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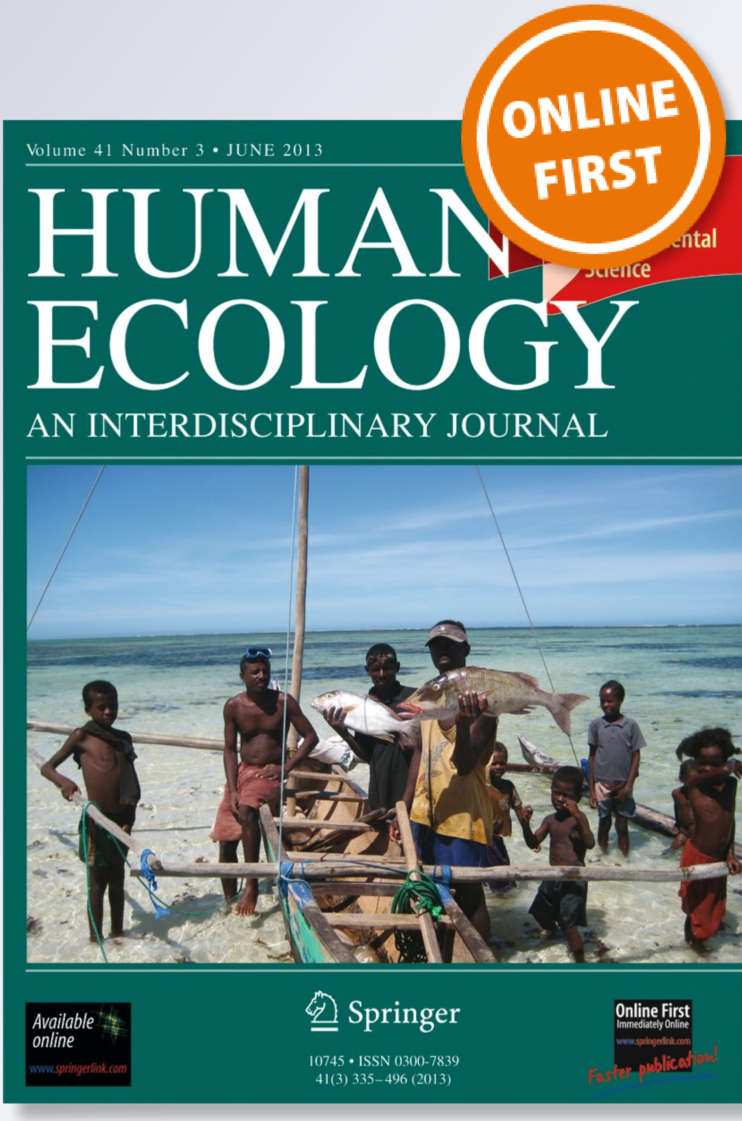
Human Ecology
An Interdisciplinary Journal

ISSN 0300-7839

Hum Ecol
DOI 10.1007/s10745-013-9608-6



Springer

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Reconfiguring Agrobiodiversity in the Amazon Estuary: Market Integration, the Açaí Trade and Smallholders' Management Practices in Amapá, Brazil

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Abstract An established body of literature documents current changes in rural livelihoods, agricultural practices, and agrobiodiversity patterns in smallholder communities across the globe. Contributing to this literature, this paper documents change in agricultural practices and agrobiodiversity patterns in a tidal floodplain settlement in Amapá, Brazil, where in recent years farmers increasingly devote their attention to the production of *açaí* fruits, an important regional crop with strong local, national and international markets. Research results indicate that farmers are abandoning subsistence production in annual fields to make room for açaí-dominated agroforests. At the same time, farmers are diversifying home gardens, and as a result conserve a portion of the crop diversity once maintained in annual fields in these areas. Agrobiodiversity documented in home gardens is much higher than previously recorded in the study area, and is equal or higher than previously reported in home gardens in other less-market integrated Amazonian communities. Research points to the need for innovative methods to document agrobiodiversity patterns in today's modifying landscapes and for the historical analysis of such patterns to avoid presumptions that observed changes are unilateral and unidirectional.

Keywords Agrobiodiversity · Market integration · Home gardens · Smallholders · Amazonia · Brazil

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Introduction

A growing body of literature documents social and economic changes in rural communities across the globe as a result of market integration, crop specialization, and urbanization and globalization processes. Many scholars have additionally become interested in change in land use and natural resource management as a consequence of these processes. The topic of farmer-held agrobiodiversity in particular has come into focus as a priority for conservation initiatives across the globe. Concern over the global erosion of agrobiodiversity increased among scientists and practitioners along with the spread of Green Revolution technologies and the replacement of traditional or local crop varieties with modern high-yielding cultivars (Veteto and Skarbo 2009). Today, diverse and numerous studies document the erosion of agrobiodiversity estimating that more than 75 % of global genetic diversity has been lost since the beginning of the twentieth century (Shand 1997). In addition to the spread of high yielding crop varieties (Brush 1995, 2000, 2004; Thrupp 2000), this loss is also attributed to more recent processes of livelihood diversification or *de-agrarianization*[1], increased rural–urban migration, and to changes in production strategies, namely market integration and crop specialization (Brush 2004; Humphries 1993; Henrich 1997; Lamont *et al.* 1999; Peroni and Hanazak 2002). Given the central role of smallholder farmers in the conservation of agrobiodiversity, community-based studies are needed to better understand drivers of agrobiodiversity loss and resilience in communities undergoing larger social and economic change in diverse regions across the globe. Insights into farmers' motivations for conserving agrobiodiversity (or not) within the context of rural change can

[1] Deagrarianization refers to the process by which smallholder farmers shift livelihood activities away from rural enterprises and incorporate wage labor and other non-farm activities and income into household production, strategies widely observed across the global south over the past 15 years (Bryceson *et al.* 2000).

Published online: 24 July 2013

potentially guide policies aimed toward conservation of agrobiodiversity in rural communities across the globe.

The current study addresses this need by examining the process of change in farming practices and patterns of community-held agrobiodiversity in the Amazon Estuary. In the study area, farmers living along the Mutuacá River, Amapá, Brazil are responding to increased demand for fruits from the *açaí* palm (*Euterpe oleracea*)—for which there are currently strong and growing local, national and international markets. Due to dramatic market changes, producers in the study area have increased the area under açaí production on their landholdings. Smallholders are both increasing the extent of native açaí stands forests, planting açaí seedlings in newly cleared areas, and in fallows dominated by secondary forest growth (Steward 2008). The intensification of açaí production in the region of the Amazon Estuary has been observed since the late 1980s. Numerous studies have been published on açaí production and sale by smallholders in the Amazonia (see Brondizio 2008a for a comprehensive review), and the process of conversion of large areas of floodplain forests to açaí-dominated agroforests is referred to regionally as the *açaíação* of the estuary (Hiroaka 1994).

The current study builds upon a sub-set of studies that address the consequences of market integration, crop specialization, and intensification on community-level agrobiodiversity patterns (Adams *et al*. 2012; Brush 1992; Godoy *et al*. 2005; Henrich 1997; Humphries 1993; Lamont *et al*. 1999; Peroni and Hanazak 2002; Vadez *et al*. 2004). Research seeks to examine changes in farmers' management practices and the subsequent transformation of land-use types (agricultural ecosystems) within the landscape as a result of the increased market demand for açaí. The study examines whether or not farmers abandon land-use types and crops as they increase the area under açaí production on their properties. This research also documents levels of agrobiodiversity held in two common land-use types—home gardens and fields—and compares these results to those recorded by scientists studying in *ribeirinho*[2] and indigenous communities across Amazonia. Using qualitative data from interviews and participant observation, the study also sheds light on the importance of agrobiodiversity for farmers in the context of agricultural change. As such, it builds upon research that describes diverse socio-cultural motivations, such as aesthetic values and importance to kin and extra-kin relationships in maintaining diversity within cropping systems (Chernela 1997; Lima *et al*. 2012; Murrieta and WinklerPrins 2006; Perreault 2005; WinklerPrins and de Souza 2005) in addition to ecological and economic motivations.

[2] Ribeirinhos are rural peoples of Amazonia who live along or near waterways in areas of floodplain.

Methodology

Study Site

The settlement of Mutuacá is located in Amapá, the northernmost state of Brazil, in the Amazon estuary (Fig. 1) roughly 50 km from the capital city of Macapá and the port city of Santana, and pertains to the municipality of Mazagão. The village is distributed along the Mutuacá River, one of five rivers that correspond to a small drainage basin referred to as the Foz de Mazagão (Fig. 1). The five riverine settlements of the Foz de Mazagão are considered a single community (*comunidade*) by local residents, and inhabitants organize themselves into community and religious associations maintaining a community center and small church. Residents are connected to nearby urban centers by state highway AP010/BR156 and via local waterways, traveling to these centers to sell agricultural and forest products, purchase household goods, visit relatives, use urban services and receive salaries, pensions and other benefits. High school-aged children often live for a time with relatives in Santana or Macapá to continue their education.

Climate and Environment

Located in the estuary of the Amazon, the greater Mazagão region is characterized by an equatorial humid climate with two seasons: a rainy season (winter) from December through June, and a dry season (summer) from July through December. The landscape of the greater study area can be divided into two main environmental areas—uplands (*terra firme*) and tidal floodplains (*várzea*), the environment of all settlement areas of the Foz de Mazagão. Terra firme lands are higher in elevation and thus escape daily flooding while the tidal várzea is influenced by daily tides, where water levels rise and fall between 1 and 4 m. Tidal várzea areas are distinguished from seasonal várzeas (Prance 1979), located in the middle and upper regions of the Amazon, by a complex flood regime that includes 29 daily tides (*mareas*) and seasonal floods, *lançantes* (Moran 1993; Padoch and Pinedo-Vasquez 1999). Daily tides cause a drop in river water levels of an average 1.2 m. Seasonal floods vary in degree of inundation depending on rainfall patterns upriver. Water levels generally reach their peak from March to April, or earlier in the wet winter months raising water levels 2.3 m above low water levels (Padoch and Pinedo-Vasquez 1999).

The tidal várzea is characterized by its diversity of land forms created by the depositional processes of the flood regime. In the tidal estuary, high levees (or *restingas*) are created when sediments are deposited adjacent to the river's course. Restingas are the sites of intensive agricultural production and thus one of the most important landforms of the tidal várzea. Additionally these areas are covered by mature mixed floodplain forests, savannas, and forests with a high density of palms, such as

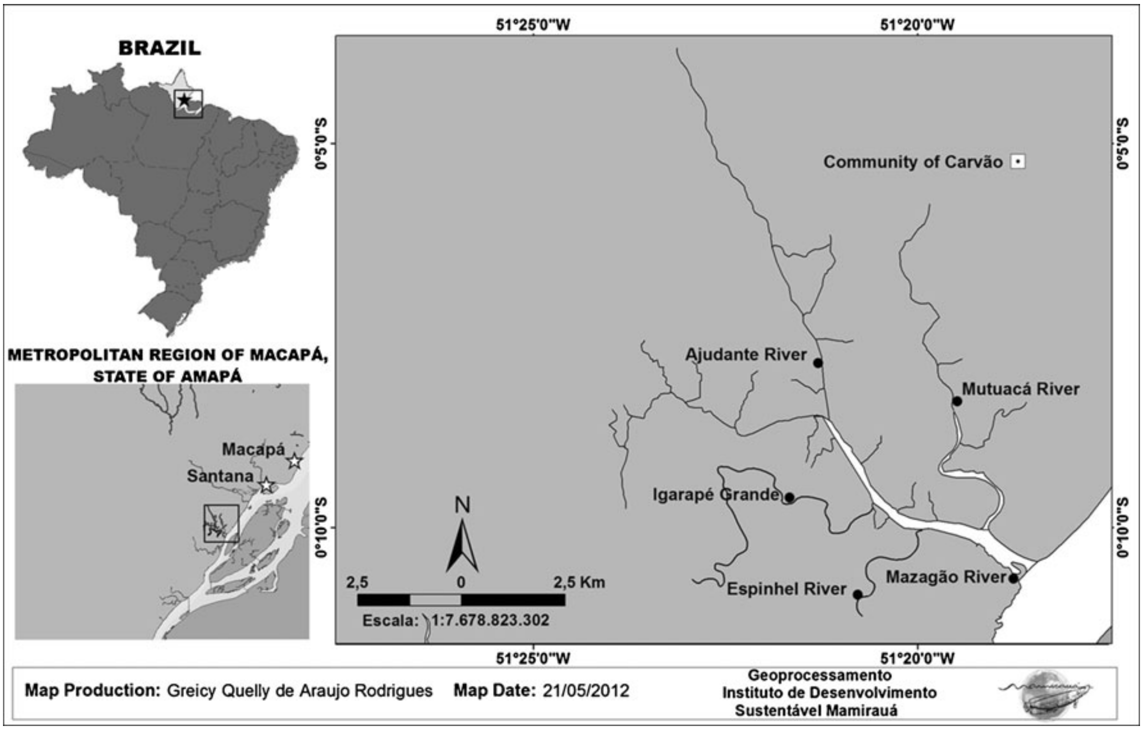

Fig. 1 Map showing the Study Area and proximity to important regional cities in Amapá, Brazil

murumurú (*Astrocaryum murumuru*), *jupati* (*Raphia taedigera*), *açaí* (*Euterpe oleracea*), *inajá* (*Maximiliana martiana*), *bacaba* (*Oenocarpus bacaba*), *patuá* (*Jessenia bataua*), *burití* (*Mauritia flexuosa*) and *ubim* (*Geonoma* sp.). Researchers have noted in particular the frequency of monospecific or *oligarghic* stands of açaí and burití (Peters *et al*. 1989; Zarin *et al*. 2001).

Socioeconomic Patterns

Mutuacá is made up of approximately 25 households spread over the right and left banks of the Mutuacá River. In recent years, the settlement has grown in population and extent with new construction restricted to the areas of high land along the banks of the river and small streams. Despite this expansion Mutuacá remains a rural settlement where transportation is limited to waterways via canoe and forest footpaths. Many residents own motorized boats used to make longer trips to Santana and Mazagão Novo. The riverside settlements of the Foz de Mazagão have been electrified since 2001, and at the time of research there was a primary school and two small stores operating along the river.

According to oral histories recorded during field work, early inhabitants of the area settled near the entrance of the present-day community of Carvão (Fig. 1). Carvão is said to have been founded by a young couple, descendents of slaves, who left the nearby Portuguese colony of Mazagão Velho[3] to cultivate cassava (manioc; *Manihot esculenta*) in the upland areas near the present-day community. Additional family members from Mazagão Velho later followed the first inhabitants and also settled in Carvão. This small group of extended kin later resided in the terra firme of Carvão adjacent to the várzea floodplains of Mutuacá—a geography that gave them access to a diversity of natural resources across both environmental zones.

The population of the region has fluctuated since those early days with regional economic boom and bust cycles centering on the sale of various plant products. Until the 1960s, residents engaged in the commercial extraction of non-timber forest products, including Amazonian wild rubber, *Hevea brasiliensis*, and oil-producing seeds of *andiroba* (*Carapa guianensis*), *murumurú* (*Astroçaryum murumuru*), and *pracaxi* (*Parkia* sp.). Later residents combined farming with the extraction of timber species, such as: *cedro* (*Cedrela odorata*), *sumaúma* (*Ceiba pentandra*), *ucúuba* (*Virola surinamensis*), *muiratinga* (*Maquira coriacea*), *andiroba* (*Carapa guianensis*), and mahogany; *Swietenia macrophylla* (Pinedo Vasquez *et al*. 2002), for international export markets. When timber stocks were depleted by the 1970s, smallholders again modified economic activities. Residents in Mutuacá engaged in small-scale commercial timber production geared toward local markets, the extraction of freshwater shrimp, subsistence farming, hunting and fishing. Since the late 1980s, the sale of açaí fruits has gained importance in Mutuacá. Increased demand for açaí is attributed in large part to the expansion of local cities due to the migration of rural residents accustomed to eating açaí as a dietary staple (Brondizio *et al.*

[3] For a history of the Mazagão colony see Vidal (2008). Because of its historical occupation process, the Carvão-Mutuacá site is considered a Quilombo community (see below for a definition of Quilombo).

2002; Hiroaka 1994; Murrieta *et al*. 1999). It is also linked to increasing national and international demand for açaí, which is being marketed as a health food and consumed by urbanites in Brazil, Europe, and the United States (Anderson and Ioris 1992; Brondizio and Siqueira 1997; Brondizio *et al*. 2002; Brondizio 2004; Murrieta *et al*. 1992; Peters 1992).

While the founders of the Carvão-Mutuacá settlement were of African descent, processes of rural migration linked to economic cycles brought together diverse peoples from various cultural and ethnic backgrounds. Today, many residents in the study area report having migrated from nearby várzea communities—including the Ilha do Para, Gurupá and Afuá. Others are migrants from the Northeastern region of Brazil. Those from the islands often call themselves *ribeirinhos*, a term that refers to rural dwellers of the Amazonian várzea of a mixed cultural background (indigenous, European and African). Others identify as *nordestinos* recalling their place of origin, or their parents' place of origin. The residents of Mutuacá and those of the Foz de Mazagão more generally maintain an economic mode of production typical of the rural Amazonian peasantry. The mixed Amazonian peasantry is commonly referred to as the *caboclo* peasantry by anthropologists and other social scientists (see Adams *et al*. 2006). However, as Lima (1999) argues the term is complex and its use problematic because its pejorative connotations. The term caboclo is often used by city dwellers and outsiders to refer to rural people in Amazonia and is associated with negative stereotypes (being lazy, backward or uneducated). Contrary to other cited terms, such as farmer (*agricultor*), or ribeirinho, cabocolo is rarely used in Mazagão as a term of self-identification. At the time of research, residents used varying terms to identify themselves depending upon the context of the conversation. People commonly identify with their main occupation (agricultor or *pescador*; fisher), or, as mentioned, as being a ribeirinho based on where they live, or finally, as *quilombola*[4]. This latter, more recent identification has come into use as a result of social movements that gained force in the region over the last 15 years, bringing visibility to the presence and contributions of slaves and their descendents in Amapá since the days of colonialism.

[4] The term Quilombolo emerged during Portuguese colonialism to describe settlements formed by slaves living outside of bondage under various conditions. Today the concept has broadened and now includes diverse contemporary groups of African descent living in different social conditions and geographical areas in Brazil. Today, Quilombo communities or remnant Quilombo communities are broadly defined as self-identifying ethnic groups with specific historical trajectories marked by a resistance to oppression; many groups' histories are linked to a specific piece of land or territory of which they have traditionally occupied. Quilombolo or Quilombola refers to a resident of a Quilombo community. (Document: Decree Number 4887 of Article 68 of the 1988 Brazilian constitution; Almeida 1996; Arruti 2006; Rappaport Center 2008). The 1988 Brazilian constitution in Article 68 guarantees descendents of Quilombo communities the right to legal tenure of their lands. Since the passing of the 1988 constitution, social movements centered on the question of Quilombo rights to land and access to services have gained momentum throughout Brazil, and in Amapá have particularly strengthened over the last 15 years. It should be noted that the definition of what constitutes a Quilombo community or group is ever-evolving and changes depending upon the context within which the concepts are being discussed.

Study Design

Research for this paper was conducted in three different phases from 2005 to 2007 and involved the following activities: household economic surveys, farm visits, botanical inventories and participant observation. During the first phase of research, household economic surveys were conducted in the form of semi-structured interviews following Bernard (2000) and Alexiades (1996) to gather demographic information and to document residents' current economic activities. A total of 17 household economic surveys with heads of household chosen at random from 25 households were completed. During the second phase of research, land-use types (agricultural systems) maintained by farmers in Mutuacá and local agricultural practices were documented through farm visits, on-site interviews, and participant observation. Twelve farm visits were conducted in Mutuacá with available producers, and key informants were interviewed to verify descriptions of farmers' management strategies. Participant observation involved accompanying farmers to their fields to observe various agricultural activities.

During the final phase of research, botanical inventories of two agricultural systems—home gardens and annual fields - were surveyed to determine the level of biodiversity held on farmers' properties. Sampling methods followed the recommendations of Brookfield *et al*. (2002) for studying agrobiodiversity.

Plant diversity was documented in 14 home gardens and four agricultural fields in Mutuacá. Inventoried home gardens were chosen by a random selection of all the gardens previously recorded during farm visits. All annual fields identified in Mutuacá were inventoried. Fields and home gardens were measured and all plant species cultivated or protected were recorded. For each species, the following were recorded: species name, abundance, habit, and primary and secondary economic uses. For each species and variety identified in fields and home gardens, a voucher specimen (to verify the identification) was collected for deposit in the state herbarium of Amapá located in the city of Fazendinha and run by the *Instituto de Pesquisas Científicas e Tecnológicas do Estado do Amapá* – IEPA (The Institute for Research and Technology of Amapá). Botanical nomenclature was verified with the use of online databases of the New York Botanical Garden (i.e., http://www.nybg.org/bsci/acre/) and the International Plant Names Index (http://www.ipni.org/index.html). For each home garden inventoried, plant species richness was calculated (number of species).

Results

Agricultural Ecosystems (Land-use Types) Maintained by Farmers in Mutuacá

Farm visits and interviews with Mutuacá residents indicate that farmers maintain various land-use types on their properties. Agricultural ecosystems in Mutuacá are characterized by different vegetation assemblages, which play a specific role in families' management practices and livelihoods. Specifically, the following land-use types were identified: i) mature tidal várzea forests (*mata brava* or *mata virgem*), ii) forests managed to increase the density of açaí palms (*açaízal*), iii) unmanaged forest fallows both young and old, where forests are regenerating (*capoeira baixa* and *capoeira alta*), iv) managed fallows where farmers conserve and/or cultivate diverse timber and fruit species (*capoeira enriquecida*) v) home gardens (*quintal*/*quintais*, plural) comprised of raised herb and vegetable beds, orchards and dense açaí patches, and vi) agricultural fields planned with annual crops (*roçado*; Table 1). Land-use types are linked to one another in space and time and are the outcome of specific farmer management practices.

Swidden-fallow Agricultural Practices of the Tidal Várzea: Historical Practices

Interviews with residents revealed that in the past famers engaged in a swidden-fallow cultivation system in which farmers first cleared and burned an area of forested vegetation on a restinga area along streams and on riverbanks. Subsequently, in late December or early January, farmers planted a first cycle of corn and beans in combination with semi-annual and perennial plants, such papaya, *mamão* (*Carica papaya*), sweet manioc, *mandioca*; *macaxiera*; (*Manihot esculenta*), banana (*Musa* sp.), lime; *limão* (*Citrus limon*), pepper; *pimenta* (*Caspicum* sp.), squash; *jerimú* (*Curcurbita* sp.) and other woody fruit trees desired for future use. Farmers would then harvest squash and corn after three months. Later during the month of May, farmers cultivated plants such as watermelon, *melancia* (*Citrullus lanatus*) and *maxixe* (*Cucumis* sp.). Residents explained that once the watermelon spread across the ground, they planted a second round of corn. At the onset of the second cropping, producers planted additional fruit trees. When the last of the annual crops were harvested, the roçado, now transitioning into a managed fallow, was managed for the production of fruit trees and other perennial species of economic value spontaneously occurring in the fallow. For instance, farmers often conserved saplings of *pau mulato* (*Calycophyllum spruceanum*) in managed forests (Sears 2003). Observations in the field also revealed that farmers commonly planted culinary and medicinal herbs scattered throughout roçados, particularly near the base of burned trees, areas where soils are more nutrient rich and/or offer structural support for more delicate plants. Plants cultivated in mixed roçados were reserved for subsistence purposes; however, at different times some products were marketed locally. The production system described here by residents is also described with some variations by Denevan and Padoch (1998), Padoch and de Jong (1992), Padoch and Pinedo-Vasquez (1999), Denevan (1984), Hiraoka (1992), Denevan *et al*. (1994), Coomes and Burt (1997) in other regions of Amazonia.

Table 1 Land-use types identified on farmers' properties (n=12 households)

Land-use type	Number of properties
Mature tidal forests – *Mata brava*, *mata virgem*	7
Managed açaí forests – *Açaízal*	12
Young unmanged agricultural fallow – *Capoeira baixa*	12
Old unmanaged agricultural fallow – *Capoeira alta*	12
Managed fallows – *Capoeira enriquecida*	10
Home gardens - *Quintal*	12
Annual fields – *Roçado*	4

Changes in Farming Practices and Landscape Patterns

Over the past ten years, increased local demand for açaí fruits in area cities (i.e., Mazagão Novo, Santana, and Macapá) has prompted farmers in Mutuacá to increase açaí production on their lands. Interviews with farmers and visits to their properties revealed that residents are increasing the production of açaí through the following methods: planting açaí in newly cleared areas among annual crops, in secondary forests, and in home gardens. Residents also manage native várzea forests to increase açaí fruit production. Based on farmers' estimates, property owners maintain from six to 13 ha in intensively managed açaí stands (*açaízais*). These calculations however do not include areas of várzea forest managed for açaí, which in fact are more extensive than home garden and planted agroforestry plots. Interviews with farmers indicate that the cultivation and management of açaí occurring in Mutuacá appear to be replacing other forms of agriculture. This process of change is described and characterized by the disappearance of mixed annual fields (roçados).

While the roçado was once quite common in Mutuacá, property visits in 2007 revealed that nobody was maintaining a "true" roçado. All roçados documented in 2007 were monocultures of corn (beans were also planted but harvested before we conducted plant surveys) and two small sugarcane patches in home gardens. All interviewed farmers explained that they had prepared these areas with the intention of planting açaí seedlings between annual crops, which they later did beginning in March of 2007. Farmers further explained that they had planted corn and beans so that land was not "wasted" or "left idle" during the time the açaí seedlings grew to a productive age in about 3 years. Açaí seedlings sown in March would later be supplemented with second crop of corn. Along with açaí seedlings, some farmers were also planting other economically important plants, such as *cupuaçu* (*Theobroma grandiflorum*) and cacao (*T. cacao*), two plants that are noted for growing successfully among açaí stands. In some cases, farmers augmented existing home gardens by planting açaí seedlings. At other times, the new açaízal is set away from the house-lot, as a separate agricultural area. In either case, new açaízais were to become more permanent fixtures in the landscape.

In addition to açaízais, home gardens are an important and common land use type found in Mutuacá. Residents consider home gardens an extension of their house, and in addition to their practical and economic value in providing household sustenance, they are valued as aesthetically pleasing outdoor spaces. Home gardens provide a leisure activity for many residents, especially the elderly and are maintained by both men and women[5]. These areas generally consist of three separate areas or zones in which different types of plants are cultivated. Directly next to the house female farmers cultivate herbaceous and semi-herbaceous plants and shrubs of medicinal or culinary value. These plants tend to be grown on raised beds that protect more delicate species from waterlogged soils. Close to their residences, farmers also store seeds and produce tree seedlings of local economic importance. In front or behind herb gardens, farmers plant a mixed variety of fruit and timber species that comprise a diverse orchard. Surrounding these two areas remaining spaces are generally being converted to açaízais.

Within the settlement, home gardens are either well-developed or, in the case of newcomers, are in the process of being planted. Like agricultural fields, gardens are weeded with machetes and hoes to clear the understory; gardens tend to be continually weeded during summer months and left to grow ground cover during the rainy season. In some cases, leaves and branches are clustered around individual plants to serve as *adubo* (fertilizer) and/or to protect plants from insects and disease.

Current Patterns of Agrobiodiversity: Annual Fields and Home Gardens

As discussed above, agricultural fields have almost disappeared in Mutuacá. The four roçados identified were monocultures of corn ranging in size from 0.12 ha to 0.5 ha. In addition to corn, these areas had also previously been planted with white bean; *feijão branco* (*Phaseolus vulgaris*) harvested before the inventories were conducted. Thus as compared to the past, these results suggest a loss in agrobiodiversity within this land-use category.

Inventories of home gardens, on the other hand, revealed that farmers are maintaining high levels of diversity within these land-use areas. In 2007, 14 home gardens, covering an area of 3.5 ha with a mean value of 0.2 ha each, were inventoried in Mutuacá from which a total of 82 species was recorded (four species were identified only by common name). An average of 32 species per home garden, with a range of nine to 41 species, was maintained by individual farmers. In terms of intra-specific richness, a total of nine banana varieties were reported, along with two mango varieties and three sweet pepper varieties.

Reflecting its local importance, açaí was the most commonly reported home garden species in Mutuacá, being found in all the inventoried gardens. Açaí is followed by taperebá and guava, both found in 13 gardens; lime is found in 12 gardens; cupuaçú and ingá cipó in 11 gardens; and firewood tree (pau mulato), cashew, mango and papaya in 10 gardens. With the exception of pau mulato, a fast-growing hardwood species sold regionally[6], the most commonly reported species were fruit species (Table 2).

The tendency to grow fruit species in home gardens is reflected in Figure 2, which shows the number of plants in primary use categories: <u>Fruit</u>, <u>medicinal</u>, <u>spice</u>, <u>other edible</u>, <u>timber</u> and <u>other</u>. <u>Other edible</u> includes vegetables, coffee and sugarcane while the category <u>other</u> includes use of plants for roof thatching and plants used in handicrafts. While some plants are used for multiple purposes, species were classified by their primary use to produce the graphic. The most commonly reported plant type (use) was fruit (35 species), followed by medicine (26 species). Together these categories account for 77 % of all identified species. Plants used as spices and for other culinary purposes accounted for a total of 14 species (17 %), timber for five species (6 %) and others for two species (2 %). These results corroborate other home garden studies that describe home gardens as sites primarily planted with fruit and medicinal species (Coomes and Ban 2004; Lamont *et al*. 1999; Padoch and de Jong 1992). Furthermore, while the timber category does not appear to be well represented, pau mulato appears in 11 of the 14 gardens, making an important contribution to the species composition. Based on species importance values (IV), previously calculated using the same data in 2008, pau mulato is in fact the most important species in home gardens based on the parameters or relative abundance, relative frequency, and relative dominance (Steward 2008).

[5] In contrast to this case study, WinklerPrins (2002), WinklerPrins and de Souza (2005), and Murrieta and WinklerPrins (2006) discuss home gardens as spaces primarily managed by women.

[6] For a detailed account of the management of pau mulato in the Mazagão region of Amapá see Sears (2003).

Table 2 List of plants found in Mutuacá home gardens: names, family, occurrence and primary uses

Common names (Portuguese/English)	Scientific Name	Family	Occurrence	Primary Uses
Açaí, Assai palm	*Euterpe oleracea* Mart.	Arecaceae	15	Fruit
Taperebá	*Spondias mombin* L.	Anacardiaceae	13	Fruit
Goaiba, Guava	*Psidium guajava* L.	Myrtaceae	13	Fruit
Limão, Lime	*Citrus* L.	Rutaceae	12	Fruit
Ingá cipó, Ice cream bean	*Inga edulis* Mart.	Mimoaceae	11	Fruit
Pau mulato, Firewood tree	*Calycophyllum spruceanum* Benth.	Rubiaceae	11	Timber
Cupuaçu	*Theobroma grandiflorum* Schum.	Sterculiaceae	11	Fruit
Caju, Cashew	*Anacardium occidentale* L.	Anacardiaceae	10	Fruit
Manga, Mango	*Mangifera indica* L.	Anacardiaceae	10	Fruit
Mamão, Papaya	*Carica papaya* L.	Caricaceae	10	Fruit
Cebola, Onion	*Allium cepa* L.	Alliacaeae	8	Other edible
Urucum, Annatto	*Bixa orellana* L.	Bixaceae	8	Spice
Pião roxo, Bellyache bush	*Jatropha gossypifolia* L.	Euphorbiaceae	8	Medicinal
Laranja, Orange	*Citrus sinensis* (L.) Osbeck	Rutaceae	7	Fruit
Graviola, Soursop	*Annona muricata* L.	Annonaceae	6	Fruit
Pupunha, Peach palm	*Bactris gasipaes* Kunth	Arecaceae	6	Fruit
Cravo, Clove	*Eugenia caryophyllata L.*	Myrtaceae	6	Spice
Jambo, Malay apple	*Syzygium malaccense* (L.) Merr. & L.M. Perry	Myrtaceae	5	Fruit
Biribá, Wild sugar apple	*Annona mucosa* Jacq.	Annonaceace	4	Fruit
Catinga de mulata	*Tanacetum vulgare* L.	Asteraceae	4	Medicinal
Pariri, Cricket vine	*Arrabidaea chica* (Humb. & Bonpl.) Verl.	Bignoniaceae	4	Medicinal
Seringueira, Brazilian rubber tree	*Hevea brasiliensis* (Willd. ex A. Juss.) Müll.Arg.	Euphorbiacaeae	4	Timber/Other
Pião branco, Barbados nut	*Jatropha curcas* L.	Euphorbiaceae	4	Medicinal
Marimari	*Cassia leiandra* Benth.	Fabaceae	4	Fruit
Virola, Baboonwood	*Virola surinamensis* (Rol. ex Rottb.) Warb	Myristicaceae	4	Timber/Medicinal
Pimenta comum, Pepper	*Capsicum* sp. L.	Solanaceae	4	Spice
Hortelã grande, Spanish thyme	*Plectranthus amboinicus* (Lour.) Spreng	Lamiaceae	3	Medicinal
Andiroba, Crabwood	*Carapa guianensis* Aubl.	Meliaceae	3	Timber/Medicinal
Cana, Sugarcane	*Saccharum* sp. L.	Poaceae	3	Other edible
Capim santo, Lemongrass	*Cymbopogon citratus* Stapf.	Poaceae	3	Medicinal
Jenipapo, Huito	*Genipa americana* L.	Rubiaceae	3	Fruit
Tangerina, Tangerine	*Citrus reticulate* Blanco	Rutaceae	3	Fruit
Chicória, Chicory	*Chichorium intybus L.*	Apiacaeae	2	Spice
Cominho, Cumin	*Cuminum cyminum* L.	Apiacaeae	2	Spice
Bacaba, Turu palm	*Oenocarpus bacaba* Mart.	Arecaceae	2	Fruit
Mastruz, Mexican tea	*Chenopodium ambrosioides* L.	Asteraceae	2	Medicinal
Cuieira	*Crescentia cujete* L.	Bignoniaceae	2	Other
Sabugueira, Sambucus	*Sambucus nigra* L.	Caprifoliaceae	2	Medicinal
Macacauba	*Platymiscium duckei* Hube	Fabaceae	2	Timber
Hortelão pequeno, Peppermint	*Mentha piperita* L.	Lamiaceae	2	Medicinal
Acerola, Barbados cherry	*Malpighia glabra* L.	Malpighiaceae	2	Fruit
Boldo	*Peumus boldus Molina*	Monimiaceae	2	Medicinal
Fruto pão, *Jaca*, Breadfruit	*Artocarpus altilis* (Parkinson) Fosberg	Moraceae	2	Fruit
Ameixa, Java plum	*Eugenia cumini* (L.) Druce	Myrtaceae	2	Fruit
Pitomba, Pitomba	*Talisia esculenta* Radlk.	Sapindaceae	2	Fruit
Cutite, Sapota verde	*Pouteria macrophylla* (Lam.) Eyma.	Sapotaceae	2	Fruit
Tomate, Tomato	*Solanum lycopersicum* L.	Solanaceae	2	Other edible
Cacau, Chocolate tree	*Theobroma cacao* L.	Malvaceae	2	Fruit
Tajá	Indet.	Araceae	1	Other edible

Table 2 (continued)

Common names (Portuguese/English)	Scientific Name	Family	Occurrence	Primary Uses
Bussú, Royal palm	*Manicaria saccifera* Gaertn.	Arecaceae	1	Construction
Côco, Coconut	*Cocos nucifera* L.	Arecaceae	1	Fruit
Mucajá, Macaw palm	*Acrocomia aculeata* Lodd. ex Mart.	Arecaceae	1	Fruit
Urucurí, Urucuri palm	*Attalea excelsa* Mart.	Arecaceae	1	Medicinal
Anador, Mugwort	*Artemisia sp. L.*	Asteraceae	1	Medicinal
Picão	*Bidens* sp. L.	Asteraceae	1	Medicinal
Couve manteiga, Collard greens	*Brassica oleracea* L.	Brassicaceae	1	Other edible
Abacaxi, Pineapple	*Ananas comosus* (L.) Merr.	Bromeliaceae	1	Fruit
Jerimum, Pumpkin, squash	*Cucurbita* sp. L.	Cucurbitaceae	1	Fruit
Manjerona, Sweet marjoram	*Majorana hortensis* Moench	Lamiaceae	1	Spice/Medicinal
Patchuli, Patchouly	*Pogostemon sp.* Desf.	Lamiaceae	1	Medicinal
Oriza, *Uriza*	*Pogostemon heyneanus* Benth.	Lamiaceae	1	Medicinal
Pau-de-angola	*Vitex agnus-castus L.*	Lamiaceae	1	Medicinal
Trevo	Indet.	Lamiaceae	1	Medicinal
Trevo grande	Indet.	Lamiaceae	1	Medicinal
Trevo roxo, Skullcap	*Scutellaria agrestis* St. Hill. Ex. Benth.	Lamiaceae	1	Medicinal
Canela, Cinnamomum	*Cinnamomum zeylanicum* Blume	Lauraceae	1	Spice/Medicinal
Sapucaia, Cream nut	*Lecythis pisonis* Camb.	Lecythidaceae	1	Medicinal
Murici, Savanna serret	*Byrsonima crassifolia* Steud.	Malpighiaceae	1	Fruit
Malvarisco, Marshmallow	*Althaea officinalis* L.	Malvaceae	1	Medicinal
Algodão, Cotton	*Gossypium sp. L.*	Malvaceae	1	Medicinal
Vinagreira, Roselle	*Hibiscus sabdariffa* L.	Malvaceae	1	Spice
Ingá amarela	*Inga* sp. Mill.	Mimoaceae	1	Fruit
Azeitona brava	*Eugenia* sp. L.	Myrtaceae	1	Fruit
Limão de caiena, Cucumber tree	*Averrhoa bilimbi* L.	Oxalidaceae	1	Fruit
Maracujá comum, Passion fruit	*Passiflora edulis* L.	Passifloraceae	1	Fruit
Eucalipto	Indet.	Polygonaceae	1	Medicinal
Amor crecido, Hairy pigweed	*Portulaca pilosa* L.	Portulacaceae	1	Medicinal
Café, Coffee	*Coffea arabica* L.	Rubiaceae	1	Other edible
Abiu, Egg Fruit	*Pouteria caimito* Radlk.	Sapotaceae	1	Fruit
Cacau jacaré	*Theobroma mariae* k. Schum.	Malvaceae	1	Fruit
Erva cidreira, Bushy lippa	*Lippia alba* (Will.) NE Br.	Verbenaceae	1	Medicinal
Gengibre, Ginger	*Zingiber officinale* Roscoe	Zingiberaceae	1	Medicinal

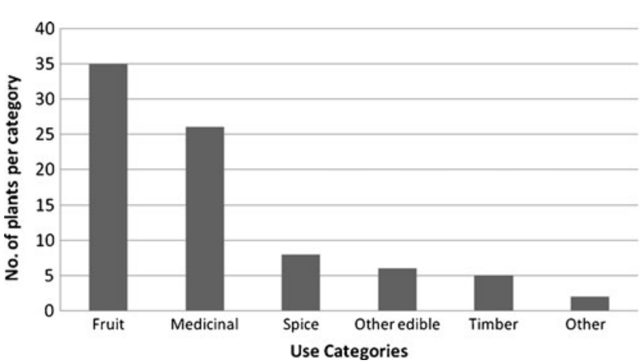

Fig. 2 Number of species per use category in Mutuacá home gardens

Importance of Cultivated Diversity Maintained in Home Gardens

As is evident from the diversity of plant species and their uses, biodiversity maintained in home gardens plays a significant role in the subsistence strategies of local families. Residents value home garden fruits as an important supplement to local diets whose daily staples include: manioc flour, açaí and various fish species. While fruits in the home garden are the property of the garden owner, in some respects they are also a commonly-held resource. Residents commonly give fruits to relatives and neighbors as gifts or in exchange for other items, and they are also offered to visitors as refreshments. Additionally, children and youth in the Foz de

Mazagão region were often observed eating fruits from neighbors' gardens and from lightly managed forest areas on the way back from fishing or from working in fields or agroforests. Similarly, residents explained that growing medicinal herbs allows them to address simple health issues despite the lack of adequate public health services in the region. Finally, residents also grow herbs and vegetables because they prefer to have these staples at their immediate disposal to prepare household meals.

Most species maintained in home gardens are used for subsistence purposes. However, a few of the more popular species are sold either regularly or occasionally by residents, at times playing a critical economic role. As discussed, in Mutuacá açaí is quickly becoming the most important economic product. Here, most families designate açaí produced in home gardens for household consumption, and sell fruits from managed forests and fallows. Fruits gathered nearby in the home gardens are thus easily transferred to areas where açaí is prepared for consumption (indoor or outdoor kitchen areas). During the peak production season, however, many farmers also sell excess fruits from home gardens to middlemen who regularly purchase açaí from area residents. In addition, farmers occasionally sell fruits, such peach-palm, taperebá and cupuaçú from home gardens when the fruits come into season and production exceeds household demands. Local schools are marketing places for fruits and pulp, and farmers generally reserve income from these occasional sales to invest in household items, such as gas stoves, freezers, boat motors or canoes.

Thus, home gardens have various social and economic functions: they serve as leisure spaces in which to receive guests, areas to cultivate useful plants and for experimentation with new ones, as well as providing an occasional source of cash income. In this sense, home gardens in Mutuacá are multifunctional, a trait that has been discussed by other researchers, and has long been an argument for the inclusion of home gardens in regional sustainable development plans and initiatives (Kumar and Nair 2006; Murrieta and WinklerPrins 2006; Smith 1996; WinklerPrins 2002; WinklerPrins and de Souza 2005).

Accounting for Agrobiodiversity in Home Gardens: Acquisition of Plant Materials

Interviews and observations revealed that seeds and seedlings planted in home gardens are acquired in various ways, and that in general, residents display an enthusiasm for gathering these materials. As one farmer stated during an interview, "if you like to plant, you gather materials from wherever you go." Many residents inherit plants from previous garden owners when acquiring an abandoned house-lot. This occurs frequently in the region and families commonly cycle through various house-lots often within short periods of time. New planting materials, on the other hand, are most commonly obtained from extended kin and neighbors. Medicinal plants, in particular, are most often exchanged through these networks. The medicinal plant, Cricket vine (pariri) valued for its use in combating anemia, can be traced back to the garden of a female farmer from the nearby community of Mazagão Velho who brought the plant back from her daughter´s house in Belém, Pará. Seeds saved from fruits purchased in urban areas are also important sources of planting materials for home gardens. Seeds for herbs and vegetables, such as *Brassica oleracea*, are often purchased in cities. While rural development and extension services in the region are generally regarded as poor or weak, RURAP (*Instituto de Desenvolvimento Rural do Amapá*), the state agricultural development agency, occasionally supplies farmers with seedlings of commercial value to plant on their properties. Seedlings of the following species: cupuaçú, graviola, peach palm, bacaba, Barbados cherry, and cashew are most commonly distributed by extension agents. These results can be compared to those of other studies on home gardens in Amazonia. Coomes and Ban (2004), Miller *et al.* (2006) and WinklerPrins and de Souza (2005) discuss the importance of kin and extended in networks in the exchange of seed material to maintain diversity in home gardens. Coomes (2010), in particular, stresses the importance of availability/access to planting material as essential to garden diversity in Peruvian Amazonian communities.

Discussion

Change in Agricultural Practices and Consumption Patterns

The landscape of Mutuacá is made up of a wide variety of land use types, which are the outcome of farmers' management strategies and the processes of natural forest regeneration. Property visits indicate that agricultural fields, roçados, are in great decline. In Mutuacá farmers are converting várzea lands to açaízais to the exclusion of this land use type, a movement that signifies the abandonment of shorter cycle, faster growing crops from the agricultural landscape. Reduction of roçado areas is a continuation of a trend observed by researchers working in Mazagão. Pinedo Vasquez *et al.* (2002) observed a decline in agricultural fields in the Foz de Mazagão from 23 to 18 between the years of 1998 to 99 in a sample of 36 households.

Observations during field work indicate that along with the abandonment of annual fields, families in general no longer produce many staple crops. Interviews and observations indicate that residents now purchase staples foods, such as manioc flour, rice, beans, and even corn used as feed for animals raised in home gardens, as opposed to cultivating these crops. Income from the sale of açaí largely enables this change, such that the intensification of one rural activity has spurred a shift toward urban consumption habits within the settlement. It should also be noted that in addition to income generated from açaí, households in Mutuacá have also benefited from cash-transfer programs (or welfare programs) and rural retirement pensions over the past 15 years, which have also increased families' ability to purchase manufactured goods.

These noted transformations—the abandonment of annual fields, diversification of income sources (specifically the inclusion pensions and other benefits) and changes in consumption patterns—are part of larger regional processes occurring in Amapá, particularly in municipalities close to the urban centers of Santana and Macapá (Pinedo-Vasquez *et al* 2010). The reduction of annual fields, in particular fields dedicated to manioc production, and the increased consumption of urban staples in Mutuaca's neighboring community of Carvão was observed during this same period (Steward 2007), while similar observations were also made in the várzea community of Ipixuna, Amapá during the time of research (Pinedo *et al*. 2009).

Observations noted by researchers in Amapá are also in line with changes documented elsewhere in Amazonia across Brazil, and can more broadly be placed within the context of global change in agricultural production patterns. Within the Middle Solimões region of Amazonia, Peralta and Lima (2011) report that household farm income in the focal area of the Mamirauá Sustainable Development Reserve suffered a 24 % reduction from 2005 to 2010, while income from government cash transfer programs (welfare and retirement programs) increased from 18 % of total household income to 42 %. Furthermore, in a recent study of shifting agricultural systems of the Atlantic Rainforest in Brazil, Adams *et al*. (2012) found that farmers are abandoning annual fields, the sites subsistence crop production, and that these traditional crops are being replaced with cash crops, such as bananas, passion fruit and peach-palm. Here, declines in subsistence farming are coupled with increased consumption of store-bought food staples, such as rice and beans. These changes are the result of the emergence of new markets for agricultural crops, livelihood diversification, and development and conservation policies. The authors reference similar observations of the disappearance of swidden fields in Mexico (Dalle *et al*. 2011) and in Cameroon (Rogiglio and Sinclar 2011) where study areas are also undergoing market integration.

Maintaining Biodiversity in the Midst of Agricultural Change

Against the backdrop of agricultural change, home gardens in Mutuacá stand out as important sites of agrobiodiversity conservation. Farmers in Mutuacá maintain numerous plant species in relatively small spaces in their home gardens—with average size of home gardens being just 0.25 ha. When compared to previously recorded data from the study area, a decrease in average garden size is noted in recent years. Pinedo Vasquez *et al*. (2002) recorded an average size of two ha for home gardens in várzea communities of the Foz de Mazagão. The same study, found that farmers in the Foz de Mazagão maintained on average 17 plant species per garden (as compared to 32 species in Mutuacá) with a maximum of 26 species in one garden (as compared to 41 species in this study). Species richness was also higher than that recorded by Coomes and Ban (2004) in their study of agrobiodiversity of home gardens in the community of Nuevo Triunfo in the Peruvian Amazon. While the authors recorded a similar total number of species (82) from a total of 24 gardens, the calculated average of 16.3 species per garden was lower than the average documented in Mutuacá.

Furthermore, results from Mutuacá were similar to those found by Lamont *et al*. (1999) in a comparative study of three communities in the northeastern Peruvian Amazon, where gardens had an average of 39, 27 and 30 species. Findings were also comparable to results provided by Padoch and de Jong (1992) in their study of house gardens in Santa Rosa in the Peruvian Amazon. Here, the authors reported an average of 34 species per garden. In the case of the latter two case studies, the total number of species recorded was higher; 161 in 56 gardens in the first study and 168 species in 21 gardens in the second. In the case of Santa Rosa, two gardens with 72 and 73 species contributed to the result of relative high species richness.

This brief comparison demonstrates that results from Mutuacá are comparable to others in the region, which also report high levels of agrobiodiversity in home gardens. Importantly, all cited studies are from areas less integrated into market economies. However, what is important to stress regarding the current case study is that home gardens in Mutuacá are diversifying *despite* their noted reduction in area since 2002. Thus, data corroborate the findings of Brush (2004) that indicate that reductions in the size of agricultural areas (in this case of home garden areas) do not necessarily lead to losses in agrobiodiversity. One possible explanation for the increase in diversity within increasingly packed gardens in Mutuacá is farmers' conservation of medicinal and culinary plants in these spaces. In the past, many of these species were planted in annual fields as previously noted. Farmers' careful manipulation of home gardens allows them to maintain different habitats, and thus cultivate various plant types. Results thus suggest farmers partially compensate for the loss of agrobiodiversity represented by the disappearance of roçados by increasing plant diversity in home gardens.

The observation of home gardens as important refuge sites for agrobiodiversity in the midst of wider agricultural change is reported in other recent studies. In their review of change in swidden cultivation systems in Southeast Asia, particularly focusing on northern Thailand and West Kalimantan, Refkasem *et al*. (2009) observe that along with the disappearance of traditional swidden practices (due largely to governmental policy interventions to curb shifting agriculture in favor of cash cropping in monocultural systems) farmers innovatively incorporate plant diversity into home gardens and other areas, such as field edges. The authors specifically cite Hmong, Lahu, and Akha-Hani farmers of northern Thailand as maintaining "elaborate home gardens" that conserve many crops previously planted in annual fields (p. 56). A study by Vadez *et al*. (2004, cited Godoy *et al*. 2005) conducted across 59 Tsimane indigenous villages in the Bolivian Amazon, provides further evidence that market integration does not always coincide with losses in agrobiodiversity. The authors conclude that Tsimane families more integrated into markets actually intercropped more, maintained a greater number of crop species and varieties, and put more crops into new fields than non-integrated market households.

Conclusions

Results of this study are mixed and point to a complexity regarding the impacts of market integration and broader livelihood changes on farmer-held agrobiodiversity. On the one hand, market integration leading to crop specialization in the greater Mutuacá region has led a decrease in heterogeneity in agricultural landscapes represented by the abandonment of annual fields and the crops typically maintained in these systems. On the other hand, agrobiodiversity has increased in home gardens arguably partially compensating for these losses. Interviews and field observations indicate residents' interest in maintaining plant diversity in home gardens for multiple reasons, including having direct access to different types of plants (medicinal, culinary, fruits and timber among others) for consumption and in some cases for occasional sale. Maintaining this diversity allows farmers a degree of autonomy, where they take pride in not having to purchase all items necessary to sustain their families.

The results of the study indicate the need to develop innovative study methods allowing for the assessment of agrobiodiversity in the context of global change, where smallholder farmers face the challenges and opportunities that come along with market integration, new conservation and development policies, and particularly in the context of rural Brazil, cash transfer and other social programs. While these programs generally benefit smallholder communities, they have been shown to have an impact on agricultural production profiles (Adams *et al*. 2012; Peralta and Lima 2011; Steward 2007). In agreement with Rerkasem *et al*. (2009:56–57), it is imperative that new methods of assessing the impacts of loss in landscape heterogeneity and reduction in smallholder farm areas on in situ agrobiodiversity be established. As the authors argue, agrobiodiversity within shifted landscapes is often invisible or difficult to locate because farmers manage these resources in refuge spaces, such as home gardens and edge zones, and/or conserve traditional crops by scattering them throughout commercial agroforestry plots.

Furthermore, we must also ask adequate questions to provide a historical context to current perceived agrobiodiversity losses. For instance, asking farmers the general question of which species and cultivars they have abandoned likely will not generate data indicating current losses in agrobiodiversity. Research shows that agrobiodiversity maintained by smallholders in production areas is in constant flux; farmers continually abandon species and varieties, and obtain new ones in accordance to their needs, preferences, opportunities, and the availability of planting materials. Thus, lists of species and cultivars previously planted (but no longer maintained) may simply be record of what farmers of one locale have planted within recent memory, and not necessarily indicate that diversity levels are in decline. Work by Lima *et al*. (2012) shows that farmers in the Middle Solimões region, Brazil, constantly substitute new manioc varieties for old varieties according to various socioeconomic factors, thus maintaining the same average number of varieties in their fields over time (i.e., farmers abandon one variety and introduce another so that intra-varietal richness remains constant).

Moreover, future studies should continue to address the question of what drives farmers to maintain agrobiodiversity despite rising incomes and opportunities in non-farm activities. The ability of smallholders, such as those in Mutuacá, to maintain agrobiodiversity within the backdrop of broad social and economic changes lies partially in their ability to secure access to planting material; it also depends on an active interest in participating in traditional seed/germplasm exchange networks. Practitioners interested in the conservation of agrobiodiversity should aim to understand the dynamics of local seed exchange and encourage farmer initiatives in this area.

Finally, an important observation regarding recent production changes in Mutuacá is that farmers have responded to market demands and increased açaí production on their landholdings with little to no outside interventions in the way of agricultural extension. The management techniques developed to augment açaí production are farmers innovations developed via on-site experimentation. This fact is testament to the flexibility of the ribeirinho agricultural system and a characteristic that will allow practices to continue to evolve and change in response to new demands and outside influences.

Presently, Mutuacá farmers consider açaízais "permanent" fixtures in the landscape in comparison to roçados, in the sense that they will not be abandoned and cleared as long as acaí is still in market demand. At the same time, however, results indicating the abandonment of roçados should not lead to the impression that this process is unidirectional. If we place recent changes in the context of the overall history of the region, the açaí boom simply represents the latest market shift that has prompted residents to modify major livelihood/agricultural activities. Given the willingness and adeptness of farmers to respond to new challenges, market demands and other opportunities, it is probable that agricultural practices, and thus landscapes, will transform once again in the Mutuacá region in concert with future socioeconomic conditions.

Acknowledgements Support for field research was granted through the EPA STAR Graduate Research Fellowship Program (2005 to 2007). A first version of this manuscript was written during my time as a NSF International Research Fellow (OISE 0905653; 2010 to 2012). I extend gratitude to the Mamirauá Sustainable Development Institute (IDSM) for further support during the elaboration of the final manuscript, and for funding fieldwork in the Middle Solimões region, which allowed study findings to be placed in a larger regional context. I recognize, in particular, Greicy Quelly de Araujo Rodrigues - IDSM for creating the study area map. I thank Christine Padoch, Oliver Coomes, and the anonymous reviewers for their comments and suggestions on earlier drafts, and am especially grateful to the residents of Mutuacá and all other research collaborators in Amapá, Brazil.

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