USE AND MANAGEMENT OF AMAZONIAN DARK EARTH IN BORBA, AMAZONAS, BRAZIL

By

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To my parents, Chris Kawa and Nora Gubbins.

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ADE	Amazonian dark earth (also known as *terra preta do índio*)
CDEA	*Centro de Desenvolvimento Energético Amazônico* (Center of Amazonian Energy Development)
CEPLAC	*Comissão Executiva do Plano da Lavoura Cacaueira* (Executive Commission for the Planning of Cacao Production)
EMBRAPA	*Empresa Brasileira de Pesquisa Agropecuária* (Brazilian Agricultural Research Corporation)
IDAM	*Instituto de Desenvolvimento do Amazonas* (Amazonas State Development Institute). The rural development agency of Amazonas state that maintains numerous agricultural extension offices, including in Borba.
INCRA	*Instituto Nacional de Colonização e Reforma Agrária* (National Institute of Colonization and Agrarian Reform)
INPA	*Instituto Nacional de Pesquisas da Amazônia* (National Institute of Amazonian Research)

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Major: Anthropology

Amazonian Dark Earth (ADE), known in the Brazilian Amazon as *terra preta do índio*, is a fertile anthropogenic soil that has been touted as a potential model for sustainable agriculture in Amazonia and beyond. However, while much has been written about the potential of ADE for sustainable agriculture, relatively little research has investigated how the soil is used and managed today by rural Amazonians. This research presents a case study from the municipality of Borba, Amazonas, Brazil, which compares management practices, agrobiodiversity, and market production on upland farms situated on ADE and non-ADE soils (*terra firme* Oxisols). The results of this study suggest that ADE farmers in Borba have a tendency towards greater market orientation and greater use of inputs, including chemical fertilizers and herbicides. However, the data show no significant difference in the agrobiodiversity managed by ADE and non-ADE farmers.

CHAPTER 1
INTRODUCTION

Use and Management of Amazonian Dark Earth

Amazonian Dark Earth (ADE), known in the Brazilian Amazon as *terra preta do índio* or simply *terra preta*, is a fertile anthropogenic soil that has become an object of fascination (or at least relative intrigue) for many soil scientists, archaeologists, anthropologists, and geographers. In contrast to the leached, yellow-orange Oxisols that dominate much of the Amazon, ADE ranges in color from light brown to black and maintains relatively high levels of stable soil organic matter and plant-available phosphorus (Lehmann et al. 2003a). Early research on the soil suggested that ADE sites were products of either alluvial deposits or volcanic ash (see Camargo 1941; Cunha-Franco 1962), but today it largely agreed that ADE is a vestige of Pre-Columbian Amerindian occupation (Smith 1980; Lehmann et al. 2003b; Glaser and Woods 2004).

In recent years, Amazonian Dark Earth has been touted as a potential model for sustainable agriculture in Amazonia and beyond. Studies have shown that pyrogenic carbon (black carbon, charcoal) is a key feature of the soil, exhibiting many important functions that enhance nutrient availability and the stability of soil organic matter (see Glaser et al. 2003; Lehmann et al. 2002). Aside from potentially heightening agricultural production, pyrogenic carbon is considered to be an important carbon sink. These factors have propelled the ADE phenomenon from relative obscurity to the attention of international agronomists and environmentalists. The media have also caught wind of the ADE phenomenon and have produced enthusiastic (although perhaps overly optimistic) articles about the potential of ADE for curbing global warming and promoting environmentally-sound agriculture.

While much has been written about the potential of ADE for sustainable agriculture, relatively little research has investigated how the soil is used and managed today by rural Amazonians. This thesis presents a case study of contemporary management of ADE in Borba, Amazonas, Brazil with the intention of describing the relationship the soil has to regional market production, agrobiodiversity, and management practices. This examination further seeks to analyze how local management and use relates to the intended global application of the ADE model.

Research Questions

Studies of contemporary management of ADE have revealed that Amazonian farmers have conflicting opinions regarding the advantages of the soil and the appropriate management of it. Complications related to weeding have been presented as a major limiting factor of ADE production (German 2001, 2003; Major et al. 2003; also see Carneiro 1957). Also, while ADE can produce nutrient-demanding crops with higher market values, market articulation has been said to be limited by differences in market access (Hiraoka 2003; German 2001), individual life histories, and regional historical ecology (Fraser et al. 2007). Building upon past studies of contemporary use of ADE, this thesis investigates the relationships between management practices, market production, and agrobiodiversity (Figure 1-1). The following research questions frame this study:

1. Do ADE farmers maintain different management practices than "non-ADE" farmers?
2. Do ADE farms maintain higher levels of agrobiodiversity?
3. Do ADE farms have a higher market orientation than "non-ADE"[1] farms?

[1] Non-ADE farms in this study mostly correspond to *terra firme* latossolos (Oxisols), often referred to locally as "barro amarelo" (yellow clay) or "barro vermelho" (red clay).

In addressing these questions, this study will also examine the way in which management practices, agrobiodiversity, and market production interrelate on both ADE and non-ADE farms, prompting the following questions:

4. Does agrobiodiversity decrease with heightened market production?

5. Does heightened market production correspond to specific management practices and techniques?

Research Design and Methods

Site Selection

The municipality of Borba, Amazonas was selected as the focus of this study for two primary reasons. First, very limited research has been conducted on the Madeira River with regards to Amazonian Dark Earth management. An exception to this is the most recent work of James Fraser, who has focused his study in the municipality of Manicoré (a municipality southwest of Borba). Through his work comparing use of dark earths in the Rio Negro and middle Madeira, Fraser has made the argument that the inhabitants of the Madeira have a greater 'culture of agriculture' than those of the Rio Negro region. Fraser relates this to the wider abundance of dark earths, the influence of várzea agriculture, and generally longer settlement of inhabitants in the Madeira region (James Fraser, Univ. Sussex, pers. comm., 2006). By examining management of ADE in Borba, this study seeks to expand ADE research in the Madeira region.

The second reason for having chosen Borba is that the Madeira is likely to undergo radical changes in its relationship to regional markets in coming years (Fearnside and Graça 2006). The imminent paving of the BR-319 highway will soon connect Borba and other nearby municipalities by road to Manaus and Humaitá. This development is likely to change the influence of markets on the area, and for this reason research in this site represented a unique opportunity to assess the management practices, agrobiodiversity, and market orientation of regional farms before such developments take place.

Sampling

Gaining access to communities that were willing to participate in the study proved to be a major obstacle confronted during fieldwork. Due to the on-going public discourse in Amazonia on biopiracy and foreign exploitation of native natural resources, many individuals were hesitant to participate in a study conducted by a foreigner researcher. Randomized sampling was not a practical strategy given the limited timeframe of the project since most individuals were only willing to participate in the research when introduced to the researcher by other community members. As a result, a strategy of snowball sampling (also known as “referral sampling”) was implemented (Bernard 2006: 192-193). Officers from IDAM, the state agricultural development agency operating in Borba, introduced the researcher to community leaders within the municipality who in turn assisted in referring the researcher to individuals that were willing to participate in the research.

Within the municipality of Borba, 19 communities (*comunidades*) were visited on three different rivers: the Rio Madeira, Rio Marimari, and Rio Canumã (Figure 1-2). Of the 19 communities visited, 3 communities served as primary centers of data collection: Puxurizal, Puruzinho, and Puru Grande. In addition to these communities, informal interviews and data were collected from farmers in the communities of Guariba, Guajará, Mucajá, and Vila do Canumã. Interviews and data were collected from farmers at 27 different *terra firme* (upland) farms, 14 of which were located mostly on Amazonian Dark Earth while the other 13 were located on non-ADE soils, which were largely Oxisols (see Table 1-1 and Table 1-2 for community and sample data)

Data Collection

Individuals who agreed to participate in this study were asked to engage in both informal and semi-structured interviews to discuss their management practices on ADE and non-ADE soils. Qualitative data was gathered through questionnaires in order to compare management practices (e.g. short fallowing; use of fertilizers and pesticides) on ADE and non-ADE soils. Semi-structured interviews also served to elicit information regarding access to credit, life histories, trade networks, and economic activities outside of farming.

In terms of quantitative data gathering, the area and number of species grown was recorded at each farm. Following Major et al. (2005), the total area of crops destined for markets was divided by the total area of cultivation at the time of the study, disregarding land left fallow (Major et al. 2005). This provided a framework to determine the degree to which an individual farm is oriented towards the market. GPS data was also collected at farms surveyed and used in the mapping of Amazonian Dark Earth sites[2]. In addition, GPS data from individual farms were used to determine the distances to urban centers and individuals' target markets.

Data Analysis

Data collected on agrobiodiversity on ADE and non-ADE farms were analyzed using t-tests to assess statistical differences between farms of the two soil groups. T-tests were also used to analyze statistical differences in market orientation between ADE and non-ADE farms. Fisher's exact test was performed to assess differences in proportions of chemical fertilizer and herbicide use among ADE and non-ADE farmers. Lastly, linear regression analysis was

[2] These data will be shared with other researchers in Brazil and abroad through a project led by Dr. Newton P. Falcão and Dr. Charles R. Clement of the Instituto Nacional de Pesquisas da Amazonia (INPA).

conducted to determine the relationship between market orientation and species diversity for all farms[3].

Research Site

The municipality of Borba is located on the Madeira River, 150 kilometers southeast of Manaus (215 km by waterway). The municipality covers an area of 44,251 km^2 and has a population of 35,525 inhabitants (IBGE 2005). In the Pre-Columbian era, the Lower Madeira is believed to have been a relatively densely populated region, although little of this history is documented. The abundance of dark earth sites in the area, paired with the findings of the brief archaeological surveys of Nimuendajú, Hilbert, and Simões and Lopes, support this claim (Nimuendajú 2004; Hilbert 1968; Simões and Lopes 1987). In the post-contact period, the Portuguese settlement of Borba was first known as "Aldeia do Trocano" and was founded by the Jesuit Priest João de Sampaio around 1728 (Comissão de Estudos da Estrada de Ferro do Madeira e Mamoré 1885: 73; Biblioteca Virtual do Amazonas 2007). In 1755, the settlement was named the first *vila* (Portuguese town) in the Amazon and became known as "Borba-a-Nova" (Leite 1943: 403). During its early history, the inhabitants of Borba were engaged in an on-going conflict with the Mura Indians, and the *vila* was attacked on numerous occasions[4] (Leite 1943; Marcoy 2001: 207; Santos 1999: 78). In 1833, shortly after one particular invasion by the Mura, Borba lost its designation as *vila* and it was given the name "Araretama" (Biblioteca Virtual do Amazonas 2007). Two years later, the Cabanagem Revolt began in which detribalized Indians (*tapuios*) and escaped slaves united in rebellion against Portuguese

[3] The statistical package employed to conduct all statistical analyses was SPSS version 11.5 (SPSS Inc., Chicago).

[4] Santos and Marcoy, among others, mention that the settlement had moved on several occasions before being established in its present location due to conflict with the Mura (Santos 1999: 78; Marcoy 2001).

settlements in the region. During this time, Borba was one of the few settlements that resisted the *cabano* rebels (ibid.) and eventually regained its status of *vila*.

In 1852, U.S. Naval Officers William Lewis Herndon and Lardner Gibbon passed through Borba while conducting a survey of the Amazon region. Herndon and Gibbon described Borba as a small town which they estimated as having 300 inhabitants[5]; the majority of the population they described as "negroes", half of which were slaves (Herndon & Gibbon 1854: 311). In regards to economic activities, sugar cane was produced in farms of the area, principally for manufacture of rum (*cachaça*) while oranges, limes, and watermelons were cultivated for local consumption (Herndon & Gibbon 1854: 312). The tobacco produced in Borba was claimed to be the best in Brazil, and was traded to the Atlantic Coast of Brazil along with cacao, sarsaparilla (*Smilax spp*.), coffee, and Brazil nuts (*Bertholletia excelsa*) (Herndon & Gibbon 1854: 311).

Between 1850 and 1880, Borba lost and gained its status as *vila* numerous times until finally in 1888, it was established definitively as a municipality (*município*). This period coincides with the rubber boom when the Madeira was flooded by immigrants mostly from the Brazilian Northeast who were seeking out the quality rubber (*Hevea brasiliensis*) found in the region.

Today, the economy of Borba depends largely on agriculture and extractive activities. Manioc, bananas, watermelon, beans, jute, and citrus are amongst the primary agricultural products produced in the area while rubber, timber, Brazil nuts, copaiba oil (*Copaifera officinalis*), and rosewood (*Swartzia spp*.) represent major extractive resources. Like much of Central Amazonia, fishing and cattle ranching are the other primary economic activities in the municipality. In the month of June, Borba is also a tourist destination, known throughout the

[5] This is a questionable figure considering that in 1864 there are said to be 2,335 inhabitants in the district (Bastos 1873).

Central Amazon region for its *Festival de Santo Antonio*. Pilgrims migrate from across the region for this particular event held from June 1^{st} to the 13^{th}.

Within the municipality of Borba, approximately 160 communities exist outside of the municipal center of the same name (Figure 1-3). In this study, 19 communities were visited, and 3 of these served as primary locations for data collection. A description of each of these is provided below.

Assentamento do Puxurizal

In the late 1990s, INCRA (The Brazilian National Institute of Colonization and Agrarian Reform) undertook the project of opening roads into the periphery of Borba's municipal center in order to provide needy families with lands for agricultural production. Of these, the primary project was that of the *Assentamento do Puxurizal* (Puxurizal Settlement), named after a stream that runs through the area[6]. Within Puxurizal, 110 lots of varying sizes were defined and allocated to families from the municipal center.

Since the opening of the *assentamento*, many of the lots have exchanged hands and not all the families that were intended to occupy the area continue to live there. Some of the lots were exploited strictly for their timber resources and have since been left relatively vacant, or have been sold. In one case, it was brought to my attention that a local *vereador* (municipal lawmaker) acquired a lot for his own personal use. Despite this, most of the lots in use are occupied by rural farmers. Of the farms that are currently being used for agricultural production, 9 were visited and formal interviews were conducted with 6. Of the 110 lots in Puxurizal, informants claimed that only 2 lots contained dark earths, with a third lot that is suspected to have dark earths, but is currently unoccupied.

[6] The Puruxizal Stream derives its name from the *puxuri* (*Licaria puchury-major*, *Lauraceae*), a tree endemic to the Rio Madeira region whose leaves and nuts are used in perfumes and medicinal teas.

Extending from Puxurizal are the communities of Piaba and Jatuarana that were also opened by INCRA. Individual farmers in these areas were also visited, and dark earths were found on one property.

Puruzinho/Puru Grande

The community of Puruzinho is located approximately 32 kilometers downstream from the municipal center of Borba. The *vila* of Puruzinho is situated between the left bank of the Rio Madeira and Puruzinho Lake (Figure 1-4). Half of the Puruzinho community lives on a stretch of terra firme on the opposite side of the lake (Figure 1-5). A second community, Puru Grande, is located on the same lake, but 5 km south of Puruzinho. As in most communities of the municipality's interior, farming, fishing, and hunting are the primary economic activities in the area. In terms of agriculture, commercial production is focused largely on watermelon, West Indian gherkin (*Cucumis anguria*), cacao, papayas, and manioc. Although all farmers in the area can be considered smallholders (with an average of 3 to 5 ha of land under management), several individuals produce for the larger regional market of Manaus. Between Puruzinho and Puru Grande, 11 terra firme farms were visited, 8 of which were located largely on dark earth.

Guariba

The community of Guariba is located on the right margin of the Rio Madeira, just east of the Vila of Puruzinho. Two individuals from this community were interviewed during research. Both individuals managed areas of várzea, but focused much of their production on terra mulata on terra firme lands that they possessed on their lots. These two individuals also managed the greatest number of total species when compared to other interviewees.

Other Communities

In addition to the communities listed above, the researcher visited several others as part of an expedition organized by IDAM to distribute seeds and collect signatures for agricultural projects managed through the institute. During these visits, which included stops in Nova Recordação, Axinim, Mucajá, Trocanã, and Vila do Canumã, information was collected on management practices and market production through informal conversations with local farmers.

Contribution of Research

The contributions of this research are both theoretical and empirical. Here are presented much-needed data regarding ADE and its relationship to market production, agrobiodiversity, and smallholder management strategies. This information is complemented by a critical theoretical discussion of the use of the ADE model in global industrial agriculture. Through this analysis, Amazonian Dark Earth can be understood as a phenomenon that is simultaneously defined by the natural and the cultural, the local and the global, the traditional and the innovative.

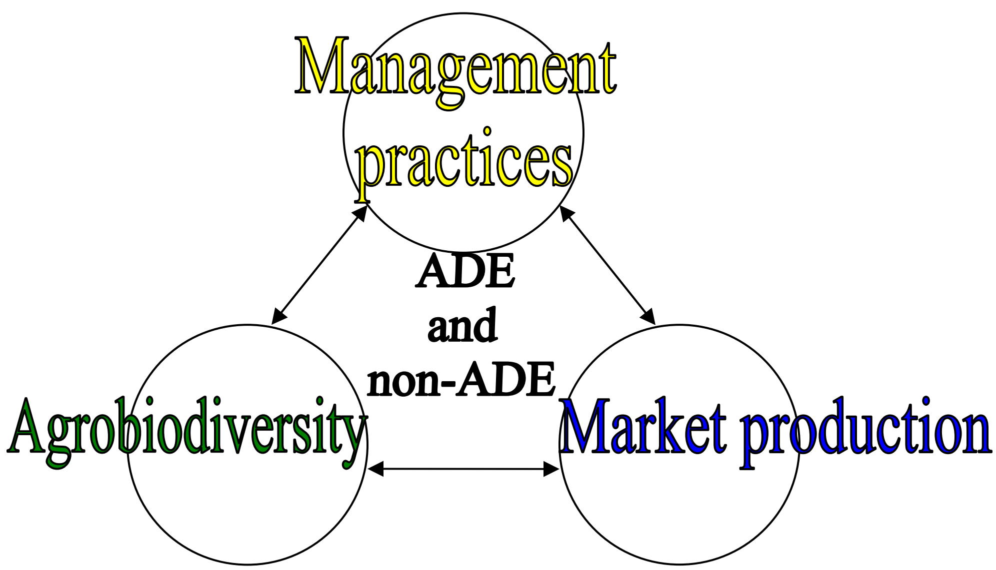

Figure 1-1. Relationships between management practices, agrobiodiversity, and market production on ADE and non-ADE farms in Borba, Amazonas, Brazil

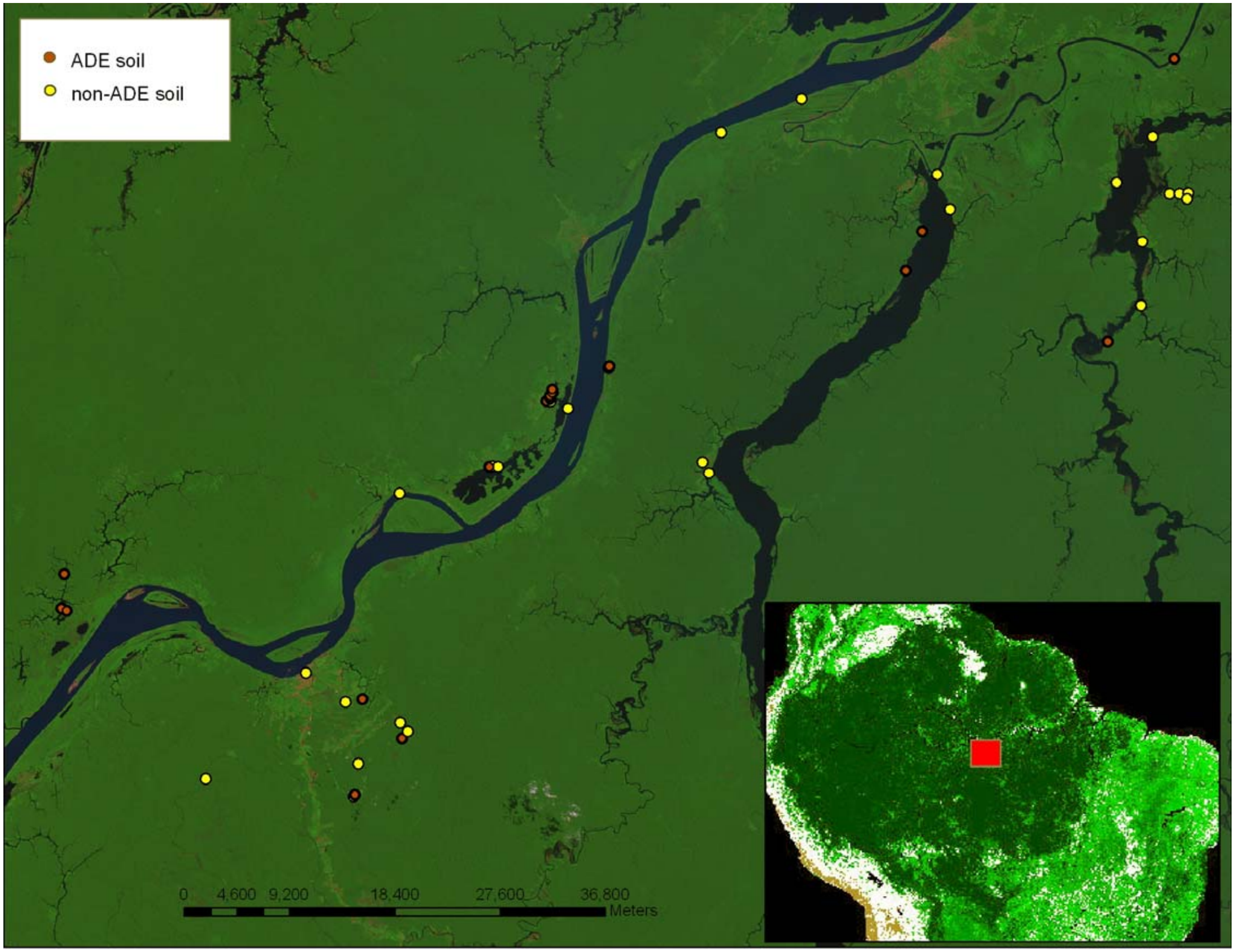

Figure 1-2. Map of sites visited and surveyed in the municipality of Borba, Amazonas, Brazil (Created by Karen Pereira. Data source USGS)

Figure 1-3. Main plaza in the municipal center of Borba (July 2003).

Figure 1-4. Puruzinho Lake (July 2007).

Figure 1-5. House of a rural farming family (Puruzinho: July 2007).

Table 1-1. Distribution of primary communities surveyed

Community	# of households	Households interviewed
Puruzinho	62	8
Puru Grande	33	3
Puxurizal	110	6
Guariba	24	2
Other	N/A	8

Table 1-2. Sociodemographic and land use data of sampled farmers

Farmer	Age	Sex	Community	Soil Under Mgmt.	Lot Area (ha)	Area Under Mgmt. (ha)	Garden Area (ha)	# of species - garden	# of species- agroplot	Total spp.
1	21	M	Guajará	ADE	72	1	0.14	20	2	22
2	55	M	Guariba	ADE	50	9	0.24	11	27	31
3	53	M	Guariba	ADE	23	12	0.4	19	19	30
4	51	M	Jatuarana	Non-ADE	26	2.5	0.3	18	1	19
5	42	M	Jatuarana	ADE	60	2	N/A	N/A	4	4*
6	36	M	Mucajá	Non-ADE	N/A	2	0.5	14	3	16
7	22	M	Mucajá	Non-ADE	N/A	2	N/A	N/A	8	8*
8	24	M	Mucajá	Non-ADE	N/A	2	N/A	N/A	4	4*
9	45	M	Piaba	Non-ADE	21	1	0.1	10	2	13
10	23	M	Puru Grande	Non-ADE	25	5	0.24	17	15	24
11	57	M	Puru Grande	Non-ADE	N/A	2	0.15	5	1	6
12	61	M	Puru Grande	ADE	125	7.25	N/A	N/A	11	11*
13	40	M	Puruzinho	Non-ADE	20.5	3.5	0.2	10	5	14
14	43	F	Puruzinho	ADE	28	0.5	0.25	16	2	18
15	26	M	Puruzinho	ADE	60	4	0.35	19	10	26
16	31	M	Puruzinho	ADE	22	3	0.25	11	10	15
17	25	M	Puruzinho	ADE	10	4.2	0.35	14	6	17
18	49	M	Puruzinho	ADE	50	10	0.32	15	5	17
19	56	M	Puruzinho	ADE	26	3	0.2	23	9	24
20	29	M	Puruzinho	ADE	30	2.25	0.3	16	4	19
21	62	M	Puxurizal	Non-ADE	35	5	0.24	22	4	23
22	47	M	Puxurizal	Non-ADE	35	6	0.36	20	2	21
23	39	M	Puxurizal	Non-ADE	45	18	0.5	20	2	20
24	52	M	Puxurizal	Non-ADE	36	5	0.42	21	3	22
25	57	M	Puxurizal	ADE	75	4	0.28	11	4	14
26	31	M	Puxurizal	ADE	39	8	0.05	4	2	5
27	41	F	Vila do Canumã	Non-ADE	97	2.5	0.18	13	7	18

*Total species in these instances are only based on agroplots.

CHAPTER 2
A HISTORY OF AMAZONIAN DARK EARTH RESEARCH

Introduction

Since the first description of Amazonian Dark Earth (ADE) was printed in the late 1800's, the perception of the soil has evolved from that of a pedological anomaly to prime evidence of widespread anthropogenic transformation in the Amazon basin. This chapter intends to trace the history of ADE research, highlighting the work of the anthropologists, archaeologists, geographers, geologists, and soil scientists that have contributed to our present knowledge of the Amazonian Dark Earth phenomenon. It should be emphasized that this history serves as a general outline and is by no means an exhaustive description of past research. Other excellent summaries of the history of ADE research can be found in Woods and Denevan (2007) and Glaser, Zech, and Woods (2004). Building upon these past historical descriptions of ADE research, this chapter serves to contextualize the present study within its larger historical surroundings, while also discussing the debates that have shaped past investigations of Amazonian Dark Earth. Ultimately, this historical overview intends to demonstrate how Amazonian Dark Earth research exposed the anthropogenic nature of the soil, spurring interest in both its management (past and present) and its potential application as a model for "sustainable" or "intensive" agriculture.

Amazonian Dark Earth Nomenclature (What's in a Name?)

The long history of Amazonian Dark Earth studies is evidenced in the varied and abundant terms used to describe this pedological phenomenon. Early descriptions referred to areas of the soil as "black lands" while the soil itself was described as "black earth", "dark earth", "terra preta do índio" ("Indian black earth" in Portuguese), or simply "terra preta" (see Hartt 1874a; Hartt 1874b; Smith 1879a; Brown and Lidstone 1878). Later references included “archaeological black earth” and “archaeological dark earth”, reflections of the abundance of potsherds and cultural material often found at such sites[7] (Costa and Kern 1999). Studies originating from Spanish-speaking countries of Amazonia, used the terms *tierras negras* (black earths) and *suelos negros* (black soils) (Andrade 1986; Herrera 1980; Mora 2002). In addition to these referents, a host of other names describing the soil and its variations have been introduced as research has changed and expanded over time.

In 1966, Wim Sombroek published his doctoral dissertation entitled *Amazon Soils: A Reconnaissance of the Soils of the Brazilian Amazon Region*, which made reference to not only terra preta, but also to an associated soil called *terra mulata* (Sombroek 1966). Woods and McCann later provided their own insights regarding terra mulata, and claimed that it could be distinguished from terra preta by its grayish-brown color, lower concentration of nutrients, lack of cultural material, and surprisingly higher content of soil organic matter (Woods and McCann 1999; Woods and McCann 2001). In their writings, Woods and McCann employed the term “Amazonian Dark Earth” in consideration of both terra preta and terra mulata. The first two books dedicated to the study of these soils also opted for the use of the term “Amazonian Dark Earth” (Lehmann et al. 2004; Glaser & Woods 2003).

In the recent history of dark earths, other names and descriptors have been incorporated into the literature, which have helped to shape the debate concerning the origin of dark earths. In 1980, Nigel Smith published the article “Anthrosols and Human Carrying Capacity in Amazonia” in which Smith’s use of the term “anthrosol” reflected the growing belief at the time that human interaction with the soil was responsible for its formation (Smith 1980). As the

[7] All true dark earth sites are archaeological sites. For a discussion of dark earths and their archaeological importance *sensu lato* see Oyuela-Caycedo et al. n.d.

human link to the soil became more accepted, more articles began referring to terra preta as an "anthropogenic" or "anthropic" soil.[8]

Most recently, an article published by Elizabeth Graham (2006) has suggested that perhaps a more appropriate term would be "Neotropical Dark Earth" (Graham 2006). Graham and her associates have examined dark earths in other parts of Latin America including Belize and Cuba, arguing that the soils can not be treated solely as an Amazonian phenomenon[9]. This development reflects the broadening of dark earth research and a resultant increasing awareness of the phenomenon.

For purposes of this research, which is focused in Amazonia, I have chosen to rely on the terms "Amazonian Dark Earth" and "dark earth" when referring to these soils in a general sense. When there is a need to discuss the variations of dark earth, I specify by employing the terms "terra preta" or "terra mulata".

The Confederados, a Canadian Geologist, and the First Amazonian Archaeologists (1860s-1880s)

When the American Civil War ended in 1865, a number of Confederate families decided to migrate to Brazil rather than remain in the defeated South. One particular man, Major Lansford Hastings, surveyed parts of Central Amazonia and chose to establish a colony in an area south of the city Santarém in 1866 (Griggs 1987). A little more than a year after having procured the land, Hastings died during a trip to recruit more settlers from the American South (ibid). Nonetheless, the colonists, known as *Os Confederados*, remained and many of them situated their plantations on dark earth sites, whose fertility they most likely had learned of

[8] Debate concerning the intentionality of dark earth creation has led some to use the term "anthropogenic" as intentionally created where as "anthropic" is used to denote unintentional creation (See Neves et al. 2003).

[9] Anthropogenic dark earths are also referred to in archaeological research outside Latin America as in the case of Carrier Mills, Southern Illinois (Jeffries 1987) and West Africa (Fairhead and Scoones 2006: 35).

through local peoples (Woods and Denevan 2007). It has been suggested that Hastings had chosen to settle in the Santarém area due in part to the abundance of dark earth and its advantages for agriculture, but this can not be verified in the literature. What can be said, however, is that the arrival of the *Confederados* to Amazonia was a critical event that led to the early recognition and archaeological investigation of terra preta sites by non-Amazonians.

Around the time of Hasting's arrival to Amazonia, Charles F. Hartt, a young Canadian geologist, was exploring parts of the region with Louis Agassiz and the Thayer Expedition (Agassiz and Agassiz 1868). As a member of the expedition, Hartt spent 15 months in Brazil and became intrigued by the geology and natural history of the land. After returning to the U.S. and accepting a teaching position at the newly founded Cornell University in 1868, he began preparing for a second trip to Brazil.

In 1870, Hartt returned to Brazil as the leader of the Morgan Expeditions. The Morgan Expeditions (1870 and 1871), financed in part by Colonel Edwin P. Morgan, were undertaken with the purpose of studying the geology of the Amazon valley (Hartt 1874b: 1). Despite this intended geological focus, considerable time was dedicated to archaeological investigation in the region. To support the second of the two expeditions, Hartt received some financial support from the Peabody Museum at Harvard University, specifically for the collection of artifacts (ibid.: 5). Consequently, Hartt, the geologist and natural historian, became a self-made archaeologist through his explorations of the wealth of cultural material in the Lower Amazon[10]. Upon return from the Morgan Expeditions, Hartt even remarked in his published preliminary report: "The archaeological material has been so rich that it has been difficult to work out. New collections have constantly been coming in, and what I intended as a short report on the

[10] Hartt's posthumous work *Contribuições para a Ethnologia do Valle do Amazona*s dealt solely with his anthropological research in the Amazon Valley (Hartt 1885).

antiquities of the lower Amazonas, has grown to be a large volume on the antiquities of the whole Empire." (Hartt 1874b: 7).

In the second Morgan expedition of 1871, Hartt and his students investigated several archaeological sites in the Middle Amazon. Hartt's student Orville Derby along with J.B. Steere, a graduate of the University of Michigan, visited the farms of American settlers (i.e. Confederados) near Santarém while Hartt went to Taperinha to re-examine "the great fresh-water Kitchen-midden" he had seen on a previous trip (Hartt 1874b: 5). During both trips to Taperinha, Hartt was accompanied by Romulus J. Rhome, a *Confederado* who operated a plantation in the area. Along with Rhome, Hartt found pottery and some bones as well as other artifacts in a nearby bluff that he described as ancient Indian settlement marked by terra preta (Hartt 1885: 3). These materials later became part of archaeological collections at Cornell and Harvard, which the archaeologist Anna Roosevelt examined in the early 1980s (Roosevelt 1995:121). In 1982, Roosevelt took a radiocarbon date of a shell from Hartt's excavations, which dated to 5705 B.P (Ibid.). In 1987, Roosevelt and colleagues conducted an archaeological investigation of the Taperinha shell midden and found the oldest pottery to date in the Amazon, believed to have been crafted around 8000-7000 years B.P. (Roosevelt et al. 1991).

It is important to note that Rhome, who assisted Hartt at the shell-midden site, resided in Taperinha and was known to collect archaeological artifacts from many of the dark earth sites in the region. Hartt's student, Herbert Smith, wrote about Rhome in his account of the Morgan Expeditions and in one passage, describes Rhome's collections as they visit a dark earth site:

> We find fragments scattered everywhere, and Mr. Rhome has been making archaeological collections for years. He gets all sorts of curious clay figures: vultures' heads, frogs, a cock with comb and wattles complete, a whistle, and one odd-looking affair punched full of holes, which – so Mr. Rhome laughingly insists – must be a toothpick-stand. (Smith 1879a: 169)

Later, part of Rhome's collection was housed at the Museu Nacional in Rio de Janeiro (see Nimuendajú 1953: 59). Although little literature is focused on Rhome specifically (with the exception of Herbert Smith's article, "An American Home on the Amazons"; Smith 1879b), his life represents an important nexus of linkages between the *Confederados*, Hartt and the geologists, and the exploration of dark earth sites.

Outside of the Santarém region, Hartt and his students also explored areas of eastern Pará, including Marajó Island. Hartt mentions having his student Orville Derby investigate the Indian burial mound of Pacoval on Marajó Island, which resulted in an important collection of pottery. In his writings, Hartt mentions that the site was brought to his attention by Domingos Soares Ferreira Penna, a Brazilian scholar who conducted a preliminary survey of Pacoval in 1870 (Hartt 1874b: 3; Palmatary 1949: 270). Ferreira Penna and Hartt had met during the latter's first visit to Brazil during the Thayer Expeditions and the two later collaborated on several occasions (Moraes Bertho 2001: 150). Some scholars consider Ferreira Penna to be one of the first Amazonian archaeologists as he surveyed numerous archaeological sites and wrote extensively about archaeology and ethnology of the Amazon[11]. Perhaps even more importantly, Ferreira Penna founded what would later become the Museu Paraense Emílio Goeldi, the primary institution of archaeological and anthropological research in Amazonia (Barreto and Machado 2001). While there is no denying that Hartt's work is well-deserving of recognition, it shouldn't be forgotten that he is also known for being the first North American scholar to take interest in Amazonian archaeology, inspiring the work of archaeologists like William Farabee, Curt Nimuendajú, Helen Palmatary, Clifford Evans, Betty Meggers, and Anna Roosevelt. As

[11] Summaries of Ferreira Penna's contributions to archaeology are included in Helen Palmatary's excellent manuscript discussing pottery of Marajó Island (Palmatary 1949:270-273) as well as Hartt's *Contribuições para a Ethnologia do Valle do Amazonas* (Hartt 1885).

scholarly ethno- and linguo-centric tendencies can inhibit our understanding of history, the work of Ferreira Penna and other early Amazonian scholars should not go unnoticed[12].

Early Interpretations of Dark Earths as Anthropogenic Landscapes (1870s-1900s)

The association of dark earths with indigenous artifacts led Hartt, Rhome, Ferreira Penna, and others who surveyed the region to the logical conclusion that dark earth sites had been former indigenous settlements. The relationship between the soil's fertility and indigenous occupation was not understood, but an accepted theory of its formation was offered in this early stage. Perhaps unknowingly, these explorers began to expose dark earths as features of much larger anthropogenic environments.

Herbert Smith, a student of Hartt, was particularly attentive to the existence of dark earths. Although Hartt was first to publish a document describing these anthrosols, much more detailed descriptions of dark earths were found in Smith's book, Brazil, the Amazons and the Coast (Smith 1879a). Smith first describes the soil while on a visit to a sugar cane field near Taperinha:

> The cane-field itself is a splendid sight; the stalks ten feet high in many places, and as big as one's wrist. This is the rich terra preta, 'black land,' the best on the Amazons. It is a fine, dark loam, a foot, and often two feet, thick. Strewn over it everywhere we find fragments of Indian pottery, so abundant in some places that they almost cover the ground. (Smith 1879a: 144)

Throughout this book, Smith cross-references his writings with those of Pedro Cristoval de Acuña, the Jesuit Priest that chronicled the Amazon voyage of Pedro Texeira in 1639. Acuña, like Carvajal who chronicled Orellana's expedition, described large indigenous populations found on the banks of the Amazon. Perhaps influenced by these descriptions, Smith viewed the dark earth sites as kitchen middens of former indigenous settlements:

[12] See Barreto and Machado 2001 for a brief summary of early contributions to Amazonian archaeology by Brazilian scholars like João Barbosa Rodrigues.

> At Taperinha, as at Diamantina and Panéma, and far up the Tapajós, the bluff-land owes its richness to the refuse of a thousand kitchens for maybe a thousand years; numberless palm-thatches, which were left to rot on the ground as they were replaced by new ones. For the bluffs were covered with Indian houses, ‘so close together,’ says Acuña, ‘that from one village you can hear the workmen of another.’ (Smith 1879a: 168)

With his knowledge of Acuña’s writing, Smith attempted to envision Amazonia as the Jesuit priest may have seen it. Smith’s awareness of dark earth sites and their association with indigenous villages, led him to compare his evidence with Acuña’s descriptions of the dense populations found in the region:

> We found the black land and its antiquities on the bluffs of Panéma and Diamantinha; we shall find it, also, all along the bluffs of the Lower Tapajos; and here, twenty-five miles below Santarem, we find it again in a like situation. Now, all these bluffs are the edges of the same plateau, and the pottery and stone implements are everywhere similar. On the Tapajós the black land occurs at intervals of one to five miles; but from Panéma to Taperinha, and for some distance below, it forms almost a continuous line; indicating, in fact, a single village, or city, thirty miles long, but extending only a little way in from the edge of the plateau. At intervals, there are signs of ancient roads leading down toward the river, as at Diamantina. Acuña gives no positive evidence of such a city; he says only, that the Tapajos region is very populous, and that he and his party encamped near a village where [there] were five hundred families. (Smith 1879a: 169)

Smith’s observations are particularly relevant to the on-going debate regarding Amazonian demographics in the pre- and early post-contact periods. Moreover, Smith’s theory linking prior human settlements to dark earth sites is an important insight that is only accepted more than 100 years after the publication of his book.

During the same time period, dark earths came to the attention of the geologists C. Barrington Brown and William Lidstone during their explorations of the Amazon. In fact, Brown and Lidstone were the first to describe the soil as “terras pretas” in print (Woods and Devenan 2007). Like Smith, they too associated the sites with indigenous settlement:

> Villages must have stood upon these sports for ages, to have accumulated such a depth of soil about them…At the present day these localities are highly prized as agricultural grounds, owing to their fertility; and they bear the name of “Terras pretas” (black earths). We have observed them occurring in many places almost too numerous to mention. (Brown & Lidstone 1878, 270-271; Smith 1999).

As evidenced in the work of Brown and Lidstone, as well as Smith, it was generally accepted in this early period of ADE recognition that the dark earths of the region were a product of indigenous occupation[13]. Friedrick Katzer, a German geologist who conducted the first soil analysis of ADE, came to a similar conclusion, suggesting that the soil had been cultivated in prehistoric times when the basin was more densely population (Katzer 1903: 68; cited in Woods 2003: 4). While the significance of this conclusion did not lead to further questioning of indigenous influence on the environment, it represents an important historical perspective that is contrary to many later writings in the mid 20th century. Today one can only guess as to why early explorers were more willing to accept dark earths as an indigenous artifact, but perhaps knowledge of historical accounts like that of Acuña, paired with the abundance of archaeological findings, facilitated the acceptance of this conclusion.

Curt Unkel: The One Who Knew How to Open His Path in This World and Conquer His Place in Amazonian Anthropology (1920s-1940s)

The legacy that Smith, Hartt, Ferreira Penna and their contemporaries left for early Amazonian archaeology and the study of dark earths was perhaps best succeeded by a German named Curt Unkel. Unkel had no formal training in anthropology, but he immigrated to Brazil in 1903 specifically to live and work with indigenous people (Schaden 1967-1968: 77-78). In 1906, Unkel was given the name “Nimuendajú” by a Guaraní group in the state of Sao Paulo. This title, which would become his official surname when he became a Brazilian citizen, meant “the one who knew how to open his path in this world and conquer his place in it” (Schaden 1967-1968: 78; Neves 2004). After spending 10 years in São Paulo, working with indigenous groups of Southern Brazil, Nimuendajú moved to Belém in Eastern Amazonia. From 1913 until

[13] Hartt, however, did not necessarily hold this viewpoint as he remarks in his writings on the ethnology of the Amazon that indigenous people had been *attracted* to terra preta soils (Hartt 1885: 12).

his death[14] in 1945, Nimuendajú split time between work in Belém and extended forays into the field. Over this period, Nimuendajú collected an incredible amount of information and materials, including ceramic artifacts, linguistic data, and skillfully drawn maps of areas he had visited. Recently, his writings and maps have been compiled and organized in posthumous works *Cartas do Sertão* and *In Pursuit of a Past Amazon* that provide a more complete vision of his life's work (see Nimuendajú 2000; Nimuendajú 2004).

Nimuendajú's contribution to Amazonian anthropology and the study of dark earths is considerable. Between 1923 and 1925, he canvassed large expanses of the Central Amazon basin, recording dark earth sites and collecting ceramics from those areas. Nimuendajú was aware of Hartt's work and it led him to investigate the area around Santarém where he made significant collections. The sites he names in the area are too many to mention, but those that he found to be most valuable in terms of ceramics collection were Santarém-Aldeia and Lavras (Nimuendajú 1953). Aside from collecting ceramics in the area around Santarém, Nimuendajú discovered many of the important anthropogenic features of the region. In his article "Os Tapajó", Nimuendajú described finding wells dug by the Tapajó Indians along the *plantalto* or riverine bluffs in the region. He claimed that the wells, about 2 meters in both diameter and depth, continued to provide water for the "neo-Brazilians" (as he referred to them) at the time of his visit. Although he found only 5 such wells, he argued that many more had to exist. Aside from these wells, Nimuendajú also documented the existence of trails (between a meter and a meter and a half in width) linking different dark earth sites together. Despite finding overgrowth occasionally interrupting the paths, Nimuendajú claimed that the paths continued to be quite visible (Nimuendajú 1953: 60). While most of the sites he investigated were found in *terra*

[14] Joao Pacheco de Oliveira presents a fascinating account of Nimuendajú's work amongst the Tikuna and the circumstances leading up to his death in 1946 (see Pacheco 1992).

firme, he also mentioned finding dark earth sites located near the edge of the floodplain, most notably at Santarém-Aldeia and Alter do Chão (ibid).

In Nimuendajú's descriptions of archaeological sites provided in the recent compilation *In Pursuit of a Past Amazon*, "terra preta" is mentioned numerous times. From his travels in the Central Amazon (1923-1925), Nimuendajú specifically mentioned terra preta in 65 different locales while surveying the area for ceramics and artifacts (Nimuendajú 1953: 59; Nimuendajú 2004). Like Herbert Smith and others, Nimuendajú argued that indigenous peoples were responsible for the formation of terra preta, and in his writings he listed the many reasons why:

> 1. Wherever the subsoil consists of clay or sand, the *terra preta* is also clay or sandy.
>
> 2. The *terra pretas* occur only as relatively small areas, in rare cases more than 500 m in diameter.
>
> 3. The black soil originating from organic matter *cannot* have been formed by deposits of dissolved vegetable substances, since it is *never* found in the beds of the valleys or in depressions, whereas it is always found on hills, where such formation cannot take place.
>
> 4. It can be observed even today how the soil of the kitchen site of a new habitation becomes coloured black after some time.
>
> 5. The fact that the *terra preta* is especially suitable for growing vegetables may be the reason why the Indians chose it for their Roças. However, the huge amount of fragments found in many *terra pretas* cannot accumulate in a plantation, but only in a place of permanent habitation.
>
> 6. Apart from fishing stations in inundated areas, all the ancient dwelling-sites I found were situated on *terra pretas*, and every *terra preta* I have seen showed traces of ancient Indian habitation.
>
> 7. In *terra pretas* with a thickness of even more than 1 m, traces of habitations are found regularly in the entire depth. At Lavras, I found hearths with ashpits, particularly of *Emys* sp., right above the yellow soil and under a *terra preta* with a thickness of 25 cm and at Santarém Aldêa almost at a depth of 1 m, facts which indicate a more or less permanent habitation
>
> (italics from text; Niumendajú 2004:122)

To conclude his list, Nimuendajú stated that the only possible reason why one would argue differently is due to the incredible thickness of the soil (up to 1.5 m) at certain sites, which could raise doubts as to how indigenous groups were able to produce such a quantity of dark earth. Despite this potential argument, Nimuendajú remained convinced that indigenous peoples were responsible for the formation of dark earths. This belief would go unchallenged until 1941.

Terra Preta in the "Modern" Age (1940s-1980s)

In the 1940's, Amazonian Dark Earth research began to change as the origin of the soil came into question. Although this debate may have begun arbitrarily, it is likely that changing historical attitudes contributed in driving the discussion. It can be argued that with the rise of modern science, indigenous technologies became viewed as increasingly antiquarian and obsolete. Moreover, many archaeologists and anthropologists of the era promoted the belief that environmental constraints inhibited the development of large, complex societies in Amazonia. From this perspective, the debate of dark earth formation developed as part of the modern questioning of the indigenous capacity to alter the Amazonian environment on a regional scale.

In 1941, Felisberto Camargo published a study of Amazonian soil profiles in which he included a description of terra preta. As to the formation of the soil, Camargo proposed the hypothesis that dark earths may have been the product of deposited volcanic ash (Camargo 1941). Shortly thereafter, Barbosa de Faria, an archaeologist who investigated areas of the Trombetas and Jamundá Rivers, offered another hypothesis suggesting that floodplain lakes may have led to the formation of dark earths (Barbosa de Faria 1944). This theory, however, did not provide an explanation for the formation of dark earths on terra firme, where the majority of ADE sites are located.

These hypotheses circulated until 1949, when Pierre Gourou, a French geographer, offered that the soils were of "archaeological" origin. Although Gourou doubted that the contemporary indigenous peoples could have been responsible for dark earth formation, he made an astute observation: "the present is not necessarily the image of the past" (Gourou 1949, author's translation). The idea described by Heckenberger as "cultural uniformitarianism" (i.e. contemporary indigenous populations are directly analogous to those of the past) appears to have influenced Gourou's contemporaries who had preferred to opt for "natural" explanations of dark earth formation (Heckenberger 2004). In contrast, Gourou reasoned that larger indigenous populations in the past may have been influential in the development of such soils.

Despite Gourou's insight, natural explanations for dark earth formation continued to be offered. In 1962, Cunha-Franco reformulated the hypothesis offered by Barbosa de Faria (Cunha Franco 1962). Cunha-Franco argued that closed depressions common throughout the Santarém planalto had filled with water during the rainy season and formed small lakes or ponds. He reasoned that indigenous peoples gravitated toward these shallow lakes in the uplands during the rainy season as they moved away from the floodplain. In this manner, seasonal villages formed near these lakes and waste was deposited in them including broken pottery, animal bones, and other organic waste. Cunha-Franco believed that over hundreds of years these shallow depressions formed dark earth sites.

Ítalo Falesi continued to shape the discussion of terra preta formation in a 1974 article published in Charles Wagley's *Man in the Amazon* (Falesi 1974). Falesi hypothesized that during the Tertiary, the massive lake that was created in Amazonia through the rise of the Andes created extensive deposits of mineral sediments. At the end of the Tertiary, the lake began to empty into the Atlantic, which drained the basin. According to Falesi's argument, depressed areas remained filled with water for a time, accumulating aquatic vegetation and other organic matter. Over time these depressions dried and indigenous groups settled on them, thus producing the archaeological context as witnessed today[15] (Falesi 1974).

The movement towards the adoption of "natural" explanations for the occurrence of Amazonian Dark Earth coincided with the anthropological model of Amazonian indigenous societies offered at the time. According to the "Tropical Forest Model",[16] which was promoted in the *Handbook of South American Indians* (Steward 1946-1959), it was asserted that small, dispersed, and impermanent settlements were characteristic of Amazonian societies throughout history (and pre-history). Betty Meggers later became the primary proponent of this model, arguing that environmental constraints prevented Pre-Columbian populations from developing large complex societies (see Meggers 1996). Although Meggers recognized that groups like the Tapajó had maintained denser populations and more socially complex polities, she stressed that they had reached the "maximum level of cultural elaboration" for their given environment (Ibid.:149).

Despite the dominant trend of the time to downplay human agency in the Amazon Basin, other scholars during this period continued to assert that humans played a crucial role in the formation of dark earth. Wim Sombroek argued that areas of terra preta were sites of former occupation while the more extensive terra mulata soils were ancient agricultural fields (Sombroek 1966:175). Other scholars like Hilgard O'Reilly Sternberg and Peter Paul Hilbert supported similar hypotheses that emphasized the human role in dark earth formation as Herbert Smith and Curt Nimuendajú had done previously (Sternberg 1956; Sternberg 1975; Hilbert 1968). In the late 1970s, Robert Eidt also contributed important findings on the use of phosphate

[15] Falesi has since agreed with the idea that ADE soils are anthropogenic in origin (N. Smith, pers. comm.)

[16] Later described as the "standard model" by Viveiros de Castro (Viveiros de Castro 1996: 180), followed by Heckenberger et al. 1999.

analysis for determining human occupation linked to anthrosols (Eidt 1977). Yet it was not until the 1980's, following the publishing of Nigel Smith's article "Anthrosols and Human Carrying Capacity in Amazonia", this human link to Amazonian Dark Earth became more widely accepted once again (Smith 1980; Woods and Denevan 2007). Contemporary research has concluded that dark earths are in fact the product of indigenous occupation, although the exact processes by which they have formed are still disputed.

ADE and the Question of Intentionality (1990s-Present)

As the debate over the natural vs. human-driven explanations for Amazonian Dark Earth formation has subsided, the question of intentionality has surfaced. Did indigenous groups intentionally create Amazonian Dark Earth or was it simply an unintentional by-product of their occupation[17]? Expanding interdisciplinary research projects oriented by the theoretical perspectives of historical ecology have sought to trace the ways in which human-environmental interactions played out in the formation of the Amazonian environment as witnessed today, yet the question of intentionality in some ways contradicts the very basis of the historical ecology approach.

One of the principal problems of the question of intentionality is of a philosophical nature. Oftentimes, the idea of intentionality reflects the assumption that the environment is an inert object acted upon by people (see Marcoulatos 2006). This notion contradicts the theoretical groundings of historical ecology, which has been described by Balée as: "…the interpenetration of culture and the environment, rather than the adaptation *of* human beings *to* the environment. In other words, a relationship between nature and culture is conceived, in principle, as a dialogue, not a dichotomy" (Balée 1998: 14). Graham identifies this obstacle with regards to

[17] Neves et al. attempt to address this issue by distinguishing anthropic and anthropogenic soils (Neves et al. 2003: 35-36).

ADE, stating: "At the level of analysis in which we explore the origins – but not the implications – of dark-earth deposits, I am uncomfortable with intentions, and I do not think we can disentangle the threads of the association between ADE and human activity if we privilege a dichotomy of intentionality versus inadvertency." (Graham 2006: 70).

Heckenberger asserts that the debate over intentionality is misdirected or perhaps unnecessary (pers. comm. 2006). Whether indigenous groups were conscious of the manner in which they produced dark earth or not, Heckenberger claims that it is obvious that they "mapped onto" these areas and exploited them. In the Kuikuru villages of the Upper Xingu, it is noted that contemporary peoples deposit organic waste outside ring plazas and over time, the soil is enriched (Heckenberger 2004). In a similar manner, the Ka'apor of Eastern Amazonia have shaped their environment through the development of agro-forestry systems and unique land management practices, yet they do not express an understanding of the long-term effects of these practices on their environment (Balée 1994). To further the complicate the issue, Posey reminds that indigenous groups may have different conceptions of what is "active" or "intentional" resource management when compared to the ecologists or anthropologists who document their activities (Posey 1992). For these reasons, it is argued here that rather than ponder the degree to which indigenous management was intentional or not in the development of dark earths, the management practices employed by groups is a more appropriate focus of research. Clearly, Pre-Columbian management practices may only be inferred by researchers, but the fields of pedology, ethnography, ethnohistory, and archaeology can yield better clues to such hypothetical practices. Under such reasoning, the question of intentionality can remain an afterthought.

The Development of Contemporary ADE Management Studies

As archaeologists investigate questions related to the formation of dark earths historically, other scholars are beginning to recognize the value of studying ADE management at present.

Since much of the Amazon basin is occupied today by rural peoples of mixed ethnic backgrounds (commonly referred to as *caboclos*), researchers hope to address how contemporary management practices can improve production of regional soils and how regional farmers may sustain production on existing dark earths. Although no direct evidence has shown that rural Amazonians continue to recreate dark earths on a large scale, their management of the soil is important for understanding both the benefits and shortcomings of agricultural production on these soils. Moreover, the role of ADE in the livelihoods of rural Amazonians and the relationship of such soils to agrobiodiversity in the basin require further attention. A case study presented in the following chapters explores precisely these issues.

CHAPTER 3
CONTEMPORARY MANAGEMENT OF AMAZONIAN DARK EARTH IN THE LOWER MADEIRA: A CASE STUDY IN BORBA, AMAZONAS, BRAZIL

Introduction

This chapter describes management practices of rural farmers in Borba, focusing on the ways that management differs on ADE and non-ADE soils[18]. Practices that are commonly shared between dark earths and non-dark earth farmers are also discussed, particularly in relation to contentious issues such as the use of fire in shifting agriculture. Lastly, general conclusions are drawn about ADE management, noting both the limitations and advantages of agricultural production on these anthropogenic soils.

Use of Fire

The use of fire by smallholders has become an increasingly controversial issue in Amazonia. Due to the impact of heightened deforestation and climatic change, researchers have argued that Amazonian forests are becoming more vulnerable to the threat of fires (Nepstad et al. 2004; Malhi et al. 2008). Nevertheless, the use of fire as a management tool is of an extended historical tradition in the basin[19] (Denevan 2001). Swidden agriculture continues to be the prominent form of management, requiring clearing and burning of vegetation (see Conklin 1961). Not only does the burning of dried vegetation release nutrient-rich ash, but charcoal from burned stumps and roots also contribute to fertility as witnessed in Amazonian Dark Earth (Figure 3-1). The contribution of nutrients from ash, however, is considered to be a short-term benefit as the majority of farmers interviewed described significant declines in production within

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[18] Non-ADE soils in this study were nearly all *terra firme* Oxisols

[19] Denevan describes many Pre-Columbian indigenous practices involving the use of fire, but he argues that swidden agriculture may be a relatively recent development. According to Denevan, Pre-Columbian agriculture was most likely more intensive, relying on in-field burning and mulching. The use of fire in practices like “coivara” is likely to be of an extended historical tradition (see Denevan 2001).

a year or two (see also Nye and Greenland 1964). Some scholars note that nutrients released by burning are not the only benefit of fire as it also helps to destroy weed seeds (Ewel et al. 1981). The local head of the state agricultural extension agency in Borba offered a third reason for burning: it is a simple and effective tool for clearing an area that requires relatively little work. Descola, amongst others, supports this final conclusion (Descola 1994: 158).

In Borba, all of the farmers interviewed used fire in management of their lands, although farmers that invested more time and space in the production of annual crops were required to burn more frequently than those that focused their production largely on perennial fruit trees. The cultivation of manioc, in particular, usually requires the clearing of new lands every 2 or 3 years due to losses in soil fertility when cultivating on Oxisols. However, recent research by Fraser has shown that in some communities of the Middle Madeira, farmers have developed management schemes that allow for continuous cultivation of manioc on ADE soils, thus requiring less frequent clearing and burning of lands (Fraser et al. 2007). On both types of soils, the management of perennial crops like cacao prevents the need for frequent burning since such species can be managed in orchards for extended periods of time.

After initially clearing an area through burning, many farmers acknowledged implementing the practice of *coivara*, a post-burn management technique. *Coivara* consists of collecting partially burned stumps and roots left in a field after a burn from which a small pile is formed and burned a second time (Cf. German 2001: 155). This practice allows for the introduction of charcoal into the soil matrix, a key characteristic of dark earths and their formation. Farmers acknowledge that these pockets of *coivara* tend to have greater fertility, and oftentimes they are treated as microenvironments used to plant crops that have greater nutrient demands. On a visit to one farm (with a member of IDAM), it was pointed out on a pineapple plot that the individual plants that fared best were located near a partially-burned tree stump that had contributed both charcoal and nutrients through the slow release of the tree's decomposed biomass.

Another method by which rural farmers improve soil fertility is through the use of *terra queimada* (burned earth). The making of terra queimada is a practice that is also present in urban areas in which small sticks and leaf litter are collected in piles outside the home and burned in the evening. This burned material is mixed with soil, which creates a nutrient rich mix of soil organic matter, charcoal, and ash (see Winklerprins and Souza 2005: 117-118). The benefits of terra queimada are well known as one farmer said, "*terra queimada é um adubo bom para qualquer planta*" ("burned earth is a good fertilizer for any plant").

Despite some of the advantages of fire as a management tool, the use of fire is also perceived locally as a problem. Many individuals claimed that fire could be a detriment to the soil, particularly if the duration of a burn was too long. Recent campaigns by IDAM have discouraged burning, particularly in the dry months of the year (July – October). Some farmers who are involved in projects with IDAM have now adopted new management techniques that seek to lessen the use of fire. One such project promoted by IDAM is the planting of açai (*Euterpe spp*.) palms in rows (*linhas*) through secondary vegetation (*capoeira*). This management practice allows smallholders to plant a species that has had considerable commercial success recently in a manner that prevents the need for burning. This practice has been largely adopted in the community of Puxurizal just outside the municipal center of Borba, where farmers tend to have greater contact with officers of IDAM.

Even with the development of new management practices that seek to minimize the use of fire, it should be reaffirmed that fire remains a primary management tool. IDAM and other agricultural extension agencies accept this tradition and have tried to promote safe practices that control burning. Many of the farmers interviewed claimed to make *aceiros* (firebreaks) to prevent the spread of fires, although accidents are not uncommon. Despite these accidents, many farmers feel that they are left with few viable alternatives to burning for clearing and "cleaning" their lands.

Fertilizers

Farmers interviewed in Borba fertilize their soils with a wide array of materials from cacao pods to cow manure to NPK. Many farmers, however, simply rely on the existing nutrients in the soil. In general, individuals that had higher market orientation tended to rely more upon chemical fertilizers, although highly market-oriented farmers also commonly used cow manure and organic fertilizers. When comparing those farmers who used chemical fertilizers with those who did not, farmers using chemical fertilizers averaged 67.4% market orientation while those who did not averaged only 47.9% market orientation. Independent t-tests confirm that these differences are statistically significant with 95% confidence (p-value= .019).

A third of farmers interviewed used chemical fertilizers. Within groups, 50.0% of ADE farmers used chemical fertilizers while only 15.4% of non-ADE farmers made use of them (Figure 3-2). Fischer's exact test was conducted to test this difference in proportions, yielding a p-value of .103 or nearly 90% confidence.

Although farmers that managed dark earths used chemical fertilizers more often, this is not necessarily because of a greater need to enhance fertility. Most ADE farmers alluded that they used chemical fertilizers on ADE to maximize production of valuable market crops like watermelon. These claims are supported by the data as all but one of ADE farmers who used chemical fertilizer produced watermelon. It is also important to mention that data on the exact amount of chemical fertilizer used by farmers was not recorded at every farm, but of the little data collected, it appears to be used very minimally, particularly when compared to large-scale mechanized operations. Most of the farmers using chemical fertilizers only had a few liters of liquid fertilizer, the most common product being Ouro Verde NPK 6-6-8.

Organic fertilizers were used by only 29.6% of farmers interviewed. Within groups 42.9% of ADE farmers used organic amendments while only 15.4% non-ADE farmers used them (Figure 3-2). The specific organic fertilizers used tend to vary greatly from farm to farm. Two farmers mentioned using a mixture of cow manure and rotting wood or mulch (*paú*), while others used manioc peels, cacao pods, and other forms of locally available plant biomass. Even though few farmers used organic fertilizers, many commented on the benefits of mulch, manure, and rotting wood, as one farmer said, "Old wood (*pau velho*) and old leaves (*folhas velhas*) are the best things in the world for plants".

No fertilizers (chemical or organic) were used by 48.1% of farmers interviewed. 76.9% of non-ADE farmers used no fertilizers while only 21.4% of ADE farmers used none. This large number of farmers who used no fertilizers (chemical or organic) is likely attributed to two principal factors. First, chemical fertilizers are often prohibitively expensive for most smallholders while the application of organic fertilizers usually requires extra labor (i.e. processing and distribution of mulch or other plant biomass). Second, the dominant crop of the Amazon, manioc, requires no fertilizer for successful production under shifting cultivation.

Crop Rotation and Shifting Cultivation

Upland shifting agriculture remains the primary agricultural land-use system in Amazonia. It is reported to contribute to upwards of 80% of the region's total food production (Serrão 1995: 267). In the municipality of Borba, the majority of farmers interviewed practiced, at least in part, a form of shifting cultivation. Few farmers who were interviewed managed to cultivate annual crops on the same plots for extended periods of time. As a general rule, farmers cultivated annual crops in a field (*plantio* or *roçado*) for 2 years and then abandoned it for at least 2 to 7 years. Many ADE farmers who planted watermelon complained that the soil simply could not withstand more than a couple of years of production without suffering serious declines. On Oxisols, manioc was often the primary crop cultivated, which was also usually only planted for 2 years, consisting of the initial planting and a second planting known as the "*replanta*".

No farmers described having any management strategies that involved crop rotation to recuperate mined soils after a year of particularly demanding cropping. However, many farmers, particularly those on ADE, adopted less demanding crops or perennials after several years of production of watermelon. Several farmers had planted watermelon for years on their ADE sites, but after what they perceived as declines in soil fertility, they opted to plant cacao and other perennials instead. One ADE farmer focused on cucurbits, beans, and corn before moving on to less demanding crops like manioc and açai as described in my fieldnotes here:

> In terms of production, Ataliba said he would plant the terra preta with manioc and would "*replantar*" [replant] for another 2 years. He said that in the terra preta, the manioc tubers would become quite large, but *adubo de gado* [cow manure] was necessary also. In the past he said he had also planted corn on terra preta as well as watermelon, cucumbers, and *feijão de praia* [beans]. He said that the *feijão* did quite well (a variety he described as *manteguinha* which is white). Nonetheless, after 25 years of production on and off, he felt that the soil was pretty worn out and with the rain water that carried topsoil down to the *igarapé* [small stream], the soil was bound to lose its productive capacity. He also mentioned in the summer, it would get pretty dried out… He mentioned planting açai in the future like many of the other farmers I met in the area.

Similarly, another ADE farmer reported to have produced watermelon for several years on his land before he felt that the soil couldn't handle it any longer. He believed that the use of herbicide had contributed to the decline in fertility. For this reason, he shifted management towards less demanding perennials including cacao, soursop (*Annona muricata*), banana, and açai.

Weeding

As noted by previous dark earth scholars (German 2001, 2003; Major et al. 2003), the proliferation of weeds on dark earths is one of the soil's major disadvantages. Due to the heightened fertility of the soils, weeds thrive in areas quickly after clearing, sometimes threatening to choke out managed species if not properly tended to. Some farmers interviewed managed large fruit orchards in which shade helped to block out the majority of insistent weeds, but this would only occur after plants had begun to fully mature (usually 3 to 4 years). For those that managed annual crops, the use of herbicide was quite common. A third of farmers interviewed reported to use herbicides. 50% of farmers on ADE soils used herbicides while only 15.4% of non-ADE farmers used them (Figure 3-2). Fisher's exact test was conducted to analyze this difference in proportions, yielding a p-value of .103. Despite common use of herbicides among farmers, particularly those managing ADE, some individuals felt that herbicides inhibited the soil's fertility as one declared: "*a herbicida prejudica a terra e enfraquece o solo*" ("Herbicide harms the earth and weakens the soil").

For ADE farmers that did not use herbicides for reasons that were either personal or financial, it was said that more frequent clearing was necessary for ADE soils than Oxisols or Ultisols. It was noted on numerous occasions: "*a terra preta cerra muito*" ("terra preta weeds up a lot"). Due to the tendency of weeds to grow more quickly on dark earths, ADE farmers that managed larger areas of land often described a need for either more labor or machinery in able to combat the proliferation of weeds. One farmer even inquired if I could use my contacts with the local agricultural extension agency to acquire a weedwacker for him as he was tired of fighting unruly invasive plants.

Controlling Pests, Fungus, and Disease

Of the many obstacles that smallholders must face, controlling pests and disease may be one of the most challenging. In the context of this analysis, it must be stressed that pests and disease present problems that affect all farms and all soils. That being said, farmers that maintain large mono-cultural plots are usually vulnerable to specific types of diseases and pests attracted to those individual crops. Here, some of the more common threats that were either encountered or described by farmers from this study are examined.

Mites, referred to as *ácaro*, are a common problem for farmers in the Amazon, particularly for those who produce papayas. The two most common mites affecting papayas in Brazil are the broad mite (*Polyphagotarsonemus latus*) and the two-spotted spider mite (*Tetranychus urticae*) (Viera et al. 2004; Collier et al. 2004). Broad mites tend to attack terminal buds while the two-spotted spider mites usually feed on older leaves, which yellow and eventually drop (Collier et al. 2004). In the latter case, fruits usually receive greater exposure to the sun, which can have undesirable affects on fruit production. In Borba, few farmers mentioned this specific pest, but during a visit to a papaya orchard in Iranduba near Manaus in 2003, a researcher at INPA informed that mites were an increasing problem for papaya farmers in the Central Amazon (Newton Falcão, pers. comm., 2003).

In the case of bananas, sigatoka and Panama disease (*mal do Panamá*) are the most common threats. Unfortunately, there are no existing pesticides to combat sigatoka or Panama disease, although it has been found that sigatoka can be controlled by planting bananas in shade (C. Clement pers. comm., 2006). EMBRAPA, the Brazilian Agricultural Corporation, has also tried to address these problems by developing cloned bananas, which have better production and are highly-resistant to such diseases[20].

For cacao (*Theobroma cacao*) and cupuaçu (*T. grandiflorum*) production, witches' broom is the primary threat. In the state of Bahia, cacao plantations have been devastated by this disease. The high humidity of the Amazonian climate is also considered to be conducive to the propogation of the causal agent, *Crinipellis perniciosa* (Purdy and Schmidt 1996). In this study, one family mentioned planting cacao in plots that were 2.5m x 3m and they said it may have been better to space the trees out in a 4m x 4m arrangement to give them room to develop and allow for better circulation of air.

Anthracnose, caused by a fungal pathogen, was cited as another frequent disease. To be specific, the term anthracnose actually refers to a group of diseases caused by infection of fungi, one of the most common being the genus *Colletotrichum* (Agrios 2005: 487). Anthracnose can affect a whole host of plants on Amazonian farms, from avocados to passion fruit to watermelon. Many farmers who produced watermelon talked specifically about this problem. Since watermelon was produced only on ADE, it is important to recognize that despite the fertility of dark earths, production is complicated by other factors like anthracnose. Since anthracnose is caused by fungi, this also inhibits the number of years one can produce on a plot as the fungi will becoming increasingly concentrated in the soil through time.

In this study, farmers managing large monoculture plots of pineapple encountered problems with what is known locally as *cochonilha* or pineapple mealy bug (*Dysmicoccus brevipes*). On one visit to the community of Puxurizal, the municipal head of IDAM identified damage characteristic of *cochonilha* on 3 different farms. The pineapple plants had begun to

[20] Despite the productive benefits of cloned bananas, several people in the municipal center claimed to avoid buying them due to an aversion to their taste.

yellow and when the base of the plant was examined closely, a white pasty substance was present. The head of IDAM said the same problem had occurred at his pineapple plot at the IDAM office in Borba and that it could be fixed relatively easily with a product known as Folisuper. Although affected pineapple can recuperate from the damage, many farmers do not always have the necessary pesticides to salvage their crop.

In many visits to farms, *queima* (burning) and *broca* were general terms employed to describe the effects of pests, fungus, and disease. On guava and soursop, one farmed said that broca could be combated by spraying the trees with horse urine. An IDAM officer also mentioned that the fruits of soursop trees affected by broca can be wrapped with plastic bags as they begin to mature in order to protect them from the disease. Unfortunately, *queima* and *broca* are blanket terms that subsume a great variation of diseases that affect different crops on rural Amazonian farms. While farmers are able to combat some recognized forms of *queima* and *broca*, many individuals would benefit from expertise of regional agronomists in identifying specific diseases and pests.

In regards to pests, leaf-cutter ants and other bugs including the *cascudinho* were commonly cited problems for farmers in Borba. A type of grasshopper known as the *gafanhoto soldado* was another frequently described pest. Some farmers mentioned using pesticides known as Mirex and Folisuper. Another farmer said he simply used boiling water to handle larger pests like the grasshoppers.

Chemical pesticides were used in some form by 48.1% of the farmers interviewed (50% of ADE farmers and 46.2% of non-ADE farmers; Figure 3-2). Agrochemical products used to combat pests and pathogens by farmers of Borba included Decis, Tamaron, Ditane, and Folisuper. Tamaron, specifically, is one of the more dangerous products and is considered very toxic. Although specific data on the amount of such products used by farmers was not collected for every farm, some individual farmers offered such information. The farmer from the highest market-oriented farm said he had used over 30 kg of pesticide and herbicide in one season of watermelon production. He said his crew sprayed 2 times a week during the raining season and once a week during the dry season. He mentioned that Ditane was especially good for the wet season. This specific farm was the most extreme case in use of pesticides; most others used pesticides sparingly if at all.

Issues of Water, Climate, and Seasonal Variation

As in most of the Amazon Basin, the region surrounding Borba is subject to two distinct seasons: the dry season (*a época de seca*; *verão*) and the wet season (*a época de chuva*; *inverno*). The rhythm of life in the region is defined by this seasonality, which affects fishing, hunting, and of course, farming. All of the farms visited during this research relied upon rain for irrigation. On many occasions, farmers expressed how the reliance on rain-fed irrigation was another factor that complicated production. One ADE farmer who produced watermelon shared the following:

> Every year the "*verão*" [summer or dry season] arrives at a different time of the year. The year before [2006] it had been raining up until June. This year, summer arrived early and we probably would have been better off if we had planted in March instead of April. The problem that we are now facing is that when the dry season really hits its peak, the soil dries out, but the plantation really needs some rain water if the watermelons are going to reach good form before the harvest. (*Tigre –ADE farmer from Puxurizal*)

Although ADE is recognized for retaining moisture better than upland Oxisols probably due to ADE's higher levels of organic matter, farmers still complained that in the summer the soil dried out. One farmer shared the following: "*Quando o verão bate, a terra fica muito seca e produção não é tão bom, mesmo na terra preta. Só na várzea que é bom porque é humedo.*" (When the summer hits, the land dries out and production isn't very good, not even on terra preta. Only on the varzea is [production] good because it's moist). Another farmer suggested that dark earths are generally more fertile and can produce crops like corn and beans except during the height of the dry season (*no verão forte*), when the drought limits production on the uplands.

Many of the farmers discussed the fertility of the várzea, which was seen to be the most fertile soil in the region, although many farmers said the várzea was relatively limited near Borba and only opened into larger stretches close to the upriver town of Manicoré. Despite its fertility, the várzea is also risky for agriculture since the floods vary greatly from year to year in their timing and extent. This irregularity can be very problematic for those farmers who depend strictly on várzea agriculture. Although farmers who cultivate upland soils are not exposed to the same degree of risk, they too are greatly affected by yearly variation in the arrival of the rains and the intensity of the dry season. With increased climatic variation expected as a result of global warming, increased irregularities in rainfall and extended droughts will further complicate smallholder agricultural production in Amazonia.

Primary Crops

Perhaps the most notable way in which management differed on the ADE and non-ADE farms is related to the market crops farmers produced. Four of the market crops that reflect these critical differences are manioc, watermelon, papaya, and cacao (Figure 3-3). These crops and their relationship to ADE and non-ADE management are discussed here.

Manioc (*Manihot esculenta*)

Manioc is the primary staple crop of the Amazon. Oftentimes when rural farmers first clear a piece of land, manioc is the crop to be planted first. The plant is uniquely adapted to Oxisols of the Amazon due to its resistance to aluminum toxicity and low pH (see Moran 1973: 36). When planting, farmers stress digging a deep hole (*cova*) to place the manioc cuttings. Depending upon the variety of manioc and the growing conditions, the manioc tubers are usually mature within 8 to 12 months on terra firme and 5 to 7 months on the floodplain. Bitter manioc varieties are processed for the production of *farinha* (manioc flour), a staple food of the Amazon. Oftentimes, farmers stagger the harvest of tubers from a field and process the flour in stages (every two weeks to a month)[21]. Tubers of certain varieties can remain in the ground upon maturity for up to 12 months or more without rotting, and by processing little by little, manioc flour sold in the local markets can bring income into the household over an extended period of time. In addition to manioc flour, bitter manioc also yields *tucupi*[22] and tapioca. Sweet manioc (*macaxeira*) can be processed to produce a different variety of manioc flour or the tubers can be sold whole without processing due to the low quantities of poisonous cyanic compounds that are more concentrated in bitter manioc.

Contrary to the findings of Hiraoka and German, many farmers interviewed in this study claimed that manioc produced well in Dark Earth soils, however only two of the individuals managing ADE had manioc on their lands at the time of the study. Some individuals claimed that manioc produced better in dark earths than Oxisols, but no quantitative data was collected to confirm such claims. Many farmers claimed dark earths to be "softer" (*mais fofa*) or "looser" (*mais solta*), characteristics considered locally to be favorable for manioc production. One individual, however, claimed that he had only planted manioc on dark earth one year because he found that the stalks and leaves of the plant had developed well, but the tubers did not mature. This claim coincides with experiences of some of the farmers that Laura German interviewed in the Rio Negro region (German 2001; German 2003). Howeler notes that manioc can be very sensitive to over-fertilization and in certain instances, very fertile soils can cause plants to be excessively leafy (Howeler 1980: 63). Another farmer from this study complained that manioc

[21] This is also common amongst Amerindian groups as described by Carneiro amongst the Kuikuru of the Upper Xingu (Carneiro 1957).

[22] Tucupi is the liquid extracted from the bitter manioc when pressed. Boiling the liquid eliminates its toxic elements (cyanic compounds) yielding a sauce commonly used in regional cuisine.

tubers planted in dark earths rotted too quickly due to the humidity of the soil. This problem could be addressed by adopting manioc varieties from the floodplain that are better suited for moist conditions. Fraser reports that communities in the municipality of Manicoré do precisely this, producing manioc in shorter periods of time than is customary on the terra firme, with as little as 5 or 6 months depending on the cultivar (J. Fraser pers. comm. 2007).

In general, farmers participating in this study reported to manage manioc fields (*roçados*) for 2 to 3 years, before letting the land go fallow from anywhere between 2 to 7 years. Despite the heightened fertility of dark earths, most farmers managing these soils claimed that continuous cultivation beyond 3 years was difficult due to the "weakening" of the soil. Interestingly, in the municipality of Manicoré, James Fraser has found that some communities have cultivated manioc on the same dark earth soils for more than 30 years with short fallows of 2 years. What may explain these seemingly contradictory experiences is that the communities studied by Fraser invest their time primarily in manioc production, which through time has allowed for the adoption of landraces that produce greater yields in that unique soil environment. For the individuals interviewed in this study, other crops with greater market value (e.g. watermelon, papaya, cacao) were the primary focus of production, and manioc production was oftentimes secondary, perhaps explaining the less intensive management practices developed in association with the crop. Since ADE soils tend to suffer from weed proliferation, it is probable that communities that have more intense weeding practices are able to sustain manioc production on ADE as weed control is also cited as one of primary determinants in obtaining high manioc yields (Toro M. and Atlee 1980: 13).

Watermelon (*Citrullus lanatus*)

Within the state of Amazonas, the Rio Madeira region is known as a major producer of watermelon. For regional farmers, the production of watermelon is seen as a lucrative enterprise, although it is also considered a risky one. On several occasions, analogies were made between watermelon production and gold mining, activities in which some individuals strike it rich and others go broke. One particular farmer lamented having invested so much time and energy in watermelon the year prior as he claimed to suffer a large financial loss in a failed crop.

Watermelon was produced by 25.9% of farmers interviewed, all of which planted the crop on dark earths. Since watermelon is a relatively demanding crop in terms of soil nutrients, dark earths are considered particularly adapted for its cultivation. This belief is supported by German who reported that farmers in the area of Açutuba (near Manaus) also favored dark earths for watermelon cultivation (German 2001; also cited in Clement et al. 2003). An added benefit of producing watermelon on dark earths on terra firme is that the crop can be harvested by June or July when market prices are particularly high and the várzea is still flooded. The other part of the watermelon destined for the market is planted on the várzea, which isn't harvested until September. Dark earths, whose fertility parallels that of the várzea, hold a unique advantage for the production of watermelon. As such, dark earths can be considered a terra firme analog of the nutrient rich várzea soils.

Watermelons are usually planted in a 3x3m scheme with their holes (*covas*) measuring approximately 40x40cm. As mentioned earlier, most of the ADE farmers utilize chemical fertilizer in watermelon production despite the heightened fertility of the anthropogenic soils. Oftentimes, West Indian Gherkin, another cucurbit, is planted alongside watermelon and harvested at the same time.

As in the case of manioc, watermelon is seen to tire the soil quickly. Most farmers claimed that they were unable to plant on the same clearing for more than a few years before experiencing significant declines in production. What is perhaps a greater obstacle to planting watermelon on dark earths in terra firme are pests and fungal diseases, such as anthracnose. Unfortunately, many farmers are unequipped to combat such pests and fungus, and suffer losses in production as a result. In this case, greater technical assistance is needed to help local farmers address these obstacles to production.

Papaya (*Carica papaya*)

Papayas, like watermelon, are a popular crop for market production on dark earths. In the town of Iranduba many farmers cultivate papaya for the market in the nearby capital of Manaus (Falcão and Borges 2006; Hiraoka et al. 2003; Clement et al. 2003; McCann 2003). Similarly, several dark farmers in the municipality of Borba plant papaya, largely producing for the market in Manaus as well. For market production, *mamão havaí* (Hawaiian Solo papaya) was the most common variety managed, usually planted in a 2.5 x 3m scheme. On average, 1 ha of papaya yield 25 tons per year (IDAM – Borba, pers. comm.).

In the communities of Puruzinho, Caiçara, and Mucajá, papayas were found on dark earth farms. Outside of dark earth soils, papayas were usually only cultivated in homegardens. Of the 8 farms where papayas were found during this study, 7 of these were dark earth sites.

Papaya seeds are bird dispersed and can often be found as volunteers in fields and homegardens where soils are relatively fertile. As such, dark earths are excellent candidates for their spontaneous establishment (Clement et al. 2003). Families will often leave the plants after they have established themselves in the garden and pick their fruits.

Cacao (*Theobroma cacao*)

Cacao, one of Amazonia’s most economically valuable fruits, was found in 51.9% of farms visited during this study. 71.4% of ADE farms managed cacao while 30.8% of non-ADE farms managed the fruit. Although cacao has greater nutrient demands than many of the perennial fruit trees that grow in poor acid soils of the Amazon, their production is possible on

Oxisols, particularly when managed under shade (Cabala-Rosand et al. 1989: 409). It is notable that 70% of the ADE farmers planting cacao were participants in cacao projects sponsored by CEPLAC (Comissão Executiva do Plano da Lavoura Cacaueira). Many factors can determine the economic crops chosen by farmers, including not only their market price and productivity in a given edaphic environment, but also the subsidies or loans available for producing such crops through government programs. The latter reason appeared to have been a strong motivation for the production of cacao for farmers in this study as they were offered up to as much as R$30,000 (approximately $15,000 U.S. dollars at the time of study) over a 5 year period of production.

Most farmers interviewed planted cacao in a 3x3m scheme. In general, trees were reported to begin bearing fruit after the third or fourth year of planting. Cloned cacao varieties were used largely by CEPLAC project participants to avoid problems with witches' broom and similar fungal diseases. Nonetheless, some farmers had plantations suffering from an unidentified disease. One father and son had hypothesized that they had planted the cacao trees too close together and fungi were able to thrive.

Conclusions

For the majority of farmers interviewed, the primary benefit of Amazonian Dark Earth is its ability to produce nutrient-demanding crops with relatively little inputs over the short term (from 2 to 3 years). Watermelon, corn, beans, papayas, West Indian gherkin, and cucumbers are all crops that farmers claimed to produce well on ADE, but performed poorly in non-ADE soils. Despite this benefit, the majority of farmers interviewed also concluded that without inputs (i.e. fertilizers, herbicides, pesticides), sustained production on a single plot was extremely challenging after two years due to complications related to weeds, pests, and disease, regardless of the soil that was being managed (ADE or non-ADE). As Denevan notes "..even on good soils, a field may be fallowed in forest, bush, or grass when labor inputs for weeding become excessive or when crop losses to pests become excessive" (Denevan 2001: 45). Thus, without ecologically-sound multi-cropping arrangements, crop rotation strategies, or labor intensive management, ADE soils are no more likely to yield sustainable agriculture systems than surrounding Oxisols of the region.

Figure 3-1. Burned secondary vegetation in a field in Jatuarana near the town of Borba. The owner was intending to plant manioc in September (July 2007).

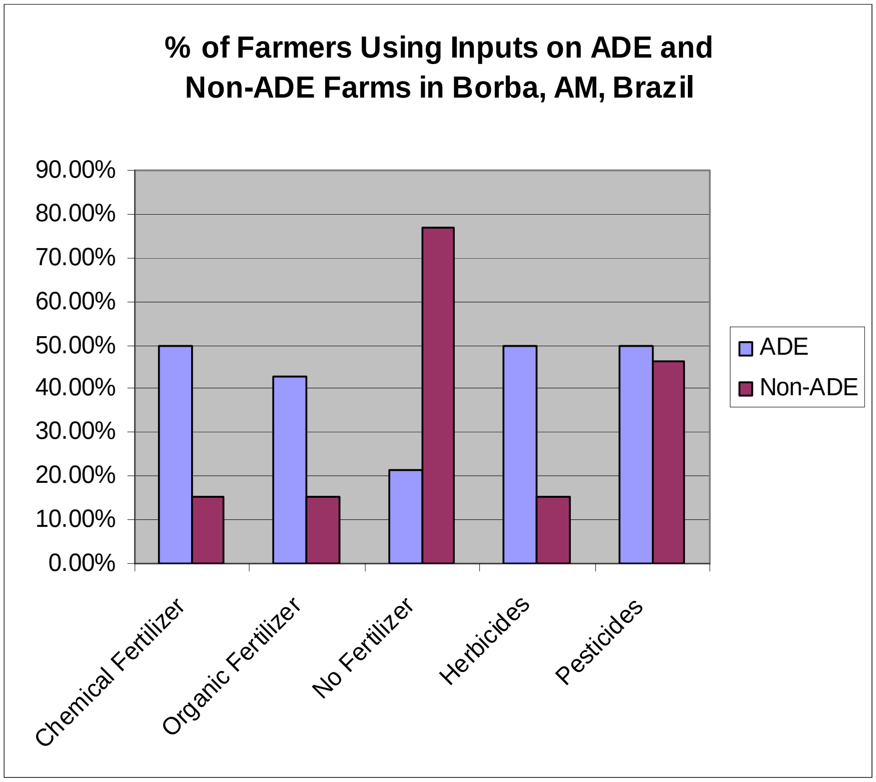

Figure 3-2. Differences in input use among ADE and Non-ADE farmers

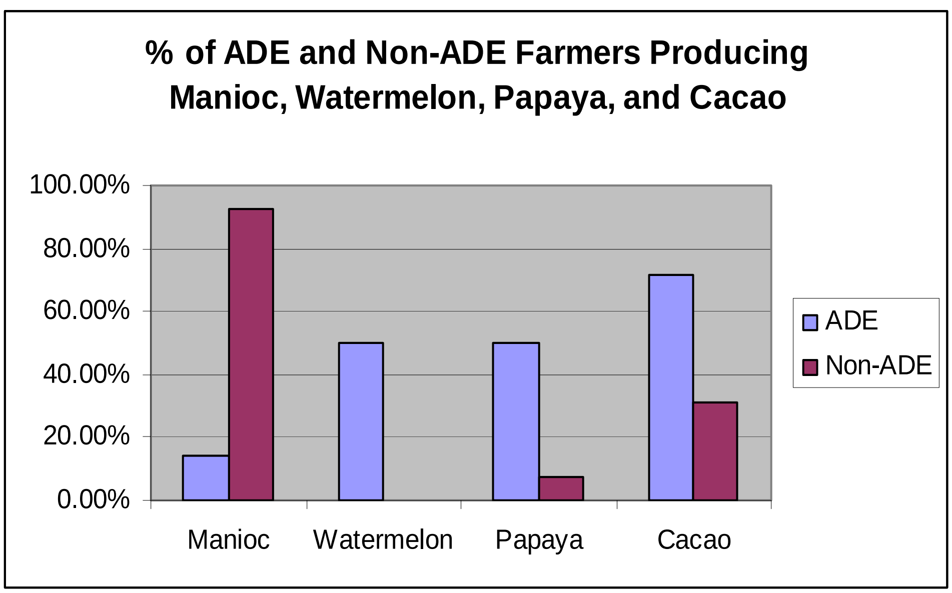

Figure 3-3. Differences in crop management on ADE and non-ADE farms

CHAPTER 4
MARKET PRODUCTION AND AGROBIODIVERISITY ON AMAZONIAN DARK EARTH FARMS IN BORBA, AMAZONAS, BRAZIL

Introduction

This chapter draws on empirical data to identify differences in market production and agrobiodiversity on ADE and non-ADE farms in the municipality of Borba, Amazonas, Brazil. This chapter also discusses ADE's unique relationship to Pre-Columbian agrobiodiversity and its advantages for market production in contemporary Amazonia. Finally, the relationship between market production and agrobiodiversity is examined here, allowing for comparison with past studies from Amazonia and other regions of the world that have attempted to determine the effect of markets on the agrobiodiversity of rural farms.

Market Orientation

To determine the market orientation for each individual farm, the total area of crops destined for markets was divided by the total area of cultivation at the time of the study, disregarding land left fallow. Data collection was complicated by the fact that many farmers did not manage discrete plots of market crops and non-market crops. In fact, several farmers maintained mixed agroforestry systems in which orchards of cacao, soursop, citrus, and other fruits were interplanted. In such polycultural orchards, some of the crops were destined for markets while others were maintained for subsistence, and yet others fulfilled both roles. Moreover, annual crops like manioc were often produced for both subsistence and local markets, making approximations of the area dedicated to market production difficult. In many instances, the area of market crops on large mixed agroforestry plots was designated at one half (.5). Fortunately, farmers with higher market orientations tended to have more distinct cropping patterns, thus allowing for more precise data collection on these farms.

In comparing means for market orientation, ADE farms averaged 61% market orientation while non-ADE farms averaged only 47.3% (Table 4-4 and Table 4-5). Independent t-tests confirm that these means are significant with 95% confidence (p=.023), demonstrating that ADE farms from this sample have greater orientation towards the market. These data are also supported by a comparison of the target markets of individual farms in which 50% of ADE farmers produced for the primary regional market of Manaus compared to only 15.4% of non-ADE farmers. This higher market orientation on ADE farms may be due in part to the fact that many agriculturalists that focus on production for larger markets tend to seek out ADE soils in order to exploit their fertility. This trend is remarked on by other researchers that conducted past management studies, specifically German (German 2003: 196). However, it is also reasonable to believe that due to the heightened fertility of ADE soils, smallholders are able to produce nutrient-demanding species with higher market values, which in turn may increase their production for the market. Since most of the communities in this study are located near the Rio Madeira, market access is relatively favorable as boats traveling to Manaus pass daily (Figure 4-1).

Agrobiodiversity Results

A total of 83 different species of plants were identified on the 27 farms surveyed[23] (Table 4-1). The most common species found on the farmers surveyed were açai (n=22), banana (n=19), orange (n=17), lemon (n=17), manioc (n=17), mango (n=17), and cupuaçu (*Theobroma grandiflorum*) (n=16). Açai, mango, lemon, orange, banana, and jambo (*Eugenia malaccensis*) were the most frequent species found in homegardens while manioc, açai, bananas, and cacao were the most common species found in agricultural plots, which consider both perennial and

[23]It was not possible to collect homegarden data at 4 of the 27 farms, thus total species and homegarden species statistics are based on a sample of 23 farms.

annual crop plots. On ADE soils specifically, açai (n=11), bananas (n=11), oranges (n=10), and cacao (n=10) were the most common species while on non-ADE soils, manioc[24] (n=15), açai (n=11), cashew (n=9), and banana (n=8) were the most frequent.

Regarding differences in agrobiodiversity on ADE and non-ADE farms, the data do not support the idea that ADE farms are more diverse than non-ADE farms. In analysis of the overall agrobiodiversity on farms in which both homegardens and swiddens were considered, ADE farms averaged 18.83 species with a standard deviation of 8.35 (Table 4-2) while non-ADE soils averaged 17.36 species with a standard deviation of 6.18 (Table 4-3). With regards to the species managed in homegardens, non-ADE soils maintained a higher average of 14.64 species (std. deviation 4.86) while ADE gardens averaged 13.42 species (std. deviation 5.83). However, on agricultural plots, ADE farms had higher means, averaging 8.14 species compared to 5.62 species on non-ADE farms. To evaluate the significance of these differences, independent t-tests were conducted. Results for the independent t-tests (equal variances not assumed) reveal that the differences in means of species between ADE and non-ADE farms are not significant ($t = .482$; $p = .635$).

Agrobiodiversity and ADE

Amazonian Dark Earths are believed to represent potentially unique reservoirs of economically important species that were managed by indigenous groups during the Pre-Columbian era (Clement et al. 2003). Despite this, ADE farms also demonstrate a greater capacity to support nutrient demanding exotics that otherwise suffer on regional Oxisols, which is evidenced in ADE farmers' production of crops like watermelon and West Indian Gherkin. As described in the last chapter, ADE farmers may manage different market crops than those

[24] This figure exceeds the number of total non-ADE farms (n=13) because 3 ADE farmers plant manioc in non-ADE soils.

individuals who farm on Oxisols, but the above data do not support the notion that ADE farmers manage greater agrobiodiversity.

Many farmers and researchers believe that abandoned ADE plots harbor concentrations of specific indicator species that are reflective of past management. Some of the species cited as indicators are tucumã (*Astrocaryum spp.),* babaçu (*Orbignya phalerata*[25]), caiaué (*Elaeis oleifera*), cacao (*Theobroma cacao*), and Brazil nut (*Bertholletia excelsa*) (McCann 1999; German 2003). In Borba, specifically, many farmers said that large *palhais* (stands of palms used for thatch, usually babaçu) were often indicative of abandoned dark earths (see Moran 1993: 69). Babaçu was noted in great concentrations at many abandoned ADE plots visited as well as some that were viewed from afar during boat trips made with IDAM. Another palm commonly associated with ADE in the Lower Madeira is caiaué, an endemic palm species, which bears fruits that can be used for oil (J. Fraser pers. comm. 2006; also see Moran 1993: 69). Urucuri (*Attalea excelsa*) is yet another common indicator on dark earths in the Madeira region (J. Fraser, pers. comm. 2008). Thus, while ADE farmers may take advantage of ADE to produce nutrient-demanding exotics (e.g. watermelon, West Indian gherkin), many abandoned stretches of ADE maintain thick stands of native palms from the region. Further research is necessary to better understand the floristic composition and historical ecology of such abandon ADE plots.

The Relationship between Agrobiodiversity and Market Orientation

Rural smallholders are considered to be in a particularly unique position to manage and maintain agrobiodiversity due to their relationship with the market economy, which is neither completely committed nor entirely detached. The dependence of smallholders on local natural resources for medicines, construction materials, and food sources allows for the maintenance of a

[25] Also classified as *Attalea speciosa*. (Henderson 1995)

wide variety of economically important species, many of which are classified as endemic species. Although not all evidence suggests that penetration of markets will lead to a degradation of genetic and species diversity on regional farms, concern over agrobiodiversity loss, particularly on ADE soils, is not unwarranted (Clement et al. 2003).

Interestingly, research by Major et al. has shown that ADE farms with lower market orientation in the Lower Rio Negro region reflected negligible difference in overall agrobiodiversity when compared with farms of higher market orientation as a result of the maintenance of species-rich homegardens (Major et al. 2005). In this study, which sampled farms considerably farther from the regional market of Manaus, the results reflect a relatively ambiguous relationship between market orientation and agrobiodiversity. Linear regression fails to reveal statistically significant relationship between market orientation (independent variable) and agrobiodiversity (dependent variable) when considering all farms (r^2= .028) or ADE and non-ADE farms individually (r^2=.183; r^2=.182, respectively). Figure 4-2 depicts this relationship between market orientation and agrobiodiversity for the entire sample (both ADE and non-ADE). Although increased market orientation does not appear to have a negative effect agrobiodiversity in this sample, it is highly probable that this is due to the fact that these farmers are all smallholders. Certainly, large-scale mechanized operations that produce strictly for the market tend to manage monocultures while smallholders who may even dedicate a large portion of their land to market crops still maintain diverse gardens and orchards that they maintain for their own subsistence.

Conclusions

From these data it is shown that ADE farms in this study tended to have greater market orientation than non-ADE farms. This distinction is evidenced in the specific crops produced by ADE farmers, the markets which they targeted, and the proportion of land that they dedicated to market production. Despite this difference, the data do not demonstrate any significant differences in the agrobiodiversity managed on ADE and non-ADE farms. Moreover, no distinctive relationship could be drawn between market orientation and agrobiodiversity for the farms (both ADE and non-ADE) visited in this study.

Figure 4-1. Watermelons from an ADE farm outside of Borba’s municipal center are loaded on to a river boat destined for Manaus (July 2007).

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Table 4-1. Species surveyed on ADE and non-ADE farms in Borba, Amazonas, Brazil

Family	Scientific Name	Local Common Name	English Name	Total freq. (n=23)	Plot Freq. (n=27)	HG. Freq. (n=23)	Forest Spp.	ADE freq.	Non-ADE freq.	Native/ Exotic
Anacardiaceae	Anacardium occidentale	Caju	Cashew	14	7	11	0	5	9	Native
Anacardiaceae	Mangifera indica	Manga	Mango	17	0	17	0	9	8	Exotic
Anacardiaceae	Spondias mombim	Taperebá; cajá	Hog Plum	5	2	3	0	2	3	Native
Anacardiaceae	Spondias spp.	Cajarana		1	0	1	0	0	1	Exotic
Annonaceae	Annona muricata	Graviola	Soursop	13	7	9	0	6	7	Native
Annonaceae	Rollinia mucosa	Biribá		4	1	3	0	1	3	Native
Annonaceae	Annona squamosa	Ata		3	0	3	0	2	1	Native
Annonaceae	Annona montana	Araticum	Mountain Soursop	1	0	1	0	0	1	Native
Apiaceae	Coriandrum sativum L.	Cheiro Verde; Coentro	Cilantro	1	0	1	0	0	1	Exotic
Apocynaceae	Himatanthus sucuuba	Sucuba		1	0	1	0	0	1	Native
Arecaceae	Euterpe oleracea; Euterpe precatoria	Açai	Açai	22	14	20	1	11	11	Native
Arecaceae	Bactris gasipaes	Pupunha	Peach Palm	13	7	8	0	6	7	Native
Arecaceae	Astrocaryum spp.	Tucumã	Star Nut Palm	12	6	6	2	6	6	Native
Arecaceae	Oenocarpus bacaba	Bacaba		9	5	4	0	3	6	Native
Arecaceae	Cocos nucifera	Côco	Coconut	11	2	11	0	7	4	Exotic
Arecaceae	Attalea maripa	Inajá		2	1	1	0	0	2	Native
Arecaceae	Oenocarpus bataua	Pataua		2	0	0	2	0	2	Native
Arecaceae	Orbignya phalerata	Babaçu		3	2	0	1	2	1	Native
Arecaceae	Mauritia flexuosa	Buriti		3	1	2	0	2	1	Native
Arecaceae	Attalea attaleoides	Palha Branca		3	0	2	1	2	1	Native
Arecaceae	Attalea phalerata	Urucuri		1	0	1	0	0	1	Native
Arecaceae	Elaeis oleifera	Caiaue	American Oil Palm	6	4	1	2	6	0	Native

Table 4-1. Continued

Family	Scientific Name	Local Common Name	English Name	Total freq. (n=23)	Plot Freq. (n=27)	HG. Freq. (n=23)	Forest Spp.	ADE freq.	Non-ADE freq.	Native/ Exotic
Asteraceae	Acmella oleracea	Jambu		1	0	1	0	0	1	Native
Bignoniaceae	Crescentia cujete	Cuia	Calabash	6	0	6	0	5	1	Native
Bixaceae	Bixa orellana	Urucum	Annato	3	1	2	0	2	1	Native
Brassicaceae	Brassica oleracaea L.	Couve		1	0	1	0	0	1	Exotic
Bromeliaceae	Ananas comosus	Abacaxi	Pineapple	10	3	7	0	4	6	Native
Caricaceae	Carica papaya	Mamão	Papaya	8	6	6	0	7	1	Native
Clusiaceae	Platonia insignis	Bacuri		1	0	1	0	1	0	Native
Cucurbitaceae	Citrullus lanatus	Melancia	Watermelon	7	7	0	0	7	0	Exotic
Cucurbitaceae	Cucumis anguria L.	Maxixe	West Indian Gherkin	4	4	0	0	4	0	Exotic
Cucurbitaceae	Cucurbita spp.	Jerimum	Squash	3	0	3	0	3	0	Native
Dioscoreaceae	Dioscorea trifida	Cará		1	0	1	0	0	1	Native
Euphorbiaceae	Manihot esculenta Krantz	Mandioca; Maniva; Macaxeira	Manioc; Cassava	17	17	1	0	2	15	Native
Euphorbiaceae	Hevea spp.	Seringa	Rubber	6	2	3	2	2	4	Native
Fabaceae	Inga edulis	Ingá, ingá cipó	Ice cream bean	12	4	9	0	7	5	Native
Fabaceae	Inga cinnamomea	Ingá açu		2	0	2	0	0	2	Native
Fabaceae	Cassia leiandra	Marimari		1	0	1	0	0	1	Native
Fabaceae	Derris spp.; Lonchocarpus spp.	Timbó		1	0	1	0	0	1	Native
Lamiaceae	Hyptis crenata.	Salva de Marajó		1	0	1	0	0	1	Native
Lauraceae	Persea americana	Abacate	Avocado	11	5	7	0	4	7	Native
Lauraceae	Licania puchuri-major	Puxuri		11	5	7	0	6	5	Native
Lecythidaceae	Bertholettia excelsa	Castanha	Brazil Nut	13	4	8	5	6	7	Native
Liliaceae	Allium schooenoprasum L.	Cebolinha	Chives	8	0	8	0	4	4	Exotic

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Table 4-1. Continued

Family	Scientific Name	Local Common Name	English Name	Total freq. (n=23)	Plot Freq. (n=27)	HG. Freq. (n=23)	Forest Spp.	ADE freq.	Non-ADE freq.	Native/ Exotic
Malphigiaceae	Malphigia glabra	Acerola	Barbados Cherry	3	0	3	0	2	1	Native
Malphigiaceae	Byrsonima crassifólia	Murici	Nance	1	0	1	0	0	1	Native
Malvaceae	Hibiscus sabdariffa L.	Vinagreira		1	0	1	0	0	1	Exotic
Malvaceae	Theobroma grandiflorum	Cupuaçu		16	8	12	0	8	8	Native
Malvaceae	Theobroma cacao	Cacau	Cacao	15	10	9	0	10	4	Native
Meliaceae	Carapa guianensis	Andiroba		5	3	3	0	2	3	Native
Monimiaceae	Peumus boldus	Boldo		1	0	1	0	1	0	Exotic
Moraceae	Artocarpus integrifolia	Jaca	Jackfruit	4	0	4	0	1	3	Exotic
Musaceae	Musa spp.	Banana	Banana	19	12	13	0	11	8	Exotic
Myrtaceae	Psidium guajava	Goiaba	Guava	12	1	11	0	7	5	Native
Myrtaceae	Eugenia malaccensis	Jambo	Malay apple	13	0	13	0	10	3	Exotic
Myrtaceae	Eugenia cuminii	Azeitona		4	0	4	0	3	1	Exotic
Oxalidaceae	Averrhoa carambola	Carambola	Starfruit	2	0	2	0	0	2	Exotic
Papilionaceae	Dipterex odorata	Cumaru	Tonka bean	1	0	1	0	0	1	Native
Passifloraceae	Passifloria edulis	Maracuja	Passion Fruit	1	1	0	0	1	0	Native
Piperaceae	Piper nigrum L.	Pimenta do reino	Black Pepper	1	0	1	0	1	0	Exotic
Poaceae	Cymbopogon citratus	Capim cheiroso; Capim santo	Citronella; lemon grass	4	0	4	0	2	2	Exotic
Poaceae	Saccharum officinarum L.	Cana de açucar	Sugarcane	2	2	1	0	2	0	Exotic
Poaceae	Zea mays	Milho	Corn	2	2	0	0	2	0	Native
Rubiaceae	Coffea spp.	Café	Coffee	11	6	9	0	6	4	Exotic
Rubiaceae	Genipa americana	Genipapo		2	2	0	0	1	1	Native

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Table 4-1. Continued

Family	Scientific Name	Local Common Name	English Name	Total freq. (n=23)	Plot Freq. (n=27)	HG. Freq. (n=23)	Forest Spp.	ADE freq.	Non-ADE freq.	Native/ Exotic
Rubiaceae	Alibertia edulis	Puruí		2	1	2	0	1	1	Native
Rutaceae	Citrus	Limão	Lemon	17	3	16	0	9	8	Exotic
Rutaceae	Citrus sinensis	Laranja	Orange	17	6	15	0	10	7	Exotic
Rutaceae	Citrus reticulata	Tangerina	Tangerine	6	2	5	0	3	3	Exotic
Rutaceae	Ruta spp.	Arruda		1	0	1	0	1	0	Exotic
Rutaceae	Citrus aurantifolia	Lima	Lime	1	0	1	0	1	0	Exotic
Sapindaceae	Paullinia cupana	Guaraná		1	0	1	0	0	1	Native
Sapindaceae	Nephelium lappaceum	Rambutan		1	1	0	0	1	0	Exotic
Sapotaceae	Pouteria caimito	Abiu		4	1	3	0	3	1	Native
Solanaceae	Capiscum chinensis	Pimenta malagueta	Hot Pepper	5	1	4	0	2	3	Native
Solanaceae	Solanum sessiflorum	Cubiu		3	0	3	0	0	3	Native
Solanaceae	Capiscum spp.	Pimenta do cheiro	Sweet pepper	5	3	4	0	3	2	Native
Solanaceae	Capiscum chinensis	Pimenta murupi	Hot Pepper	4	1	3	0	2	2	Native
Solanaceae	Lycopersicon esculentum Mill.	Tomate	Tomato	1	1	0	0	1	0	Exotic
Solanaceae	Capiscum annuum L.	Pimentao	Bell Pepper	1	1	0	0	1	0	Exotic
Zingiberaceae	Zingiber officinale	Gengibre; Magarataia	Ginger	1	1	0	0	1	0	Exotic

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Table 4-2. ADE farms species distributions

ADE	Total Spp.	Homegarden Spp.	Agroplot Spp.
No. Valid	12	12	14
No. Missing	2	2	0
Mean	18.83	13.42	8.14
Median	17.5	14.5	5.5
Std. Dev.	8.354	5.583	6.982
25th Percentile	14.5	11	3.5
50th Percentile	17.5	14.5	5.5
75th Percentile	24.75	17.75	11

Table 4-3. Non-ADE farms species distributions

Non-ADE	Total Spp.	Homegarden Spp.	Agroplot Spp.
No. Valid	11	11	13
No. Missing	2	2	0
Mean	17.36	14.64	5.62
Median	19	16	4.0
Std. Dev.	6.185	4.864	4.057
25th Percentile	13	11	2.5
50th Percentile	19	16	4.0
75th Percentile	23	18	10

Table 4-4. ADE farms market orientation (descriptive statistics)

ADE	Market Orientation (%)
No. Valid	14
No. Missing	0
Mean	61
Median	49.35
Std. Dev.	18.8834
25th Percentile	47.975
50th Percentile	49.35
75th Percentile	73.525

Table 4-5. Non-ADE farms market orientation (descriptive statistics)

Non-ADE	Market Orientation (%)
No. Valid	13
No. Missing	0
Mean	47.629
Median	47.5
Std. Dev.	7.1903
25th Percentile	44.05
50th Percentile	47.5
75th Percentile	50

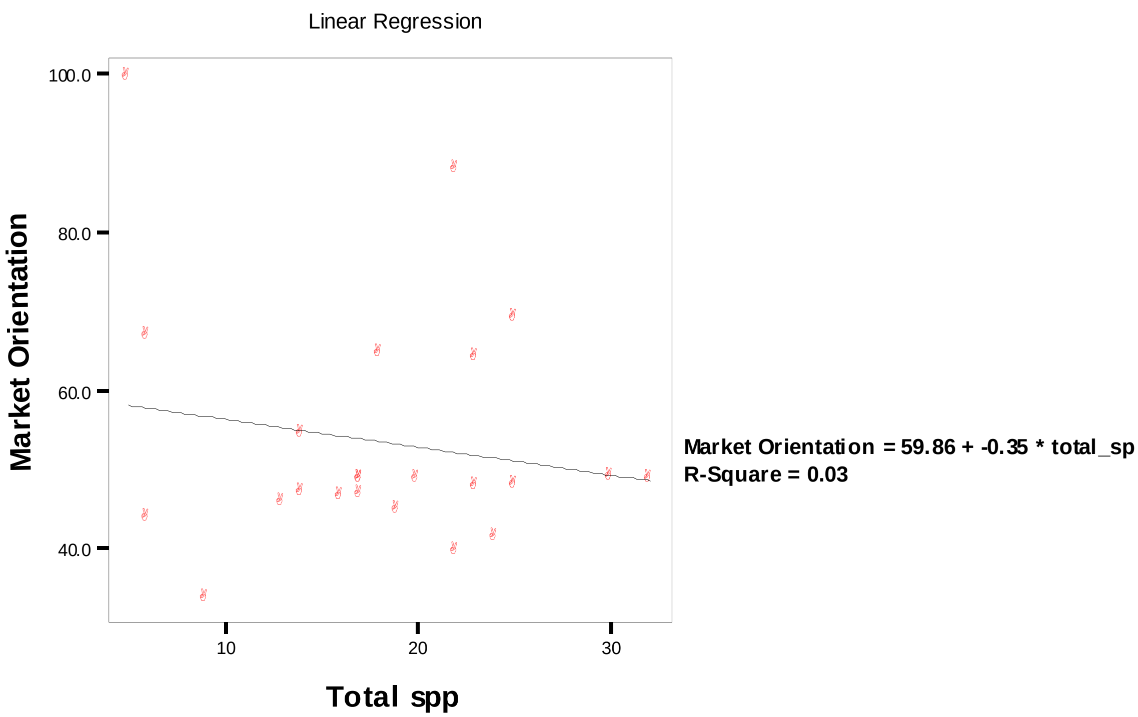

Figure 4-2. Relationship between species under management and market orientation

CHAPTER 5
AMAZONIAN DARK EARTH IN THE CONTEMPORARY GLOBAL CONTEXT: A MODEL OF "SUSTAINABLE AGRICULTURE"? FOR WHOM?

Introduction

Outside of Amazonia, the Amazonian Dark Earth model is being adapted as a tool to combat climate change through carbon sequestration. Although this new technology described as "bio-char" or "agri-char" is in many ways far-removed from the anthropogenic soils managed by Amazonians, the development of this technology is a direct result of interdisciplinary research conducted in Amazonia over recent decades. Today as North American and European businesses intend to promote bio-char in the new "green" economy, the original intention of the Terra Preta Nova project, which was to enhance smallholder agricultural production capacity, is largely being overlooked.

This chapter examines the process by which this "local" or "regional" model has made the transition to a global market and how this transition affects its local re-application. This discussion also addresses the conflict of adapting past indigenous property to contemporary problems while exploring issues of intellectual and cultural property. Lastly, suggestions are made as to how new technologies inspired by the Amazonian Dark Earth model may be introduced into smallholder communities of Amazonia.

Terra Preta Nova: A model for sustainable agriculture

Much attention has been drawn to dark earth as a result of its perceived potential as a technology for sustainable agriculture. This interest has been driven by a growing need to intensify agricultural production, particularly on abandoned or degraded lands. While the region is traditionally conceived of as having nutrient poor soils unfit for sustainable agriculture (particularly in Amazonian blackwater environments), ADE seemingly contradicts the notion of the Amazon being a land of extreme environmental constraint.

In 2002 during the First Amazonian Dark Earth Workshop in Manaus, the late Wim Sombroek proposed the idea of the Terra Preta Nova (TPN) project. The project was designed with the aim of replicating dark earths in order to improve the capacity of small-holder agriculture in the Amazon (Sombroek et al. 2002). The project was also presented as an opportunity for ADE researchers to network and collaborate. Members of the workshop agreed with the proposal and institutions from Brazil, the United States, Germany, and the Netherlands were invited to participate. Universities, research institutes, and a museum were integrated into the project in addition to EMBRAPA, the Brazilian Agricultural Research Corporation[26]. Since 2002, soil scientists from EMBRAPA and INPA have been conducting experiments in order to determine the key components of the soil's physical and chemical make-up. Through these experiments, it was hoped that a model for a "new dark earth" could be produced.

Biochar: A Terra Preta Technology

At the time that the Terra Preta Nova project was conceived, the corporation EPRIDA was founded in the United States[27]. The founder of the company, Danny Day, had collaborated with laboratories from the U.S. Department of Energy to develop a process by which biomass could be used to produce hydrogen fuel. Day found that charcoal produced in this same process could also be used as a fertilizer following the Amazonian Dark Earth model. From this research, Day founded EPRIDA and filed a patent for his process of producing hydrogen fuel and charcoal fertilizer, known as "bio-char". Day demonstrated that when biomass is converted to bio-char, the carbon that is normally released into the atmosphere during the decomposition of

[26] See Madari et al. 2004 for a complete listing of institutions participating in the Terra Preta Nova project.

[27] Visit www.eprida.com for further information regarding the company's history and its products.

the organic matter is locked in the charcoal. Thus, bio-char represents a simple technology that can diminish carbon emissions and improve agricultural yields by storing charcoal in soil.

Since EPRIDA opened its business, a number of other alternative energy companies have adopted similar models for the production of bio-char including Dynamotive, Bioware, Best Pyrolysis, and Terra Humana Clean Energy. Today companies offering bio-char products and bio-char processors (known as “pyrolizers”) exist in 11 countries across the world (Table 5-1). While EPRIDA is promoted as a socially-responsible corporation focused on assisting subsistence farmers, other companies are beginning to market the model towards industrial farmers and large agribusinesses. With the advent of carbon markets, it is believed that the use of bio-char for carbon sequestration can render such models more than profitable.

Responses to the Bio-char Fertilizer

U.S. and European news corporations have caught on to the ADE phenomenon, publishing articles with such titles as “Scientists Promote Benefits of ‘Black Magic’ Soil” (Binns 2006) and “Black is the new green” (Marris 2006). However, not everyone has shared the same enthusiasm for the development of a new and profitable charcoal fertilizer. Some scholars feel that with the promotion of bio-char as a product designed for industrial agriculture, the original intention of the Terra Preta Nova project is being abandoned for big profits in international markets. In response to the *Nature* article “Black is the new green”, three researchers spoke specifically about this trend:

> …one might be left with the impression that the biochar initiative is solely directed towards agribusiness applications. From the start, this has certainly not been the case. Indeed, innovative biochar field trials involving a variety of crops are currently being conducted in Amazonia…These trials are specifically designed for implementation by smallholders, who comprise most of the world’s farmers” (Woods et al. 2006).

Other concerns are voiced by Madari and company in the volume *Amazonian Dark: Explorations in Space and Time* (Madari et al. 2004). Due to the larger history of Amazonian Dark Earth and its relationship to indigenous people of South America, they argue that it is more appropriate for such technology to be developed and managed in the region (specifically Brazil):

> It is important to emphasize that many of the ADE sites have a reasonable amount of archaeological material which makes these areas important subjects of cultural heritage preservation. The objective of studying this phenomenon by no means can be the exploration of discovered new sites, but the use of the 'buried' information in these soils. This information should be considered as the intellectual property of the indigenous people of Amazonia. For this reason, it would be fortunate if the administration of a project aiming to study and use the knowledge of this phenomenon stayed with a Brazilian national institution like Embrapa (Brazilian Agricultural Research Corporation) which would ensure proper handling of intellectual property rights and even-handed and socially acceptable distribution of the products and technologies. (Madari et al. 179)

By the time these words were published, however, the development of such technologies had already moved beyond the Amazon to the U.S., linking it to the larger global market. How this development relates to the original terra preta and the application of bio-char in Amazonia is a question that requires analysis.

Cultural and Intellectual Property Questions

Due to Amazonian Dark Earth's association with indigenous settlements, Madari et al. (above) claimed that such soil should be considered either cultural or intellectual property of indigenous people (Madari et al. 2004). However, ambiguities that exist in our understanding of ADE and intellectual and cultural properties themselves make such a determination problematic at best. Strathern describes cultural property in the following manner: "…one of the tests of a group's claims may the transmissibility of cultural knowledge over the generations: it is authentic because it can be shown to have been handed on" (Strathern 1999:169). Clearly, Amazonian Dark Earth fails to hold up to this definition. These soils are in part defined contemporarily by their divorce from the peoples that are responsible for their formation.

Intellectual property, in contrast, is described by Stathern as claimable precisely because it is not handed on over generations (ibid.). In other words, the knowledge associated with the phenomenon must be isolated and controlled. Amazonian Dark Earth does not comply with this definition of property either. First, the soil is distributed widely throughout the basin, in a number of different countries and contexts. Second, no evidence has shown that ADE is more than a by-product of indigenous habitation, begging the question as to whether or not there is any human process related to its formation that can be considered “intellectual”.

Yet, the fact remains that ADE’s origins are intimately linked to past indigenous occupation in the Amazon. How these anthropogenic landscapes can be managed and defined as “properties” are issues that will require consideration by anthropologists in coming years. At the moment, the FAO is considering dark earths as one of the world’s Globally Important Ingenious Agricultural Heritage Systems (GIAHS 2006). Programs such as this may draw greater attention to the existence of anthropogenic environments and their value for understanding co-evolutionary relationships between humans and the environment through time.

Biopiracy and the Neighbors to the North

The tensions that are apparent in the commercialization of bio-char and the handling of dark earths as a cultural property are situated in a larger context of Brazilian uneasiness with foreign interests in Amazonia. In October of 2006, the British Secretary of State for Environment, Food and Rural Affairs, David Milliband, was planning to propose an initiative that would call for the privatization of parts of Amazonia (Hennessey 2006). When the news was released by the British newspaper *The Daily Telegraph*, Miliband’s office rejected the story, in attempt to avoid mounting political backlash. Responding to the notion of such a plan, Brazil’s Foreign Minister and Environment Minister simply stated: “Amazonia is not for sale.” (Geraque and Canônico 2006).

Since Henry Wickham left Belém with a ship full of rubber seeds, which later led to the establishment of rubber plantations in Southeast Asia and the bust of the 'Rubber Boom', Brazilians have become increasingly suspicious of the activities of foreigners in Amazonia. Some have argued that Wickham left the country with the Brazilian port authority's full knowledge of the seeds that he was carrying, but regardless of whether this is true or not, the event became symbolic of a larger concept introduced to contemporary discourse concerning property rights and biological research: the notion of "biopiracy".

Biopiracy is a concept that has been used to describe foreign extractive activities that lead to the development of products derived from biota endemic to an area or region. The American Heritage Dictionary defines biopiracy as the following: "The commercial development of naturally occurring biological materials, such as plant substances or genetic cell lines, by a technologically advanced country or organization without fair compensation to the peoples or nations in whose territory the materials were originally discovered." (Pickett 2000). One recent example of biopiracy comes from a patent filed for the process to extract fat from cupuaçu (*Theobroma grandiflorum)* seeds. The process, which is used for the making of *cupulate* (a product similar to chocolate) was developed by EMBRAPA, but had been claimed by the Japanese corporation Asahi Foods. Asahi Foods also placed a trademark on the name "cupuaçu" for the sale of its products derived from the fruit. Both of these claims eventually went to international courts and were sided in favor of EMBRAPA (Medina and Almeida 2006). Similar legal wrangling occurred over international patents and trademarks related to the use of the recently popularized Amazonian berry, açai (ibid.). As Amazonians witness foreigners attempt to profit from products native to their region, their relationships with these outsiders is not without a sense of resentment and regret.

In the case of bio-char, biopiracy is not an issue, yet research and development on the subject may cause similar tensions. As outside companies develop processes to produce pyrolizers and charcoal fertilizer inspired by ADE, Amazonians are faced with another example in which outsiders are capitalizing upon their natural and cultural resources.

Revisiting World Systems Theory and Dependency Theory

A multitude of theoretical arguments have been made to explain the process by which some nations and/or groups have exploited others through time in the global economic and political arena. In the 1970s, Immanuel Wallerstein's "World Systems Theory" and Andre Gunder Frank's "Dependency Theory" were particularly popular models for explaining the historical forces which bind "developing" nations to a cycle of "underdevelopment."

In Wallerstein's work *The Modern World System I* (1974), he examines the origin of the European World-Economy in the 16th century. In this historical account of capitalist origins, Wallerstein distinguishes between "core" countries and "the periphery". The relationship between the periphery and the core is defined by unequal exchange, in which the core countries produce high-profit, high-capital intensive goods that are exchanged for low-profit, low-capital intensive goods produced in the periphery. Wallerstein concluded that this unequal exchange produced increasing social and economic disparities between the core and the periphery, which perpetuated such imbalance.

Andre Gunder Frank, a contemporary of Wallerstein, had proposed similar ideas, describing countries in terms of "metropoles" and "satellites". Rather than view "development" and "underdevelopment" as two distinct phenomena, Frank understood them as being intimately linked. According to his argument, the metropolis extracted surplus from the satellites, inhibiting their development and feeding its own. Frank described this as "the development of underdevelopment”, which perpetuated the same disparities as described by Wallerstein (Frank 1966).

In the contemporary knowledge-based economy (Gibbon et al. 1994), it is difficult not to draw similar comparisons between the manner in which information and knowledge is drawn from the periphery and satellites to the contemporary cores and metropoles, much in the same way natural resources and labor once were (and are). However, critics of the work of Wallerstein and Gunder Frank have described these models as too simplistic, essentialist or deductivist. It has been pointed out that *within* nations termed as either metropoles or satellites, there exist further networks of metropoles and satellites. Moreover, it has been argued that with the advent of the internet and global mass communication, the flow of information and resources is far too disarticulated to be explained by models presented in such terms. Yet it is recognized that rural Amazonia remains at the periphery, or at best, the frontier. This is evidenced by its treatment historically as a target of *extraction* and not a focus of *development*. In fact, much of the debate regarding issues of sustainability, biodiversity maintenance, and global climate change has centered on the issue of whether the global community should allow for the development of Amazonian forests. As such, the U.S., Western Europe, and Japan have sought to promote research to understand and protect Amazonia’s natural wealth while attempting to bar Amazonian nations from developing the region for their own needs of land, energy, and resources. Although the development of bio-char as a technology modeled after ADE is only a footnote in the larger history of this process, it is testament to the perpetuation of a lopsided exchange.

Ironically, it can be argued that the force that led to the end of ADE’s formation (i.e. Western imperialism powered by global capitalism) is the same force that has led to the introduction of this indigenous phenomenon to contemporary global markets. Global capitalism's opportunistic exploitation of resources and knowledge is a familiar intellection, but its increasing capacity to transform local natural and cultural resources into new global technologies while simultaneously isolating the actors from which they were drawn is concerning. Fortunately, in the case of Amazonian Dark Earth, the process that foreign corporations have developed to produce bio-char fertilizer does not prevent South American corporations from devising a similar process for the production of charcoal fertilizer and carbon sequestration technologies, and some corporations in Brazil have begun to do so. Yet whether these models will ever come to benefit to rural Amazonian smallholders is another question entirely.

A Terra Preta Technology Exchange?

For non-Amazonians, ADE and more specifically, bio-char, represents a model that can facilitate a shift towards agriculture that is perceived as environmentally friendly and "sustainable". How this development of sustainable agriculture can benefit rural Amazonians is not clear. As much of the present research regarding bio-char is moving its focus towards application for large-scale mechanized agriculture, it appears that the rural smallholders of Amazonia will have little to gain from these developments.

Interestingly, Rubem César Rodrigues Souza, a researcher from the Centro de Desenvolvimento Energético Amazônico from the Universidade Federal do Amazonas[28] has developed a machine for a small community in the state of Amazonas which processes açai seeds and creates a form of biodiesel that can be used to power the community's generator. As diesel is rather expensive and often in high demand in rural communities of the interior of the Amazon,

[28] Visit the site for the Center of Amazonian Energy Development from the Universidade Federal do Amazonas at http://cdeam.ufam.edu.br/

a consistent energy source for individuals in these communities is a priority that is much more immediate than carbon sequestration. With nearly endless supplies of biomass that represent potential fuel for these communities, all that is missing is technology that can convert these sources into fuel. As EPRIDA and other corporations have shown, technology has been developed to not only harness fuel from this biomass, but create bio-char, which could serve as an added bonus for local farmers, all while sequestering carbon for the North. Although it would require tremendous investment, pyrolizers modeled after those of bio-char corporations could not only contribute to the development of a “New Dark Earth” in the Amazon, but they could also potentially provide rural communities with an excellent solution for energy independence, a hugely important step towards development in rural Amazonia. Moreover, as state and federal governments actively invest in infrastructure and agricultural financing projects to minimize migration of rural peoples to urban capitals, technologies modeled after bio-char pyrolizers could represent unique alternatives to provide communities with energy, subsequently improving the quality of living in these areas and deterring potential out-migration. In order to test the potential of this technology for rural agricultural communities, pilot projects must be carried out, preferably in tandem with organizations like the Centro de Desenvolvimento Energético Amazônico.

Conclusion

The development of bio-char as a technology is the indirect result of more than 100 years of research in Amazonia and an even longer history of occupation by its indigenous inhabitants. The potential this technology has for improving agricultural production and sequestering carbon is promising, but how these benefits will be distributed is yet to be seen. The purpose of this analysis here is not to demonize foreign corporations for profiting on this model since they are equally responsible for its modern application, but rather point out that efforts must be made to implement these technologies for the benefits of rural farmers in Amazonia and the tropics in general, as these were the originally intended beneficiaries of ADE research. If Amazonia and the rest of the developing tropics are to become images of "sustainable" development, then we must cease to be view them as "pristine" forests needing to be saved, but rather complex social spaces where development projects must attend to not only the needs of the local environment, but its people as well. By providing alternative sources of energy while sequestering carbon in the form of charcoal, new bio-char processing technologies have the potential to do exactly this.

Table 5-1. Companies that produce bio-char and pyrolyizers

Company	Country	Products Offered
Advanced Biorefinery Inc.	Canada	Transportable pyrolizers
Agri-Therm Ltd.	Canada	Portable and stationary equipment for bio-oil production
Appropriate Rural Technology Institute	Pune, India	Pyrolizers for sugar cane waste
Best Pyrolysis, Inc.	USA/ Australia	Pyrolizers and gasification technologies
Biocarbo	Brazil	Biochar and wood vinegar
Bioenergy, LLC	Russia	Pyrolizers
Bioware	Brazil	Pyrolizers for charcoal powder and bio-oil; training and consulting
Cleanfuels	Netherlands	International consulting and business development for pyrolysis oil and charcoal production
Carbon Diversion Technologies	Hawaii, USA	Flash carbonization technology
Dynamotive Energy Systems Corp.	Canada	Fast pyrolysis technology for BioOil and Biochar production
Envipower	Lyngby, Denmark	Biomass boilers for carbon fertilizer production
Eprida	Georgia, USA	Biochar fertilizer and pyrolysis technology; consulting
Ensyn Corporation	Canada	Rapid thermal processing technology
International K & K Enterprise	Korea	Charcoal processing and charcoal products
Pronatura	France/ Brazil	
Renewable Oil Corporation Pty Ltd	Australia	Pyrolysis technology
Renewable Oil International, LLC	Alabama, USA	Fast pyrolysis biorefinery technology
Terra Humana Clean Technology Ltd	Hungary	Thermal desorption, pyrolysis and low temperature carbonization technologies for specific COAL & CARBON applications for industry, agricultural biotechnology science and agricultural applications.

CHAPTER 6
CONCLUSIONS AND FINAL CONSIDERATIONS

Summary of Research Findings

As described in the first chapter, this case study sought to answer five specific research questions regarding management practices, agrobiodiversity, and market production among ADE and non-ADE farmers in Borba, Amazonas, Brazil. Based on the data gathered in this study, the findings are presented here.

1. *Do ADE farmers maintain different management practices than "non-ADE" farmers?*

These data suggest that ADE and non-ADE farmers did maintain different management practices. Specifically, ADE farmers had a greater tendency towards the use of both chemical and organic fertilizers as well as herbicides. Moreover, ADE farmers tended to manage different market crops, particularly watermelon and papayas, in contrast to non-ADE farmers who placed greater focus on manioc.

2. *Do ADE farms maintain higher levels of agrobiodiversity?*

The data do not reveal any significant differences in the agrobiodiversity managed on ADE and non-ADE farms. Although it is believed that abandoned ADE sites harbor higher concentrations of economically important plants from the Pre-Columbian era, contemporary ADE farmers in Borba do not necessarily manage a greater diversity of economic plants than non-ADE farmers.

3. *Do ADE farms have a higher market orientation than "non-ADE" farms?*

The data do suggest that ADE farms from this sample have a higher market orientation than non-ADE farms. In comparing means for market orientation, ADE farms averaged 61.0% market orientation while non-ADE farms averaged only 47.3%. Independent t-tests confirm that these means are significant with 95% confidence ($p=.023$).

4. *Does agrobiodiversity decrease with heightened market production?*

This research reveals no distinct relationship between market orientation and agrobiodiversity for the farms surveyed. Linear regression analysis yields an extremely weak r^2 value of .028, suggesting that the relationship is poorly defined in this sample.

5. *Does heightened market production correspond to specific management practices and techniques?*

The farmers in the study who maintained higher market orientation (oftentimes ADE farmers) did maintain different management practices, particularly with regards to inputs. When comparing those farmers who used chemical fertilizers with those who did not, farmers using chemical fertilizers averaged 67.4% market orientation while those who did not averaged only 47.9% market orientation. Independent t-tests confirm that these differences are statistically significant with 95% confidence (p-value= .019).

Final Considerations

The case study presented in this thesis demonstrates that Amazonian Dark Earth soils appear to provide distinct advantages for rural Amazonian farmers, particularly with regards to production of valuable market crops over the short-term. However, the degree to which these soils represent a model of sustainable agriculture is unclear. Research by Fraser and company shows that long-term, intensive management of ADE soils occurs in the region of the Middle Madeira with minimal use of inputs (Fraser et al. 2007), but it should be recognized that those communities focus on the production of manioc, a crop that is not particularly nutrient-demanding. Contrasting Fraser’s research from Manicoré with the research presented here from Borba, I would surmise that as farmers seek to produce for larger regional markets, the adoption of more demanding crops will limit the long-term productivity capacity of Amazonian Dark Earths if farmers do not invest considerable agricultural inputs (i.e. organic or chemical

From a global perspective, ADE has a different value as it demonstrates the utility of charcoal as an agricultural input. The high concentration of charcoal in ADE is believed to help maintain stable soil organic matter, prevent nutrient leaching, and potentially serve as an important carbon sink. The development of bio-char technologies modeled after ADE have been popularized internationally due to their potential for improving agricultural production in leached soils across the world, however such global popularization has yet to produce any direct benefit for rural Amazonians. I suggest that as pyrolizers and other technologies are developed to produce bio-char, bio-diesel, and other similar products, Amazonian governments and businesses can harness these technologies and develop pilot projects in rural communities following the lead of Rubem César Rodrigues Souza and other researchers at CDEA. Hopefully rural Amazonians will then have the option to produce either bio-char for agricultural application or bio-diesel for much-needed energy in their communities.

APPENDIX A
INTERVIEW GUIDE

DATA:
No. de entrevista:

Perguntas para entrevista

Informações biográficas

1. Nome:

2. Idade:

3. Sexo:

4. Quantos anos você mora na Amazônia?

5. Os seu pais são da Amazônia?
   a. Mãe b. Pai

6. Você trabalhava na roça quando era mais novo?

7. você caça ou pesca: No caso sim, para subsistência ou para vender?
   C - P –

8. Quais são outras atividades que você faz para sustentar a sua família?

9. Quantas pessoas moram na sua casa?

10. Qual é a área total do seu lote?
    a. Área de roça:
    b. Área de capoeira:
    c. Área de fruteiras e perenes:
    d. Área de pastagem:
    e. Área de mata:

Manejo

11. Você tem certas práticas ou métodos para manter boa fertilidade de solo? (exemplo, rotação de culturas)

12. Você usa fertilizante? No caso sim, adubo químico ou orgânico?

    a. Q ______________ b. O ______________

13. Quantas roças você tem no momento?

14. Em geral, quantos anos você trabalha (cultiva) uma roça?

15. Como e quando você decide abandonar uma roça (para poder recuperar)?

16. Quantos anos você deixa uma roça recuperar (descansar) antes de cultivar novamente?

17. Quais fatores influenciam o tempo que você deixa uma área recuperar?

18. Como você maneja áreas de recuperação?

19. Você planta certas culturas/árvores nessas áreas?

20. Como e quando você decide fazer uma roça nova?

21. Quais fatores importantes são mais importantes para você quando faz uma roça nova: sol, drenagem, vento, vegetação, solo?

22. Quando (qual época do ano) você faz a derruba?

23. Como você derruba a vegetação?

24. Como você derruba arvores grandes?

25. Quem ajuda você nesse processo todo? Você participa em mutirão?

26. Você usa fogo para o manejo do seu terreno? No caso sim:

    a. Quando você queima a área?

    b. Quais plantas/espécies queimam facilmente?

    c. Quais plantas/espécies são mais resistentes ao fogo?

    d. Qual é a temperatura ideal para a queima?

    e. Qual é a duração ideal para a queima?

    f. Quantas vezes você queima uma roça nova?

    g. Como você controla o fogo (usa aceiros)?

    h. Como você usa/maneja cinza, carvão, raízes e tocos (stumps) queimados?

    i. Você queima certas áreas uma segunda vez ou coleta materiais para fazer coivara?

    j. Você usa fogo para caçar ou usa em outras atividades fora de agricultura?

27. Você utiliza um sistema de irrigação? No caso sim, que tipo de sistema?

28. Se não usa irrigação:
    a. Como você sabe quando preparar a roça e plantar antes da chuva chegar?

    b. O que você planta na época de seca?

    c. Quais são os métodos que você usa na época de seca?

29. Quais culturas são interplantadas (plantadas em associação com outras)?

30. Como você escolhe sementes (ou material vegetativo)?

31. Quais são razões para perda de produção (ex, pestes, doenças, etc.)?

32. Você tem métodos para eliminar pestes (como a formiga saúva)?

33. Como você lida com plantas invasoras Tem prática ou técnicas para evitar a roça de "cerrar muito"?

34. Qual é o rendimento previsto (aproximadamente) este ano?

35. Quando e como você faz a colheita?

36. Como você guarda ou armazena a colheita?

37. Quais problemas você enfrenta no armazenamento da colheita?

Produção para subsistência e para o mercado

38. Qual parte (porcentagem) da sua produção é para o consumo de você e a sua família?

39. Qual é a área de culturas produzidas para o mercado e a área total sob cultivação?
    a. Mercado: b.Total sob cultivação:

40. Tem certas culturas que você só vende para o mercado? Quais?

41. Quais são as outras culturas que você vende também?

42. Como você leva produtos para o mercado?

43. Se você não leva, quem leva? Como você conhece essa pessoa?

44. Quantas pessoas são envolvidas na venda do seu produto?

45. Que tipo de transporte você usa para levar produto para o mercado (ex, barco, caminhão)?

46. Onde você vende os seus produtos? (Borba, Manicore, etc.)

47. Quantos anos você esta produzindo para o mercado?

48. Você tem acesso a credito? Quanto mais ou menos?

49. O que impede a sua produção para o mercado?

50. O que ia ajudar melhorar a sua produção para o mercado?

51. Quanto você ganha por mês? Por ano? Quanto vem de agricultura?

Agrobiodiversidade

52. Quantas culturas diferentes você tem na sua(s) roça(s)?

53. Quantas cultivares (variedades) das culturas principais?

54. Quantas espécies diferentes no quintal? Na roça?
    Q - R -
55. Escreve uma lista de culturas cultivadas normalmente (última pagina).

Terra Preta

56. Você maneja roças de terra preta de uma forma diferente do que as roças de solo comum?

57. Quantos anos dá para você cultivar ou trabalhar uma roça de terra preta antes de perceber uma perda na produção? Como isso compara com o solo comum?

58. Em sua opinião, existem culturas que rendem melhor na terra preta? Têm outras que rendem pior?

59. Existem vantagens de cultivar terra preta? Quais são?

60. Existem desvantagens de cultivar terra preta?

61. Tem culturas ou plantas que só pode cultivar na terra preta? Quais são?

62. Você achou cerâmica e outro material arqueológico na terra preta?

63. Você sabe como a terra preta foi formada/criada?

64. Você acha que a terra preta pode ser reproduzida?

65. Você acha que vai ter produção melhor na terra preta do que em solo comum?

66. Você acha que tem mais ou menos caça em áreas de terra preta?

GPS DATA

UTM da casa Oeste: ________________ Sul: _________________

Lat.: ________________ Long.: _________________

Localização das fronteiras do lote:

Oeste: _________________ Sul: __________________

Oeste: _________________ Sul: __________________

Oeste: _________________ Sul: __________________

Oeste: _________________ Sul: __________________

OTHER NOTES

LISTA DE CULTURAS (com número de indivíduos de cada uma quando possível)
R= roça Q= quintal

Nome	Location (R,Q)	Número indiv.	Nome	Location	Número
1			26		
2			27		
3			28		
4			29		
5			30		
6			31		
7			32		
8			33		
9			34		
10			35		
11			36		
12			37		
13			38		
14			39		
15			40		
16			41		
17			42		
18			43		
19			44		
20			45		
21			46		
22			47		
23			48		
24			49		
25			50		

OUTRAS CULTURAS CULTIVADAS NORMALMENTE:

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BIOGRAPHICAL SKETCH

Nick Kawa was born in a small town in northern Illinois and grew up in the city of Batavia, a suburb of Chicago. In 1999, he attended the University of Arizona where he studied Anthropology and Spanish. After receiving his B.A. in 2002, Nick worked as an English teacher in the Amazonian city of Manaus. While in Manaus, Nick also interned at the National Institute of Amazonian Research (INPA). In 2006, he began his studies in anthropology at the University of Florida. Having completed his master's degree in anthropology, Nick intends to continue his Ph.D. at UF studying the historical ecology of Central Amazonia.