[29] Plants that served strictly medicinal purposes were omitted to avoid issues of access to traditional knowledge associated with Brazilian biodiversity laws. While homegardens are rich in medicinal species, they occupy only a very small area of the homegarden. Their omission is not important for the purposes of this study because the study is concerned with wider patterns of agrobiodiversity in different soils, rather than the presence or absence of a few individuals of certain species, for which soil fertility constraints can be overcome by planting in raised beds.

will be greater. The higher the index, the greater the agrobiodiversity.The Shannon Biodiversity index is calculated with the following equation (Krebs 1989)

$- H' = -\Sigma\, pi(\mathrm{Ln}\, pi)$ and $pi = ni/N$

Where *ni* is either the Density or Area Coverage per Hectare for each species, and N is the total density or area coverage for all the species of the homegarden.

Two different methods were employed in order to compare the relative similarities and differences of the species assemblages in homegardens in each soil. These were non metric multi-dimension scaling (Borg and Groenen 2005) and similarity percentages analysis (Clarke 1993). Non-metric multidimensional scaling (MDS) is a set of statistical techniques often used to visualize information in order to explore similarities or dissimilarities in data. MDS is a form of multi-variate analysis that uses ordination, a method complementary to data clustering used mainly in exploratory data analysis (as opposed to hypothesis testing). Ordination orders objects (in this case homegardens) that are characterized by values (Species Assemblages) composed from multiple variables (Species Richness, Density and Area per hectare) so that similar objects are closer to one another and dissimilar objects more distant from one another. These relationships between the objects, on each of multiple axes (one for each variable), are then characterized numerically and graphically. Non-metric multidimensional scaling is an ordination technique that is based on a distance matrix computed with different measures of distance. The measure of distance employed here is Sørensen (Bray-Curtis) (Sørensen 1948). If there are patterns of culturally salient agrobiodiversity, the symbols for homegardens in each soil type should cluster together.

The SIMPER (Similarity Percentages) method seeks to understand how much each species contributes to the average similarity or dissimilarity between two groups (in this case, soils). It does this by creating a triangular similarity/difference matrix, and using this to compare the relative similarity and difference of richness, density and area coverage per hectare of each of the homegardens in the different soils. The method first compares similarity among homegardens in the same soil type (for each of richness, density and area per hectare) the higher the score, the greater the similarity, before looking at difference between homegardens in different soil types (for each of richness, density and area coverage per hectare), the higher the score, the greater the difference (Clarke and Gorley 2006).

6.4 Homegardens in Different Soils on the Middle Madeira

This section discusses and compares the general characteristics of species assemblages in homegardens (including some of the most important species) on Oxisols (6.4.1), in the floodplain (6.4.2), and ADE (6.4.3) in turn. Section 6.4.4 then presents more statistical comparisons.

6.4.1 Oxisol Homegardens

The Oxisol homegardens featured in this study - located on the upland *terra firme* bluffs of the Madeira River, Manicoré River, and Genipapo Lake - are standard features in rural areas of Central Amazonia. These homegardens and the opportunities they afford for livelihoods serve as a baseline against which to compare homegardens on floodplain and ADE soils. The most important and/or predominant species on Oxisol homegardens of the Middle Madeira are the fruit and nut trees Coffee, Brazil nut and Cupuaçu, the latex yielding Rubber, and the palms Açaí, Bacaba, Peach Palm and Tucumã, Of these species, Açaí, Brazil-nut and Tucumã are of significant economic importance to livelihoods Figure 18, Table 31.

The Brazil-Nut tree (*Bertholletia excelsa*) is a very common element of the upper-story of *terra firme* homegardens, but appears not to grow in the floodplain. Brazil-Nut groves occur throughout the Amazon Basin and their distribution has been associated with human settlement patterns. This species was probably an important food source for pre-Columbian populations, and continues to be so today. After conquest, the Brazil nut became an important element of the extractive economy and today gathering Brazil-nuts continues to provide an important source of income, and visits to sometimes distant *castanhais* (brazil-nut groves) are a regular livelihood activity during the rainy season. An important stimulus for this activity in recent years has been the form of the agro-extractivist cooperative of Manicoré. This pays a higher price for Brazil-Nuts, cutting out the exploitative middle men or bosses. On the Middle Madeira, Nuts are consumed raw, roasted, mixed with the flour when making *tapioca* or *beijú*, are used to make sweets and porridge, and used to make a sauce to accompany meat or fish. The tree has several other uses the bark is medicinal and its fibers are used to waterproof canoes, the exocarp of the fruit is burned in ovens, when trees fall down (or sometimes cut) the wood is used for construction. The bark is said to be medicinal and used to treat inflammation of the uterus.

Açaí do Amazonas (*Euterpe precatoria*) is a palm fruit that is consumed in the form of a deep red liquid, locally known as 'wine,' that is made by removing and pulping the thin layer of fruit which surrounds every seed in water. Its use appears to be ancient, indicated by carbonised seed remains at early archaeological sites (Morcote-Ríos 2008; Mora 2003). In recent years Açaí has become extremely popular with the urban populations of small interior towns such as Manicoré (where Açaí is so popular demand frequently outstrips supply), in the Amazon cities of Manaus and Belém, in southern Brazil, and more recently in the United States and Europe. This has stimulated rural dwellers to plant more Açaí in their homegardens. Today the main use of Açaí is to make wine for subsistence use and sale. The seeds after processing are often used as fertiliser.

Cupuaçu is a relative of cacao, and is also a very common element in Amazonian homegardens. The two species are botanically close but dissimilar in product technology and market. While it has been a feature of subsistence since pre-Columbian times, the fruit was not widely propagated as the Cacao, nor was it important in early colonial forest product extraction. The fruit pulp of Cupuaçu is commercialised but needs cold storage. There is a market for fruit pulp-juice for distant countries needs this storage technology, which is not readily available in more remote regions of the interior such as Manicoré. Its seed which is very similar to cacao beans – yet the fruit pulp is quite different, can produce a sort of (pseudo)-chocolate, but there is not yet a good market for that product, thus the beans are thrown away. This market is much more recent than that of cacao and consequently is still in development (Van Leeuwen pers Comm). Cupuaçu was domesticated in the pre-Columbian era and has its centre of genetic diversity in Western Amazonia (Clement Pers Comm.). Today on the Middle Madeira it is sometimes sold when there are buyers, but most generally used to make fruit juice.

The Tucumã (*Astrocaryum aculeatum*) palm is a common feature of swidden-fallow mosaics throughout Amazonia. It is also present in many homegardens. It is an invasive pyrophyliac plam, but highly valued for Its golfball sized seed surrounded by a starchy mesocarp, which is widely consumed both in rural areas and in the city where it is seen as an authentic caboclo foodstuff. This urban demand means that sale of the seeds is an increasingly worthwhile livelihood activity.

The Bacaba palm that is most common on the Middle Madeira is *Oenocarpus minor*, a slender, shorter variety which contrasts with the taller, thicker trunked *Oenocarpus bacaba* most common to other Amazon regions. Bacaba is another very common homegarden palm. It is presence is a result of both conscious planting and propagation by animals. It yields a seed covered in a thin fruit pulp, and is processed the same way as Açaí, and also consumed as a 'wine'. Its use is mainly for subsistence consumption however, as the preference of urban consumers for Açaí limits the commercial potential of bacaba.

The relative lack of other important economic species appearing in the more fertile soil types (Plantain, Cacao and Orange) can be attributed to restrictions inherent in poor soils, rather than lack of trying. People were found to be willing to give any species a try, but were often disappointed when species such as Orange and Cacao failed to yield. The presence of some more nutrient demanding crops such as Banana can be explained by mulching and ash and charcoal additions and planting on the banks of rivers or lakes (such as the River Manicoré, or Lake Genipapo) which are more fertile owing to occasional inundation by water that has received washes of whitewater from the Madeira River.

The homegarden species that figure most centrally in the livelihoods of the inhabitants of Oxisol homegardens are Acaí, Brazil-nut, Lime, Tucumã, Cupuaçu, Banana and Peach Palm. These species were both observed to be widely used during ethnography, and have higher culturally salient species area per hectare. Rubber is widespread because of planting during the boom, but little used owing to the current low prices. The palms Inajá and Palha Branca are widespread because they are aggressive volunteers, but little used compared to other homegarden species. Coffee is also widespread because homegarden production once provided for subsistence consumption, but the use of this species has decreased owing to the availability of cheap industrial coffee Table 31. Oxisol homegardens lack the widespread cacao and plantain of floodplain homegardens because these species do not grow well in these soils, despite many attempts to plant them.

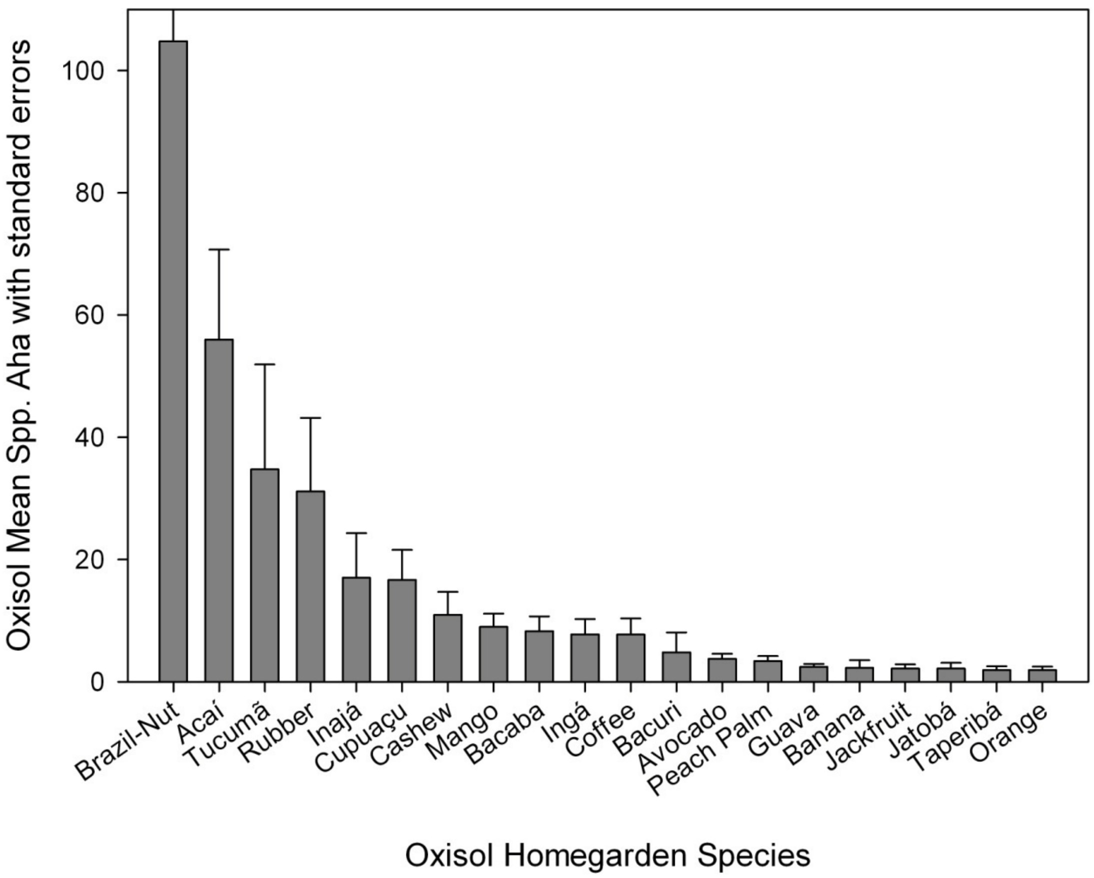

Figure 18 Mean Species area per hectare for the twenty most predominant species in 20 Oxisol homegardens on the Middle Madeira River, in the Municipality of Manicoré, Amazonas State, Brazil. Note that two outliers, Jutai Pororoca and Palha Branca, present in large numbers in a single homegarden each, were removed from the chart because their inclusion would give the impression they are common homegarden species.

6.4.2 Floodplain Homegardens

The advantage of floodplain soils is that they are highly fertile, which allows cultivation of nutrient demanding annual crops and trees, if these species have short life cycles or can withstand some flooding, respectively. Floodplain homegardens on the Middle Madeira River are dominated by two important economic species: Plantain and Cacao, Figure 19, Table 31. There are as much as ten times the numbers (density) of these species as other homegarden plants. This is an outcome of both high fertility and position of homegardens on the main channel of the Madeira that gives optimum market access. Other important species commonly grown in the floodplain include Açaí, Peach Palm and Coconut.

Cacao (*Theobroma Cacao*) is an ancient floodplain crop, having been transplanted from the *terra firme*, it came to dominate floodplain forests long before Europeans arrived. Cacao originates in the Andean foothills of Western Amazonian in southern Colombia and northern Ecuador in the river valleys of the Napo and Putumayo. This region is endowed with better soils as they are located in the Andes with influence of nearby volcanoes (Clement Pers. Comm.). The early Spanish chroniclers reported many large cacao groves along on the floodplain lining the banks of the river Amazon (Patiño 1963; Acuña 1942; Bartley 2005). A recent review of historical evidence of cacao cultivation concluded that it was widely planted in the floodplain by Indigenous peoples (Smith 1999). In early colonial times, cacao extraction by native labour was an important economic activity for the Portuguese crown. In the year 1730 cacao had become the region's principal export, and continued to be so for more than a century (Alden 1976). Today cacao is an important source of income and is also used to make chocolate and fruit juice.

Plantain (Musa Spp.) was one of the first crops taken to the New World during the European conquest, and were quickly adopted by Amerindians. In some cases bananas arrived before the European explorers themselves: the Yanomamo tribe of northwestern Amazonia adopted bananas and they became their staple subsistence crop (Clement 2004). Owing to this circulation they quickly became major components of subsistence. Tellingly, one of the contemporary Amazonian names for plantain – *Pacovão* –is actually a Tupi word (Keller 1874). The economic ascendance of Plantain as a cash crop is a much more recent phenomenon, occurring as little as twenty years ago. Plantain is now the most important floodplain crop. It is sold and eaten, raw when ripe, fried or boiled while still green. Much of the area of many sites visited consisted of monocrop plantations of one or both of these species and their predominance makes floodplain homegardens the most economically oriented of all homegardens. Floodplain homegardens are highly specialized in these two crops, which are central to floodplain livelihoods.

Peach Palm (*Bactris gasipaes*) or *Pupunha* as it is known in Brazil is the only fully domesticated palm species of south America. Domesticated in south-eastern Amazonia, it has been an important source of dietary fats and protein for Amazonian peoples for thousands of years. It is well adapted to poor Oxisols, but thrives on better soils such as those of the Floodplain and ADE (Clement *et al.* 2008). Today Peach Palm is consumed and increasingly sold. It is an authentic Caboclo foodstuff, and along with Tucumã and Acaí, is very popular amongst urban populations. On the Middle Madeira it is eaten after boiling and sold. A flour made by grinding up boiled fruits is sometimes produced.

Coconut (*Cocos nucifera*) originates in the Indo-Malayan region of South-East Asia, the coconut palm reached Amazonia long before the Europeans. Today it is a reasonably common element of homegardens in central Amazonia. Coconuts are popular in the cities, sold for 2 reais per nut. Producers receive 1 real per nut (30p). Owing to a burgeoning urban demand, Coconut is becoming an increasingly important market crop. While it does grow on Oxisols, it produces better on ADE and in the Floodplain, according to local farmers.

A great limitation of floodplain homegardens is their vulnerability to inundation when there is a high flood. Floodplain homegardens are always located on the high floodplain, or *restinga*, which floods once every ten years or so; when this happens it can kill many homegarden species in a matter of days. While some species (such as Cacao and Mango) can survive the occasional flood, others (such as Plantain and Orange) cannot. This risk of flooding is likely to be responsible for the relative lack (when compared to ADE) of other important species, such as Orange and Avocado, both of which are easily killed by flooding, and take years to reach maturity when replanted. Other species, such as the Brazil nut and Tucumã palm, are completely absent from floodplain homegardens. Floodplain homegardens exhibit the lowest species richness of the three soil types, and this mirrors a trend noted for floodplain forests, which when compared with upland *terra firme* forests tend to exhibit low biological diversity, with dominance by one or two species, often of high economic value (Anderson et al. 1995).

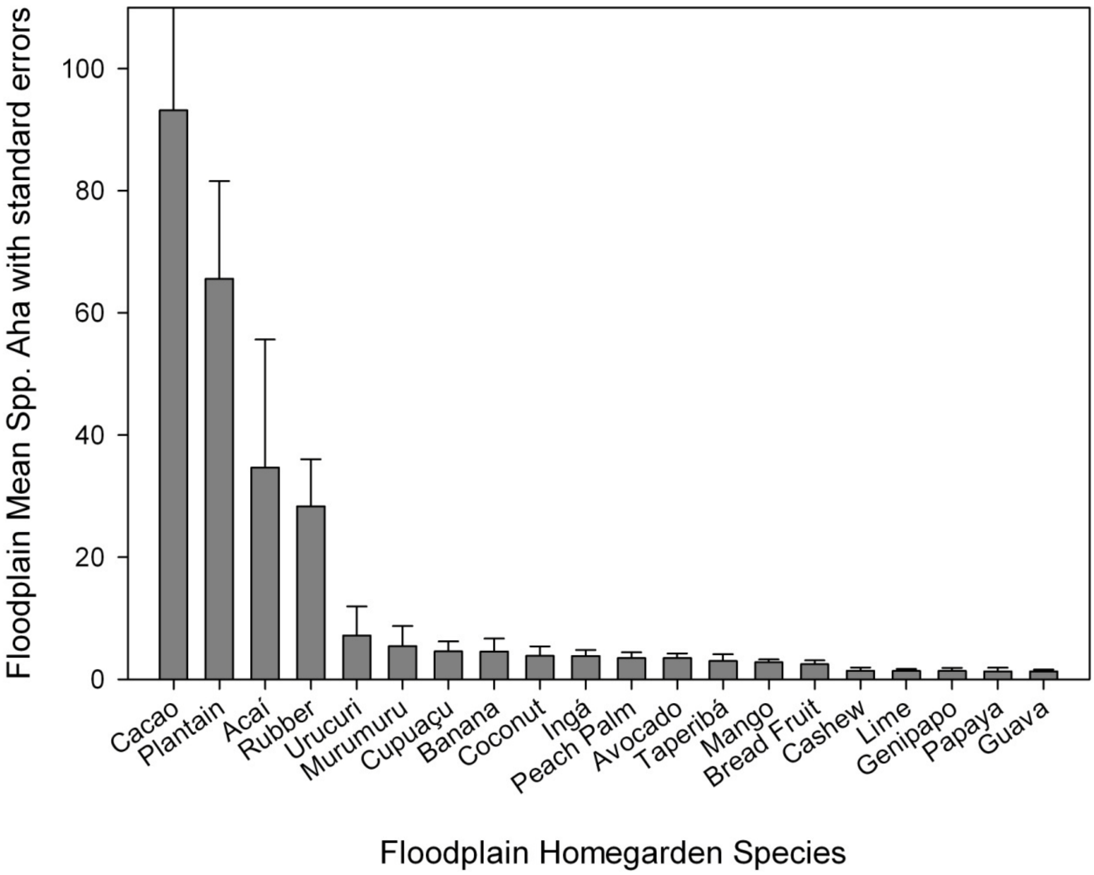

Figure 19 Mean Species area per hectare for the twenty most predominant species in 21 Floodplain homegardens on the Middle Madeira River, in the Municipality of Manicoré, Amazonas State, Brazil. Note that one outlier, the timber species Cedro, was removed from the chart as it was present in one homegarden, and therefore its inclusion would give the impression it was a common homegarden species.

6.4.3 ADE Homegardens

The first notable thing about ADE homegardens is that they some of the most important species of Oxisol homegardens; Brazil Nut, Coffee, Açaí, with those of the floodplain, Plantain, Cacao, and Coconut, and others such as Avocado, Orange, Lime and Papaya which are most common in ADE, Figure 20, Table 31. It has often been argued that ADE contains more exotic species than Oxisols (Clement *et al.* 2003; Kluppel 2006; German 2001; Major *et al.* 2005a). This is the case for Plantain, Avocado, Coconut and Orange and Lime, which are much more abundant on ADE than on Oxisols. This is certainly because all these species require soils of a higher fertility to yield well, and are intolerant of flooding. Other exotics, such as Mango, appear with similar frequency in all types of soil. Coffee is also equally prevalent on ADE and Oxisols, but less frequent in the floodplain. Overall, there are significantly greater area per hectare of Old World Crops in ADE and the Floodplain compared to Oxisols, Table 30

Of the native Amazonian trees, Brazil-nut is abundant on ADE. It is an indicator of anthropogenic disturbance, and grows better in open (e.g. cleared) spaces. It is even more abundant on Oxisols however, suggesting that in this case, fertility does not affect its distribution. Cacao on the other hand, is significantly more abundant on ADE than Oxisols. While cacao is a native Amazonian crop, it has greater nutrient demands than many of the perennial fruit trees that grow in poor acid soils of the Amazon and while production is possible on Oxisols, better soils are preferable (Cabala-Rosand 1989:409; cited in Kawa 2008). On the Lower Madeira in the municipality of Borba, Nick Kawa found 71.4% of ADE homegardens contained cacao while 30.8% of non-ADE farms planted the fruit.

Another important difference between ADE homegardens and the others is in the amount and diversity of both staple root crops and supplementary food crops found in ADE gardens. Bitter manioc was present in around 20% of the homegardens, and Sweet Manioc in 25%. At Água Azul and Boa Vista, residents claimed to have been planting both Bitter and Sweet Manioc in ADE for decades, with only months of fallow between croppings, with little loss in yield. Supplementary food crops are also more present in ADE than on other soils. While floodplain homegardens contain the greatest abundance of economic species, in the form of extensive plantations of Plantain and Cacao, ADE contain the greatest diversity of economic and useful species, including the most important of the floodplain, non-ADE upland soil species, and others such as Orange, Coconut and Avocado, which are most abundant in ADE.

Avocado (Persea Americana, Mill) is a major tropical fruit, and is thought to have been among the first to be domesticated in the Neotropics. Archaeological traces of this tree have been found in Tehuacan valley, Puebla, Mexico and dated to 8,000-7,000 B.C. and possibly domesticated since 6,400 (Galindo-Tovar 2008). P. Americana had spread throughout Mesoamerica had spread into north-western Amazonia by the time of conquest. Avocados have been referred to as the most nutritious of all fruits (Purseglove 1968). Approximately three quarters of an avocado's calories come from fat (most of which is monounsaturated). Avocados also have 60% more potassium than bananas and are rich in B vitamins, vitamin E and vitamin K. They also have the highest fibre content of any fruit. Avocados are important subsistence resources. On the Middle Madeira P.Americana is eaten raw and in the form of "*abacatada*" (beaten and mixed with sugar). It is also sold in local markets. Various medicinal uses were recorded, using the leaves and the seed. A tea made from boiling its leaves is said to cure anemia, be good for the liver, blood and "rin." It is also used as a calmant. The ground up seed is used to heal wounds, inflamations and rin, upset stomach, diarrea, stingray stings, "amerilão," snakebite, inflamed uterous, diuretico. The leaves are also used in making medicinal water for bathing babies.

Orange (*Citrus sinensis*) was introduced to central Amazonia during the beginning of the colonial period, and quickly became a common element of homegardens throughout the region. Today on the Middle Madeira the fruit is eaten and used to make fruit juice, and is an important cash crop. Furthermore it is said to have medicinal properties by many informants. A tea made from the leaves is said to cure fever, and the bark to cure stomach ache. A tea made from the root is said to cure fever. The second (inner) layer of bark is ground up in water and used to wash cuts. To seal the wound, the bark is applied after being ground up into dust. Orange only yields well on ADE on the Middle Madeira.

Lime (*Citrus limonia*) is used on a daily basis by most Caboclo families to *lavar peixe*, literally: wash the fish. The purpose of this is to mask the smell of the fish which people find distasteful. Similarly it is used to wash bush-meat, again to disguise the smell that the meat develops after days of being kept. Limes are used to make lemonade. Limes are also sold, as there is a large demand for them from people living in urban centers for the same purposes of fish preparation. Lime juice is also used for medicinal purposes; to treat colds, fever, diarrea and “amoebas.” Tea is made from leaves and this is said to treat stomach ache. The leaves are also used in making medicinal water for bathing babies. While Lime yields adequately in Oxisols, it produces much more in ADE. In the floodplain it grows well but is not flood-tolerant.

Papaya (Carica papaya) is a Mesoamerican fruit, domesticated in Yucatan, Mexico. It had spread throughout Amazonia well before the Europeans arrived. Papaya occurs spontaneously, especially on more fertile soils; propagated by birds. The tendency for Papaya volunteers to appear on Dark Earths is well documented (German 2001). On the Middle Madeira Papaya fruits are consumed raw, used to make desserts, and when green are boiled as part of soups. The fruits are also sold in local markets. The plant is also said to have medicinal properties. The seeds when consumed are said to treat stomach ache and vermin.

The most useful and important crops in the livelihoods of inhabitants of ADE homegardens are Açai, Plantain, Cacao, Brazil nut, Orange, Coconut, Papaya, Banana and Avocado. A greater usage of these species was observed and these observations are supported by species area per hectare data. Rubber is widespread because of planting during the boom, but little used owing to the collapse in prices. The plams Caiaué, Urucuri and Murumuru are widespread because they expand through ADE sites aggressively, but are used less than planted homegarden species present in similar quantities.

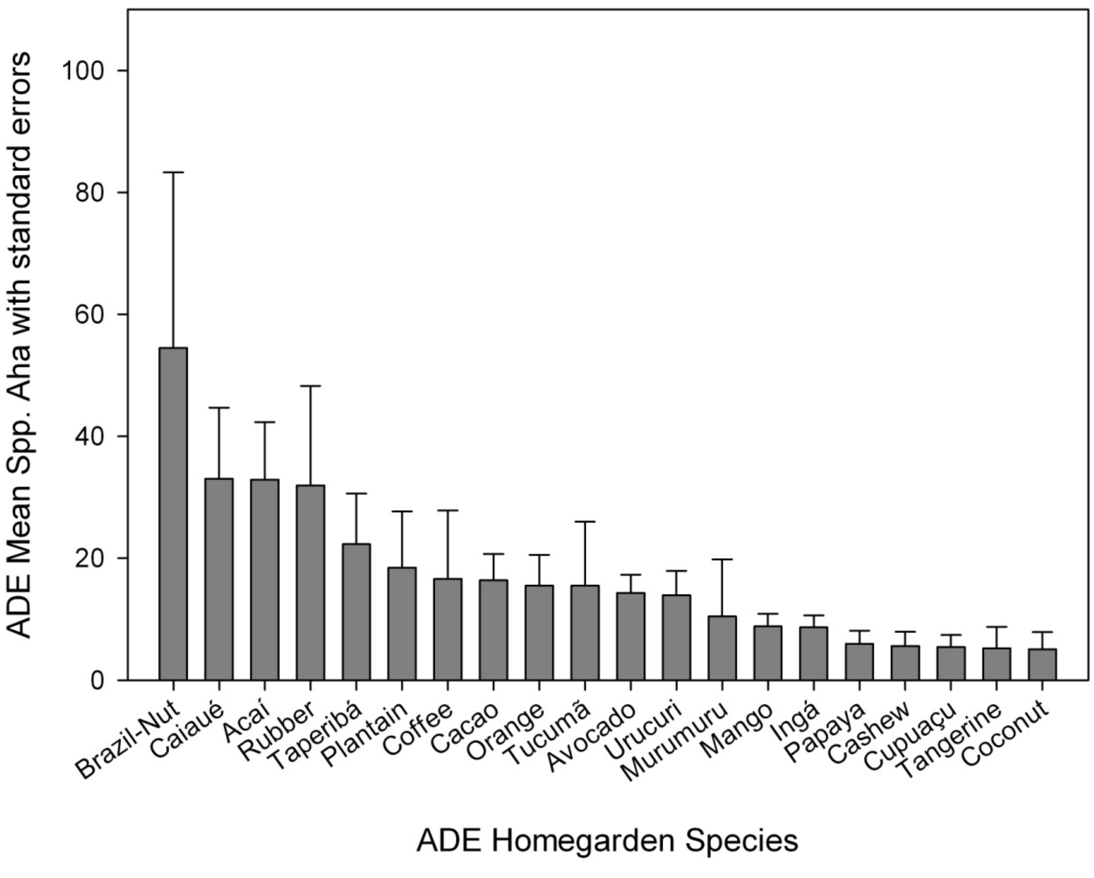

Figure 20 Mean species area per hectare for the twenty most predominant species in 22 ADE homegardens on the Middle Madeira River, in the Municipality of Manicoré, Amazonas State, Brazil.

Table 30 Mean, Standard Error and Median for Species Area Per Hectare of plant and tree species of South American, Meso American and Old World origins for homegardens on three kinds of soil on the Middle Madeira River in the Municipality of Manicoré, Amazonas State, Brazil.

Origins	**Floodplain**		**Oxisol**		**ADE**	
	Mean ± SE	*Median*	*Mean ± SE*	*Median*	*Mean ± SE*	*Median*
S. American	178.7 ± 49.8	108.5	360.4 ± 60.6	251.4	298.7 ± 58.7	206.3
Meso America	5.51 ± 0.99	4.6	15.2 ± 10.1	4.9	21.6 ± 3.2	19.6
Old World	90.8 ± 16.6	68.6	37.3 ± 6.1	23.2	85.0 ± 19.8	45.3

Table 31 Culturally Salient Species Richness (Rich) [number of homegardens a species is present in] Density (Den) (number of individuals) and Area per Hectare (Aha) for selected species found in 21 Floodplain, 20 Oxisol and 22 ADE Homegardens covering 54, 38 and 39 hectares respectively along the Middle Madeira River in the municipality of Manicoré, Amazonas, Brazil.

		Floodplain			Oxisols			Amazonian Dark Earths		
Local Name	**Scientific Name**	**Rich**	**Den**	**Aha**	**Rich**	**Den**	**Aha**	**Rich**	**Den**	**Aha**
Abiu	*Pouteriacaimito*	5	12	2.8	15	76	24.5	16	123	40.7
Abiu Guajara	*??*							3	5	10.3
Açaí	*Euterpe precatoria*	17	3280	763.3	19	3823	1231.8	19	2189	723.9
Acerola	*Malpighiaglabra*	6	21	2.7	3	4	0.7	5	13	2.4
Andiroba	*Carapaguianensis*	7	51	18.5	3	16	8.1	2	7	3.6
Araçá	*Eugenia patrisii*							1	3	1.0
	Psidium guineensis							1	1	0.3
Araçá-boi	*Eugenia stipitata*	4	8	1.9	5	14	4.5	5	22	7.3
Araticum	*Annona Montana*	1	1	0.4	10	20	10.1	10	37	19.1
Avocado	*Persea Americana*	19	146	76.4	15	114	82.6	19	423	314.7
Azeitona	*Syzygium cumini*	6	11	7.8	6	28	27.6	1	2	2.0
Bacaba	*Oenocarpus minor*	15	183	10.6	18	2259	182.0	17	771	63.7
Bacaba Grande	*Oenocarpusbacaba*							1	3	1.6
Bacuri	*Rheedia macrophylla*	11	35	18.3	14	146	105.8	18	147	109.4
Banana	*Musa Spp*	9	765	100.1	10	275	49.8	16	556	103.4
Batata	*Ipomoea batatas*							2	45	0.9
Biribá	*Rollinia mucosa*	13	51	18.5	10	35	17.6	15	81	41.9
Biriba da Mata	*???*							1	50	16.5
Bitter Manioc	*Manihot esculenta*				1	200	4.0	6	2100	43.3
Brazil-Nut	*Bertholletiaexcelsa*				18	1145	2305.8	15	580	1198.8
Bread Fruit	*Artocarpus altilis*	16	76	54.2				3	3	3.0
Buriti	*Mauritia flexuosa*	1	1	0.7	1	1	1.0			
Cacao	*Theobroma cacao*	20	8808	2049.7	10	89	28.7	21	1092	361.1
Cacao da Mata	*Theobroma speciosum*				1	50	16.1	8	52	17.2
Cacao de quina	*Theobroma mariae*				4	29	9.3	9	70	23.1
Caiaué	*Elaeis oleifera*	6	23	12.0				15	977	726.9
Cajuaçu	*Anacardium giganteum. Hanc ex Engl.*							1	1	1.3
Cana	*Saccharum officinarum*	1	10	0.0				2	45	0.2
Cará	*Dioscorea trifida*							2	95	2.0
Carambola	*Averrhoa carambola*	1	1	0.4				1	1	0.5
Cashew	*Anacardium occidentale*	12	43	30.6	15	244	240.8	14	122	123.6
Cedro	*(blank)*	1	200	142.5						
Chili	*Capsicum Spp*	11	1283	4.7				6	50	0.3
Coconut	*Coco nucifera*	17	119	84.8	6	16	15.8	11	110	111.4
Coffee	*Coffea Spp*	3	208	12.1	15	2110	170.0	15	4423	365.7
Copaiba	*Copaiba officinalis*				1	10	9.9			
Cubiu	*Solanum sessiliflorum*				1	10	0.2	1	30	0.6
Cuia	*Crescentia cujete*	8	30	7.0	4	4	1.3	8	59	19.5
Cupuaçu	*Theobroma grandiflorum*	19	276	100.4	20	729	367.0	19	231	119.4
Feijao	*(blank)*							2	60	0.1
Flesha	*(blank)*							1	30	0.2
Genipapo	*Genipa Americana*	13	82	29.8	7	24	12.1	10	33	17.1
Graviola	*Annona muricata*	11	50	18.2	5	9	4.5	7	37	19.1
Guabiraba	*Campomanesia lineatifolia*	9	24	5.6	3	3	1.0	5	20	6.6
Guava	*Psidium guajava*	17	122	28.4	19	167	53.8	16	330	109.1
Guava-Araçá	*Psidium guineensis*	2	5	1.2	4	17	5.5	7	28	9.3
Inajá	*Maximilana maripa*				8	516	374.1	2	10	7.4
Ingá	*Inga Spp*	17	160	83.8	16	235	170.4	16	256	190.5
Jackfruit	*Artocarpus heterophyllus*	12	22	20.5	12	37	47.7	6	18	23.8
Jambo	*Eugenia malaccensis*	15	49	25.7	13	31	22.5	6	68	50.6
Jatobá	*Hymenaeacourbaril*				11	48	47.4	12	94	95.2
Jauari	*Astrocaryum jauari*	1	1	0.4						
jutai-pororoca	*Dialiumguianense*				1	50	64.4			
Lima	*Citrus aurantifolia*	1	3	0.7				9	85	28.1
Lime	*Citrus limonia*	20	130	30.3	15	109	35.1	16	238	78.7
Lime Caiane	*Averrhoa bilimbi*							2	4	1.3
Mango	*Mangifera indica*	22	117	61.3	20	272	197.2	21	263	195.7
Maracuja	*Passiflora edulis*	4	233	3.4				3	21	0.4
Mari Gordo	*Poraqueiba paraensis*				1	1	0.7	2	2	1.5
Mari Vermelho	*Couepia subcordata*							1	1	0.5
Marmeleira	*Bunchosia armeniaca*							2	21	3.9
	Eugenia patrisii							1	2	0.4
Milho	*Zea Mays*							2	400	0.5
Mulateiro	*Calycophylum spruceanum*							2	54	71.4
Muruci	*Byrsonima crassifolia*							3	156	51.6
Murumuru	*Astrocaryum murumuru*	12	330	120.0	1	20	10.1	4	445	229.9
Orange	*Citrus sinensis*	12	61	22.2	13	83	41.8	18	660	341.0
Orange da Terra	*Citrus aurantium*							1	5	2.6
Palha Branca	*Attalea attaleoides*				1	200	197.4			
Papaya	*Carica papaya*	12	219	28.7	5	26	4.7	11	703	130.8
Peach Palm	*Bactris gasipaes*	18	211	76.7	17	147	74.0	12	54	27.9
Pineapple	*Ananas comosus*	3	18	0.3	5	305	6.1	3	53	1.1
Piquia	*Caryocar villosum*				1	1	1.3			
Pitanga	*Eugenia uniflora*				8	12	3.9	2	4	1.3
Pitomba	*Talisia esculenta*	1	1	0.0	9	263	5.3	14	160	3.3
Plantain	*Musa Spp*	20	11020	1442.5	1	50	9.1	10	2185	406.4
Purui	*Albertia Edulis*	6	29	3.8	15	208	37.7	12	261	48.6
Purui Grande	*Borojoa sorbilis*							3	43	14.2
Rubber	*Hevea brasiliensis*	16	2679	623.4	16	2126	685.0	11	2125	702.7
Squash	*Cucurbita Spp*	1	5	0.1				5	62	1.3
Sweet Manioc	*Manihot esculenta*				1	100	2.0	7	760	15.7
Tangerine	*Citrus reticulada*	3	7	2.5	9	73	36.8	11	223	115.2
Taperibá	*Spondias mombim*	8	126	66.0	10	58	42.0	19	659	490.3
Tucumã	*Astrocaryum aculeatum*				17	1054	764.1	8	458	340.8
Tucuma do Para	*Astrocaryum vulgare*							1	4	3.0
Urucum	*Bixa orellana*	4	5	1.2	10	69	22.2	3	7	1.8
Urucuri	*Attalea phalerata*	11	302	158.1	2	3	2.2	15	413	306.9
Uxi	*Endopleura uchi*				2	10	9.9			

6.4.4 Comparing Structural and Floristic Characteristics of Homegardens

The average sizes for homegardens surveyed were 2.6 ha in the Floodplain, 1.9 on Oxisols and 1.8 on ADE[30]. The greatest species richness was found in homegardens on ADE, significantly greater than that found in homegardens on Oxisols (F 5.5, p 0.024) or in the floodplain (F 8.4, p 0.006) which were not significantly different from one another (F 8.3, p 0.37), table 1. When compared to other studies of tropical homegardens (e.g. Kumar and Nair 2006), the mean species richness of each soil type on the Middle Madeira appears to be low. However, this is likely to be a result of the methodology, where informants' memory of their homegarden, rather than the homegarden itself, is quantified. The exclusion of medicinal plants, also lowers the mean species richness. These richness scores are therefore not directly comparable with other homegarden literature, where every plant was included, but demonstrate that the culturally salient species richness of ADE homegardens was significantly different from that of the other two soils.

The data in Table 32 show the clear differences between species density and species area per hectare in different soil types. The most salient difference is that while the Floodplain has the highest overall species density, we see that Oxisols and ADE have higher species area per hectare. From this we can conclude that the structure of vegetation of homegardens in different soils is quite different. The predominance of Plantain and Cacao in floodplain homegardens explain the species higher density, but smaller area per hectare of these species, because more individuals can be planted but take up less space in the homegarden. The higher mean and total area per hectare of Oxisol and ADE homegardens implies that these are more multi-strata in form than the Floodplain.

[30]All the homegardens in these communities on ADE of sufficient size (over 1 hectare) were included in the study. The homegardens included in this study were typically from areas of lower population density. This is because these were found to be the largest homegardens. In localities of high population density (such as the community Barro Alto), homegardens tended to be small, with many of the homegarden trees gradually being removed to make way for houses.

Table 32 Mean and Total Homegarden Culturally Salient Species Richness, Density and Area per Hectare for 63 homegardens in the Floodplain, Oxisols and ADE along the River Madeira, in the Municipality of Manicore, Amazonas State, Brazil.

Soil	Mean Richness	Mean Species Density	Mean Area per Ha	Total Species	Total Density	Total Area per Ha
Floodplain	23.8	63.3	12.8	52	31653	6375.1
Oxisols	25.15	35.3	15.7	58	17774	7907
ADE	28.7	41.1	13.8	79	26034	8728.6

Table 33, shows that when measured by culturally salient species density, homegardens on Oxisols and ADE are significantly more agrobiodiverse than those in the floodplain, but there was no significant difference between the former two. ADE homegardens exhibit a significantly higher agrobiodiversity than homegardens in both Oxisols and in the floodplain when measured by culturally salient species area per hectare.

Table 33 Shannon Biodiversity Index (H') and ANOVA for *Culturally Salient Species Density* (*italic*) and **Culturally Salient Species Area per Hectare (Bold)** in 22 Floodplain homegardens, 20 Oxisol Homegardens and 21 ADE homegardens on the Middle Madeira River in the Municipality of Manicore, Amazonas State, Brazil

Soil	Mean Shannon Biodiversity Index (H') ± Standard Error	ANOVA Comparison	F	p
Floodplain	*2.023 ± 0.175*	*Floodplain - Oxisol*	*25.029*	*<0.001*
Oxisols	*3.048 ± 0.102*	*Oxisol - ADE*	*1.158*	*0.288*
ADE	*3.242 ± 0.144*	*ADE-Floodplain*	*29.054*	*<0.001*
Floodplain	**2.389 ± 0.166**	**Floodplain - Oxisol**	**8.06**	**0.007**
Oxisols	**2.983 ± 0.125**	**Oxisol - ADE**	**5.402**	**0.025**
ADE	**3.441 ± 0.149**	**ADE-Floodplain**	**22.286**	**<0.001**

In the MDS analyses presented in Figure 21, the homegardens cluster in interesting ways. In the richness sub-figure the three soil types are the closest of all three subfigures to forming discrete groupings, the Oxisols and Floodplain are entirely separate, the ADE group has more outliers that overlap the same spaces as the other two soil types. The other two the ADE homegardens are more fully overlapping with each of the other two soil types. Why do ADE overlap with each of the other groups, while Oxisols and

Floodplains only overlap with ADE but not one another? This is because they tend to feature certain species which are normally only present *either* in non-ADE upland soils (e.g. Brazil nut) *or* in the floodplain (e.g. plantain), as well as those which appear in both (e.g. açaí), see table 4. The presence of species normally found in the floodplain on ADE is something also found in secondary forests; examples are samaúma (*Ceibapentandra* (L.) Gaertn.), mata-pasto (*Sennaalata*, Fabaceae) and escova de macaco (*Apeibatibourbou*, Malvaceae), which occur spontaneously on ADE, but are rare on Oxisols (Junqueira, pers. comm.).

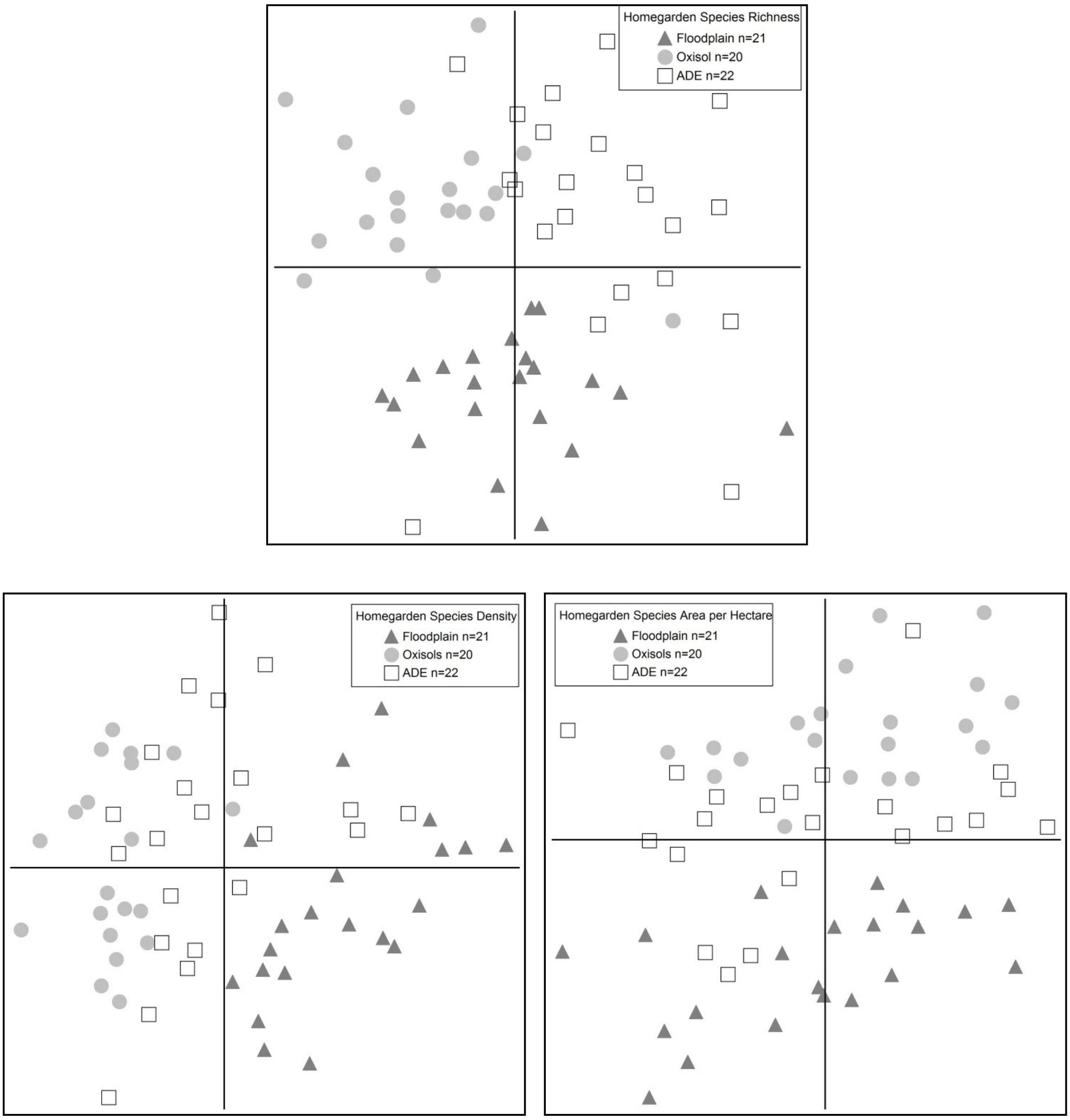

Figure 21 non-Metric Multi-dimensional scaling analyses (nMDS) for Culturally Salient Species Richness, Density and Area Coverage per Hectare. Distance measured by Sorensen (Bray-Curtis). Generated in PC-ORD 5.0.

The results of the SIMPER statistical test for Average Similarity indicate that floodplain homegardens display the greatest homogeneity in species densities, followed by Oxisols. ADE score the lowest, indicating that individual sites are the most different from one another, Table 34. The species densities of floodplain homegardens are so similar because of the heavy emphasis on Cacao and Plantain, and a more restricted suite of tree species. The Average Dissimilarity shows that floodplain and non-ADE soils are the most dissimilar. From these analyses we see what the individual species comparisons were pointing to. ADE tends to combine the most predominant species of the Floodplain and Oxisols, and therefore appears to be located between the two in the MDS. The similarity percentages analysis show that ADE is more similar when compared to Floodplain and Oxisol respectively, than these two are when compared to one another.

Table 34 Average Similarity for Homegardens within a soil type and Average Dissimilarity between homegardens on different soil types for comparisons of culturally salient species richness, density and area per hectare in the Floodplain (21), Oxisols (20) and ADE (22) on the Middle Madeira River, Amazonas State, Brazil.

Comparison	Rich Avr Sim	Rich Avr Diff	Den Avr Sim	Den Avr Diff	Aha Avr Sim	Aha Avr Diff
Floodplain	63.45		31.85		32.83	
Oxisol	63.15		29.83		30.68	
ADE	54.59		21.43		24.3	
Floodplain vs Oxisol		49.62		88.18		86.81
Oxisol vs ADE		46.34		79.56		78.48
ADE vs Floodplain		49.31		83.9		81.81

6.5 Conclusions

This chapter has contributed towards supporting the hypothesis that different patterns agrobiodiversity, evidenced in the predominance of different species, are associated with homegardens on different soil types on the Middle Madeira River. These distinct patterns are the outcome the interaction between people's practices of planting and management with the different opportunities that each soil affords for homegarden species. Using three measures of culturally salient agrobiodiversity, homegardens on ADE in different locations were shown to exhibit a signature patterning of agrobiodiversity, which is because they combine the heightened fertility of the Floodplain, with the secure *terra firme* positioning of Oxisols. This allows the cultivation of species such as Plantain and Cacao that owing to higher fertility requirements, are generally restricted to the floodplain, as well as species that are cultivated only on Oxisols, such as Brazil-nut and Tucumã. Furthermore, other species that require higher fertility but do not grow well in the Floodplain, such as Orange and Lime can be cultivated in ADE (Table 30). This distinct patterning was revealed by the MDS analyses, which showed, for all three measures of agrobiodiversity, that ADE homegardens tend cluster between homegardens of the other soils. The SIMPER analyses support this finding because they show that ADE homegardens are the most dissimilar from one another (presumably because of the wider range of species that can be cultivated), but are more similar to Oxisols and Floodplains than these latter two are to one another (because ADE share more common species with each of Oxisols and the Floodplain than they do with one another). The greater abundance of useful species should result in greater culturally salient agrobiodiversity in ADE homegardens than in homegardens in the Floodplain or on Oxisols. This seems to be the case: ANOVA showed that there was a significantly greater culturally salient species richness and Shannon Biodiversity index of culturally salient species area per hectare on ADE.

The research has implications for the conservation of agrobiodiversity in Amazonia. Firstly, it highlights the likelihood that ADE sites, and the families and their homegardens that occupy them constitute areas of abundant agrobiodiversity. More comparative work is needed to verify this, in particular using transects to demonstrate actual species richness and density. The wider spectrum of crops in ADE homegardens contributes to greater resilience in the livelihoods of families in homegardens on these soils, compared to those on Oxisols and in the Floodplain, who typically rely on fewer crops and are therefore more affected by seasonality and market fluctuations. The diversity of culturally salient species found in homegardens on ADE today show how *Caboclos* exploit the opportunities presented to them by ADE, itself a legacy of previous human occupation. ADE present unique affordances to people, who respond to them creatively. The outcome is a unique patterning of culturally salient agrobiodiversity in ADE, which provides an example of how people today take advantage of previously “upgraded,” landscapes, increasing their agrobiodiversity and broadening their subsistence base.

Chapter 7: Anthrosols and Agriculture in Central Amazonia: A Synthesis

a) Bitter Manioc in the homegarden at Boa Vista
b) Intensive bitter manioc swidden behind the homegardens at Barro Alto
c) Bitter Manioc in the homegarden at Community Terra Preta
d) Bitter Manioc swidden just behind the homegarden at Community Terra preta
e) ADE formation in kitchen midden with papaya (*Carica Papaya*) and chilli (*Capsicum*). Lower Negro River
f) ADE formation in raised beds made from burnt earth, ADE and rotting wood at Community Terra Preta

This thesis has explored the diverse creative practices and knowledge that exist amongst *Caboclos* who achieve aspects of their subsistence through the cultivation of anthropogenic soils on the Middle Madeira River. This concluding chapter synthesizes the main findings of the thesis, placing them in the context of broader debates on agricultural origins and the relationship between anthrosols and agriculture. It explores the origins of domesticated crops - in particular bitter manioc – in the context of the history of cultivation in Amazonia (from mobility and campsites to sedentism and swiddens) and the relationship between these processes and the emergence and use of anthrosols. Bitter manioc and anthrosols are related in temporal (oldest ADE exist in the region where manioc was domesticated) and spatial (ADE formation and bitter manioc cultivation spread out together) dimensions.It is argued that because scholars have focused on bitter manioc cultivation in marginal environments, insufficient attention has been paid to cultivation in central white water regions. This is where the bulk of bitter manioc cultivation takes today, and took place in the late pre-Columbian period. These are the regions where pre-Columbian populations were biggest, which resulted in the largest concentrations of ADE. This thesis has shown how *intensive* bitter manioc cultivation systems are present in the more fertile soils (ADE/Floodplain) along the Middle Madeira River, quite different to long fallow shifting cultivation practiced in infertile soils of the *terra firme*. Of particular interest is the history of "weak"landraces (the product of selective pressures under intensive cultivation in fertile soils of the floodplain) and their co-evolution in these landscapes. Furthermore, homegardens on ADE on the Middle Madeira were found exhibit greatest culturally salient agrobiodiversity when compared to other soils. *Roças* and *sítios* on the Middle Madeira are looked at together as continuous *cultivated landscapes*. These cultivated landscapes are characterised by divergent patterns of agrobiodiversity manifest in the tendency for different bitter manioc landraces and homegarden species to predominate in different types of soil: the outcome of trajectories of *Caboclo* agency *vis-a-vis* soil affordances and plant responses over time. This examination of *Caboclo* subsistence cultivation on ADE, in the context of a review of historical and archaeological material, provides a springboard to address some questions concerning the relationship between ADE and agriculture during the late pre-Columbian period.

7.1 The Origins of Crops, Agriculture and Anthrosols in Amazonia

The need to study the diverse forms of agriculture found in different parts of the world on their own terms has long been emphasized in the literature (Harris 1977). Despite this, agriculture across the globe is often evaluated using concepts, lines of evidence, and methods derived from Eurasian research. Research has demonstrated that traditional and pre-historical agriculture and plant exploitation in regions such as lowland South America, humid Africa and New Guinea is fundamentally different from those found in other parts of the world (Denham *et al.* 2007). Several recent global overviews that examine the periods in which agriculture emerged give scant attention to agricultural origins in Amazonia (Bellwood 2005; Mithen 2004; Harris 2005). Long considered to be peripheral to the origins of agriculture, the lowland New World Tropics - the Neotropics - of South America is now known to be a region where agriculture appeared *independently*, in not one but several different regions (Denevan 2001; Piperno 2006). Early European agriculture is defined by way of several discrete centers of origin, a few founder seed crops, and an agricultural crop package that radiated through the continent. Early Neotropical agriculture by contrast is characterized by "a mosaic-like pattern diffuse in space, with multiple areas of early, independent agriculture involving different plants" (Iriarte 2007:172; see also Iriarte 2009). The Neotropics provide more than 50% of cultivated crops in the Americas, and its native peoples domesticated the largest assemblage of root and tuber crops in the world (Sauer 1952; Piperno and Pearsall 1998a; Iriarte 2007; Clement *et al.* 2010). Clement (1999a) found that some 138 crops, in 44 botanical families, were either cultivated, managed or promoted in Amazonia at the time of contact.[31]

The Amazon and the wider lowland Neotropics have a history of plant domestication and horticulture that stretches back well over 10,000 years. It is now widely accepted that human inhabitation of the Amazon basin is as old as the occupation of any other parts of South America. Macrobotanical analyses suggest that

[31] The major domesticated and cultivated species originate around the periphery, rather than in the center of Amazonia (Clement *et al.* 2010). From these hearths of domestication plant artefacts flowed through the Amazon basin as part of the process of human mobility (Clement *et al.* 2008). It is now commonly accepted that the Vavilovian notion - that places of crop domestication and regions of greatest crop diversity are coterminous - is false; as plants often go on to diversify most in other regions which impose different selective pressures on the genetic material in plant populations (Harlan 1992).

since the Amazon basin began to be occupied around 15,000 years ago, people have been inadvertently creating concentrations of useful tree and palm species by way of discarding seeds and nuts at seasonal campsites (Roosevelt *et al.* 1996; Morcote-Ríos *et al.* 1996; 1998; Morcote-Ríos and Bernal 2001; Morcote-Ríos 2008). By 8,500 BP there is evidence of human occupation in a range of different environments, in both riverine and interfluvial locales (Barse 2003; Meggers and Miller 2003; Roosevelt *et al.* 2002). As bands of Amerindians dispersed into the Amazon basin, stands of useful fruit trees and palms became increasingly common forms of landscape domestication (Clement 2006). These anthropogenic patches exerted different selective pressures on the species, and attracted game into the milieu. The greater density of useful species and game encouraged itinerant human groups to keep returning to these places, and in doing so continuing the processes that create and maintain these locales. Such seasonal campsites where discarded seeds formed clumps of useful species were essentially early homegardens. These anthropogenic niches are still produced by trekking peoples today, such as the Nukak of the Colombian Amazon (Politis 2007).

In a parallel process, the soil fertility of these campsites/homegardens was increased through the formation of dump heaps, consisting of charred organic material, fish bones and other human detritus that resulted in enhanced pH, organic matter and nutrient levels (Anderson 1952). These dump heaps can be considered as proto-*terra preta*. These spaces therefore also began to be associated with improved soils, and these may well have been the site of the cultivation of the first non-arboreal crops in the region. Such anthropogenic niches with useful species and fertile dump heaps located near sources of aquatic protein became attractive locations for resettlement and homegardens (Arroyo-Kalin 2008). Prominent students of the origins of agriculture now believe that many tree crops followed “the dump heap or incidental route to domestication” (Piperno and Pearsall 1998a:158). The most prominent commentators assert that tropical food production began in small-scale homegardens that also functioned as laboratories of plant domestication (Piperno and Pearsall 1998a:7; Lathrap 1977; Harris 1989). Following this line of argument, it is likely that ADE have long been both the sites of homegardens (Andrade 1986) and theatres of plant and tree domestication (Arroyo-Kalin 2008).

The consensus among regional commentators therefore is that “Agriculture” in the Neotropics would have first appeared in the form of horticulture/arboriculture in dooryard or homegardens which are thought to have been the theaters where mutualisms between people and wild plants first emerged, and finally domestication occurred (Lathrap 1977; Rindos 1984; Hastorf 1998; Zeder 2006). In the beginning, anthropogenic stands of fruit trees and palms were important sources of carbohydrates for human groups. By 9000-8000 BP, evidence of changes in plants (larger seed and phytolith size), that are associated with systematic cultivation and domestication appear (Piperno and Pearsall 1998a). The strongest evidence currently comes from Panama, Ecuador and Colombia. A set of studies of microbotanical evidence, i.e. pollen, phytoliths and starch grains, indicates domestication of various species, including squashes (*Cucurbita* spp.*)*, bottle gourd (*Lagenaria siceraria*) arrowroot (*Maranta arundinacea*), manioc (*Manihot esculenta*), leren (*Calathea allouia*), yam (*Dioscorea* spp.), maize (*Zea mays*) and peach palm (*Bactris Gasipaes*) (Oliver 2001; 2008; Mora 2003; Aceituno 2005; 2007; Piperno 2006; Pohl *et al.* 2007; Morcote-Ríos 2008). Between 5000 and 3000 years BP, swidden agriculture (with bitter manioc as a primary crop) emerged as a primary form of staple carbohydrate food production in some regions and with it came the beginning of widespread ADE formation in the Amazon basin.

7.2 The Amazonian Staple: Bitter Manioc and ADE

Recent archaeological investigation has uncovered extensive evidence of pre-Columbian settlements in the form of large-scale landscape transformations in many areas of the Amazon basin (Denevan 1966; 1976; 2001; Lathrap 1970b; Roosevelt 1980; 1999; Erickson 1980; 2000; Balée 1989; Heckenberger 2005; 2007; 2008; Baleé and Erickson 2006; Mann 2008; Silverman and Isbell 2008; Schaan *et al.* 2008; Parssinen *et al.* 2009; Neves *et al.* n.d.). Among the best known of these are the anthropogenic soils known in the literature as Amazonian Dark Earths (ADE). These areas of dark and highly fertile soils that can support intensive farming are common features of bluffs overlooking major river courses in Central Amazonia, undermining earlier interpretations that infertile soils could not support large settled populations (Woods *et al.* 2010). The most important carbohydrate staple that through which the populations that created these soils achieved their subsistence, was Bitter Manioc (*Manihot esculenta* Crantz) (Arroyo-Kalin 2008). The richest environments of the

Central Amazon are major whitewater rivers, and owing to a superabundance of aquatic protein and fertile floodplains, they were the most heavily populated areas in the late pre-Columbian period, evidenced by the large number and size of ADE sites found in these regions today.

The premier starchy domesticate of the lowland Neotropics is Manioc (*Manihot esculenta* Crantz). Manioc was domesticated around ten thousand years ago in southern Amazonia - in a region which today falls in the Brazilian states of Mato Grosso and Rondonia - from a single wild *Manihot* species: M. *esculenta* ssp. *flabellifolia* (Olsen 2002; 2004; Olsen and Schaal 1999; 2001; 2006). This region is also where the oldest ADE sites have been discovered, leading to the hypothesis that manioc may have been domesticated in homegardens on incipient anthrosols (Arroyo-Kalin 2010). The pathways that pre-Columbian agriculture followed progressed from homegardens, niches where clumps of useful perennial fruit species and palms were established and managed, through an increasing of root-crop horticulture, cumulating in larger bitter manioc fields by the late-pre-Colombian period (Arroyo-Kalin *et al.* 2008). Bitter manioc emerged as the principal crop cultivated by Amerindian farmers as they became increasingly dependent on food production systems about three thousand years ago (Lathrap, 1970; Piperno and Pearsall, 1998; Oliver, 2001). Maize (*Zea Mays*) has been present in Amazonia for 6000 years, but human bone isotopic evidence suggests that it became a primary staple in some regions only at the very end of in the late Pre-Columbian period (isotopic evidence from Roosevelt 1989; 2000; cited in Arroyo-Kalin 2008:44). The importance of maize to pre-Columbian subsistence in Central Amazonia may have been overstated (e.g. Roosevelt 1980), not least because it appeals to the Eurasian preoccupation with seed-crops, whereas Neotropical carbohydrate staples are typically root crops (c.f. Iriarte 2007; 2009). Furthermore, the higher protein content of maize, sometimes cited as a reason for its superiority over manioc, is insignificant in the context of a superabundance of aquatic protein in eutrophic whitewater riverine and lacustrine environments. In more peripheral areas of Amazonia such as the Orinoco, it is possible that the opposite is the case[32]. In the Central Amazon therefore, maize

[32] Linda Perry has recently convincingly shown that what were thought to be manioc processing artefacts in the Orinoco may actually have been used to process a wider range of crops including several starchy roots such as arrowroot (Maranta sp.), guapo (*Myrosma cf. cannifolia*), yam (Dioscorea sp.) , and ginger (*Zingiberaceae*, sp.) as well as seeds including maize and palms (Perry 2005). Stéphen Rostain (2008) has similarly found maize to be the crop focus of intensive pre-Columbian agriculture on the French Guiana coast.

probably only became more important than bitter manioc as a source of staple foodstuffs in the last few centuries before the Europeans arrived. Commentators regard bitter manioc as fundamental in understanding the emergence of sedentary life in pre-Columbian Central Amazonia because of its ability to grow on acid soils and the capacity of tubers of some landraces to remain in the ground for years, allowing 'underground storage' (Heckenberger 1998; Piperno and Pearsall 1998b).

The ADE sites that are found throughout the Amazon basin today are the legacy of the long-term sedentary activities of pre-Columbian Amerindian groups who principally cultivated bitter manioc. That these two phenomena (bitter manioc agriculture and ADE) co-existed we can be sure. The question is: what kind of relationship existed between them? Since the 1960's scholars from disciplines such as paleoecology, geography and archaeology have posited links between sedentism, population growth the intensification of bitter manioc agriculture (Lathrap 1970a), "cultural evolution," and most recently, the formation of ADE (see Peterson et al. 2001 p 101-103). The following three quotes, each roughly a decade apart, show the progressive development of this idea, from its original proponent, Lathrap, to the association of bitter manioc with population pressure and intensified swiddening by Piperno and Pearsall, to finally the recent association of manioc agriculture with the spread of ADE proposed by Arroyo-Kalin.

"I conclude that the single 'Neolithic revolution' in the New World was an intensification of a system of cultivation of bitter manioc centered in the alluvial flood plains of Amazonia and northern South America" (Lathrap 1977:717)

"this efficient, undemanding carbohydrate source [bitter manioc] became an increasingly attractive crop as human populations grew and pressure on land increased (i.e., shortening fallow periods and decreasing time for recovery of soil fertility). Its increasing importance may correlate with evidence for the development and intensification of swiddening" (Piperno and Pearsall 1998a:125)

"the key factor that kick-starts the widespread development of anthropogenic dark earths in the Central Amazon region is none other than the introduction of bitter manioc by Barrancoid groups, followed by population growth and agricultural intensification that is respectively tracked by the formation of *terras pretas* and *terras mulatas.*" (Arroyo-Kalin 2008:174-5)

7.3 From the Periphery to the Centre: Bitter Manioc Cultivation in Richer Environments:

Where would bitter manioc have been planted in pre-Columbian times? How would selection for traits in different agro-ecological zones affect the development of landraces? What kind of cultivation techniques would have been employed? What kinds of social organization would this agriculture have supported? The Standard Model of "Tropical Forest Culture," exemplified by the work of Steward (1948) and Meggers (1971) held that the small scattered Amerindian settlements practicing long fallow shifting cultivation found in the upland interfluvial regions today represent an optimum adaptation to a fragile environment. This approach has been rejected because many contemporary settlement patterns are the legacy of massive demographic and social transformations changes brought about by European conquest, and are therefore not adequate material for projection into the past (Balée 1992; Roosevelt 1989). While Meggers (1971) recognized the fertility of whitewater floodplain regions, and the larger populations present in them, she emphasized the inherent instability of floodplain planting zones, and for her this precluded the development of complex social forms there (Stahl 2002). Despite these recent theoretical re-orientations, anthropological studies of manioc agriculture in Amazonia have continued to focus principally on long fallow shifting cultivation in *marginal* environments (i.e., the old, heavily leached and infertile soils of the upland *terra firme*) (Carneiro 1983; Boster 1984; Chernela 1987; Elias *et al.* 2000; Wilson and Dufour 2002). These environments are located on the *periphery* of Amazonia (the Guianas, the Orinoco, the Upper Xingu and the Upper Negro). This research bias is largely because most extant Amerindian people have survived by virtue of their migration to remote interfluvial regions (Balée 1992), or because they are trekking populations who have always kept to the uplands (Rival 2002). This research focus has given rise to certain assumptions in the literature on bitter manioc agriculture in Amazonia. It has been argued that manioc does not yield well on fertile soils; that manioc is best adapted to extensive, longer cropping (1-3 yr) systems on *terra firme* (Moran 1989; Roosevelt 1980) and that the modern long fallow shifting cultivation of manioc was the also a predominant mode of production in pre-Columbian times (Meggers 1954; 1971; Steward and Faron 1959).

However, various authors have long argued that bitter manioc cultivation would have occurred in rich environments. Donald Lathrap was one of the first to emphasize the high productivity of floodplain soils. Lathrap built on the work of Sauer, who first noted that tropical forest agriculture is essentially carbohydrate based; dietary fats and proteins are derived primarily from aquatic fauna. Lathrap asserted that the earliest migrations through Amazonia would have been along the major rivers and their floodplains. He argued that the productivity of the floodplain underwrote the growth of large and dense human settlements, sparking competition and warfare between groups for these rich but spatially limited areas. Lathrap linked contemporary linguistic distributions with archaeological data to propose a series of migrations along the major riverine systems that eventually populated most of the Neotropical lowlands (Lathrap 1970b; 1977). Lathrap's work has been continued by William Denevan who, in an inversion of classical Boserupian ideas on agricultural intensification where extensive practices, or long fallow, evolve into intensive practices characterised by short fallow, annual cropping, multi-cropping, has argued that:

"agriculture began as annual cropping in floodplain environments and developed later in forested uplands as *short fallow.... long fallow is a late development* associated with the introduction of efficient forest clearance tools and the *displacement of populations from preferred habitats*" (Pearsall 2007:211, my emphasis; referring to Denevan's model, which builds on the work of Lathrap and Sauer)

Denevan's bluff model strengths Lathrap's earlier argument by answering Meggers' contention that the floodplain alone is too unstable an environment to support larger settlements. Denevan recognized that that large scale bluff settlements could not have been supported by seasonal floodplain cultivation. He proposed that settlements located on the bluffs would simultaneously exploit fertile but unstable floodplain zones *and* the terra firme bluff areas that were safe from flooding but located on infertile soils (Denevan 2001; Denevan 1996). People therefore pursued a dual strategy of floodplain (river and lake) and *terra firme* cultivation and resource use. Denevan contends that bluff cultivation would have been semi-permanent, intensive with nutrient additions and short fallowing and could have created *terra mulata* (Denevan 2001; 2004; 2006).

7.4 Agriculture *on* ADE?

ADE sites throughout Brazilian Amazonia are prized today by more agriculturally-oriented individuals and groups (German 2001; Hiraoka *et al.* 2003; Kawa 2008; Fraser *et al.* 2009). On the Middle Madeira River many are now the sites of long-term communities. But were Amazonian Dark Earths (ADE) used for agricultural purposes in the late pre-Columbian period? Owing to a lack of data, this has remained one of the most contentious questions in the field of ADE studies. It seems likely that ADE were cultivated, in any one of or a combination of the following forms. Firstly, people would have cultivated the middens forming within current settlements, as some contemporary Amerindian groups have been shown to do (Hecht 2003; Schmidt 2008). Within settlement zones, areas of habitation and their middens shift over time and it is inconceivable that people engaged in cultivation would not take advantage of the enhanced fertility of ADE that form the most durable legacy of previous generations of inhabitants. Secondly, groups re-occupying the middens of previously abandoned habitation zones would have cultivated ADE, in a similar fashion to the *Caboblo* farmers that are the subject of this paper. In pre-Columbian times, established ADE sites were frequently abandoned and reoccupied several times by different groups and this is evidenced in overlapping ADE sites from different occupations (Meggers and Miller 2006; Neves *et al.* n.d.). Thirdly and more controversially, cultivation may have involved purposeful soil modifications in agricultural zones adjacent to living areas. Today some *Caboclos* have become aware of how dark earths form, and this means it is probable that pre-Columbian farmers would also have become conscious of the processes through which they form (Chapter 3). Some historical evidence supports these contentions. The first Spanish chroniclers reported that people were cultivating the islands in certain areas of the Solimões(Acuña 1942; Carvajal 1934). Those islands today have late prehistoric ADE sites on them. If people were cultivating the islands, then they were cultivating ADE (Anna Roosevelt, Personal Comment.). The same observers reported extensive plantations of manioc and maize on the riverside bluffs in the region inhabited by the Omagua Indians, in the region that today lies up and downstream from the city of Tefe. Today, many large ADE sites are located on the bluffs of the west bank of the Solimões in this region (Fraser, unpublished data).

7.5 Rethinking Pre-Columbian Agriculture in the Central Amazon

I am *not* suggesting that bitter manioc fields and homegardens on ADE today on the Middle Madeira are *directly* analogous with pre-Columbian cultivation systems. Homegardens were found throughout the Amazon by the time of the arrival of the Europeans (Miller *et al.* 2006). The Jesuit friar Carvajal reported the presence of fruit and nut trees in abundance at several locations mentioned in his accounts of his trip down the Solimões in 1541/1542 (Carvajal 1970 [1542]). In pre-Columbian times, the heightened fertility of ADE sites and their proximity to dwellings would have made them sites where mutualisms between people and plants eventually resulted in degrees of plant domestication. The increased fertility coupled with the lack of threat from flooding of ADE would also have made these soils likely candidates for the incorporation of "exotic" or allochothonus plants and trees, that originate in regions of higher soil fertility and could not otherwise be so successfully exploited. As exotic species flooded in with the arrival of Europeans, ADE would have been valued for their capacity to support the more nutrient demanding crops trees (such as Citrus spp.).

On the Middle Madeira River, Homegardens on ADE were shown to contain the highest culturally salient species agrobiodiversity when compared to Oxisol and Floodplain homegardens. This is because ADE homegardens *combined* the most important species of Oxisols, such as Brazil Nut, Acaí, Tucumã, with those of the floodplain, such as Plantain and Cacao, with others found most commonly on ADE, such as Avocado and Orange. Two analyses of the similarity and difference of the species area coverage per hectare of homegardens confirmed this observation by showing that ADE homegardens are more similar to both Oxisol homegardens and Floodplain homegardens than these latter two are to one another. ADE homegardens were also the sites of intensively cultivated kitchen gardens, absent in the other kinds of soil. The fact that homegardens in ADE contain a high area per hectare of the most important species suggests that homegardens in ADE broaden the subsistence base for *Caboclo* families and therefore contribute to more sustainable livelihoods. This also suggests by analogy that in the pre-Colombian period, Amerindians would have taken advantage of the higher fertility of ADE to cultivate diverse annual and perennial crop species that require more fertile soils. This has been observed today amongst Kuikuru

Indians of the Upper Xingu, who establish homegardens on midden soils (Schmidt 2008). Chapter 6 showed how in homegardens on the Middle Madeira this is still the case today, where ADE support the greatest diversity of exotic species. ADE homegardens in the late pre-Columbian period may have been characterised by different patterns of agrobiodiversity than homegardens on other soils for reasons similar to those we observe today: higher fertility and secure positioning allow the cultivation of crops and trees planted in Oxisols/Ultisols, the Floodplain, and exotics that require better soils and are not flood-tolerant.

In the late-pre-Columbian swiddens; cropping systems would have been more diverse than the bitter manioc monoculture of extensive the shifting cultivation characteristic of traditional and indigenous agriculture in Amazonia today (Heckenberger and Neves 2009). Pre-Columbian swiddens would probably be more reminiscent of today's intensively cultivated kitchen gardens and swidden fields than extensive bitter manioc monocultures. Pre-Columbian swiddens were likely to have been polycultures with manioc only one of several other crops (such as yams, arrowroot, malanga) under cultivation (Neves 2007). Direct nutrient inputs through mulching and infield burning are likely (Hecht 2003). The intermingling of swidden and agroforestry production is also a possibility (Schmidt 2008). However, some elements of today's bitter manioc swidden cultivation on ADE - short-cropping, short-fallowing manioc production– with associated suite of landraces and local knowledge – may have some parallels with pre-Colombian cultivation. The shorter cropping periods and shorter fallows associated with swidden cultivation on ADE today, and the selective pressures these impose on manioc landraces, would have also been present in pre-Colombian systems. This means that the divergent co-evolutionary processes we observe with manioc today in different kinds of soil may allow us to conjecture the kinds of evolutionary forces that would have shaped the landraces of poly-crop swiddens on bluff ADE in the late pre-Columbian period.

This thesis has demonstrated that bitter manioc farming on ADE on the Middle Madeira is often a cultivated under a swidden system (shorter cropping cycles, shorter fallows), and fields in these soils were shown to have a predominance of so called "weak" landraces, fast maturing; lower starch varieties originating in the floodplain. Indeed, bitter manioc farming in ADE was similar to floodplain farming in other respects too; it was shown to be characterised by shorter fallows, smaller fields and greater yields. Conversely, in the Oxisols and Ultisols of the *terra firme*, bitter manioc agriculture was less intensive, characterized by longer fallows, "strong" landraces, slower maturing high starch varieties typical of upland manioc cultivation, and larger fields. Farmers in all soil types were shown to incorporate cuttings from seeding volunteers into their stock of clonal planting material, and this increases the likelihood of the incorporation the traits that they have selected for (e.g. fast or slow maturing, performance in certain soils, durability), in this new planting material. Because farmers were shown to select different landraces in different kinds of soil, over time, the outcome of this is should be divergent co-evolutionary dynamics in different soil types. This hypothesis is now being tested with ongoing genetic research on bitter manioc landraces from the Middle Madeira. The findings are also significant as an example of how manioc swiddening can successfully be intensified on better soils, which, I argued, has significance for reinterpreting bitter manioc cultivation in the late pre-Colombian period.

In the late pre-Columbian period, cultivation in enhanced bluff soils to provide for relatively large populations would have imposed certain selective pressures in polycrop swiddens and agroforests.With manioc traits that caused to landraces yield better in improved soils, and mature faster may have been selected for. With fruit and nut yielding trees, larger fruit/nuts and ability to thrive in more fertile soils might have been selected for. While it is impossible to know what traits would have been attractive to farmers, it seems probable that they would have selected for traits that would have improved crop performance in certain agro-ecological contexts (swidden cultivation in fertile soils as opposed to long fallow shifting cultivation in poorer soils).Swidden cropping and homegardens in different agro-ecological contexts would have therefore imposed both natural selective pressures (nutrient availability, soil characteristics) and cultural selective pressures (farmer agency vis-à-vis plant responses to agronomic context).

Bitter manioc was probably first domesticated and cultivated within homegardens, and here there was possibly a selection for varieties with traits advantageous for planting in enriched soils (Arroyo-Kalin 2010). As populations grew, bitter manioc would have been cultivated more extensively in fields, analogous to the swidden cultivation described in this thesis. Bitter manioc was observed to be cultivated in *sítios* and in many *roças* close to homesteads on ADE throughout the Middle

Madeira, with a predominance of the same "weak" bitter manioc landraces. More bitter manioc was cultivated in sitios on ADE than in *sítios* on other soils (in 6 of 21 homegardens) *and roças* on ADE most closely resembled homegarden cultivation in kitchen gardens. In these instances *roça* and *sítio* differ not so much in type so much as in intensity of cultivation: bitter manioc is cultivated often semi-continuously in *sítios* with very short fallows of several months. These soils can probably withstand this intense cultivation as nutrients are restored by the frequent low intensity fires, lit to dispose of organic waste, chicken manure and other organic waste management practices associated with the inhabitation of sitios. Given the proximity to residence, weeding is practiced very frequently. Most *roças* on ADE are swidden fields, characterised by short fallow, short cropping periods with a predominance of faster maturing landraces, that are in some ways like kitchen gardens, only without so many nutrient additions. Furthmore, ADE swiddens are usually closer to the homestead that those in other soils; for geographical reasons; because most communities cultivating ADE are located on ADE. In the context of ADE bitter manioc swidden rocas close to the homestead, the distinction between *roça* and *sítio* dissolves. These similarities between *roças* and *sítios* therefore makes their complete separation problematic. For this reason, they are perhaps better conceived of as continuous *cultivated landscapes* (see section 7.6).

Many aspects of the knowledge and practices that *Caboclos* use in the cultivation of bitter manioc on ADE have developed recently. This does not preclude the possibility that some current knowledge of ADE cultivation (e.g. management of seedlings, landraces appropriate to ADE) derives from older local knowledge, because *Caboclos* have intermingled with Amerindians, some of whom are older inhabitants of the Middle Madeira landscape. Given the extend of the social upheaval brought on by the arrival of the Europeans, it is also by no means certain that extant Amerindian practices have not developed as recently as *Caboclo* practices. Oral histories are both vague and only can take us up to 90 years or so into the past. What is certain is that *Caboclo* subsistence on the Middle Madeira shares a fundamental aspect – bitter manioc - with pre- Columbian Amerindian subsistence on the Middle Madeira. Each group devoted a good deal of time and effort to its cultivation, and they inhabited the same environment. Therefore, it is possible that some of the practices that we observe today (weak landraces being planted in ADE, bitter and sweet being crossed into "intermediate" varieties, for example), were practiced in the past, even if the same practices were independent innovations, rather than one continuous trajectory.

7.5.1 The origins of "weak" landraces

As manioc spread through Amazonia, diversity was generated in the form of many different landraces or varieties, each exhibiting different combinations of genetic traits: from sweet to bitter, slow to fast maturing. These traits were generated in different landscapes that – through the interplay of human management and environmental conditions - imposed different selective pressures on successive populations of manioc plants. The great diversity of bitter manioc landraces throughout Amazonia is a function of this continuous generation of genetic diversity in distinct environments. The greater part of manioc cultivation both today and historically, has taken place in the richer and more heavily populated environments of *central* Amazonia. The largest Amerindian populations of the late pre-Columbian era were located in the richest environments, such as along the Solimões and Madeira rivers (Meggers 1971; Petersen *et al.* 2001). These people needed to produce the greatest quantities of manioc-based foodstuffs in order to provide themselves with calories. Amerindian manioc farmers in the rich bluff-floodplain zones of major floodplain rivers in the late pre-Columbian era would have responded to a quite different set of environmental affordances than to the majority of upland, long fallow cultivators that are the subject of most research on bitter manioc. From around the time that the floodplains of whitewater rivers began to form some 5000 years ago (Latrubesse and Franzinelli 2002; Irion *et al.* 1997) we can assume that people began to plant in them. It has recently been demonstrated the floodplain bitter manioc is genetically distinct from that of bitter manioc being planted in the uplands (Pereira 2008). The very presence of floodplain landraces, selected for fast yield and ability to thrive in richer soils, would be a cumulation of selective trajectories in this soil type. Their existence is the outcome of selection for certain agronomic attributes. People would have selected for performance in a different soil type (the floodplain) since before Colonial times.

The historical and contemporary material discussed above means it is likely that bitter manioc has long been cultivated in dump-heaps, and proto-ADE in small settlements, and that cultivation in enriched anthrosols could mean that traits advantageous to cultivation in these soils could have been selected for. Planting on the floodplain *and in enriched bluff soils*, or ADE, would have placed different selective pressures on landraces. Planting in richer soils of the floodplain and in ADE would have selected for higher nutrient thresholds in landraces. More intensive planting regimes, the result of flood regimes and population pressure, may have selected for fast maturing landraces. In short, planting in floodplain-bluff ADE intensive systems would impose certain selective pressures on landraces, and planting in long-fallow, upland Oxisol-Ultisol scenarios would impose other selective pressures. By examining bitter manioc farming in these soil types today we can identify what kinds of characteristics – that would have adapted them to intensity and soil type of agriculture - might have been selected for by farmers in the past planting in different soils, under short fallow swidden, or long fallow shifting cultivation.

The constellation of traits that farmers on the Middle Madeira today refer to as “weak” (fast maturing-low starch) might well have come from selective trajectories imposed in such landscapes. These fertile areas would have been unsuited for strong varieties better adapted to infertile, acid soils. The highly bitter, slow maturing landraces of modern upland cultivation in poor acid soils probably evolved away from these centers where different environments and social organization imposed a different set of selective pressures. These strong varieties would have been more prominent as farmers colonized new areas of terra firme in whitewater regions, and in blackwater and interfluvial regions, characterised by more infertile soils and have their highest reported diversity in the upper-Negro river basin (Emperaire 2001). Thus, while both the weak and strong bitter manioc landraces that are planted today on the middle Madeira have recently emerged and emerging, the constellations of genetic traits that farmers refer to as “weak” and “strong” are likely to have deeper, pre-hispanic origins.

It was once thought that bitter manioc is not well suited to floodplain soils. It is now being suggested that been the planting of manioc in whitewater floodplains may have been one of key ways that manioc spread though Central Amazonia (Clement, Pers. Comm.). The Middle Madeira connects the genetic homeland of manioc - the south-western fringe of Amazonia in today’s states of Rondônia and Mato Grosso, Brazil – to all the major arteries of the Amazon and beyond. Migrations by groups of

Amerindians with manioc as a principal cultivar would almost definitely have passed down the Madeira. Weak manioc may then be thousands of years old.

Colonialism and associated epidemics completely transformed the human geography of the region, and resulted in the large scale loss of agrobiodiversity (Clement 1999a; Clement 1999b). The diversity of weak landraces would have been drastically reduced after the arrival of the Europeans, especially because they would have been concentrated in whitewater floodplain regions, which were among the first to be radically transformed by contact. Despite this, homegardens and shifting cultivation of manioc remain the principal forms of land-use in regions where traditional forms of livelihood characterise life in the interior. While much of the agrobiodiversity generated by Amerindian populations has been lost, other forms of landscape domestication remain largely unchanged, in particular the anthrosols known as Amazonian Dark Earths. Bitter Manioc remains the most important crop, even though its genetic diversity has been transformed. Indeed, it has probably increased in importance as a subsistence crop since European contact. The diversity we find today on the Middle Madeira is then partly the outcome of recent *Caboclo* creativity in the cultivation of bitter manioc in rich environments. They have taken what remained of the genetic diversity of weak landraces left after conquest and both conserved and amplified this diversity.

7.6 Cultivated Landscapes and Culturally Salient Agrobiodiversity

When looked at together, *roças* and *sítios* may be characterised as "cultivated landscapes" (Denevan 2001). Cultivated landscapes are anthropogenic spaces that are part of wider domesticated landscapes. Cultivated landscapes range from swiddens dominated by only a few crop species (but possibly many varieties or landraces), to kitchen gardens and agroforests (known collectively as Homegardens). Clement (1999) recognized several different degrees of landscape domestication. These are **Pristine** (no human intervention), **Promoted** (low level encouragement of useful plants through minimal forest clearance and expansion of the forest fringes), **Managed** (involving partial forest clearance, expansion of the forest fringes, transplanting of useful species, fertilization, reduction of competition) and **Cultivated**, which involves the complete transformation of the biotic landscape to favour the growth of one or a few selected food plants which are managed by localized or extensive tillage, seedbed preparation, weeding, pruning, manuring, mulching, and watering in any combination (of which swidden-fallow and monoculture are subclasses). *Roças* and *sítios* then fall into this last category. While *Caboclos* generally see them as distinct areas, there are ways in which they mingle. Today, the first stage in making a new *sítio*, is the clearing and burning of land and then often the planting of a roça, which is then planted with fruit species as the bitter manioc is harvested. This was observed to take place at various communities on the Middle Madeira and elsewhere. Furthermore, there are parallels between intensely managed kitchen gardens and rocas. On ADE sites in particular, bitter manioc was sometimes cultivated in kitchen gardens, with near-continuous (or at least short fallows of 6 months-year) cultivation stretching continuously back for decades.

If we look at *roças* and *sítios* on ADE on the Middle Madeira as a continuous cultivated landscape, and compare it with similar cultivated landscapes on the *terra firme* Oxisols/Ultisols and in the Floodplain, we observe differences in management (fallow lengths, months of burning) and divergent patterns of agrobiodiversity (assemblages of homegarden species and bitter manioc landraces, and associated knowledge). The term Agrobiodiversity refers to the "variety and variability of living organisms that contribute to food and agriculture in the broadest sense, and the knowledge associated with them" (Jackson *et al.* 2007:197). The current magnitude of agrobiodiversity is the outcome of thousands of years of selection, exchange and experimentation by local inhabitants across the world, is well adapted to local ecosystems, changing as they change, and plays a fundamental role in ensuring local subsistence and food security (Nabhan 2009). Agrobiodiversity is important because it contains a wide range of plants that through usage fulfil human needs for food, income, medicine, technology. It represents the genetic resource base upon which agriculture in the widest sense depends, and ensures the achievement of subsistence and social wellbeing of local communities (Smale 2006; Perrings 2006; Kontoleon 2008; Nabhan 2009).

Agrobiodiversity exists within different niches in cultivated landscapes (e.g homegardens, swiddens, fallows) and is shaped by associated human management in each of these spaces (Thrupp 1998; 2000; Eyzaguirre 2004). Homegardens and Manioc Fields are increasingly recognized for their role as agrobiodiversity reservoirs. The practices and knowledge with which local people that manage these cultivated landscapes is an important component of agrobiodiversity (Harrop 2007). Therefore the local knowledge and practice of cultivating bitter manioc swiddens and homegardens on the Middle Madeira is a component of the agrobiodiversity of that region. Research conducted recently in Amazonia has shown how unevenly distributed agrobiodiversity is, even in neighboring communities (Coomes and Ban 2004; Padoch and de Jong 1991).Researchers have sought to explain this *patterning* of agrobiodiversity by emphasizing how an interplay of cultural, social, and economic factors have shaped crop assemblages and associated genetic diversity (Perrault-Archambault and Coomes 2008; Emperaire and Peroni 2007). This thesis has shown that there are divergent patterns of agrobiodiversity in *roças* and *sítios* on different soils on the Middle Madiera River. This is an outcome of the creativity of Caboclo subsistence cultivation *vis-a-vis* different soil characteristics. This "agrobiodiversity" encapsulates both the divergent patterns of manioc landraces and homegarden species, and the knowledge and practices of Caboclo subsistence that create these divergent patterns. This has implications for our understandings of the agrobiodiversity of cultivated landscapes on different soils both today and in the pre-Colombian period.

7.7 Are ADE only a pre-Columbian phenomenon in the Amazon?

The widespread production of ADE was a function of certain pre-Columbian settlement patterns. Settlement patterns that are in some ways analogous to these, such as the Kuikuru of and Kayapó Indians of the Upper and Middle Xingu River, are today rare (Hecht 2003; 2009; Schmidt 2008; Schmidt and Heckenberger 2009). The production of ADE on a grand scale (such as to produce sites greater than 50 hectares), ended as part of a general process of population decimation, migration, social transformation and the loss of knowledge and agrobiodiversity associated with previous settlement patterns and ways of life. Despite these massive changes, *Caboclos* produce ADE in raised beds (observed by the author on the Madeira, Negro and Solimões) ; a form of contemporary intentional ADE formation as also documented by Steiner *et al*. (2009) and Winklerprins (2009). Furthermore, some individuals ascribe the origins of ADE sites to the inhabitation and burning practices of Amerindians, while yet others understand processes of burning and nutrient deposition that lead to the formation of these soils (Chapter 3). On the lower Negro, an elderly couple that cultivated ADE, migrants from the Solimões, observed the formation of a small patch of ADE, with hot peppers and papaya sprouting on the Oxisol dump heap outside their kitchen subject to diverse charred and fresh organic matter disposal. They said they were "*atterando*" (making land) (Fraser, fieldnotes). Therefore, *Caboclos* today on the Middle Madeira and elsewhere practice carbon enrichment (with varying degrees of intentionality) in management of soils (in homegarden, and in restricted areas of the roça with fire, burning vegetation). The historical ecology of the Madeira with its communities with long term agro-ecological trajectories in situated localities, facilitates these understandings of carbon enrichment processes amongst *Caboclos*.

7.8 *Caboclo* subsistence and ADE: Creativity and heterogeneity in diverse historical environments

This thesis has demonstrated some of the diverse and creative ways in which *Caboclo* subsistence is achieved in relation to different soil environments. Local and regional historical ecology have been shown to condition the significance of ADE to Caboclo subsistence. It has shown how *Caboclo* subsistence cultivation on ADE diverges from that in Oxisols/Ultisols and in the Floodplain in both *roças* and *sítios*. It has revealed some of the local knowledge and practices associated with them, including the categories "weak" and "strong," used to refer to certain landrace traits and soil successional processes. This thesis has shown then that cultivated landscapes tend to diverge on different soil types and different historical circumstances. This is an outcome of *Caboclo* subsistence trajectories on different soils that shape cultivated landscapes that are characterized by different patterns of agrobiodiversity. These cultivated landscapes are created and maintained through the interaction of *Caboclo* agency, intentionality and creativity, which is both always emerging and historically shaped; and diverse environmental (in particular soil chemical characteristics) and plant responses over time. Different crop varieties or landraces are selected for in different cultivated landscapes (including anthrosols) because different traits and different species perform better or worse in different soil types and cultivation practices. Different cultivated landscapes themselves represent arenas where divergent co-evolutionary dynamics between the people and plants within them occur. If people manage certain species or landraces differently (planting / managing greater numbers of individuals, selecting for certain traits) in response to soil or other characteristics of environments, they unknowingly shape the co-evolutionary dynamics between themselves and plants within these environments. These selective trajectories, along with the associated local knowledge and practice that has built up in different localities over generations, are shown to shape both locally and regionally distinct cultivated landscapes over time.

The detrimental effect of humans on the environment is a central feature in popular media and academic debates (e.g. Ehrlich and Ehrlich 2008). Yet such Neo-Malthusian approaches ignore the fact that in some cases people have been improving soils and plant diversity on a local scale for thousands of years. This thesis has contributed to our understanding of *Caboclo* subsistence in history, manioc cultivation in diverse environments, and homegardens on ADE and other soils, and this has provided material allowing a rethinking of pre-Columbian agriculture. It has shown how in creatively using anthropogenic soils to achieve their subsistence, *Caboclos* on the Middle Madeira - by way of locally situated knowledge and practice - shape divergent cultivated landscapes and the patterns of culturally salient agrobiodiversity within them. This, along with other research in the field of historical ecology (Balée and Erickson 2006; Fairhead and Leach 1996) would suggest that, while Neo-Malthusian approaches may be persuasive at global scales, there are numerous examples at a more local level of how people have enduringly enhanced the productivity and agrobiodiversity of cultivation systems in the landscapes that they inhabit.

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Annex

Table 35 Plantation Spacing Used to calculate the Area per hectare for species found in 63 homegardens on the Middle Madeira River in the municipality of Manicoré, Amazonas, Brazil.

Local Name	Scientific Name	Spacing	Crown Surface Area
Abiu	*Pouteria caimito*	4 x 5 m	12.566371
Abiu Guajara	??	10 x 10	78.539816
Açaí	*Euterpe precatoria*	4 x 4 m	12.566371
Acerola	*Malpighia glabra*	3 x 3 m	7.0685835
Andiroba	*Carapa guianensis*	5 x 7 m	19.634954
Aracá	*Eugenia patrisii, Psidium guineensis*	4 x 4 m	12.566371
Araçá-boi	*Eugenia stipitata*	4 x 4 m	12.566371
Araticum	*Annona montana*	5 x 5 m	19.634954
Avocado	*Persea americana*	6 x 6 m	28.274334
Azeitona	*Syzygium cumini*	7 x 7 m	38.48451
Bacaba	*Oenocarpus minor*	2 x 2 m	3.1415927
Bacaba Grande	*Oenocarpus bacaba*	5 x 5 m	19.634954
Bacuri	*Rheedia macrophylla*	6 x 6 m	28.274334
Banana	*Musa Spp*	3 x 3 m	7.0685835
Batata	*Ipomoea batatas*	1 x 1 m	0.7853982
Biribá	*Rollinia mucosa*	5 x 6 m	19.634954
Biriba da Mata	???	4x4 m	12.566371
Bitter Manioc	*Manihot esculenta*	1 x 1 m	0.7853982
Brazil-nut	*Bertholletia excelsa*	10 x 10 m	78.539816
Buriti	*Mauritia Flexuosa*	7 x 7 m	38.48451
Cacao	*Theobroma cacao*	4 x 4 m	12.566371
Cacao da Mata	*Theobroma speciosum*	4 x 4 m	12.566371
Cacao de quina	*Theobroma mariae*	4 x 4 m	12.566371
Caiaué	*Elaeis oleifera*	6 x 6 m	28.274334
Cajuaçu	*Anacardium giganteum. Hanc ex Engl.*	8 x 8 m	50.265482
Carambola	*Averrhoa Carambola*	5 x 5 m	19.634954
Cashew	*Anacardium occidentale*	7 x 7 m	38.48451
Cedro		7 x 7 m	38.48451
Chili	*Capsicum Spp*	0,5 x 0,5 m	0.1963495
Coconut	*Coco nucifera*	7 x 7 m	38.48451
Coffee	*Coffea Spp*	2 x 2	3.1415927
Copaiba	*copaiba officinalis*	7 x 7 m	38.48451
Cowpea		0,5 x 0,25	0.0452389
Cubiu	*Solanum sessiliflorum*	1 x 1 m	0.7853982
Cuia	*Crescentia cujete*	4 x 5 m	12.566371
Cupuaçu	*Theobroma grandiflorum*	5 x 5 m	19.634954
Flesha	*Gynerium sagittatum*	0,5m x 0,5m	0.7853982
Fruta Pão	*Artocarpus altilis*	7 x 7 m	38.48451
Genipapo	*Genipa americana*	5 x 5 m	19.634954
Graviola	*Annona muricata*	5 x 5 m	19.634954
Guabiraba	*Campomanesia lineatifolia*	4 x 5 m	12.566371
Guava	*Psidium guajava*	4 x 5 m	12.566371
Guava-Araçá	*Psidium guineensis*	4 x 5 m	12.566371
Inajá	*Maximilana maripa*	6 x 6 m	28.274334
Ingá	*Inga Spp*	6 x 6 m	28.274334
Jaca	*Artocarpus heterophyllus*	8 x 8 m	50.265482
Jambo	*Syzygium malaccensis*	6 x 6 m	28.274334
Jatobá	*Hymenaea courbaril*	7 x 7 m	38.48451
Jauari	*Astrocaryum jauari*	5 x 5 m	19.634954
Jutai-pororoca	*Dialium guianense*	8 x 8 m	50.265482
Lima	*Citrus aurantifolia*	4 x 5 m	12.566371
Lime	*Citrus limonia*	4 x 5 m	12.566371
Lime Caiane	*Averrhoa bilimbi*	4 x 4 m	12.566371
Maize	*Zea Mays*	0,25 x 0,5 m	0.0490874
Mango	*Mangifera indica*	6 x 7 m	28.274334
Mari Gordo	*Poraqueiba paraensis*	6 x 6 m	28.274334
Mari Vermelho	*Couepia Subcordata*	5 x 5 m	19.634954
Marmeleira	*Bunchosia armeniaca*	3 x 3 m	7.0685835
Mulateiro	*Calycophylum spruceanum*	8 x 8	50.265482
Muruci	*Byrsonima crassifolia*	4 x 4 m	12.566371
Murumuru	*Astrocaryum murumuru*	5 x 6 m	19.634954
Orange	*Citrus sinensis*	5 x 5 m	19.634954
Orange of the Land	*Citrus aurantium*	5 x 5 m	19.634954
Palha Branca	*Attalea attaleoides*	7 x 7 m	38.48451
Papaya	*Carica papaya*	3 x 3 m	7.0685835
Passion Fruit	*Passiflora edulis*	1 x 1 m	0.7853982
Peach Palm	*Bactris gasipaes*	5 x 5 m	19.634954
Pineapple	*Ananas comosus*	1 x 1 m	0.7853982
Piquia	*Caryocar villosum*	8 x 8 m	50.265482
Pitanga	*Eugenia uniflora*	4 x 4 m	12.566371
Pitomba	*Talisia esculenta*	1 x 1 m	0.7853982
Plantain	*Musa Spp*	3 x 3 m	7.0685835
Purui	*Albertia edulis*	3 x 4 m	7.0685835
Purui Grande	*Borojoa sorbilis*	4 x 4 m	12.566371
Rubber	*Hevea brasiliensis*	4 x 5 m	12.566371
Squash	*Cucurbita Spp*	1 x 3 m	0.7853982
Sugar Cane	*Saccharum officinarum*	0,5 x 0,5 m	0.1963495
Sweet Manioc	*Manihot esculenta*	1 x 1 m	0.7853982
Tangerine	*Citrus reticulata*	5 x 5 m	19.634954
Taperibá	*Spondias mombim*	6 x 6 m	28.274334
Tucumã	*Astrocaryum aculeatum*	6 x 6 m	28.274334
Tucuma do Para	*Astrocaryum vulgare*	6 x 6 m	28.274334
Urucum	*Bixa orellana*	4 x 4 m	12.566371
Urucuri	*Attalea phalerata*	6 x 6 m	28.274334
Uxi	*Endopleura uchi*	7 x 7 m	38.48451
Yam	*Dioscorea trifida*	1 x 1 m	0.7853982