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Diversifying Incomes and Losing Landscape Complexity in Quilombola Shifting Cultivation Communities of the Atlantic Rainforest (Brazil)

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Abstract Shifting cultivation systems have been blamed as the primary cause of tropical deforestation and are being transformed through various forms of conservation and development policies and through the emergence of new markets for cash crops. Here, we analyze the outcomes of different policies on land use/land cover change (LUCC) in a traditional, shifting cultivation landscape in the Atlantic Forest (Brazil), one of the world's top biodiversity hotspots. We also investigate the impacts of those policies on the environment and local livelihoods in *Quilombola* communities, which are formed by descendants of former Maroon colonies. Our findings show that conservation and social policies have had mixed effects both on the conservation of the Atlantic Forest and on the livelihoods of the *Quilombola*. We conclude that future interventions in the region need to build on the new, functional links between sustainable livelihoods and biodiversity, where less restrictive state policies leave room for new opportunities in self-organization and innovation.

Keywords Shifting cultivation · LUCC · Forest transition · Atlantic Forest · Brazil

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Introduction

Deforestation is the main path for land use/land cover change (LUCC) in tropical forested areas. However, two recent worldwide meta-analyses that evaluated the human ecology of land cover change in tropical forest-agriculture frontiers suggested that deforestation is no longer the only trend in tropical forests (Rudel, 2012; van Vliet *et al*, 2012). Other trends, including afforestation and reforestation, have been documented in a process known as forest transition (Hecht and Saatchi 2007; Rudel *et al*. 2005, 2009; Rudel 2012). These multiple land use/land cover changes are caused by a complex combination of different proximate and underlying factors such as policy, demographics, economics and socio-cultural changes (Lambin *et al* 2001; Geist and Lambin 2002; Hecht and Saatchi 2007; Rudel 2012; van Vliet *et al*. 2012).

For many years, shifting cultivation was seen as the primary cause of deforestation and was frequently viewed as a "wasteful" and "destructive" technique (Brady 1996; Tinker *et al*. 1996; Geist and Lambin 2002; Mertz *et al*. 2009; Pedroso *et al*. 2009; Padoch and Pinedo-Vasquez 2010). As a result, shifting cultivation landscapes have been transformed in the past decades into more permanent land uses and altered by various forms of conservation and development policies and the emergence of new markets for cash crops (Ziegler *et al*. 2011; van Vliet *et al*. 2012). In some regions, shifting cultivation practices have completely disappeared, while in others, shifting cultivation dominates or remains as a part of diversified production systems (van Vliet *et al*. 2012).

In the Atlantic Forest of Brazil, indigenous populations have used and managed *roças*, the Brazilian term for shifting cultivation plots, since pre-Columbian times (Dean 1996, Adams 2000, 2003; Balée 2009). Broadly defined, the region known as the Brazilian Atlantic Forest originally extended approximately 3,300 km along the coastline from 3°S to 30°S and from sea level up to 2,700 m, covering 148,194,638 ha (Metzger 2009; Ribeiro *et al*. 2009). Because it has historically harbored the largest share of Brazil's human population, it has experienced significant deforestation for timber, agriculture, cattle ranching, firewood and urban expansion (Dean 1996). As a result, only 11.7 % of the original forest cover remains (Ribeiro *et al*. 2009). These remnants are home to indigenous peoples, including 70 Amerindian reserves and 375 *Quilombola*[1] communities (SOS Mata Atlântica 2011), many of which still depend on shifting cultivation for their livelihoods. However, during the last 50 years, rural inhabitants living with this traditional agricultural system have been discouraged by conservation policies intended to protect one of the world's top biodiversity hotspots (Myers *et al*. 2000) and a World Heritage Site by the United Nations or have been slowly pulled from this traditional system by different policies put in place to develop the State of São Paulo.

The primary goal of this paper is to analyze both the outcomes of these different development and conservation policies on LUCC within a traditional shifting cultivation landscape in the Atlantic Forest (Ribeira Valley, Southeastern Brazil) and the impacts of these policies on the environment and local livelihoods in *Quilombola* communities since the 1950s. We tested whether, in communities from the Atlantic Forest where land tenure rights have been recently reaffirmed through tenure reforms, local livelihoods are taking people away from the land and whether local landscapes are experiencing forest transitions as predicted by Rudel (2012) in places sharing those socio-economic characteristics. Alternatively, policies and the development of market opportunities, pushing to more intensive production systems, could have resulted in the demise of shifting cultivation, offering economic benefits to smallholders, but also resulting in long-term negative impacts on forests and local livelihoods, as observed elsewhere (see examples in van Vliet *et al*., 2012).

In the first section of this paper, we describe the changes observed in *Quilombola* land use and environmental management practices. We then describe how these changes have influenced *Quilombola* livelihoods with a particular focus on demographic changes, transformations in local household economies and nutritional transition.

Background

This section introduces the different environmental and developmental changes that have directly or indirectly influenced the dependence on shifting cultivation in Brazil.

Environmental Policies Driving People from Shifting Cultivation

From 1965 until May 2012, the Forest Code stated that 20 % of any rural property in the Atlantic forest biome should be left intact as a legal reserve (Brasil 1965). Moreover, the vegetation covering the margins of rivers, the upper part of mountains and slopes of over 45° were declared permanently protected areas. However, these regulations were minimally enforced and largely ignored by the indigenous peoples until the 1980s. In 1993, the historically high levels of deforestation in the Atlantic Forest led the government to pass Federal Decree 750 (Brasil 1993), which prohibited the suppression of primary and secondary vegetation in

[1] The *Quilombolas* are descendants of former Maroon colonies, and are among the poorest and most marginalized rural communities in Brazil (Schmitt *et al*. 2002; Penna-Firme and Brondizio 2007).

intermediate or late stages of regeneration. The decree had a direct impact on the indigenous peoples' shifting cultivation, and local non-governmental organizations (NGOs), based on their rights to practice historical subsistence activities, began to demand that the government change the environmental regulations.

As a result, Federal Decree 750 was replaced by the Atlantic Forest Law in 2006 (Federal Law 11.428/2006, Federal Decree 6.660/2008) (Brasil 2006, 2008). The new law allows for the suppression of secondary vegetation in the initial stages of regrowth for subsistence agricultural activities on a smallholding provided a license is obtained (Varjabedian 2010). In the state of São Paulo, this license is issued by the Environmental Company of the State of São Paulo (CETESB) under Resolution 27/2010 (São Paulo 2010). Although these changes were meant to facilitate the process of obtaining licenses for traditional agriculture (Fundação Florestal 2011), the resolution prohibits the use of fire, a crucial element in the shifting cultivation system, based on State Law 10.547/2000 (São Paulo 2000). Hence, the legal procedures for obtaining a license and the prohibition of using fire are considered by the *Quilombolas* to be an embargo on shifting cultivation, and formal complaints have recently been made to CETESB.

Social and Land Tenure Policies that are Reducing People's Dependence on Shifting Cultivation for Their Livelihoods

Food Security Programs for Smallholders

In 1996, the government launched the National Program for the Improvement of Family Agriculture (PRONAF) (Schneider *et al*. 2004). PRONAF'S main programs include special credits for smallholders and the direct acquisition by the government of local food produce from targeted smallholders through the National Food Acquisition Program (PAA). The purchased goods are then distributed free of charge through local social assistance networks to families suffering from food insecurity (Chmielewska and Souza 2010). In 2003, food security became a state priority, and the Zero Hunger Program (PFZ) was launched (Belick *et al*. 2001). The PFZ was composed of a set of policies aimed at reducing poverty and food insecurity, incorporating PRONAF, PAA and PNAE, the National Program for School Food, which is responsible for feeding public school students (FAO 2006). In 2004, in the wake of an increasing recognition of indigenous rights and the importance of small-scale family agriculture in Brazil, the National Program for Technical Rural Assistance Delivery (PNATER) was launched, which was aimed at supporting smallholders in general but also prioritizing indigenous and poor farmers including the *Quilombolas* (Beduschi Filho 2007). In 2007, the National Policy on Indigenous People's Sustainable Development (PNPCT) was passed with the goals of fostering sustainable development and the recognition of indigenous peoples' social, land, economic, cultural and environmental rights and unifying programs run by different governmental agencies.

Social Policies to Improve the Livelihoods of Rural Families

In 1988, the new Constitution universalized access to medical care and granted all citizens the right to free medical assistance. In the 1990s, the Family Health Program (PSF) reorganized basic health care in Brazil, which increased the National Health System coverage in rural communities. Another major outcome that had a positive impact in rural areas was the regulation of the Social Security System (SSS), which was passed in 1991 (Schwarzer 2000). According to the new rules, rural old-age pensions were made equal to urban workers (100 % minimum wage, meaning an increase in 50 %), the minimum age of eligibility for rural retirement was reduced, and the same rights were recognized for men and women (Schwarzer 2000; Carvalho Filho 2008). Additionally, the *Benefício de Prestação Continuada* (BPC) program has paid a minimum wage per month to poor disabled and elderly people since 1995 (Dulci 2009). During President Lula's first term in office (2002–2006), the four existing cash transfer programs, *Bolsa-Escola, Bolsa-Alimentação, Auxílio-Gás* and *Cartão-Alimentação*, were unified into a single program: the *Programa Bolsa Familia* (PBF), with the primary goal of reducing poverty, hunger and food insecurity (Soares *et al*. 2007; Hall 2008). The PBF is a conditional, cash transfer program that pays a monthly stipend, usually to mothers, depending on their income and number of children, with a maximum benefit of R$ 306.00 (US$ 151.28). In return, parents have to ensure that their children attend school and are vaccinated (Burlandy 2007; Soares *et al*. 2007; Dulci 2009).

Recognition of Land Rights to Quilombolas: The Afro-Brazilian Communities

The 1988 Constitution was also a landmark in the recognition of the country's ethnic diversity and minority rights (Chagas, 1998). After it was passed, *Quilombola* associations in Brazil began to demand official recognition of traditional land, legal titles, and the expulsion of land grabbers and non-*Quilombola* farmers. With the support of several institutions, the process of land titling of *Quilombola* communities began in the 1990s. In 2000, the regulation of Article 68 of the Constitution was passed, granting land titles to *Quilombola* communities based on ethnicity, settlement history, and Afro-Brazilian ancestry. The *Quilombola* territories are collective properties of land, and the communities are not allowed to sell, transfer, or rent the land. Because the criteria used to identify them were based on self-recognition, the new regulation started an ongoing debate about the legal and cultural definition of this new identity as the number of people claiming to be *Quilombola* increased (Arruti 1997, Schmitt *et al*. 2002, French 2002; Penna-Firme and Brondizio 2007). At present, 3,524 communities have been recognized by the federal government (http://www.seppir.gov.br/acoes/pbq).

Methods

Study Site

The Ribeira Valley (2,830,666 ha) (Santos and Tatto, 2008) is situated between two of the country's most important cities, São Paulo and Curitiba, and is the largest Atlantic Forest remnant in Brazil (Fig. 1). The area is covered mainly by dense ombrophylous forest (Joly *et al*. 1999) and has a tropical monsoon climate (Am Köppen). The annual temperature varies between 17.4 °C and 30.4 °C (average 23.9 °C), and the mean annual rainfall is 1,521.5 mm and is concentrated in the summer (January–March) (CEPAGRI-UNICAMP 2011). Due to the mountainous relief, the area is unsuitable for mechanized agriculture, and road access is difficult, which has limited the development of the region (Hogan *et al*. 1999; Santos and Tatto 2008). The regional economy is based on tea and banana plantations, limestone mining, palm heart extraction and tourism. Home to 59 *Quilombola* communities (Santos and Tatto, 2008), the region is characterized by a low human development index (HDI), due to low levels of education and income and high levels of infant mortality and illiteracy (Hogan *et al*. 1999; Alves 2004).

The data presented here were collected in ten *Quilombola* communities situated in the municipalities of Eldorado and Iporanga (State of São Paulo, Brazil): Maria Rosa (MR), Pilões (PI), Galvão (GA), São Pedro (SP), Ivaporunduva (IV), Pedro Cubas (PC), Pedro Cubas de Cima (PCC), Sapatu (SA), André Lopes (AL) and Nhunguara (NH) (Fig. 1). These communities were founded by slaves and

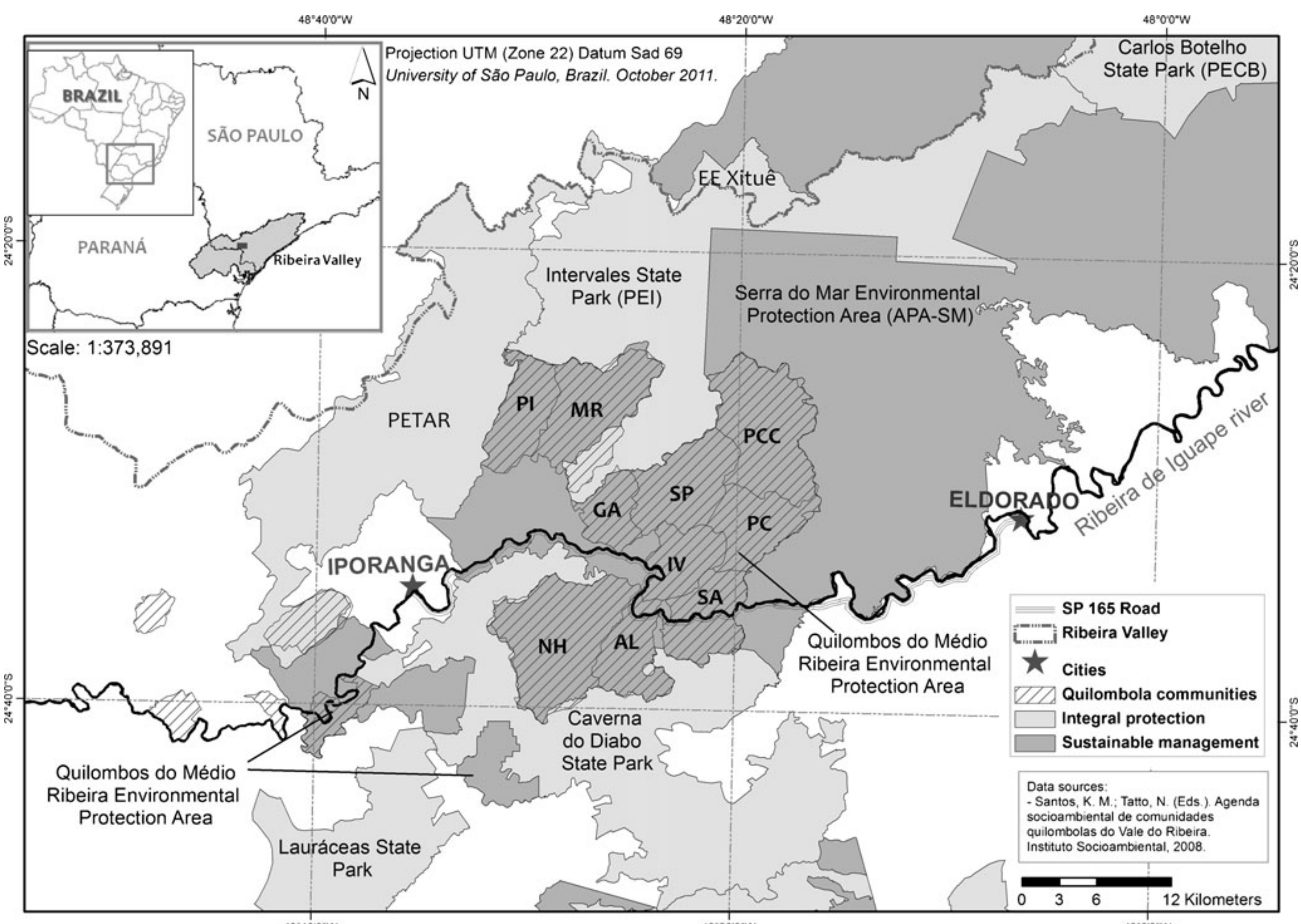

Fig. 1 Studied *Quilombola* communities and the surrounding protected areas in Ribeira Valley (São Paulo, Brazil)

their descendants following the abolition of slavery in 1888 (Queiroz 2006). We focus particularly on the communities of SP, PC, PCC and SA (Table 1), which have been officially recognized as *Quilombola* communities, although only PC and SP have received land titles (in 2001 and 2003, respectively). SA is located along the Ribeira River and the SP 165 road that links the cities of Eldorado (40 km) and Iporanga. PC, PCC and SP are located on the left margin of the Ribeira River, 35–60 km from Eldorado. The river must be crossed by ferry, but since 2010, a new bridge has facilitated access to SP. For historical reasons, PC was divided in two communities, PC and PCC, during the titling process (Santos and Tatto 2008).

Environmental and Development Policies in the Ribeira Valley

Creation of Protected Areas (PAs)

In the Ribeira Valley, the first PAs—the Upper Ribeira Valley Touristic State Park (PETAR, 35,712 ha) and the Jacupiranga State Park (PEJ, 150,000 ha) (Silveira 2001)—were created in 1958 and 1969, respectively, to protect the limestone caves and the Atlantic Forest and overlapped the traditional land of *Quilombolas* (Fig. 1). Restrictions on subsistence activities imposed by the PAs made the extraction of palm heart *(Euterpe edulis* Mart.) from the forest, formerly used only for subsistence needs, illegal (Sanchez 2004; Queiroz 2006). In the 1980s, three new PAs were created in the region (Fig. 1): Carlos Botelho State Park (PECB, 37,644 ha, 1982), Serra do Mar Environmental Protection Area (APA-SM, 569,450 ha, 1984), and Intervales State Park (PEI, 49,000 ha, 1995). In all three, shifting cultivation, hunting and palm heart extraction were closely monitored. In 1988, the Atlantic Forest was declared a National Patrimony; in 1991, the Atlantic Forest Biosphere Reserve was created (29,473,484 ha), and in 1999, it was recognized by the United Nations as a World Heritage Site (Rylands and Brandon 2005). In 2008, as part of the strategy of the Atlantic Forest Biosphere Reserve to improve the management of protected areas and to solve land conflicts, PEJ (formerly a strictly protected area) was transformed into a mosaic of 16 PAs. The areas occupied by indigenous people and smallholders were excluded or reclassified as sustainable use areas (87,351 ha) (Rylands and Brandon 2005; Lino 2009).

Infrastructure Development in the Ribeira Valley

The 1950s were a period of political stability and economic development in Brazil, and a top priority during this period was the development of the hinterlands. Considered a backward and isolated region, the Ribeira Valley received several infrastructure projects including the opening of new highways (BR 116, linking São Paulo to Curitiba, in 1961) and local roads (SP 165, linking Eldorado to Iporanga, 1969) (Fig. 1) and plans for the construction of hydroelectric power dams on the Ribeira River (Braga 1999; Queiroz 2006). In the 1970s, during the military dictatorship, more investments were made in the region in an effort to counteract the guerilla movement (Hecht 2010). Rural schools were set up in many villages, and tax incentives and other benefits were given to farmers for cattle ranching and banana and tea plantations. These new opportunities also attracted land grabbers and professional palm heart extractors, and land conflicts emerged (Queiroz 2006). In the 1980s, during the period of democratic transition, social and environmental movements took root in the region. With support from the Catholic Church (*Comissão Pastoral da Terra*), the *Quilombolas* organized themselves into associations, demanding land titles and infrastructure services and participating in the national social movement against the construction of river dams (MOAB).

Methodology

Household Economics

A socioeconomic and demographic household survey using structured interviews (Bernard 1995) was conducted in 2003 within the ten communities (Table 1). A total of 479 households, with 2,032 individuals (mean 4.2 persons per household), were surveyed. These data were complemented in 2010 (May–July) by a household survey of 33 households in the communities of SA, PC and PCC (19.3 % of all households) focused on a broader range of livelihood changes and land-use patterns over the last decade (2000–2010) (Table 1). The households were chosen from among those that had participated in the 2003 household survey based on the importance of shifting cultivation for household subsistence, the head of the household residing in the community for most of his/her life, their self-recognition as *Quilombola*, and their willingness to participate in the research. The main focus of the second household survey was to uncover what was perceived by the local people as the main drivers of change in their livelihoods, how natural resources and human management practices had changed during the period of investigation, and how these changes were reflected in the local landscape and livelihoods of the *Quilombola* communities. A detailed ethnographic inquiry (Hammersley and Atkinson 1983) of 11 households in PC, PCC, SA and SP was conducted between 2006–2007 to understand the socioeconomic, political and environmental aspects of household decision-making and the changes in livelihood strategies since the 1930s (Table 1). The sample was chosen based on the same criteria listed above. Data

Table 1 Communities, area (ha), population, number of households and individuals investigated in the *quilombola* communities in the Ribeira Valley (municipalities of Eldorado and Iporanga, São Paulo, Brazil), 2003–2010

Community	Area (ha)[a]	Population (# inhab.)	# Households							# Individuals	
			Household economics			Land cover investigation		Ethnobotanical surveys		Nutritional Status, Dietary and Activity Patterns	
			Demographic/ socioeconomic/ livelihood surveys		Ethnographic inquiry	Oral/life history interviews	Plot/ fallow interviews	Agro-biodiversity	Home gardens	Nutritional status	Diet / Activity
		2003	2003	2010	2006–2007	2006–2010		2006–2007	2007–2009	2003	2007
André Lopes (AL)	3,200	305	68	–	–	–		–	–	84	–
Galvão (GA)	2,234	115	28	–	–	–		–	–	21	–
Ivaporunduva (IV)	2,754	317	78	–	–	–		–	–	–	–
Maria Rosa (MR)	3,376	49	11	–	–	–		–	–	–	–
Nhunguara (NH)	8,101	461	99	–	–	–		–	–	67	–
Pedro Cubas (PC)	3,806	274	68	10 (26 %)[b]	4 (6 %)	15 (49 %)[b]	9 (13 %)	4 (6 %)	27 (40 %)	57	–
P. C. de Cima (PCC)	6,875			6 (23 %)[b]		9 (39 %)[b]					–
Pilões (PI)	6,222	91	24	–	–	–		–	–	–	–
Sapatu (SA)	3,712	297	75	17 (23 %)	4 (5 %)	9 (16 %)	4 (5 %)	4 (5 %)	30 (40 %)	57	27
São Pedro (SP)	4,688	123	28	–	3 (11 %)	17 (89 %)	8 (29 %)	3 (11 %)	14 (50 %)	43	21
Total	44,968	2,032	479	33	11	50	21	11	71	329	46

[a] ITESP (2008)

[b] based on a household survey carried out by Santos and Tatto (2008)

were gathered through semi-structured interviews and oral histories with the heads of the households (8 males, 3 females), monthly visits to garden plots and participant observation.

Land Cover Data

A combination of ethnographic, participant observation and oral and life history interviews were used to assess the history of changes in the shifting cultivation system and the associated landscape since 1930 (Hammersley and Atkinson 1983; Rockwell 1991; Bernard 1995; Slim *et al*. 2006; Styger *et al*. 2007). A total of 66 individuals from 50 households (36–75 years old, 34 women and 32 men) were interviewed in PC, PCC, SA and SP between 2006 and 2010 (Table 1), which previously corresponded to 57 households (some were from the same family). Additionally, a sub-sample of 21 individuals from different households were selected for field interviews in old fallows and areas still under shifting cultivation (Table 1) to record present and past land use (Alexiades and Wood Sheldon 1996). A total of 30 areas were visited, and all sites were mapped using GPS and plotted in aerial photos to investigate changes in the landscape. Aerial photo interpretation was performed for two periods: 1962 and 2000. For 1962, a 1:40,000 aerial photo from the Executive Group for Greater São Paulo (GEGRAN/SACS, Baixada Santista e Planalto) was used. For 2000, we used a 1:35,000 photo from Instituto Florestal (Instituto Florestal/PPMA/SMA). Land use was classified as forest (mature forests and fallows >10 years), area under management (cleared areas under cultivation, areas for raising poultry and pigs, fallows <10 years, home gardens and villages), or pasture (opened by land grabbers). Landscape metrics calculations (shape and patch cohesion index) were performed following McGarigal and Cushman (2002) to investigate how the landscape structure changed during this period.

Nutritional Status and Dietary and Activity Patterns

Data on nutritional status, diet and activity patterns were collected to understand the effects of livelihood changes on the health of the local peoples. These data were collected using the following methods: (1) comparing data on growth status (height-for-age) among those born before (40+ years) and after (<40 years) the construction of the SP-165 road that connects these rural communities to the larger region; (2) comparing the nutritional status (body mass index (BMI=Wt (kg)/Ht (m^2)) of adult men and women to each other and to national data collected by the Brazilian government in 1975; and (3) describing the modern diet and activity patterns of men and women and comparing them with past patterns obtained via interviews. Data on the nutritional status of 329 adults (20–79 years) representing 40 % of the adult population living in AL, GA, NH, PC, PCC, SP and SA were collected in 2003 (Table 1) (Crevelaro 2009). In July (winter) 2007, a follow-up study on the diet and activity patterns of adults (20 men and 28 women) in SP and SA (29 % and 14 % of the adult population, respectively), was conducted. The anthropometric data were collected following standardized procedures (Lohman *et al*. 1988) and included data on weight, height, skinfolds and circumferences. The dietary data were collected over three consecutive days using the 24-hr recall method (Quandt 1986; Gibson 1990). Brazilian food composition tables (IBGE 1999; Philippi 2002; Franco 2003, UNICAMP 2004) were used to convert recalled daily intakes into total energy (kcal), determine macronutrient consumption (carbohydrate, protein and fat) and identify the most important sources of energy and protein in the diet. Data on daily time allocation for the adults were collected using the 24-hr recall method on the same three days when the dietary data were collected. The activity data were classified into 21 different categories that captured the range of activities performed (Prado 2011). Interviews with 34 women and 32 men in the communities of PC, PCC, SP and SA were used to gather data on diet and activity patterns in the 1960s (Table 1).

Ethnobotanical Surveys

A floristic survey was also conducted In the 11 households from PC, PCC, SA and SP that were interviewed for the ethnographic inquiry that included the identification of all the species and ethno-varieties from the shifting cultivation plots. In addition, between 2007 and 2009, we conducted additional semi-structured interviews with 71 households (41.5 %) with the person responsible for taking care of the home gardens (63 women and 8 men) (Table 1). Our goal was to characterize the function of *Quilombola* home gardens and document changes in their composition over the past decades. Ethno-varieties were identified based on pictures (Lorenzi and Matos 2002; Lorenzi and Souza 2002; Souza and Lorenzi 2005) or botanical specimens with the help from a specialist from the São Paulo Botanical Institute.

Results

The major changes affecting forests and livelihoods in *Quilombola* shifting cultivation landscapes since the 1950s are represented in Fig. 2. The main drivers of change are policies (environmental, developmental and social) and increased access to markets, primarily as a consequence of development/infrastructure policies. The interaction between these drivers has impacted *Quilombola* land use and environmental management (plots, agro-biodiversity and

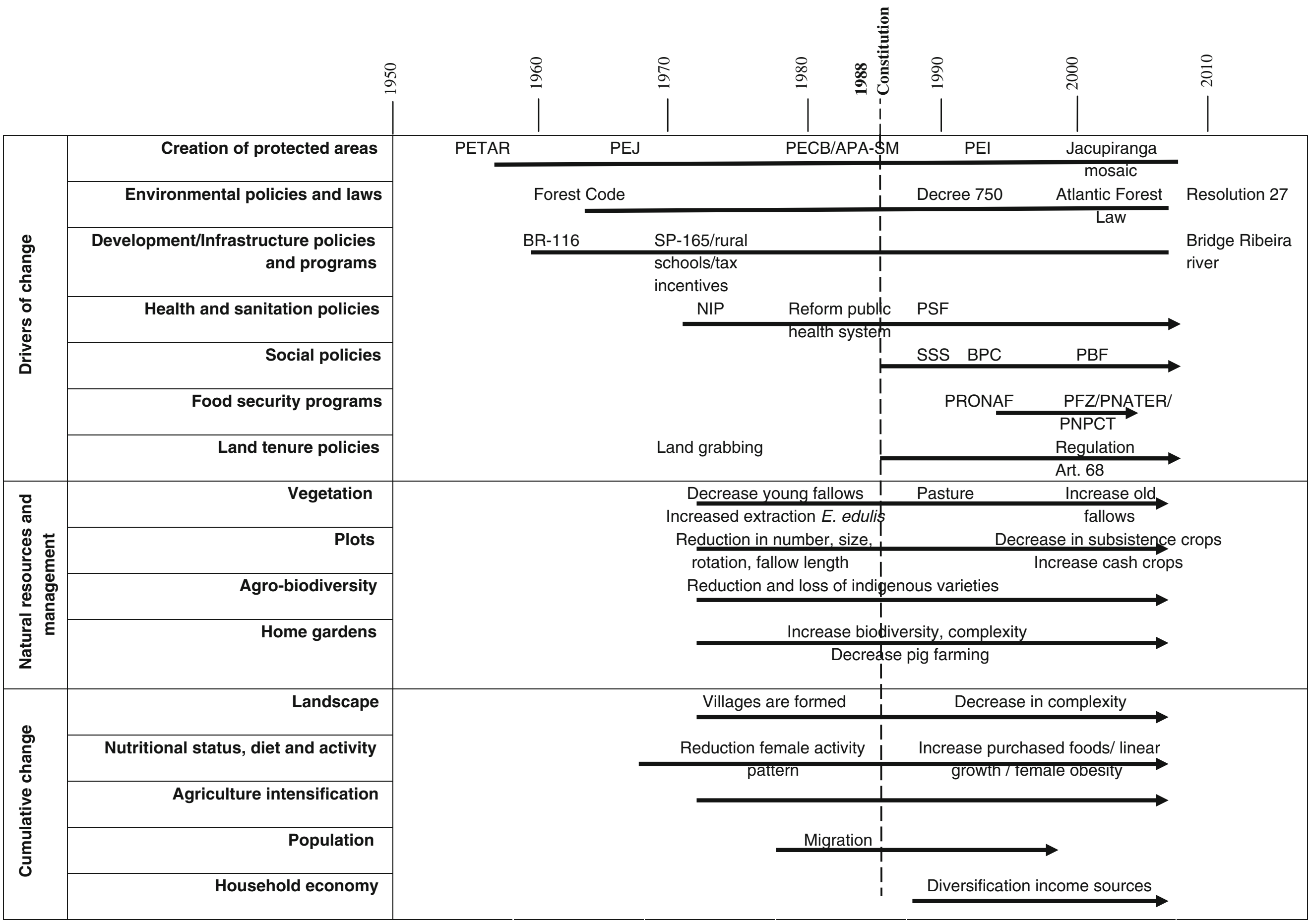

Fig. 2 Coupled human-environment timelines of the *Quilombola* communities from the Ribeira Valley (São Paulo, Brazil), 1950–2010

home gardens) with cumulative effects on the landscape and on *Quilombola* livelihoods. These changes are discussed in the following paragraphs.

Changes in Land Use and Agricultural Activities

In the past, subsistence was based on shifting cultivation (cassava, rice, beans, and maize), animal husbandry (pigs and poultry), hunting and fishing. Surplus was sold to local merchants in exchange for salt, clothes and kerosene. The larger clearings were used for rice and maize that was consumed by the family, fed to the animals and sold to local merchants. Each household had up to 4 ha in use (one or more areas), which were cultivated for 2 years and left to fallow for 10 to 25 years. Cassava, coffee, sugar cane and vegetables were grown in smaller areas of approximately 0.5 ha. Bitter varieties of cassava were preferred because they were more resistant to pests and most animals would not eat them, although they had to be processed into flour. At that time, most households were comprised of two distinct areas: the *moradia* and the *capuova* (Fig. 3). The *moradia* was the more permanent family home that was surrounded by the home garden, an area for raising domestic animals, including pigs, and planted fruit trees. The *capuova* was the cultivated area and typically included a small, multifunctional, mobile hut that was used during the planting season. These areas were often surrounded by a mosaic of fallows at different stages of re-growth. This complex unit was isolated from the main trails, and each family typically maintained more than one *capuova* at the same time, which were distributed on the landscape according to usufruct rules and interwoven with *capuovas* from other families and common areas. According to these rules, access rights to land were based on a "first-come, first-served" policy, which meant that the family who first arrived and cleared the area to grow crops could use it for as long as necessary. The usufruct rights were passed from one generation to the next and were respected by community members. The existence of several scattered household units created a highly complex mosaic of cultivated areas,

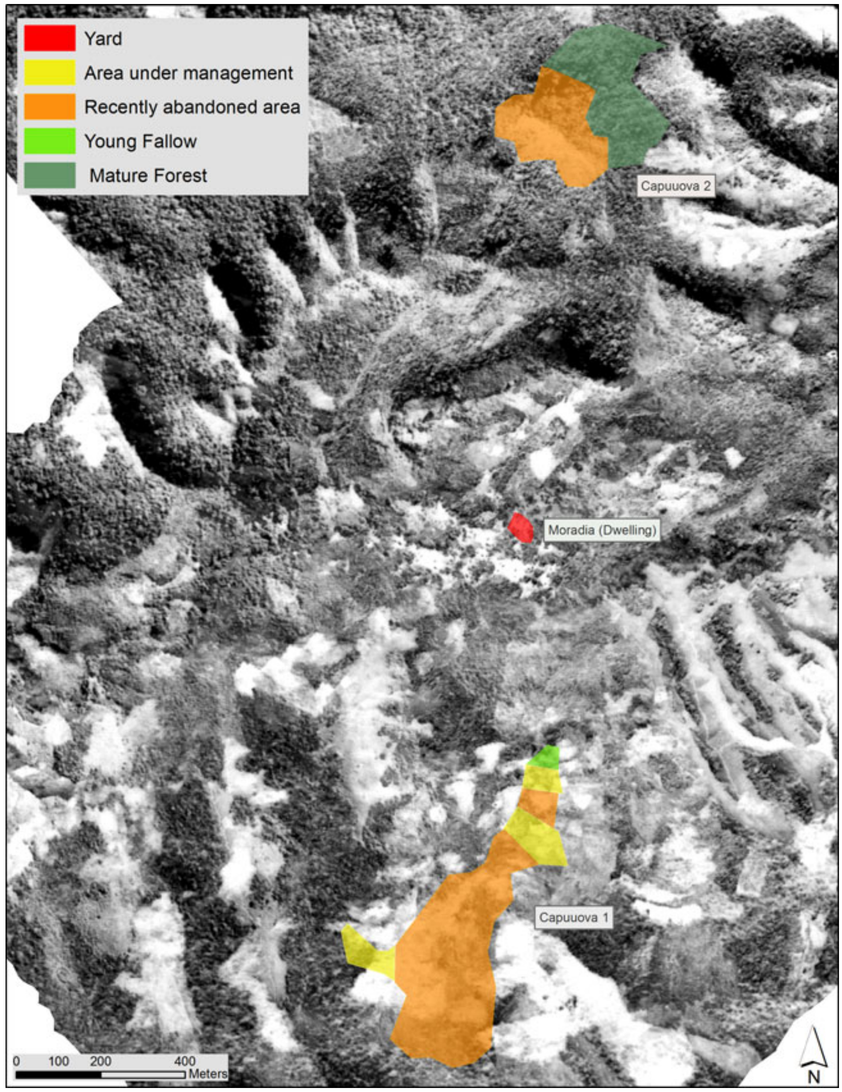

Fig. 3 Aerial photograph (1962) showing an example of the spatial organization of one *Quilombola* family household (*moradia* and two *capuovas*) in the community of São Pedro, Ribeira Valley, São Paulo (Brazil). The areas in between belong to other families or are common areas

secondary forest and primary forest, resulting in a heterogeneous landscape.

The interviews and oral life-histories revealed that the establishment of the first rural schools in the region in the 1970s sparked the abandonment of the *moradias* and the construction of new houses. This led to the formation of small villages where access to electricity and public transport to Eldorado was easier. Women moved to the villages to take care of their children, who attended school and were no longer able to help in the *capuovas*. In addition, environmental restrictions on shifting cultivation and hunting and the increased demand for palm heart induced young men to move to illegal extraction or to leave for better jobs. The land-grabbers, attracted by the opening of the new roads, forced several families out of PC and PCC, and in SA, all of the dwellers from the left margin of the Ribeira River were also expelled. With the reduction in labor and the increase in environmental surveillance in the 1980s, more families moved their *moradias* to the village, and the *capuovas* began to be abandoned which was followed by a decrease in plot rotation, plot size (from approximately 2.0 to 0.5 ha) and fallow length (from approximately 10–25 to 0–6 years). Pig farming was also gradually abandoned when the *moradias* moved to the village.

Over the years, the changes in land use reported by individual households have resulted in the concentration of agricultural activities around the village and the abandonment of scattered shifting cultivation plots, as confirmed by aerial photo interpretation (Fig. 4a–d) and landscape metric analysis (Table 2). State environmental restrictions on shifting cultivation (Resolution 27/2010) have continued to limit the land available for planting. Moreover, since 2006, CETESB has issued very few licenses for shifting cultivators, and many households have been at risk of being caught by the environmental police and paying fines. As a result, the number of units used for agricultural activities (home gardens, cultivated fields, fallow) fell from 250 to 154 (PC,

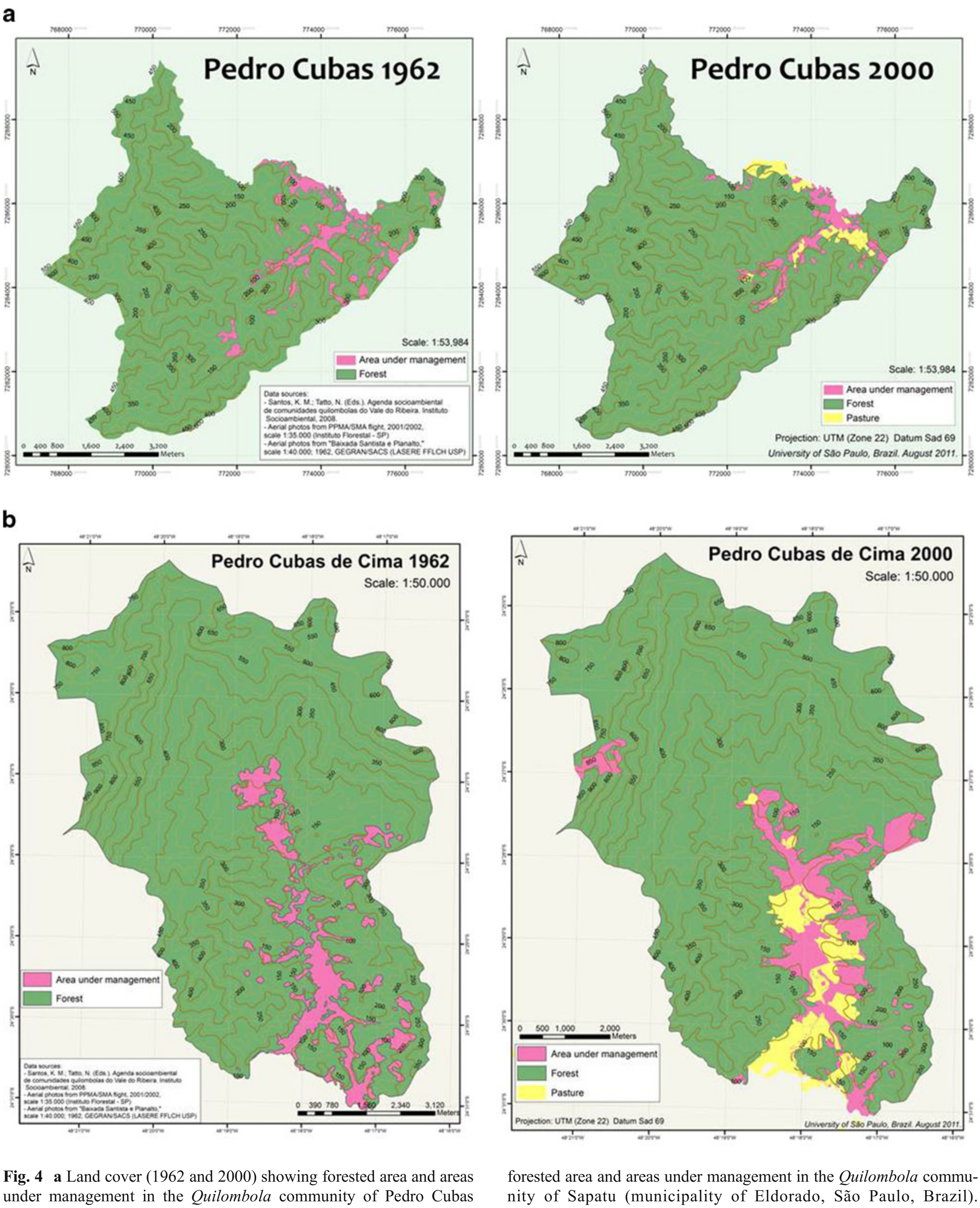

Fig. 4 **a** Land cover (1962 and 2000) showing forested area and areas under management in the *Quilombola* community of Pedro Cubas (municipality of Eldorado, São Paulo, Brazil). **b** Land cover (1962 and 2000) showing forested area and areas under management in the *Quilombola* community of Pedro Cubas de Cima (municipality of Eldorado, São Paulo, Brazil). **c** Land cover (1962 and 2000) showing forested area and areas under management in the *Quilombola* community of Sapatu (municipality of Eldorado, São Paulo, Brazil). **d** Land cover (1962 and 2000) showing forested area and areas under management in the *Quilombola* community of São Pedro (municipalities of Eldorado and Iporanga, São Paulo, Brazil)

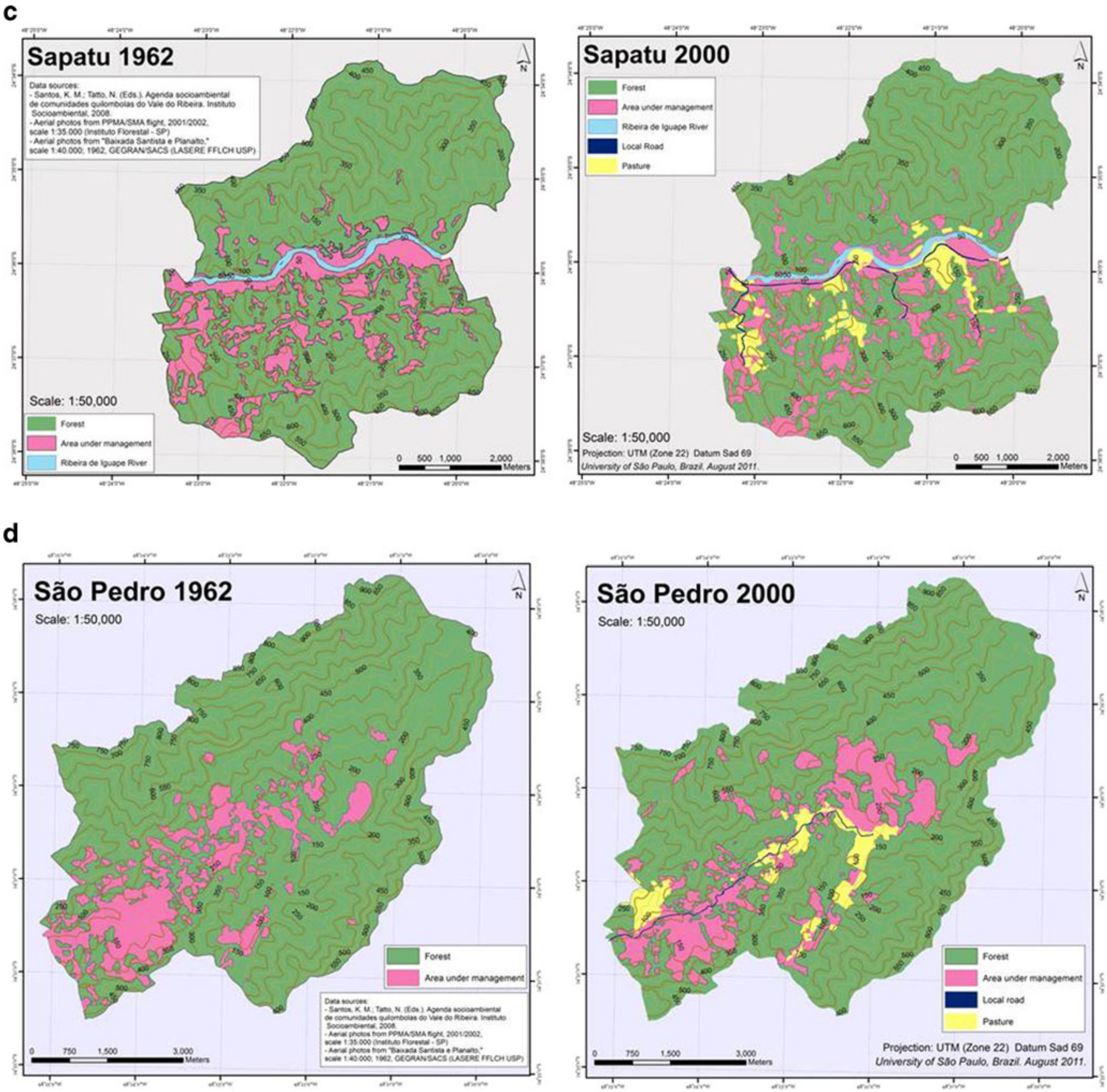

Fig. 4 (continued)

PCC, SA and SP), while their mean size increased from 12.6 to 24.7 ha between 1962 and 2000 (Table 2, Fig. 4a–d). This increase in mean size is also explained by the pasture areas opened by the land-grabbers that did not exist in 1962 (see Fig. 4a–d) and that, in SP and PC, were expelled when the government issued the land titles to the *Quilombolas*. Since then, a few households have been raising cattle, but most pasture areas are abandoned and left to fallow.

In 2010, the majority of households described an increase in old fallows and a decrease in new fallow areas, which was due to environmental restrictions and the lack of manpower to work in the *capuovas*. Some households reported cutting young fallows before they reached the legal limit as way to keep agricultural land available for future needs. Although the use of forested areas for shifting cultivation has decreased, the *Quilombolas* still visit the forest to gather fruits and yams (*Dioscorea* spp.) in the abandoned plots, to hunt, and to gather *E. edulis* palms and other timber and non-timber products for building houses and making tools. Several households still produce subsistence crops but only in limited areas (less than 0.2 ha) that are usually closer to their homes. According to our information, most of the agricultural area is used for cash crops such as bananas (particularly is SA), peach-palm heart production (*Bactris*

Table 2 Landscape metrics of the *quilombola* communities of Pedro Cubas, Pedro Cubas de Cima, Sapatu and São Pedro (1962 and 2000)

Landscape Metrics	Pedro Cubas		Pedro Cubas de Cima		Sapatu		São Pedro		Total	
	1962	2000	1962	2000	1962	2000	1962	2000	1962	2000
Total forested area – ha (% total area)	3,570.41 (93.86)	3,586.14 (94.30)	6,371.9 (91.99)	6,012.43 (86.80)	2,679.85 (73.14)	3,029.23 (82.66)	3,933.44 (84.51)	3,786.23 (81.34)	16,555.60 (86.9)	16,414.03 (86.2)
# Units under management	54	21	51	21	82	83	63	29	250	154
Mean size of units under management (ha)	4.32	10.33	10.88	43.55	23.72	15.13	11.44	29.94	12.59	24.70
Total area under management – ha (% total area)	233.55 (6.14)	216.91 (5.70)	554.64 (8.01)	914.60 (13.20)	984.37 (26.86)	635.64 (17.34)	720.95 (15.49)	868.32 (18.66)	2,493.51 (13.1)	2,635.47 (13.9)
Pasture area – ha (% managed area)		81.01 (37,35)		324.8 (35,31)		149.2 (23,47)		183.3 (21,11)		738.3 (28,02)
Pasture area (% total area)	–	(2.13)	–	(4.69)	–	(4.07)	–	(3.94)	–	(3.70)

gasipaes, Kunth; mainly in PC, PCC and SP), rice, passion fruit and fruit trees (in PC, PCC and SP) and to grow vegetables (such as lettuce, carrots and eggplant) as part of the PAA. In SP, the *Quilombolas* benefited from the abandonment of a large area with *Bactris gasipaes* (200,000 palm trees), which was abandoned when a land grabber was removed by the government.

The changes observed at the level of the municipality of Eldorado can be tracked from the agriculture census data (Table 3) (IBGE 1991a, 2009). Between 1985 and 2006, there was a decrease in the area that was planted and in the total production of three of the four *Quilombola* subsistence crops (cassava, beans and maize). Rice is the only exception, but in this case, subsistence production has been substituted by mechanized agriculture with input from non-*Quilombola* farmers in the municipality, including one land grabber in PCC. During the same period, banana production increased from 65-thousand tons in 1985 to 155-thousand tons in 2006, showing the increasing importance of this cash crop for the local economy both for *Quilombolas* and other farmers.

The forest area in the four communities represents from 81.3 % to 94.3 % of the total community territory (Table 2, Fig. 4a–d), and despite the socio-economic and environmental changes that have occurred during this period, the total forested area and the total area used for agricultural activities in PC, PCC, SA and SP have not significantly changed between 1962 and 2000 (a 0.7 % reduction in forested area and a 0.8 % increase in total area used under management—Table 2). However, some local differences were observed. In PC, the forested area increased slightly (0.4 %), while in SA, the increase was much greater (9.6 %), most likely due to a higher degree of agricultural intensification and an abandonment of shifting cultivation plots in connection to road access. In contrast, the forested area in PCC and SP decreased by 5.1 % and 3.2 %, respectively, presumably due to an increase in pasture areas by land grabbers (Table 2, Fig. 4a–d).

Changes in Agro-biodiversity

The changes observed in household land use have also affected agro-biodiversity. Although 53 different species and 116 ethno-varieties were still being cultivated as food by the *Quilombolas* in 2007 (in home gardens, more permanent and the remaining shifting cultivation plots), the curtailment of shifting cultivation and agricultural intensification has caused an overall reduction in agro-biodiversity. According to local informants from PCC, PC, SA and SP, 52 % of local varieties have been lost over the last 50 years.

Table 3 Area (ha) with subsistence crops, total subsistence crop production (tons), and productivity (tons/ha) in the municipality of Eldorado (SP) in 1985 and 2006 (IBGE 1991, 2009)

	1985				2006			
	area	% total area	production		area	% total area	production	
	ha		tons	tons/ha	ha		tons	tons/ha
Cassava	109	0.13	404	3.7	61	0.00	188	3.1
Beans	136	0.16	86	0.6	50	0.08	30	0.6
Maize	496	0.60	452	0.9	98	0.15	94	1.0
Rice	844	1.02	476	0.6	111	0.17	402	3.6
Total area (ha)	83,066				66,609			

Table 4 Number of varieties cited for the main subsistence crops by *quilombola* households in the communities of PC, PCC, SA and SP, and number of varieties lost (adapted from Pedroso-Junior 2008)

Popular name	Species	Botanical family	NV	NVL
Rice	*Oryza sativa*	Poaceae	22	11
Cassava	*Manihot esculenta*	Euphorbiaceae	19	10
Banana	*Musa paradisiaca*	Musaceae	16	3
Beans	*Phaseolus vulgaris*	Fabaceae	13	2
Pumpkin	*Cucurbita pepo*	Cucurbitaceae	10	4
Yam	*Dioscorea spp.*	Dioscoreaceae	10	6
Maize	*Zea mays*	Poaceae	2	0
Total			92	36

NV Number of cited varieties; *NVL* Number of varieties cited as lost by all the households

Rice (*Oryza sativa*) and cassava (*Manihot esculenta*) were the crops that lost the greatest number of varieties (Table 4). Older rice varieties are being substituted for by more productive and faster-growing ones that are capable of growing in poor soils and are being cut before they need to be weeded. In the case of cassava, the old, bitter varieties are being substituted for by sweet ones or simply abandoned. Only a few households still have the processing equipment needed to make cassava flour, and the bitter varieties cannot be planted in the home gardens because of the risk they pose to domestic animals. Moreover, increased income has allowed the *Quilombolas* to buy cassava flour in the markets in Eldorado or to substitute it with other staples such as rice and pasta that do not carry the stigma of being a food associated with being poor (Adams *et al.* 2009). For the same reasons, varieties of yam (*Dioscorea* sp.), sweet potato (*Ipomoea batatas*), and cocoyam (*Xanthosoma sagittifolium*) that were consumed together with coffee, are being substituted by industrialized crackers. In contrast, banana (*Musa paradisiaca*) varieties are being maintained, and no maize (*Zea mays*) variety has been reported to be lost (Table 4). In addition to being a cash crop, bananas can be maintained in the fallows for decades. This has resulted in old varieties being kept for household consumption while commercial varieties are sold to middlemen. As for maize, despite the reduction in cultivated areas due to the abandonment of raising swine, the *Quilombolas* still prefer local varieties to the hybrid commercial ones that are considered more productive and adapted to local conditions.

Impacts on Livelihoods

Demographic Changes

Household data collected in 2003 shows that the age structure in *Quilombola* communities is typical of poor, rural areas in Brazil and was comprised of 28.4 % children (<10 years), 22.2 % young people (11–20 years), 39.2 % adults (21–60 years) and 10.2 % elderly people (> 60 years). The population pyramid also shows a slight reduction of young people (21–40 years), especially males, which is suggestive of out-migration. Forty-three percent of the heads of households were illiterate or functionally illiterate. The 2010 survey confirmed that 37.0 % of household members have permanently migrated (usually by the time they reached 25 years old) for marriage or work in the closest towns (mainly Eldorado and Curitiba), reducing the available manpower for agricultural activities. In the municipality of Eldorado, the rural population has decreased 2.4 %, while the urban population has increased 20.6 % from 1991 to 2000 (IBGE 1991b, 2000).

Changes in Household Economics

In the past, households relied mainly on shifting cultivation, animal husbandry, hunting and fishing for subsistence. During the last decades, shifting cultivation is being replaced by the perennial cultivation of cash crops such as bananas, passion fruit and peach-palm and other income sources. In 2003, the main income sources were cash-transfer programs and agriculture, and 53.7 % of the households were still cultivating merely for their own consumption. In 2010, only one out of the 32 households relied solely on agricultural activities, and 53.0 % of the households interviewed depended on perennial agriculture as one of their sources of income. On average, the households interviewed had at least two sources of income, and the major source was cash-transfer programs. Seventy-eight percent of households relied on government pension funds, and 25 % received the *Bolsa Familia* (PBF). On average, retirement pensions provided twice the income reported for agricultural activities. Moreover, 18 % of the families were receiving a monthly *cesta básica* from the government (basic food stuffs such as rice, beans, sugar, oil and coffee for one standard family), 12 % had engaged in the PAA, and 34 % were receiving credits from PRONAF for cash crops.

As subsistence farming has decreased, the most important type of expenditure is food bought in supermarkets followed by medicine, gas and electricity. On average, the budget spent on food per household represents 76.0 % of their total expenditure, showing an important dependence on market food prices and a decrease in food security. Over the last ten years, the studied communities have improved their living standards, including an increase in access to electricity, communitarian telephones and brick houses (Fig. 5), which were mainly received from the state government as part of a program to improve housing conditions (Santos and Tatto 2008). Nevertheless, at the time of this study, the communities still lacked good sanitation (e.g.,

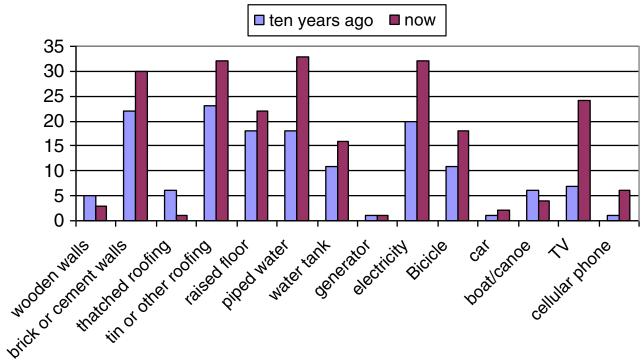

Fig. 5 Changes in *Quilombola*'s household assets between 2000–2010 (PC, PCC, SA)

only 50 % of households had a pit toilet) (Santos and Tatto 2008) and transportation remained poor.

Changes in Nutritional and Activity Patterns

According to the men and women interviewed, the majority of foods consumed in the past were planted, raised or gathered/hunted/fished from the surrounding forested areas and rivers. Key sources of dietary energy included rice, corn, manioc and yams, and the most important sources of protein were fish and wild game. In terms of physical activity, both men and women were active in subsistence activities, although men were more active than women due to their primary roles in food cultivation, hunting and fishing. Dietary data collected in 2007 revealed three key changes: (1) an increased reliance on purchased foods (in fact, by 2007 the majority of all foods were purchased); (2) an increase in the consumption of processed carbohydrates, specifically refined sugar, crackers/cookies and bread; and (3) a shift in sources of dietary protein from fish and game to beef and beans. However, it is important to note that the main sources of carbohydrates did not change significantly over time. The 2007 data also indicate important changes in daily activity patterns. Women in SP and SA spent the majority of their time in leisure activities (30.3 %), which mainly consisted of sitting and talking with friends and family and in domestic work (29.7 %). Productive activities, including work in home gardens, salaried work and craft production, occupied an additional 7.5 % of their time. None of the women reported working in food production for household consumption, and the time women spent in commercial crop production was minimal (< 1.0 %). The men in these communities spent an average of 37.8 % of their time in leisure activities and 23.6 % of their time in productive activities, which included wage labor, work in agricultural fields (bananas and passion fruit), and craft production. Overall, the time allocation data indicate that the physical activity levels of men and women in these communities has declined over time, although men remain more physically active than women.

These changes in diet and activity patterns are accompanied by changes in nutritional status. In terms of stature, independent sample t-tests indicate a significant increase in stature over time among both men ($t=2.4$, $p=0.02$) and women ($t=4.5$, $p<0.01$). A number of potential factors could account for the observed increase in stature including better access to food and health care. Comparing the BMI of adult men and women in these *Quilombola* communities with Brazilian data from 1974/75, we observed a significant increase in the number of individuals classified as overweight or obese. For example, Monteiro *et al*. (2007) reported that, in southeastern Brazil in 1974/75, the rate of obesity (BMI≥30 kg/m^2) among adults in the poorest quartile was 1.6 % and among females alone it was 6.1 %. This contrasts sharply with the rates of obesity found in our 2003 survey, where 7.1 % of men and 21.7 % of women were classified as obese. Similar to the pattern observed at the national level, the females in our study had higher BMI values compared to the men ($t=-5.3$, $p<0.01$) (Table 5).

Discussion

Losing Landscape Complexity

We have shown that, in the Ribeira Valley, conservation policies and market development have curtailed *Quilombola* subsistence activities including shifting cultivation, gradually changing agricultural activities toward the perennial cultivation of cash crops, findings that are in line with those of van Vliet *et al*. (2012). Unlike what has occurred in other shifting cultivation landscapes (Birch-Thomsen *et al*. 2010; Palao *et al.* 2011), where farmers have maintained shifting cultivation despite the trend towards agricultural intensification, *roças* have almost disappeared in the Atlantic Forest and are likely to completely do so in the next decade. Intensification has contributed to a loss of agro-diversity and landscape structural complexity, as also observed in Mexico (Dalle *et al*. 2011) and Cameroon (Robiglio and Sinclair 2011). However, the gradual abandonment of shifting cultivation and the intensification of land use has neither translated into an increase in total

Table 5 Anthropometric data (height, weight, BMI) of *quilombola* adults ($n=329$)

	N	Height (cm) Mean±SD	Weight (kg) Mean±SD	BMI (wt/ht^2) Mean±SD
Males	140	165.4±6.9	65.3±11.8	23.8±3.6
Female	189	153.3±6.6	62.0±13.5	26.3±5.2

forested area (Rudel 2012; Baptista and Rudel 2006; Walker 2012) nor in a net deforestation (Geist and Lambin 2002; Cramb *et al*. 2009; Ziegler *et al*. 2011), despite the opening of pasture areas by land grabbers (Table 2, Fig. 4a–d). The total forested area has decreased by only 0.7 % in 40 years, while the pasture area has increased 3.7 %.

Although our case study combines several of the characteristics predicted by Rudel (2012) for places experiencing forest regrowth: the *Quilombolas* inhabit a rugged landscape, have been granted land tenure rights, and household economies are less dependent on agriculture income, we do not observe the occurrence of a forest transition. One of the reasons for this could be that our study has not yet captured recent land cover change because land rights have only been granted recently (2000s) and pasture areas opened by land grabbers are gradually being left to fallow. Yet, as other factors that were noted by Rudel (2012) as drivers of forest regrowth can be seen in the area (e.g., increased access to urban markets through road development, agricultural intensification in lowlands along the roads, abandoned lands, out-migration and growth in non-farm economic sectors), one could expect to see an increase in forested areas in the next few decades, when the old generation gives up land and fewer young smallholders continue with cash crops. Another reason could be that forest transition will simply not occur and that *Quilombolas* will carry on depending on forest products due to the low price of farm labor *vis a vis* the lack of well-paying jobs for people with low schooling and the high cost of living in urban areas as seen in other developing countries (Baptista and Rudel 2006).

Diversifying Income, Securing Livelihoods?

Since the 1960s, local livelihoods in the studied *Quilombola* communities have increasingly diversified with new opportunities associated with tourism, small businesses, and market-oriented agricultural production. Income is less reliant on agricultural activity, particularly for families that benefit from cash transfer programs. Social policies have also contributed to increase schooling, which has led to increased youth out-migration. As in other regions, shifting cultivation has been in decline due to "progressive shifts from farm to non-farm activities", including mixed-forms of "pluriactivity", full-time commercial agriculture, and/or non-agricultural employment (Schmidt-Vogt 2001; Castella *et al*. 2005; Rigg 2005, 2006; Saito *et al*. 2006). Farmers allocate most of their resources to supplying the market and rely on purchasing commodities and services with subsistence farming becoming a spare-time activity. As described by Cramb *et al*. (2009), in Southeast Asian swidden landscapes, the shift from subsistence to market-oriented agriculture has been accelerated by the improvement of transportation and market infrastructure.

These changes in livelihoods associated with the demise of shifting cultivation usually have implications for food security and nutrition (Kuhnlein and Damman 2008; Cramb *et al*. 2009). In situations where it is being restricted without the provision of alternative livelihood options (e.g., in parts of Laos and Vietnam), food security has declined. This decline is not observed in the *Quilombola* communities, as people are able to purchase manufactured foods with cash received from social benefits or other income sources. However, the decrease in food production for self-consumption and the trend toward a diet based on purchased foods renders households more dependent on policy changes and more vulnerable to a rise in food prices (Kuhnlein and Damman 2008; FAO 2011), even though legal recognition of land rights is an asset that has increased their adaptability in case of policy or economic changes. One of the outcomes of the increased dependence on purchased foods is a change in health status that is caused by shifts in diet and activity patterns that lead to a net-positive energy balance, which together is referred to as Nutrition Transition (Popkin 2001, 2003). The increase in stature and high rates of obesity found among the *Quilombolas* in our study are similar to patterns found among other rural populations transitioning from a subsistence to a market-oriented economy (Godoy *et al*. 2010; Lingarde *et al*. 2004; Benefice *et al*. 2007; Lourenço *et al*. 2008; Welch *et al*. 2009; Hansford 2011; Piperata *et al*. 2011). These changes also endanger the maintenance of cultural diversity and the transfer of traditional food knowledge to younger generations, which has long been part of the complexity and dynamism of swidden and smallholders (Kuhnlein and Damman 2008; Padoch and Pinedo-Vasquez 2010).

Conclusions

As in other tropical forests, Atlantic Rainforest smallholders have had to adapt their practices to the socio-environmental context (Padoch and Pinedo-Vasquez 2010), which can include contradictory environmental and social policies. On the one hand, effective land tenure and social policies that guarantee education, health and a non-negligible source of income for rural households have improved the livelihood and increased the stature of the *Quilombola*. On the other hand, these changes have contributed to reduced food security by decreasing agro-biodiversity and have increased both the dependence on the market for food and obesity rates. Additionally, a decline in shifting cultivation has had negative impacts on the structural complexity of the forest (Martin 1997; Russell 1997; Sheil 2001) and has not led to forest regrowth, as was predicted by Rudel (2012).

We believe that future interventions in the area need to build on the new functional links between sustainable livelihoods and biodiversity, where less restrictive state policies leave room for new opportunities of self-organization and innovation (Xu *et al*. 2009; Hecht 2010; Ziegler *et al* 2011). In other words, the *Quilombolas* must be seen as allies and not drivers of deforestation, the "protagonists of political ecologies of forest transitions embedded in inhabited landscapes" (Hecht 2010).

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