Convergence and Contrasts in the Adoption of Cattle Ranching: Comparisons of Smallholder Agriculturalists and Forest Extractivists in the Amazon

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Abstract
The Amazon ranching sector is expanding due to powerful political economic forces, which has led diverse social groups to adopt cattle. This paper draws on multi-temporal household survey data of smallholder agriculturalists and forest extractivists and presents a dynamic comparative analysis of their cattle ranching practices. The first part of the analysis confirms expanding pasture and herds. The second part of the analysis compares aspects of ranching practices, and shows differences in capitalization and sales. The factors promoting ranching affect different locations and groups differently, and bear implications for the future of ranching in the Amazon.
Keywords: *Amazonia, cattle ranching, rubber tapper, smallholder*

Resumo
O setor pecuário da Amazônia está se expandindo devido ao seu poder na esfera da economia política, o que tem levado diversos grupos sociais a adotar a pecuária. Este artigo baseia-se em dados multi-temporais de entrevistas com pequenos agricultores e extrativistas florestais e apresenta uma análise comparativa dinâmica das suas práticas de criação de gado. A primeira parte da análise confirma a expansão de pastagem e rebanho bovino entre duas regiões e grupos sociais. A segunda parte da análise compara aspectos das práticas de pecuária, e mostra diferenças em capitalização e venda. Os fatores que promovem a pecuária afetam diferentemente os grupos sociais e seus territórios, ocasionando implicações diferenciadas e específicas para o futuro do setor da pecuária na Amazônia.
Palavras chave: *Amazônia, pecuária, seringueiro, pequeno produtor*

Introduction

Research on the environmental costs and economic benefits of land-cover change in the Amazon often features cattle ranching (Faminow 1998; Veiga *et al.* 2004; Barreto *et al.* 2005; Nepstad, Stickler, and Almeida 2006; Smeraldi and May 2008). While debate over cattle ranching in the Amazon mainly focuses on large properties, observers increasingly recognize that other landholders are buying cattle and planting pasture (Walker, Moran, and Anselin 2000; Mertens *et al.* 2002; Veiga *et al.* 2004; Barreto et al. 2005; Pacheco 2009). The shift toward cattle, called *pecuarização* ("cattle-ization") in Brazil, raises questions about this apparent convergence on ranching among social groups with historically contrasting livelihood systems.

Two such groups increasingly engaged in cattle ranching are smallholder agriculturalists and forest extractivists. Smallholders historically focused on crop cultivation, and engaged in ranching as a secondary activity (Moran 1981; Fearnside 1986). For different reasons, forest extractivists such as rubber tappers also had relatively little history of raising cattle (Weinstein 1983; Dean 1987). By the 1990s, however, the livelihood systems of both groups had changed significantly. Cattle ownership among smallholders in the Amazon grew faster than herds on large properties (Perz 2002), and rubber tappers, who in the 1970s and 1980s constituted a grassroots social movement to forestall deforestation for ranching, were themselves breeding cattle for sale (Gomes 2001, 2009).

This paper assesses the extent and specifics of the shift toward cattle ranching among smallholders and extractivists. The Brazilian Amazon has become an economically attractive region for beef production for Brazilian as well as global markets. We therefore review of political economy of cattle ranching in the Amazon. On the other hand, the geographical, historical and large cultural differences between smallholders and extractivists require comment, as neither has a long history of commercial ranching. As a result, we therefore outline two study sites featuring smallholders and extractivists, and highlighting the historical origins of their livelihood systems.

This background provides the framework for our analysis, which addresses two questions. Our first question concerns the dynamics of the livelihood systems in the two study groups with a focus on the "convergence on cattle." The first part of the analysis therefore highlights the expanding ranching activities in both cases. The second question asks about contrasts in ranching practices in these heretofore different livelihood systems. The second part of the analysis shows significant differences in ranching practices as evidence of contrasts despite the convergence on cattle. The paper concludes with a discussion of explanations for adoption of ranching among smallholders and extractivists, and implications of shifting livelihoods for Amazon conservation and development.

The Political Economy of Cattle Ranching in the Brazilian Amazon

Cattle ranching in the Amazon has been vilified for negative ecological impacts such as forest loss and climate change (Barbosa and Fearnside 1996; Wu *et al.* 2000). In Brazilian frontier areas it is associated with problematic social outcomes such as rural violence and limited employment generation (Schmink and Wood 1992; Almeida 1995). Nevertheless, ranching is motivated by powerful economic incentives, stemming in part from public policies.

During the 1960s and 1970s, generous subsidies supported the establishment of large-scale cattle ranches (Mahar 1979; Guimarães 1991). Fiscal incentives were promulgated in tandem with construction of new highways linking key Brazilian cities to

towns in the Amazon (Moran 1981; Schmink and Wood 1992). While incentives encouraged investment, infrastructure reduced transport costs and opened large swaths of land for occupation (Walker *et al.* 2009). Rapid population growth in Brazil during the 1970s and 1980s (Perz 2002) also yielded a growing constellation of regional cities, which constituted new markets for Amazonian beef (Faminow 1998). These changes offset Brazil's economic crisis and the withdrawal of fiscal incentives in the 1980s and permitted ranching to expand.

The 1990s saw significant shifts in the Amazon ranching sector. Monetary reforms introduced by the Cardoso administration led to declining prices for Brazilian exports on international markets (Walker *et al.* 2009). Trade reforms removed tariffs on Brazilian agricultural exports. Both policy shifts made Brazilian beef more attractive to growing international markets, especially in Asia. However, Amazonian cattle still faced the problem of hoof-and-mouth disease (*Aphtae epizooticae*) (Smeraldi and May 2008). The Brazilian government therefore embarked on a successful campaign to eradicate the disease (MAPA 2005; Walker *et al.* 2009). Frontier areas of the Amazon now have cattle vaccination and hygiene programs (Smeraldi and May 2008; Lima *et al.* 2005). Under these favorable circumstances, banks expanded credit to Amazonian producers, particularly for cattle ranching (Arima *et al.* 2006). As a result, from 1990 to 2000, the cattle herd in the Brazilian Amazon grew from roughly 25 million to 50 million; by 2005, the herd reached 75 million.[1] By 2006, 90 percent of Amazonian beef was sent to other parts of Brazil, and 20 percent of Brazil's beef exports originated in the Amazon (Walker *et al.* 2009).

Beef is cheaper to produce in the Amazon than elsewhere, making it eminently competitive globally (Nepstad *et al.* 2006; Walker *et al.* 2009). Land prices in the Amazon are lower than elsewhere in Brazil, which makes Amazon land attractive for buyers. The challenges of sustainably managing Amazon pastures have increasingly been addressed through new agricultural research (Rueda *et al.* 2003; Valentim and Andrade 2005). This has permitted higher levels of beef production per hectare in the Amazon than elsewhere in Brazil. Consequently, the profitability of ranching in the Amazon exceeds that seen elsewhere in Brazil (Barros 2002).

These changes made cattle more viable for small producers and others not historically involved in commercial ranching (Walker *et al.* 2000). In particular, smallholder agriculturalists are increasingly turning to cattle (Walker *et al.* 2000; Ludewigs *et al.* 2009; Pacheco 2009). Whereas annual crops command low prices and perennial crops have variable prices and are subject to pest attacks, cattle prices have been stable or rising. Cattle constitute a capital reserve that provides an insurance function in moments of crisis. Further, cattle can be sold at any time of the year, and they can be walked to town (or hauled by cattle buyers) instead of being hauled by producers as in the case of crops. Additionally, forest extractivists such as rubber tappers are also clearing forest for pasture and breeding cattle (Gomes 2001, 2009; Ehringhaus 2005; Vadjunec 2007). The significance of cattle for rubber tappers is politically complicated, since the expansion of ranching previously threatened forest extractivism (Sobrinho 1992; Calaça 1993). Nonetheless, declines in prices for non-timber forest products (NTFPs) has made cattle a more attractive livelihood option for forest extractivists (Salisbury and Schmink 2007; Gomes 2009).

These changes raise questions about cattle ranching among smallholders and extractivists. While there is evidence of an economic logic behind their "convergence on cattle," it is less clear how cattle ranching fits in their rather different livelihood systems. We therefore complement our political economy discussion by turning to two study cases featuring smallholders and extractivists. Each case has a different cultural history, and

thus embodies a distinct context for the shift toward cattle ranching. Local differences may also influence the "convergence on cattle," such that ranching strategies and practices may differ among places and social groups.

The Importance of Place: Historical Contrasts in Local Livelihoods

The foregoing discussion of political economy motivates additional research questions, focusing on similarities and differences in ranching among different locations and groups. Here we focus on smallholder agriculturalists and forest extractivists. Our first question is what are the dynamics of extractivism, agriculture and ranching among smallholders and extractivists? Given their contrasting cultural histories, we anticipate contrasting profiles of livelihood activities, with smallholders placing greater emphasis on crops whereas extractivists focus more on NTFPs. But given a political economy that favors cattle, we expect to see a growing emphasis on ranching in both groups. Further, both groups are risk averse, and livelihood diversity is one means of managing risk, so smallholders and extractivists may turn to cattle.

Second, do specific ranching practices differ among smallholder agriculturalists and forest extractivists who run cattle? To speak of a "convergence on cattle" among diverse social groups in different locations can obscure contrasts in goals and strategies for ranching. The ranching sector in the Amazon encompasses diverse types of operations, including beef and dairy, and within beef enterprises, there are breeding, fattening, and other operations in the commodity chain from ranches to slaughterhouses to markets (Veiga *et al.* 2004; Toni 2007; Smeraldi and May 2008). Consequently, stocking densities, pasture rotation, the use of mineral salts and vaccinations, and the composition and growth rate of cattle herds may vary among landholders engaged in "cattle ranching." Further, smallholders and extractivists operate under different land tenure regimes in terms of deforestation limits, which likely affects their ranching practices. Hence we anticipate contrasts in cattle ranching among smallholders and extractivists.

Our case study sites (Figure 1) involve smallholder agriculturalists in the municipality of Uruará, in the eastern Brazilian Amazonian state of Pará, and forest extractivists in the Chico Mendes Extractive Reserve (CMER), centered on the municipality of Xapuri, in the western Brazilian state of Acre. We selected these sites for several reasons. First, the two sites are located far apart, so common processes such as cattle adoption are not due to one case influencing the other. Second, Uruará and the Xapuri have very different histories, being founded at disparate historical moments for different reasons. Third, as a result of their locations and contexts, the cultures and livelihood systems in these two locations differ substantially. This implies that cattle ranching may differ in the two locations, despite being situated in a shared political economy encouraging ranching. Fourth, we have fairly recent multi-temporal data about rural livelihoods for both sites, which makes possible an analysis of livelihood change.

Smallholder Agriculturalists in Uruará, Pará

Uruará, is a municipality situated on the Transamazon highway (IDESP 1990). Uruará was founded in the early 1970s as a roadside colonization project to resettle rural families from the Brazilian Northeast. The state agency for colonization and land titling, INCRA, demarcated and distributed lots of 100 hectares to a first wave of colonists, who began to develop small farms featuring annual crops.

Brazil's economic crisis during the 1980s led the state to abandon official colonization, leaving smallholders to fend for themselves. But in the mid-1980s, perennials such as cocoa and black pepper commanded high regional prices, which prompted households to expand their clearings for cash crops (IDESP 1990). Economic dynamism

in Uruará in the 1980s gave way to difficulties in the 1990s (Nascimento and Drummond 2003). Pests attacked cocoa and black pepper, reducing cash crop production just as perennial crops also incurred price declines, which reduced agricultural incomes. These difficulties stimulated political mobilization in Uruará, as small producer organizations as well as business interests sought new directions for community development (Toni 2003). This period also witnessed the emergence of the Movement for Transamazon Survival (MPST), which helped form alliances among producer groups (Nascimento and Drummond 2003).

At the same time, the Amazon Development Bank (BASA) offered a special credit line for small producers, called FNO-e. Many local organizations obtained FNO-e funds and used them for cattle ranching (Toni 1999). Smallholders thus shifted to commercial ranching due to the more stable prices than for perennials, the ability to sell cattle year-round instead of at harvest as with perennials, and easier sales due to trucking provided by slaughterhouses (Veiga *et al.* 2004). Establishment of a vaccination program in Uruará also improved cattle health and survival, making ranching more productive and profitable.

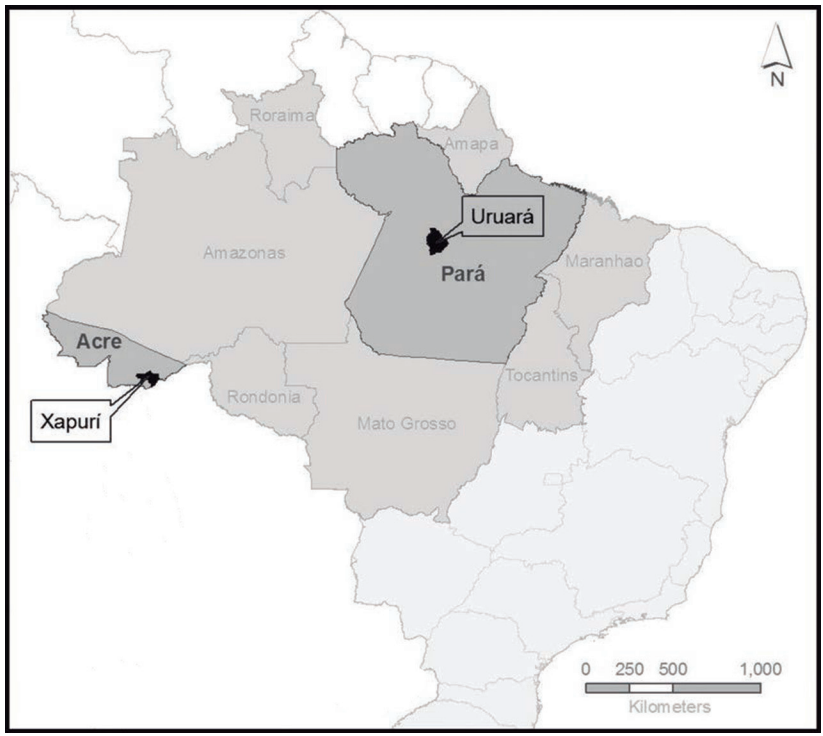

Figure 1. Two study cases in the Brazilian Amazon: Uruará, Pará and Xapuri, Acre

Forest Extractivists in Xapuri, Acre

Acre's high density of rubber trees made it a commercial center during the rubber boom that began in the late 19th century (Weinstein 1983; Dean 1987). Rubber "barons" claimed large rubber estates, which they divided up among rubber tappers, who each had access rights to a homestead (*colocação*) with several forest trails providing access to rubber trees. However, most rubber tappers arrived in Acre in debt to the rubber baron for the price of their passage. Rubber barons bought rubber at low prices, which maintained debt peonage among rubber tappers. The barons also prohibited rubber tappers from growing food crops or breeding livestock, which ensured a focus on rubber tapping and prevented cattle ranching. Brazil's monopoly on rubber production was finally broken in the early 20th century when rubber seeds were taken out of the Amazon and transplanted to rubber plantations in Malaysia where production costs were cheaper, causing the Brazilian rubber boom to go bust. During World War II, rubber production was revived when the Axis powers cut off trade routes, but after WWII, rubber prices fell again (Corrêa 1967; Martinello 2004).

Many rubber barons therefore abandoned their estates (Tocantins 1979). Freedom from debt-peonage led rubber tappers to diversify their forest-based livelihoods. Other forest products such as Brazil-nuts became more important, and rubber tappers engaged in subsistence agriculture as well as livestock raising, including dairy production. Cattle ranching was thus part of the livelihood system, but mostly for transportation and subsistence dairy production, representing only 4 percent of the income for rubber tapper families (CNS 1992).

Eastern Acre incurred further changes in the 1970s, when Brazil's government built highways to integrate the Amazon. The BR-364 highway through neighboring Rondônia connected Acre to southern Brazil. While migrants from the south flooded into Rondônia by the thousands in the 1970s, the governor of Acre gave a speech to investors in São Paulo, extolling the virtues of Acre's cheap land (Bakx 1988; Silva 1990). The arrival of roads and investors led to conflicts over the organization of space in eastern Acre. Whereas rubber tappers still viewed the forest in terms of rubber estates defined by rubber trees, large ranchers saw properties based on cleared land with good access to roads.

Forest communities and rural workers mobilized to engage in non-violent resistance to ranchers. Mobilization began in Xapuri, making it the birthplace of the rubber tappers movement (Sobrinho 1992; Calaça 1993). During the 1980s, rural violence intensified in Acre as in other frontier areas of the Amazon. The murder of rubber tapper leader Chico Mendes on December 22, 1988, which concluded a year of unprecedented levels of deforestation, catapulted the rubber tappers into international headlines as defenders of the rain forest (Allegretti 1990; Schwartzman 1989).

Recognition of the negative social and ecological consequences of deforestation prompted the creation of federal extractive reserves (ERs) (Allegretti 1990; Schwartzman 1989). ERs legitimated the productive activities and environmental stewardship of rubber tappers. While ER land legally belongs to the government, rubber tapper communities collectively manage areas corresponding to old rubber estates, wherein each household retains access rights to its rubber trails. ER rules impose a deforestation limit of 10 percent of the total area of a reserve, along with a 5 percent limit on pasture area. The Chico Mendes Extractive Reserve (CMER) was one of the first federal ERs established in 1990, and currently encompasses 930,985 ha (Government of Acre 2000). However, rubber prices went into decline due to government policies aimed at opening new markets, and consequently, the federal government rubber subsidy was cut in the mid-1980s. Despite such challenges, leaders of the rubber tapper movement began win-

ning local and state elections in Acre in the 1990s (Toni and Souza 2003). In the 1998 state and national elections, a former advisor of Chico Mendes, Jorge Viana, was elected Acre's governor. The new state government, known as the "Forest Government," pursued policy initiatives to capitalize on Acre's comparative advantage – forest resources – by improving infrastructure, subsidizing the processing and commercialization of NTFPs, and other initiatives (Kainer *et al.* 2003; Viana 2004; Government of Acre 2005). Government policies in Acre encourage extractivists to diversify their activities. Such "neo-extractivism" (Rêgo 1999) argues that improvements in the economic situation of extractivists require new technologies to add value to traditional NTFPs, along with support for commercialization of new NTFPs, often by securing access to new markets. Xapuri now supports local industries that process NTFPs, including rubber.

Despite these policies, cattle ranching is expanding in Acre (Valentim *et al.* 2002; Toni 2007), including in the CMER (Gomes 2004), revealing the limitations of NTFP policies. During the 1990s, deforestation rose in the CMER (Sassagawa 1999), and continued during the 2000s (Vadjunec *et al.* 2009). One recent governmental study suggests that of the 46 rubber estates that comprise the CMER, 14 have surpassed the deforestation limit, a reflection of the growing importance of ranching for family income (SEMA/CNS 2010). Many analysts have argued that the rise in cattle and deforestation was due to poorly defined markets for rubber, Brazil-nuts, and other NTFPs (Gomes 2001; Toni 2007; Wallace 2004; Ehringhaus 2005).

Field Methods and Survey Data

This analysis draws on field survey data for both agriculturalists in Uruará and extractivists in the CMER. We draw on data for two time points in both sites, and feature households that were re-interviewed, which facilitates temporal comparisons. In both sites, one or more authors were involved in data collection.[2]

Survey data for Uruará refer to 1996 and 2002. In June and July 1996, a research team administered a survey questionnaire to farm households in Uruará (Walker *et al.* 2000; Perz *et al.* 2006). The questionnaire was divided into two components, where the first addressed household characteristics and the second concerned the lot(s) held by households. The household component addressed family composition, sources of income, and material wealth. The lot component included items on land use, access to credit, use of agricultural technologies, and distance to market. It also included questions on ranching, including items on pasture formation and cattle management.

Systematic sampling of farm lots proved intractable because not all lots had houses on them. Moreover, systematic sampling of houses encountered was problematic because residents were sometimes absent. We therefore sampled by "first opportunity" of residents encountered on their lot. We employed a cadastral map of Uruará from Brazil's agricultural research agency, EMBRAPA/ CPATU, as our sampling frame, to ensure that sampling was not spatially clustered or selective of households by socioeconomic status.[3] The 1996 sample included 261 households, or 12 percent of all rural households in Uruará at the time (IBGE 1998b).

In 2002, another team administered a second questionnaire in Uruará (Aldrich *et al.* 2006). This questionnaire had many of the same items as the 1996 instrument, but was more extensive and included additional questions about pasture and cattle. A key goal of the 2002 fieldwork was to locate lots and households sampled in 1996 in order to constitute a panel for temporal comparisons. The 2002 panel sample included 143 households, which held 170 lots in 1996 and 221 lots in 2002. The difference is due to sales and especially purchases of lots during the interim. We defined the panel on the basis of whether a lot had been in the 1996 sample.[4]

We also conducted interviews with families in the CMER in 2000 and 2004/5. For 2000, we employed a questionnaire including items on land use and forest extractivism. The initial sample included 66 households in four rubber estates of the CMER in Xapuri and two neighboring municipalities, Brasiléia and Assis Brasil. While this does not guarantee representativeness of all households in the CMER, it does capture heterogeneity in the reserve.[5]

In 2004 and 2005, we administered a more extensive questionnaire with additional items on commercialization of agricultural production, forest extractivism, and livestock, as well as land tenure rules for resource use in the CMER. We obtained a larger sample (n=149 households) in eight rubber estates (including all four rubber estates visited in 2000). We again targeted communities that differed from each other in terms of their productive activities.

The 2004/5 sample included some of the same households from the 2000 research, affording a panel for temporal comparisons. We compared the names of forest homesteads and their owners in the two data sets and identified 35 homesteads interviewed (panel sample) at both time points. Because this panel is smaller than both of the full samples for 2000 and 2004/5, we present data for both full samples as well as the panel homesteads at the two time points.

Analysis

The analysis is divided into two parts in order to address our two questions. First, we evaluate livelihood dynamics in the two sites, focusing on forest extractivism, agricultural production, and cattle ranching. The second part examines the most recent data in terms of ranching practices, and via use of inputs, herd composition, and sales of cattle.

Dynamics of the Livelihood Systems

Table 1 presents selected indicators of land use, forest extractivism, agriculture, and ranching for Uruará, and Table 2 does the same for the CMER. In Uruará, the panel in 1996 shows larger properties than for the full sample, an indication of some selectivity of households with more lots.[6] But in both, primary forest covered roughly 60 percent of properties in 1996, and of the remaining area, the largest land use category is cattle pasture, which averaged roughly 30 ha. By 2002, property sizes, forest cover, and cropland in the panel had not changed significantly, but pasture area and secondary growth had both risen significantly.

In the CMER, homesteads claimed much larger areas, a reflection of the extensive nature of forest extractivism, where rubber tappers originally extracted from trees along 4-6 trails, each covering roughly 100 ha (Gomes 2001). A comparison of the panel to full samples indicates some selectivity towards larger homesteads in the panel. CMER homesteads in the panel did not exhibit significant changes over time in total area, forest cover, or cropland. Interestingly, the rise in pasture area was not statistically significant, though there was a rise in secondary growth.[7] These dynamics are not as pronounced as in the Uruará panel. Caution is necessary for conclusions about pasture expansion based on the CMER panel, as the full samples for 2000 and 2004 suggest expanding ranching.

Table 1. Natural resource management for select land-use variables , farm households in Uruará, Pará

	Uruará 1996 [1] Full Sample	Uruará 1996 Panel Sample	Uruará 2002 Panel Sample	p(t-test), 1996-2002
Land use (ha)				
Total Area Claimed	133.44 (83.03) [2]	151.37 (98.41)	151.78 (119.35)	0.85
Primary Forest	86.10 (67.49)	95.18 (82.07)	84.11 (63.92)	0.25
Annual, Perennial Crops	8.85 (8.80)	10.51 (9.11)	10.34 (13.30)	0.90
Cattle Pasture	29.48 (27.06)	34.79 (26.75)	46.92 (76.44)	0.02
Secondary Vegetation	9.02 (11.04)	10.89 (13.72)	16.50 (21.52)	<0.01
Forest Extractivism (kg)				
Brazil Nut	NI	NI	5.58 (29.43)	N/A
Rubber	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.00
Annual Crops (kg)				
Rice	3007.92 (3669.43)	3326.02 (4140.03)	1159.42 (2131.41)	<0.01
Beans	284.83 (481.32)	264.69 (441.08)	184.96 (619.69)	0.32
Perennial Crops (kg)				
Cocoa	816.59 (2537.62)	1196.55 (3212.84)	1147.05 (3757.70)	0.85
Coffee	394.63 (1304.90)	560.75 (1691.10)	524.89 (1657.41)	0.01
Black Pepper	658.40 (1241.93)	973.25 (1507.91)	366.93 (748.23)	<0.01
Cattle (heads)				
On Own Property	23.52 (38.30)	28.68 (32.33)	68.56 (150.04)	<0.01
On Other Properties	2.49 (8.04)	3.40 (10.14)	12.49 (48.99)	0.02

Notes.

1. The full Uruará sample contains 261 households and 347 lots; the Uruará panel contains 143 households with 170 lots in 1996 and 221 lots in 2002.

2. Values shown are either proportions (for binomial variables) or arithmetic means (for continuous variables). Values in parentheses are standard deviations.

Table 2. Natural resource management for select land-use variables, seringal households in the Chico Mendes Extractive Reserve, Acre

	CMER 2000 Full Sample [1]	CMER 2000 Panel Sample	CMER 2004/5 Panel Sample	CMER 2004/5 Full Sample	p(t-test), 2000-2004	p(t-test), Uruará
Land use (ha)						
Total Area Claimed	566.67 (319.29) [2]	633.33 (360.16)	634.29 (335.14)	491.89 (459.89)	0.99	<0.01
Primary Forest	551.21 (318.04) [3]	616.80 (357.62)	612.41 (330.71)	469.09 (458.71)	0.87	<0.01
Annual, Perennial Crops	2.28 (1.59)	2.35 (1.78)	1.83 (0.99)	2.26 (1.60)	0.14	<0.01
Cattle Pasture	7.10 (10.06)	7.93 (9.96)	9.17 (7.48)	8.80 (7.62)	0.55	<0.01
Secondary Vegetation	6.08 (4.23)	6.26 (4.76)	11.19 (8.88)	12.04 (16.85)	<0.01	0.05
Forest Extractivism (kg)						
Brazil Nut	2499.67 (3134.72)	2070.44 (2732.79)	2441.06 (2665.33)	1686.25 (2680.94)	0.56	<0.01
Rubber	268.61 (418.36)	250.56 (378.43)	200.60 (312.91)	142.68 (269.91)	0.55	<0.01
Annual Crops (kg)						
Rice	1248.79 (1342.09)	1378.33 (1687.85)	948.00 (832.86)	937.78 (664.75)	0.18	0.24
Beans	495.61 (834.96)	554.44 (965.73)	537.14 (648.17)	393.21 (431.71)	0.93	<0.01
Perennial Crops (kg)						
Cocoa	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.00	<0.01
Coffee	NI	NI	49.03 (207.60)	45.11 (194.58)	N/A	<0.01
Black Pepper	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.00	<0.01
Cattle (heads)						
On Own Property	8.35 (10.32)	10.50 (12.10)	16.57 (17.48)	14.20 (17.57)	0.09	<0.01
On Other Property	NI	NI	1.71 (5.62)	1.27 (3.70)	N/A	<0.01

Notes.

1. The CMER panel contains 35 households, each with one colocação. The full CMER sample in 1999 includes 66 households, and the full sample in 2004 includes 149 households, each with one colocação.
2. Values shown are arithmetic means. Numbers in parentheses are standard deviations.
3. Values for primary and secondary forest in 1999 are estimates based on swidden area and assumptions about fallowing practices.

Tables 1 and 2 also present indicators of forest extractivism, annual and perennial crop production, and cattle. In Uruará, there was minimal extractivism. Despite some selectivity in the panel for larger production systems, there was considerable annual crop production (as indicated by rice and beans) as well as production of perennial crops (indicated by cocoa, coffee, and black pepper). From 1996 to 2002, according to the panel, rice production declined significantly, but not bean production. There were also significant declines in coffee and especially black pepper, though not in cocoa. By contrast, cattle herds expanded significantly, more than doubling in heads per property in the panel from 1996 to 2002.

In the CMER, forest extractivism remained important. There were differences between the full samples and panel and the resulting trends run in the opposite directions, so we emphasize the panel when making temporal comparisons. Brazil nut extraction increased while rubber declined, but neither change was statistically significant, and extraction of both Brazil nut and rubber continued as of 2004/5.[8] Production of annuals also exhibits a mixed picture, with rice in decline and beans holding steady. Cocoa, coffee, and black peppers are of little agricultural importance in the CMER. Cattle, on the other hand, rose in importance over time; though this was of marginal significance in the panel, a similar change appears if we compare the full samples for the two time points. In 2004, we found anecdotal evidence of households running cattle on other homesteads, and as discussed below, there were indication of awareness of deforestation limits. As their cattle herds grow, some rubber tappers prefer to avoid increasing pasture area, which can lead to substantial fines; instead, they transfer part of their herd to other homesteads within the CMER. This helps explain the limited expansion of pasture despite growing cattle herds in the CMER.

Ranching Practices

The second part of the analysis focuses on practices related to pasture and cattle management. We focus on the most recent survey data, i.e., the 2002 panel in Uruará and the full sample for 2004/5 in the CMER. Table 3 presents comparisons of six groups of indicators: capital investments, ranching practices, herd composition, and sales of cattle, along with site-specific indicators concerning future plans (in Uruará) and compliance with deforestation rules (in the CMER).

Capital investments include chainsaw ownership and construction of a corral. Half of the respondents in Uruará had a chainsaw, compared to one-third in the CMER. Significant differences also appear for investments in enclosed pastures: roughly half of households in Uruará had corrals while about 30 percent did in the CMER.

Differences for ranching practices themselves send a somewhat different message. On the one hand, more households relied on fire for pasture maintenance in the CMER than in Uruará, which also indicates a lack of management alternatives in the CMER. However, pasture planting was more common in the CMER, and cattle vaccinations were not significantly different in the two sites. The picture that emerges is one where capitalization differs, while specific management practices did not vary as much.

Table 3 also presents data on cattle herd composition. Herd composition in the CMER and that anecdotally observed in Uruará appear typical of breeding systems for beef, involving a few bulls, many cows and numerous calves (Tourrand and Veiga 2003; Veiga *et al.* 2004). There is considerable variability in herd size among households in both of the sites, and in the CMER this applies to each category in the herd.

Table 3. Cattle and pasture management, farm households in Uruará, Pará, and seringal households in the Chico Mendes Extractive Reserve, Acre

	Uruará 2002 Panel Sample [1]	CMER 2004/2005 Full Sample	p(t-test), Site Comparison
Capital Investments			
Chainsaw (0=No, 1=Yes)	0.53 (0.50)[2]	0.34 (0.47)	<0.01
Corral (0=No, 1=Yes)	0.49 (0.50)	0.29 (0.46)	<0.01
Ranching Practices			
Fire Maintenance (0=No, 1=Yes)	0.50 (0.50)	0.73 (0.44)	<0.01
Pasture Planting (0=No, 1=Yes)	0.80 (0.40)	0.92 (0.27)	<0.01
Vaccinations (0=No, 1=Yes)	0.82 (0.39)	0.78 (0.42)	0.35
Cattle Herd Composition (Heads)			
Bulls	NI	0.62 (0.67)	N/A
Cows	NI	5.57 (7.59)	N/A
Calves	NI	8.01 (10.24)	N/A
Total (Own Property Only)	67.56 (150.04)	14.20 (17.57)	<0.01
Cattle Sales, Previous Year (Heads)			
Bulls Sold	10.38 (71.68)	0.19 (0.60)	0.10
Cows Sold	4.81 (14.72)	0.45 (1.32)	<0.01
Calves Sold	28.42 (151.96)	2.17 (3.99)	0.04
Total Cattle Sold	43.62 (168.30)	2.84 (4.77)	<0.01
Deforestation Rules			
Agree with 10% Deforestation Rule (0=No, 1=Yes)	N/A	0.81 (0.39)	N/A
Agree with 5% Pasture Rule (0=No, 1=Yes)	N/A	0.62 (0.49)	N/A
Future Planning			
Plans for Pasture (0=Other, 1=Expand)	0.59 (0.49)	NI	N/A
Plans for Cattle (0=Other, 1=Expand)	0.77 (0.42)	NI	N/A

Notes

1. The Uruará panel in 2002 includes 143 households with 221 lots; the Chico Mendes full sample in 2004 includes 149 households, each with one colocação.

2. Values shown are either proportions (for binomial variables) or arithmetic means (for continuous variables). Values in parentheses are standard deviations.

More illuminating are the data for sales of cattle. Whereas households in Uruará sold several bulls, a few cows, and many calves, totaling roughly half the herd size, in the CMER, sales comprised a smaller proportion of the herd, especially for cows and calves. This suggests that cattle ranching among smallholders in Uruará is more focused on breeding for sale, whereas ranching in the CMER emphasizes accumulation.

Table 3 also deals with ranching issues specific to one of the two sites. In the CMER, a key issue involves the regulations limiting deforestation. While all available data indicate rising deforestation and expanding pasture areas in the CMER, a large majority of respondents in 2004/5 supported the 10 percent deforestation rule (Vadjunec 2007). However, a somewhat smaller majority supported the 5 percent pasture rule. Remote sensing data for the CMER at the time of our study (Vadjunec, *et al.* 2009) suggest that clearing had not yet approached the 10 percent limit, but if pasture has since continued to expand, it possibly surpassed the 5 percent limit for some households by the mid-2000s.

In Uruará, a key issue concerns the future sustainability of ranching. In the 1996 survey, roughly 50 percent of the households interviewed indicated intentions to expand their cattle herd. In the 2002 survey, this figure had risen to 80 percent. This suggests that liquidation may be shifting toward expansions in herd size.

Discussion

Our comparative analysis permits an assessment of the convergences and contrasts in cattle ranching among smallholder agriculturalists and forest extractivists in our two study sites. With regard to the "convergence on cattle," the findings from the first part of our analysis confirm expectations. The livelihood systems for agriculturalists and extractivists differed substantially in the importance of agriculture and extractivism, but both groups showed evidence of an increasing focus on cattle in terms of cattle pasture and/or herds (Tables 1 and 2). Concerning "contrasts", the second part of the analysis on ranching practices largely confirmed expectations. Smallholder agriculturalists appear more capitalized in terms of chainsaws and corrals, and they are more engaged in sales of cattle given their larger herds; but extractivists were more likely to practice fire maintenance and pasture planting, and there were no differences in the use of cattle vaccinations. Capitalization and ranching strategies thus differ between the two groups, often in ways that reflects the scale of their ranching operations: agriculturalists have larger herds and are more capitalized. This leaves open questions as to whether extractivists will expand their operations to increasingly approximate the scale of ranching seen here for agriculturalists.

These findings motivate further discussion of the broader context generating not only convergence on cattle but also contrasts in how ranching is conducted and the nature of the cattle economy among different groups in the Brazilian Amazon. The observation that extractivists are ranching begs questions about the importance of NTFPs in their livelihoods. Despite the economic potential of NTFPs (Peters *et al.* 1989; Godoy, et al. 1993; Grimes et al. 1994) initiatives to raise incomes via NTFPs face thorny obstacles (Godoy *et al.* 1997; Godoy 2000), a problem seen in ERs in Brazil (Homma 1992; Browder 1992). Impediments include poorly defined markets, difficult market access, inefficient distribution networks, and weak institutions for business management of value-added processing. Due to their low aggregated value, NTFPs put pressure on family labor, which makes it easier for it to be replaced by alternative sources of income, such as cattle ranching, which is less demanding on family labor. Despite advances in promoting markets for NTFPs promoted by various agencies to facilitate dialogue between communities and markets, such initiatives have failed to overcome their "experimental" character and need to gain economies of scale. It is in this vacuum that cattle ranching is taking up space as an economic alternative for income generation among extractivist populations.

We suggest that cattle ranching among forest extractivists in the CMER reflects not only 1) the economic value of cattle, but also 2) easier market access, 3) social learning from neighboring landowners with cattle, 4) the lack of enforcement of deforestation restrictions, and 5) social institutions for distribution of benefits from economic exchanges (Gomes 2009). Cattle are considered a means of storing and accumulating wealth, enabling extractivists to sell when cash is needed. This advantage is highlighted by a CMER respondent who sees his cattle as a life insurance policy: "Extractivists are investing in cattle because it's the easiest product to sell and it can guarantee security for the producers, which you can't get with extractivist or agricultural products."[9]

Much of the CMER is surrounded by large cattle ranches with extensive pastures. Forest extractivists see their neighbors practicing ranching, and with better housing and electricity, which constitutes proof to forest extractivists that cattle improves well-being. As one Rubber Tappers Association leader explained:

> "How was the idea of raising cattle born for the extractivist? When everyone was engaged in tapping rubber and the price was very low, a rubber

> tapper had to tap 15 kilos of rubber to buy a jug of milk in the city for his child. Everyone already has thoughts of keeping a few heads for milk and transportation. They then start to feed on this idea and begin to like raising cattle."

In many respects, the reasons for extractivists to adopt cattle parallel those given previously for smallholder agriculturalists, who also faced uncertainties concerning the marketing of agricultural produce (Tourrand and Veiga 2003; Smeraldi and May 2008; Walker *et al.* 2009). Price variability and pest attacks on key crops proved a liability for smallholders much as similar uncertainties have undermined prospects for NTFPs. Smallholders such as those along the Transamazon Highway therefore took advantage of an expanding ranching sector.

In the state of Pará in the eastern Amazon and its neighbor Mato Grosso in the southern Amazon, the ranching sector has since the 1990s become consolidated around a network of breeding and fattening operations, now closely articulated to a network of meatpacking operations (Arima *et al.* 2006; Faminow 1998; Smeraldi and May 2008). Even smallholders in places like Uruará have become enmeshed in the beef commodity chain for purposes of accessing credit, acquiring inputs and herd stock, and securing buyers tied to meatpacking and exports.

That said, the seemingly universal "convergence on cattle" must be tempered by recognition that the local level of importance of the cattle ranching economy in our two study sites is quite different. If Pará has a large and consolidated cattle economy, Acre is the "end of the line" in Brazil, with fewer ranches, cattle, meatpacking houses, and highway connections, along with greater transport distances to reach key Brazilian markets and ports. While the regional consolidation of ranching implies a geographic expansion in cattle activities, which makes the adoption of ranching among even extractivists in the CMER feasible, consolidation primarily occurs in the more accessible eastern and southern Amazon and thus affords certain comparative advantages to Uruará over Xapuri.

A major question for the Amazon's entire ranching sector concerns its future prospects for continued expansion and consolidation in new areas. In Uruará, smallholders with growing cattle herds face the challenge of acquiring more land, which is often difficult precisely due to the expansion and consolidation of ranching activities (Aldrich *et al.* 2006). Land scarcity has in turn driven road extensions as families seek additional land where they can in turn establish ranching enterprises (Perz *et al.* 2007). However, such extensions sometimes penetrate indigenous territories and protected areas, raising political questions about the viability of additional ranching activities.

In parallel fashion, in the CMER, there are significant constraints on ranching among extractivists. A key issue for expanding herds is the weak enforcement of land use restrictions in the CMER. The irony of erstwhile "rubber tappers" engaging in commercial ranching has become politically awkward in light of deforestation limits in ERs. Among forest extractivists, the historical commitment to rubber tapping and the crucial role of collective mobilization against ranchers still have salient associations with the "rubber tapper" identity, and have divided CMER residents on the question of ranching (Gomes *et al.* 2012). This includes tensions over whether neighbors clearing more forest for pasture should be reported to authorities who administer the CMER.

Given the growing challenges to a lucrative activity like ranching among both agriculturalists and extractivists, the hunt for sustainable economic alternatives has intensified. One candidate could prove to be payments for environmental services via the Reduced Emissions from Deforestation and Degradation (REDD+) program, which

would compete with ranching by encouraging forest cover maintenance (Nepstad *et al.* 2009). It remains to be seen if climate negotiations to incorporate REDD+ will impel forest conservation in the face of economic pressures and institutional arrangements that encourage ranching (Laurance 2008; Hall 2008).

Conclusion

The findings indicate expanding cattle ranching among both smallholder agriculturalists and forest extractivists in disparate study sites in the Brazilian Amazon. Cattle ranching among these and other groups is driven by regional, national and global market forces and public policies. That said, our analysis also indicates that historical and cultural specificities among locations and groups also affect cattle ranching strategies and practices. The "convergence on cattle" has important nuances that result in contrasts in the use of inputs, pasture management, and the accumulation and sales of cattle. Some of these differences may reflect time since cattle adoption, but given historical differences in livelihood strategies and contemporary contrasts in tenure rules for resource management, it remains an open question as to whether differences in ranching practices of agriculturalists and extractivists observed here will persist.

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Notes

[1] By "Brazilian Amazon" we refer to the "Legal" Amazon, a state planning region that encompasses nine states in the Amazon biome in Brazil (IBGE 1998b).

[2] The two surveys were conducted at different times, which prevents a fully experimental design for direct comparisons. However, the timing of cattle dynamics also differs between the two sites, and the timing of the surveys fits the timing of cattle expansion in each site, making the surveys advantageous for our purposes. The late 1990s/early 2000s were the moment when ranching began its sustained rise in Uruará, which is the time period we cover with the 1996 and 2002 data, whereas cattle became more prevalent in Xapuri in the early 2000s, covered by the 2000 and 2004/5 surveys (IBGE 2009).

[3] The 1996 Brazilian population count (IBGE 1998b) and 1995/96 Brazilian agricultural census (IBGE 1998a) allow for comparisons to assess sampling bias. In terms of household size and land allocation, the survey data are very similar to census data for Uruará sample.

[4] One might argue that because the lots included in the panel for the two dates are different, the panel is not comparable. But if we link data for the two dates in terms of production systems, in the presence of an active land market, the result will necessarily be different lots in the household panel at different moments, which itself is necessary

to capture in order to observe the changes in production systems over time (Aldrich *et al.* 2006).

[5] In terms of variables such as household size and agricultural product and NTFP harvests, the figures reported here are similar to data collected by others in the CMER for similar dates. For example, government data for the entire CMER indicate that forest homesteads average 671.7 ha per household (IBAMA/CNPT 1999), a figure similar to our CMER panel. Data from 1996/1997 (Rêgo, et al. 2003; Cavalcanti 2002) indicate average brazil nut extraction of 2178 kg per household, which is similar to our values for 2000. Rubber extraction reported in the same sources for 1996/1997 was around 633 kg, higher than we report in 2000, but consistent with the ongoing decline during the 1995-2000 period. Finally, previous work reports 3.6 heads of cattle per CMER household, a lower value lower than ours, but consistent a rise in cattle herds since the mid-1990s.

[6] All t-tests are two-tailed tests that do not assume equal variances in the samples.

[7] The results for secondary growth in the CMER may be an artifact of differences in the data. We estimated secondary growth for 2000, based on the area under cropland and assumptions about cultivation time (3 years) relative to fallowing durations (8 years), derived from observations during fieldwork and from knowledgeable informants who have conducted extension work in the CMER. Data on secondary vegetation for 2004/2005 are areas reported by respondents.

[8] Brazil nuts extraction is typically measured in "latas." We follow Wadt, Kainer, and Gomes-Silva (2005) in converting latas to kg by assuming 11 kg per lata.

[9] All quotations are taken from the household surveys and key-informant interviews and have been translated by the authors from Portuguese.

References

Aldrich, S. P., R. T. Walker, E. Y. Arima, M. M. Caldas, J. O. Browder and S. Perz. 2006. Land-cover and land-use change in the Brazilian Amazon: Smallholders, ranchers, and frontier stratification. *Economic Geography*, 82: 265-288.

Allegretti, M. H. 1990. Extractive reserves: An alternative for reconciling development and environmental conservation in Amazonia. In *Alternatives to Deforestation: Steps toward Sustainable Use of the Amazonia Rain Forest*, A. B. Anderson, ed. pp. 252-264. New York, NY: Columbia University Press.

Almeida, A. W. B. 1995. *Carajás: a guerra dos mapas*. Belém, Pará: Editora Supercores.

Arima, E., P. Barreto and M. Brito. 2006. *Cattle Ranching in the Amazon: Trends and Implications for Enviromental Conservation*. Belém: Imazon.

Bakx, K. 1988. From Proletarian to Peasant: Rural Transformation in the State of Acre, 1870-1986. *The Journal of Development Studies*, 24: 141-160.

Barbosa, R. I. and P. M. Fearnside. 1996. Pasture Burning in Amazonia: Dynamics of Residual Biomass and the Storage and Release of Aboveground Carbon. *Journal of Geophysical Research-Atmospheres*, 101: 25847-25857.

Barreto, P., J. Souza, R. Noguerón, A. Anderson and R. Salamão. 2005. *Pressão humana na floresta Amazônica Brasileira.* Belém: WRI-Imazon.

Browder, J. O. 1992. Social and Economic Constraints on the Development of Market-Oriented Extractive Reserves in Amazon Rain Forests. *Advances in Economic Botany*, 9: 33-41.

Calaça, M. 1993. Violência e Resistência: O Movimento dos Seringueiros de Xapuri e a Proposta de Reserva Extrativista. Ph.D. Dissertation, Rio Claro, SP: Universidade Estadual Paulista.

Cavalcanti, F. S. 2002. A política ambiental da Amazônia: Um estudo sobre as Reservas Extrativistas. Ph.D. Dissertation, Campinas, SP: Universidade Estadual de Campinas.

CNS (Conselho Nacional dos Seringueiros). 1992. Relatório sócio econômico e cadastro da Reserva Extrativista Chico Mendes. Rio Branco, Acre: Unpublished report.

Corrêa, L. M. 1967. *A borracha da Amazônia e a II Guerra Mundial.* Manaus, AM: Governo do Estado do Amazonas.

Dean, W. 1987. *Brazil and the Struggle for Rubber: A Study in Environmental History*. Cambridge, MA: Cambridge University Press.

Ehringhaus, C. 2005. Post-Victory-Dilemmas: Land Use, Development, and Social Movement in Amazonian Extractive Reserves. Ph.D. Dissertation, New Haven: Yale University.

Faminow, M. D. 1998. *Cattle, Deforestation, and Development in the Amazon: An Economic, Agronomic, and Environmental Perspective*. Wallingford, Oxon, UK: CAB International.

Fearnside, P. M. 1986. *Human Carrying Capacity of the Brazilian Rain-Forest*. New York: Columbia University Press.

Godoy, R. A., R. Lubowski and A. Markandya. 1993. A Method for the Economic Valuation of Non-Timber Tropical Forest Products. *Economic Botany*, 47: 220-233.

Godoy, R. A., D. Wilkie and J. Franks. 1997. The Effects of Markets on Neotropical Deforestation: A Comparative Study of Four Amerindian Societies. *Current Anthropology*, 38: 875-878.

Godoy, R. A. 2000. Valuation and Consumption and Sale of Forest Goods from a Central American Rainforest. *Nature*, 406: 62-63.

Gomes, C. V. A. 2001. Dynamics of Land Use in an Amazonian Extractive Reserve: The Case of the Chico Mendes Reserve Acre, Brazil. Master Thesis, Gainesville, FL: University of Florida.

_____. 2004. Cattle Ranching Expansion Among Rubber Tapper Communities in the Chico Mendes Extractive Reserve in the Southwestern Brazilian Amazon. Rio Branco, Acre, Report for WWF-Brazil.

_____. 2009. Twenty Years After Chico Mendes: Extractive Reserves' Expansion, Cattle Adoption And Evolving Self-Definition Among Rubber Tappers in the Brazilian Amazon. Ph.D. Dissertation, Gainesville, FL: University of Florida.

Gomes, C. V. A., J. M. Vadjunec and S. G. Perz. 2012. Rubber Tapper Identities: Political-economic Dynamics, Livelihood Shifts, and Environmental Implications in a Changing Amazon. *Geoforum*, 43: 260-271.

Government of Acre. 2000. *Zoneamento ecológico-econômico do Acre: Aspectos Socioeconômicos e Ocupação Territorial, Fase I*, Volume II. Rio Branco, Acre, Brazil: Governo do Acre.

_____. 2005. *Acre: The State of Florestania in the Brazilian Amazon*. Rio Branco, Acre, Brazil: Governo do Acre.

Grimes, A., S. Loomis, P. Jahnige, M. Burnham, K. Onthank, R. Alarcon, W. P. Cuenca, C. C. Martinez, D. Neill, M. Balick, B. Bennett and R. Mendelsohn. 1994. Valuing the Rain-Forest - the Economic Value of Nontimber Forest Products in Ecuador. *Ambio*, 23: 405-410.

Guimarães, R. 1991. *Ecopolitics of Development in the Third World*. Boulder, CO: L. Reinner Publishers

Hall, A. L. 2008. Better RED than Dead: Paying People for Environmental Services in Amazonia. *Philosophical Transactions of the Royal Society*, B 363: 1925-1932.

Homma, A. K. O. 1992. The Dynamics of Extraction in Amazonia: A Historical Perspective. In D. C. Nepstad (ed.), *Non-Timber Products From Tropical Forests: Evaluation of a Conservation and Development Strategy*, pp. 23-33. New York: The New York Botanical Garden.

IBAMA/CNPT. 1999. Projeto RESEX: Um Futuro Sustentável para a Amazônia. Brasilia: Ministério do Meio Ambiente - MMA; IBAMA/CNPT.

IBGE. 1998a. *Censo Agropecuário 1995/96*. Rio de Janeiro: IBGE.

_____. 1998b. *Contagem Populacional 1996*. Rio de Janeiro: IBGE.

_____. 2009. *Pecuária Municipal*. http://www.sidra.ibge.gov.br/. Accessed January 2009.

IDESP. 1990. *Uruará*. Belém, PA: Instituto de Desenvolvimento do Estado do Pará (IDESP).

Kainer, K., M. Schmink, A. C. Leite, and M. J. Fadell. 2003. Experiments in Forest-Based Development in Western Amazonia. *Society and Natural Resources*, 16: 869–886.

Laurance, W.F. 2008. "Can Carbon Trading Save Tropical Forests?" *BioScience* 58(4): 286-287.

Lima, R. C. A., S. H. G. Miranda and F. Galli. 2005. F*ebre aftosa: impactos sobre as exportações brasileiras de carnes e o contexto mundial das barreiras sanitárias*. São Paulo: Icone/Cepea.

Ludewigs, T., A. D. D'Antona, E. S. Brondizio and S. Hetrick. 2009. Agrarian Structure and Land-cover Change along the Lifespan of Three Colonization Areas in the Brazilian Amazon. *World Development*, 37: 1348-1359.

Mahar, D. J. 1979. *Frontier Development Policy in Brazil: A Study of Amazonia*. New York: Paeger Publishers.

MAPA. 2005. *Programa nacional de erradicação da febre aftosa: Relatório anual 2005*. Brasília, DF: Governo Brasileiro - Ministério da Agricultura, Pecuária e Abastecimento.

Martinello, P. 2004. *A "Batalha da Borracha" na Segunda Guerra Mundial*. Rio Branco, AC: EDUFAC.

Mertens, B., R. Poccard-Chapuis, M. G. Piketty, A. E. Lacques and A. Venturieri. 2002. Crossing Spatial Analyses and Livestock Economics to Understand Deforestation Processes in the Brazilian Amazon: The Case of Sao Felix do Xingu in South Para. *Agricultural Economics*, 27: 269-294.

Moran, E. 1981. *Developing the Amazon*. Bloomington, IN: Indiana University Press.

Nascimento, E. P. and J. A. Drummond. 2003. *Amazônia: Dinamismo Econômico e Conservação Ambiental*. Rio de Janeiro: Garamond.

Nepstad, D., C. M. Stickler and O. T. Almeida. 2006. Globalization of the Amazon soy and beef industries: Opportunities for conservation. *Conservation Biology*, 20: 1595-1603.

Nepstad, D., B. Soares-Filho, F. Merry, A. Lima, P. Moutinho, J. Carter, M. Bowman, A. Cattaneo, H. Rodriguez, S. Schwartzman, D. McGrath, C. Stickler, R. Lubowski, P. Piris-Cabezas, S. Rivero, A. Alencar, O. Almeida, O. Stella. 2009. The End of Deforestation in the Brazilian Amazon. *Science* 326: 1350-1351.

Pacheco, P. 2009. Agrarian Reform in the Brazilian Amazon: Its Implications for Land Distribution and Deforestation. *World Development*, 37: 1337-1347.

Perz, S. G. 2002. The Changing Social Contexts of Deforestation in the Brazilian Amazon. *Social Sciences Quarterly*, 83: 35-52.

Perz, S. G., R. T. Walker and M. M. Caldas. 2006. Beyond Population and Environment: Household Demographic Life Cycles and Land Use Allocation among Small Farms in the Amazon. *Human Ecology*, 34: 829-849.

Perz, S.G., M. Caldas, E. Arima, and R.T. Walker. 2007. Socio-spatial Processes of Unofficial Road-building in the Amazon: Socioeconomic and Biophysical Explanations. *Development and Change* 38(3): 529-551.

Peters, C. M., A. H. Gentry and R. O. Mendelsohn. 1989. Valuation of an Amazonian Rainforest. *Nature*, 339: 655-656.

Rêgo, J. F. 1999. Amazonia: do Extrativismo ao Neoextrativismo. *Ciencia Hoje*, 25 (147): 34-37.

Rêgo, J. F., O. S. Costa Filho and R. R. A. Braga. 2003. *Análise econômica dos sistemas de produção familiar rural da região do Vale do Acre, 1996/1997*. Rio Branco, Acre, Brazil: UFAC/SEBRAE/Ford Foundation.

Rueda, B. L., R. W. Blake, C. F. Nicholson, D. G. Fox, L. O. Tedeschi, A. N. Pell, E. C. M. Fernandes, J. F. Valentim and J. C. Carneiro. 2003. Production and Economic Potentials of Cattle in Pasture-based Systems of the Western Amazon Region of Brazil. *Journal of Animal Science*, 81: 2923-2937.

Salisbury, D., Schmink, M., 2007. Cows versus Rubber: Changing Livelihoods among Amazonian Extractivists. *Geoforum* 38 (6): 1233-1249.

Sassagawa, H. S. 1999. Técnicas de Sensoriamento Remoto e Sistema de Informações Geográficas (SIG) para Estudo de Ocupação do Espaço Físico e dos Tipos Florestais da Reserva Extrativista Chico Mendes, Estado do Acre. MA Thesis, São José dos Campos: Instituto Nacional de Pesquisas Espaciais.

Schmink, M. and C. Wood. 1992. *Contested Frontiers in Amazonia*. New York: Columbia University Press.

Schwartzman, S. 1989. Extractive Reserves: the Rubber Tappers' Strategy for Sustainable Use of the Amazon Rain Forest. In *Fragile Lands in Latin America: Strategies for Sustainable Development*, ed. J. O. Browder, pp. 150-165. Boulder, CO: Westview Press.

SEMA/CNS. 2010. *Diagnóstico socioecônomico e cadastro da Reserva Extrativista Chico Mendes*. Rio Branco: Secretaria de Estado de Meio Ambiente do Governo do Acre, Conselho Nacional dos Seringueiros.

Silva, A. F. 1990. *Raízes da ocupação recente das terras do Acre: movimento de capitais, especulação fundiária e disputa pela terra*. Rio Branco: Casa da Amazônia.

Smeraldi, R. and P. May. 2008. *O Reino do Gado: Uma Nova Fase na Pecuarização da Amazônia Brasileira*. São Paulo: Amigos da Terra-Amazônia Brasileira.

Sobrinho, P. V. C. 1992. *Capital e trabalho na Amazônia Ocidental: contribuição à história social e das sindicais no Acre*. São Paulo: Cortez.

Tocantins, L. 1979. *Formação Histórica do Acre*. Rio de Janeiro: Civilização Brasileira.

Toni, F. 1999. Relations on the Agricultural Frontier: The Struggle for Credit in the Transamazônica Region. Ph.D. Dissertation, Gainesville, FL: University of Florida.

_____. 2003. Uruará: Pecuarização na fronteira agrícola. In M*unicípios e gestão florestal na Amazônia*, eds. F. Toni and D. Kaimowitz, pp. 175-217. Natal, Brasil: A.S. Editores.

_____. 2007. *Dinâmica da pecuária na região de fronteira agrícola do Alto Rio Acre*. Brasília, DF: UnB.

Toni, F. and C. A. Souza. 2003. Xapuri: Movimentos sociais no poder. In *Municípios e gestão florestal na Amazônia*, F. Toni and D. Kaimowitz (eds.), pp. 337-372. Natal: A.S. Editores.

Tourrand, J. F. and J. B. da Veiga (eds.). 2003. *Viabilidade de Sistemas Agropecuários na Agricultura Familiar na Amazônia*. Belém: Embrapa Amazônia Oriental.

Vadjunec, J. M. 2007. The Role of Institutions in Land-Use/Cover-Change in the Chico Mendes Extractive Reserve, Acre, Brazil. Ph.D. Dissertation, Worcester, MA: Clark University.

Vadjunec, J. M., C. V. A. Gomes and T. Ludewigs. 2009. Land-Use/Land-Cover Change among Rubber Tappers in the Chico Mendes Extractive Reserve, Acre, Brazil. *Journal of Land Use Science*, 4(4): 249-274.

Valentim, J. F. and C. M. S. Andrade. 2005. Tropical Kudzu (Pueraria phaseoloides): Successful Adoption in Sustainable Cattle Production Systems in the Western Brazilian Amazon. *Tropical Grasslands*, 39: 221-221.

Valentim, J. F., C. P. Sá, F. C. R. Gomes and J. C. Santos. 2002. Tendências da pecuária bovina no Acre entre 1970 e 2000. In *Boletim de Pesquisa e Desenvolvimento* 38: 1-36. Rio Branco, Acre, Brazil: Embrapa Acre.

Veiga, J. B., J. F. Tourrand, M. G. Piketty, R. Poccard-Chapuis, A. M. Alves and M. C. Thales. 2004. *Expansão e trajetórias da pecuária na Amazônia, Pará, Brasil*. Brasília: UnB.

Viana, J. 2004. Foreword. In *Working Forests in the Neotropics: Conservation Through Sustainable Management?*, D. J. Zarin, J. R. R. Alavalapati, F. E. Putz and M. Schmink (eds.) pp. xiii-xvi. New York: Columbia University Press.

Wadt, L. H. O., K. A. Kainer and D. A. P. Gomes-Silva. 2005. Population Structure and Nut Yield of a Bertholletia Excelsa Stand in Southwestern Amazonia. *Forest Ecology and Management*, 211: 371-384.

Walker, R., E. Moran and L. Anselin. 2000. Deforestation and Cattle Ranching in the Brazilian Amazon: External Capital and Household Processes. *World Development*, 28: 683-699.

Walker, R., Browder, J., Arima, E., Simmons, C., Pereira, R., Caldas, M., Shirota, R., de Zen, S., 2009. Ranching and the New Global Range: Amazonia in the 21st Century. *Geoforum* 40: 732-745.

Wallace, R. 2004. The Effects of Wealth and Markets on Rubber Tapper Use and Knowledge of Forest Resources in Acre, Brazil. Ph.D. Dissertation, Gainesville, FL: University of Florida.

Weinstein, B. 1983. *The Amazon Rubber Boom, 1850 -1920*. Stanford, CA: Stanford University Press.

Wu, X. B., T. L. Thurow and S. G. Whisenant. 2000. Fragmentation and Changes in Hydrologic Function of Tiger Bush Landscapes, Southwest Niger. *Journal of Ecology* 88: 790-800.