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Revisiting Theories of Frontier Expansion in the Brazilian Amazon: A Survey of the Colonist Farming Population in Rondônia's Post-frontier, 1992–2002

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Summary. — In the 1970s, extensive areas of Brazilian Amazon were settled by landless farmers. These internal migrations prompted theoretical scholarship on the nature and outcomes of frontier expansion from three general frameworks: the capitalist penetration thesis, the inter-sectoral articulation thesis, and the household life-cycle thesis. This paper reports selected findings of a 10-year (1992–2002) panel study of 240 farms in three settlement areas in Rondônia. The empirical findings of this longitudinal survey research do not unequivocally confirm any of these theses. Instead, elements of each emerge from the data analysis inviting a more locally nuanced, pluralistic approach to understanding the frontier colonization experience.

Key words — Frontier settlement, land tenure change, agricultural development, socio-economic differentiation, Amazon, Brazil

1. INTRODUCTION

For five centuries, episodic waves of explorers, conquerors, and colonists have penetrated various sections of the vast Amazon Basin, exploiting its natural resources and native peoples in a series of cultural successions, called "frontiers." The latest of these frontiers was opened in the mid-1960s, bringing dramatic social and environmental changes to the region. Now, more than a generation later, many parts

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of the Amazon are fast approaching a turning point, becoming what we shall provisionally call a "post-frontier." As authors steeped in the North American frontier tradition, it is tempting to reach for the familiar Turnerian metaphor of the "closing frontier," with its suggestion that untamed wilderness has been subdued, that civilization has, at last, brought its comforts to the backlands. But, such a metaphor would constitute a gross over-simplification of the Amazonian reality of today. [1] This conceptually awkward transition time, between first generation pioneers and second-generation followers, between frontier and post-frontier, is the subject of this research report and analysis.

The post-frontier is of particular interest given the outcomes of the frontier experience predicted by scholars beginning three decades ago. These predictions were based on three distinct analytical frameworks: *the capitalist penetration thesis*, *the inter-sectoral articulation thesis*, and *the household life-cycle thesis*. This paper revisits the central propositions of these perspectives through an examination of twelve hypotheses.

The most recent frontier expansion experience in the Amazon (roughly 1968—present) brought monumental population growth to the region. From 1970 to 2000, the human population of Brazilian Legal Amazon region rose from 7.5 million to 20.1 million. While most of this population growth occurred in the region's burgeoning towns and cities (Browder & Godfrey, 1997), significantly 6.3 million people inhabited rural areas of the region by 2000. By the early 1990s, the Amazon supported an estimated 500,000 colonist households, staking small claims across the basin (Homma, Walker, Scatena, Carvalho, & da Rocha, 1992 in Laurance, Albernaz, & da Costa, 2001, p. 307).

Despite their demographic importance, surprisingly little is known about what happened to this first generation of migrants to Amazônia. Many valuable household-level studies of colonist farming systems were undertaken in the 1990s to better understand their land-use decision-making and impacts on the Amazon forest conversion. These were mostly based on single case study "snap-shots," producing cross-sectional data from which long-term trends have been inferred (see Angelsen & Kaimowitz, 1999 for a review). But with few exceptions (Caviglia-Harris, 2004; Lena, 1991; Pan, Murphy, Sullivan, & Bilsborrow, 2001), longitudinal panel studies documenting the demographic, economic, and land-use processes experienced by the same colonist households over extended periods of time are largely absent from the research literature on Amazônia (Marquette, 1998, p. 595). It is precisely this type of analysis that is necessary to assess the earlier predictions about frontier outcomes, as well as to understand the impacts of frontier expansion on household livelihoods and land use. [2]

This paper fills part of this knowledge gap by providing findings from a longitudinal 10-year study (1992–2002) of 240 farm properties in three rural communities in the western Amazon Brazilian State of Rondônia, where frontier dynamics have been particularly intense. Here, an estimated 783,500 migrants staked rural land claims during 1970–94 (SEPLAN, 1998), and deforestation increased from 0.3% to 23.5% of the state's total area (IBAMA, 1999). Our specific research objective is to interpret the patterns of Rondônia's development in light of the frameworks mentioned above. In particular, we wish to determine the extent to which the developmental trajectories predicted by theoreticians writing in the 1970s and 1980s are borne out by empirical observations during the 10-year study period. Our rationale for focusing on households is that expectations of these theoretical models of frontier development can be most effectively addressed by the analysis of demographic and economic conditions evident at the farm level that have emerged over the final, transitional years of the frontier period in Rondônia. [3]

This paper pursues its objective first with a review of the theoretical literature on frontier expansion and the specification of hypotheses (Section 2). This is followed by a short history of the settlement of Rondônia, focusing on two World Bank co-financed regional development programs that establish important contexts for understanding the contemporary period of frontier expansion in this section of the Basin (Section 3). The research methodology and study site descriptions follow (Section 4). Our principal findings, based on a comparative analysis of changes in colonist household demography, economy, and land use during 1992–2002, are then presented (Section 5), followed by a synoptic discussion and conclusions (Sections 6 and 7, respectively).

2. THEORETICAL PERSPECTIVES ON AMAZONIAN DEVELOPMENT

Amazonian development has often been described in terms of "the frontier" and its

advance into expansive forest lands of the basin. According to the influential account by Turner and his interpreters, the passage of a frontier is also the march of civilization, which gives rise to institutional innovations that contribute to nation-building (Bylund, 1960; Cronon, 1991; Faragher, 1994; Hudson, 1969; Olsson, 1968; Turner, 1920). [4] But as an empirical concept, the frontier remains somewhat ambiguous. For example, it can be a point of historical transition marking the arrival of modernity into an unexplored wilderness (Watts, 1993), the periodic "re-territorialization" of a given space by different social groups competing for resources (Little, 2001), and the spatial limit between subsistence and market-oriented agriculture (Katzman, 1977). Other interpretations characterize the "frontier" as a temporal dimension, an historical phase in which a specific economic activity prevails in a region and then, over time, is replaced by another (Steffen, 1980). In most definitions, the frontier is a spatial entity—an area, a region, or a territorial boundary—and possesses dynamic properties. It arrives and passes in an historical sense, replacing one matrix of social relations with another.

Given the pervasive reference to Amazonian development as "frontier" expansion during the formative years of organized theorizing about this contemporary phenomenon (Schmink & Wood, 1984 provide a salient example), four general theoretical perspectives have framed much of the scholarship on this subject, the latter three of which mentioned here constitute the theoretical core of this analysis: (1) a *neoclassical economic perspective,* based on the original theoretical works of Von Thunen (1826), Lewis (1955), Todaro and Harris (1970), and applied to the Amazonian context by Katzman (1977), Baer (1989), Mahar (1989), Ozorio de Almeida (1992), Schneider (1995), among others. (2) S*tructuralist interpretations* of frontier expansion in Amazônia have assumed three distinctive forms: (i) the capitalist penetration thesis (Bartra, 1974; Grindle, 1986; Foweraker, 1981; Martine, 1988; Sawyer, 1984; Singer, 1979; Velho, 1972), (ii) inter-sectoral articulation thesis (Moreira, 1985; Oliveira, 1972; Sorj, 1980), and the (iii) world systems-surplus extraction thesis (Brum, 1988; Bunker, 1985; Sampaio, 1980; Weinstein, 1983), the first two of which will be the focus of this analysis of the structuralist perspective (see Browder & Godfrey, 1997, for a review of these perspectives). (3) More recently several empirical studies have supported the development of a *demographic household life-cycle framework* (McCracken *et al.*, 1999; Moran *et al.*, 2001; Pan *et al.*, 2001; Perz, 2000; Walker, 1999; Walker & Homma, 1996; Walker, Moran, & Anselin, 2000).

Conceding its importance as the hegemonic framework employed by official government and multi-lateral institutions that have directed much of the Amazon's development activity (e.g., the World Bank, the Brazilian Government), analyses based on the neoclassical economic model have tended to rely on aggregated economic and land-use data that are not readily amenable to validation by household level survey-based data analyses. Hence, this paper focuses on the prevailing critical structuralist perspectives, the capitalist penetration thesis, and inter-sectoral articulation thesis, and the more recently developed demographic life-cycle framework, all of which are well suited to assessment using household level survey data.

(a) *The capitalist penetration thesis*

In seeking to explain the dynamics of frontier change in Amazônia, many commentators have adopted a "capitalist penetration" framework. Here, frontier change is associated with the progressive spread of capitalist relations of production into this "non-capitalist" frontier environment. Frequently, this process is depicted as occurring in a linear sequence of stages, spreading out from the industrialized south in episodic waves, replacing the largely autarchic, primitive economies of Amazonia with industrial and post-industrial modes of production, connecting production in the north with consumption in the south (Cleary, 1993; Foweraker, 1981; Little, 1992; Schmink & Wood, 1982, 1992; Sawyer, 1984).

Theorists of the Amazon frontier, especially in Brazil, anticipated mostly negative consequences stemming from this process of regional integration, with both social and environmental dimensions. By this structuralist narrative, capitalist production relations in general led to the economic ruin of the region's pre-existing populations. The expansion of capitalism was aided by government subsidized fiscal incentives and rural credit programs targeted toward large corporate interests (Bunker, 1985; Pompermayer, 1979). It was argued that land in the frontier that had been "improved" (i.e., deforested) by peasant labor was eventually appropriated by industrial and merchant capital through foreclosure, intimidation, and violence

(Foweraker, 1981; Ianni, 1979). Accordingly, this dispossession of land from the peasantry leads to rural depopulation and to a demographically *hollow* frontier, a term first used to describe the dynamics of coffee production in the southern and central parts of Brazil, where large-holders consolidated the properties of small family farms turning small-holders into an impoverished landless class of rural day workers (*boias frias*) or urban migrant slum dwellers (*favelados*) (Casetti & Gauthier, 1977; James, 1969; Taylor, 1973). A similar process was predicted for the Amazon region, with large-scale cattle ranching replacing colonists and other settlers, engaged mostly in subsistence farming (Foweraker, 1981; Wood, 1983). And if not ranchers, then speculators would consolidate the small holdings to take advantage of land as a hedge against inflation, which ravaged the Brazilian economy in the 1980s. This process was facilitated by corporate monopolistic control of marketing and finance opportunities. Once the improvements made by labor to the land were appropriated, labor could be eradicated and replaced by corporate properties capitalized by appropriated labor value. Spatial differentiation in the pattern of development would be largely influenced by the State, in its infrastructure investment decisions (e.g., roads and utility extensions into the frontier) and in fiscal incentive policies targeted to specific regions that would invite capital investment there.

Although some commentators on the Amazon frontier considered possible environmental implications of capitalist penetration (e.g., Browder & Godfrey, 1990; Sawyer, 1984; Wood, 1983), interest in its advance into the region focused mainly on social conflict and on equity issues associated with dispossession of the rural poor (e.g., Foweraker, 1981; e.g., Schmink & Wood, 1992).

The capitalist penetration thesis arguably supports four hypotheses that are testable using household level survey data:

> H1: After the frontier has been occupied, over time, land consolidation is the dominant tendency in land tenure change in the capitalist penetration model and the average size of land holdings increases;
> H2: Over time, as the initial settler homesteads are consolidated into larger properties, the rural population declines.
> H3: Those initial settlers who manage to retain their properties become economically worse-off than they were at the initial settlement due to growing monopolistic control of marketing and credit by capitalist entities.
> H4: Most land in the "post-frontier" now under corporate ownership and largely deforested is converted from mixed-crop farming to commercial cattle or soy bean production.

(i) *The inter-sectoral articulation thesis*

The second structuralist perspective examined here focuses on the persistence of the peasantry in various forms under capitalism. Oliveira (1972) and Sorj (1980) emphasized that the reproduction of non-capitalist forms of rural production is functional, not inimical, to the accumulation of urban industrial capital in Brazil:

> The peasant and urban informal sectors are articulated to the urban industrial sector in that "primitive" production directly subsidizes urban capital accumulation by reducing the long-term reproduction cost of labor employed in the urban capitalist sector. Food crops can be produced with unpaid family labor for less that the subsistence wage rate. Hence, the "use-values produced by non-capitalist forms of production subsidize urban capital accumulation by depressing rural real wages, and the real prices of foodstuffs" (Goodman, Bernardo, & John, 1984, p. 190; de Janvry, 1981, pp. 85–93 cited in Browder & Godfrey, 1997, p. 35).

The central assumption of the inter-sectoral articulation model is that "development" (i.e., the accumulation of capital derived from the appropriation of surplus labor value) requires a captive labor force to exploit. The frontier serves to contain labor at no cost to capital until such time as its surplus value can be appropriated by periodic spurts of capitalist economic activity. Spatial differentiation in patterns of such capitalist economic activity, according to this perspective, is determined by trends in labor reproduction costs at different geographic locations. Capitalism expands into those locations where labor reproduction costs are the lowest (i.e., presumably the frontier). Inter-sectoral articulation theory is silent on the question of socio-economic differentiation within the labor population, focusing as it does instead on the relationship between capital and labor, as different socio-economic classes. However, the inter-sectoral articulation thesis postulates a specific dynamic within the rural population that leads to two outcomes: First, the continuous displacement and relocation of the peasant population ("reterritorialization" of the peasantry) perpetuating an ever moving frontier on the one hand; and second, the

temporary containment of displaced farmers in the regional towns and cities, rural labor control points, on the other.

The inter-sectoral articulation thesis could be validated in part by accepting the following hypotheses:

> H5: A significant proportion of the rural population, that which is functionally articulated to the urban capitalist sector, persists in the post-frontier, but increasingly as informal workers rather than as property owners.
> H6: The rapid population growth of frontier towns and cities is attributed to the influx of displaced rural workers turning these centers of labor control into "cities of peasants."
> H7: Since capitalism retains a certain level of "primitive" production to supply the urban work force with cheap food, we would expect the farming sector to be producing mainly food crops (i.e., annual crops).

(ii) *The household life-cycle perspective*

Unlike the structuralist framework, with its focus on the emergent social relations of production on the frontier, the demographic model is more deterministic and emphasizes the links between the stages in a household's "life-cycle" and land use, and implications for the Amazonian environment. Central to the household life-cycle perspective is the assumption that the settler cohort group first arriving to the frontier is generally homogeneous in household structure and composition—they enter the frontier at a similar stage in their household life-cycle. Furthermore, any socio-economic differentiation that occurs in this cohort population would be the result of unexpected changes in household structure or composition. Axiomatically, any significant spatial differentiation in socio-economic patterns of development would be a derivative of the time-period and the historic sequence in which different frontiers were first settled.

Although research on smallholders began as early as structuralist theorization (Moran, 1975; Smith, 1976; Staniford, 1973), systematic themes and a unified demographic narrative did not emerge until the 1990s with concepts relating to the household life-cycle and links to both land cover and land-use change. As described by McCracken *et al.* (1999), Walker and Homma (1996), Perz (2001), among others, young smallholders with non-working children typically minimize their risks due to high household dependency and a limited family workforce. This involves the selection of time-tested food crops with annual yields, produced with a system of shifting cultivation and relatively minimal forest clearance. As time passes, the family gains knowledge of the agricultural potential of their holdings, as well as their confidence in farming. Children enter the household workforce, becoming producers and not just consumers. These various developments lower household vulnerability and risk aversion, with the effect that the family now undertakes investments, shifting its production based from annual crops to perennials, ranching, or some combination. In later "empty nest" stages of the household life-cycle, grown children usually leave the farm and the aging first generation pioneers shift to more casual, less-labor demanding production strategies, such as cattle ranching (Walker *et al.*, 2000). Many sell off or bequeath their properties to newcomers or heirs, and move to nearby towns or return back to their place of origins. Farm sub-division is the predominant pattern.

Empirical research suggests certain links between household demographic processes and patterns of development over time. Demographic characteristics such as family size (Pinchón, 1997; Rudel & Horowitz, 1993), household composition (Sydenstricker & Vosti, 1993; Walker, Stephen, Marcellus, Luiz, & Teixeira, 2002), and internal household dependency (Walker *et al.*, 2002) influence forest clearing and crop choices. Other attributes also play a role, like level of household wealth (Alston, Libecap, & Schneider, 1993, 1996; Pinchón, 1997; Walker *et al.*, 2002), length of family residence on the holding (Godoy, Wilkie, & Franks, 1997; Godoy *et al.*, 1998; Pinchón, 1997; Walker *et al.*, 2002), and transportation costs (Godoy *et al.*, 1997; Moran *et al.*, 2001; Pinchón, 1997; Walker *et al.*, 2002). Evidently, household demography and productive assets, as well as market access factors, play key roles in smallholder deforestation (Brondízio, 1997; Walker, 2003).

The demographic household life-cycle framework may be assessed by 5 hypotheses:

> H8: Over time, in later stages of the household life-cycle, the initial pioneers begin to sub-divide their original properties among their heirs or to other unrelated second generation households. Property subdivision is the predominant tendency.

H9: The rural population of the post-frontier declines as children of the pioneer households grow up and leave empty nests behind as manifest by smaller and older remaining households.
H10: With fewer unremunerated household workers land-use shifts from labor intensive activities (e.g., perennial crops) to more casual pursuits (e.g., cattle raising).
H11: With fewer household workers deforestation rates decline over time.
H12: Over time households that remain on the frontier accumulate productive assets due in part to the increase in land values reflected by the increasing value of production.

3. A BRIEF HISTORY OF CONTEMPORARY SETTLEMENT IN RONDÔNIA

Until the 1970s, the Federal Territory of Guaporé (now the State of Rondônia) was a distant backwater about the size of the US State of Montana with fewer than 100,000 inhabitants and with little economic significance, except briefly during the Amazon rubber boom—roughly 1880–1910 (Figure 1). [5] In the late-1960s, following a devastating frost that destroyed much of the coffee plantations in the South of Brazil, and a rise in global demand for edible vegetable oils, agriculture quickly shifted to a new industrial export crop, soy beans. One important consequence of this shift in agricultural production from a labor-intensive to a capital-intensive mode of production was the displacement of thousands of sharecroppers who subsisted on the fringes of the traditional coffee plantations (Bakx, 1987; Browder & Godfrey, 1997; Millikan, 1988; Mueller, 1980; Quandt, 1986). During the 1970s, an estimated 2.5 million displaced rural workers left the State of Paraná alone in the wake of this agricultural "modernization" (Mahar, 1989, p. 52; Martine, 1988). Anxious to deflect the growing tide of landless migrants streaming toward Brazil's already bulging metropolitan centers (Rio de Janeiro and São Paulo), Rondônia was hastily opened to new land settlement as part of the government's ambitious Amazon regional development program (POLAMAZONIA). Initial government efforts to stimulate the rapid settlement of Rondônia into 6 planned colonization areas were overwhelmed from the start. Thousands of landless migrants poured into the Territory in response to government promises of free land. From 1971 to 1985, the population of Rondônia grew at the dizzying annual rate of 16%, from 111,000 to 1,122,800 (SEPLAN, 1985), in what the *Washington Post* called the "greatest land rush since the settling of the American West" (Bridges, 1988).

In 1981, responding to the massive influx of migrants into Rondônia and western Mato Grosso, the Brazilian government secured a loan from the World Bank to partially finance the US $1.5 billion Northwest Region Development Program (POLONOROESTE). Intending to "help bring order to the large, spontaneous migratory flow to the Northwest" (World Bank, 1981, p. iii), the centerpiece of the Program was the construction of an all-weather highway (BR 364) linking the Territory to Brazil's national highway system. Once paved in 1984, the flow of incoming settlers nearly doubled (SEPLAN, 1985). Other Program objectives included the establishment of new colonization areas, rural development, public health, environmental protection, and defense of Amerindian communities. Farmland expansion, which had claimed only 3.1% of the Territory's natural forest cover in 1980, accounted for 14.1% of natural cover alteration by 1990 (INPE, 1992). By 1994, an estimated 783,500 migrants had settled in Rondônia (SEPLAN, 1998). Although initially projecting a hefty internal rate of return of 22% on investments in POLONOROESTE (World Bank, 1981, p. 47), by 1987 the World Bank had virtually acknowledged that the Program had failed. "Despite the intentions and safeguards of the Northwest project designs, deforestation has accelerated sharply and uptake of sustainable farming systems has been less than expected." (World Bank, 1987, p. i). By the end of 1987, much publicized satellite images documenting the conflagration consuming Rondônia's tropical forest landscape evoked an international outcry from environmentalists, progressive political leaders, and the press. POLONOROESTE was condemned as a development disaster and an environmental catastrophe. [6]

In 1992, the World Bank approved a second loan for US $167 million to support the Rondônia Natural Resources Management Project (PLANAFLORO). The original goal of PLANAFLORO was to encourage the intensification of agriculture in areas that had already been settled with the expectation that increasing incomes would reduce the incentive

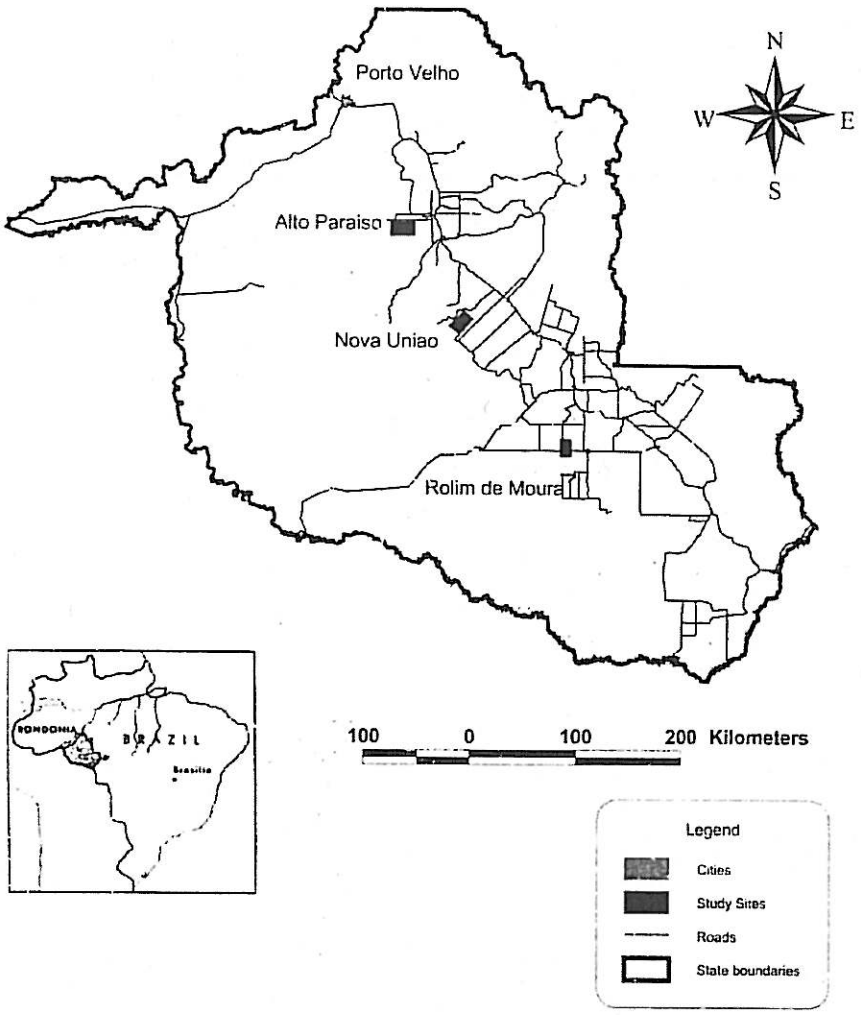

Figure 1. *Location of study sites in the state of Rondônia, Brazil.*

to clear more forest (Mahar and Ducrot, n.d.). A plan dividing the State into six different "agro-ecological and economic zones" was elaborated (SEPLAN, 1998). A popular, but controversial program to support community-based conservation and development projects was also established in 1994 targeting farmers groups (Browder, 2002). Non-governmental organizations that were vociferous critics of POLONOROESTE were added to the new program's advisory panel. The language used to define the goals of the Project shifted away from the decidedly "developmentalist" tone of POLONOROESTE to embrace the 1990s rhetoric of environmental conservation and sustainable development (World Bank, 1995). Despite its noble intentions, implementing PLANAFLORO proved to be administratively problematic, involving dozens of federal, state, and local government agencies, the World Bank, the UNDP, the FAO, community organizations, and other non-governmental entities.

By 2003, Rondônia's estimated population stood 1.4 million and 23.5% of the State's natural forest vegetation had been cleared, mainly by small farmers (IBAMA, 1999). The termination of PLANAFLORO program and World Bank investment in Rondônia around 2000 also corresponded to a slow-down in the Rondônian state economy. In 1999, Rondônia was the second poorest state in the Brazilian Amazon (after Tocantins), based on average worker remuneration (IBGE, 2000, pp. 2–103).

After 30 dizzying years of rambunctious expansion, it would be difficult now (in 2007) to characterize contemporary Rondônia as an

overheated "frontier." During the time-frame of this study, Rondônia's frontier essentially filled up, or perhaps more accurately fizzled out, providing an opportunity to examine life in the period following the frenzied convulsions of speculative land-grabbing and pioneer settlement and to reflect on the longer-term process of frontier expansion, consolidation, and national integration. Population growth rates, which averaged 16% per year during the sizzling 1970s, dropped to a comparatively cool 2.1% per year in the 1990s (IBGE, 2000, pp. 2–10, 2–11). Today, the market economy is firmly established in Rondônia. World market prices for beef, coffee, and cacao can be accessed daily at internet cafés scattered throughout many larger towns in the State. Satellite dishes dot the rural landscape. This once distant outpost at the end of a national telegraph line is now integrated into the national highway network and global telephone system, and is poised to become an international trade gateway once the new Pacific Highway is opened. Most of the State's rural population is connected to a statewide electrical power grid. Malaria, once a regional epidemic, has been largely tamed in the older settlements. Porto Velho, the State's capital, a backwater depot of the rubber boom 100 years ago, is now an emerging regional metropolitan center hosting coffee houses, book stores, tattoo parlors, art galleries, a federal university, daily commercial jet service to the rest of the country, and, alas, sprawling peri-urban slums. However, Rondônia might be characterized, one would be hard-pressed to call it still a "frontier." To what extent are the predictions offered by frontier theorists validated by the Rondônia post-frontier experience? What patterns of development emerge from this landscape after some 30 years of occupation and the appearance of a second generation of property owners?

4. PROJECT STUDY SITES AND METHODOLOGY

In 1992, 3 *municipios* (out of 26 existing at that time) that were settled in the late-1970s-mid-1980s were selected as part of this longitudinal study: Rolim de Moura (separated from Gy-Parana *municipio* in 1982), Nova União (formerly part of Ouro Preto D'Oeste), and Alto Paraiso (initially part of Ariquemes *municipio*) (Figure 1, Table 1). The spatial organization of each study site is characterized by parallel feeder roads (*vizinhais* or *linhas*), at 4 km intervals, connected perpendicularly to a main trunk road linking *municipio* urban centers. Along each feeder road are individual rural properties, originally distributed by the Brazilian Colonization and Agrarian Reform Institute (INCRA) mostly in rectangular 100 ha lots (500 m × 2000 m), creating a regular "fishbone" grid pattern of spatial organization. In the project's study sites, all feeder roads were divided into roughly 7 km-long segments. Then, nine segments were randomly sampled. Every farm property in each segment was visited and its occupants interviewed using a standardized questionnaire. Repeat visits were required in approximately 15% of the cases. In 1992, a total of 240 farm lots were sampled in this fashion. The survey generated an extensive data base (65 discrete variables) on household composition, economic activity, socio-economic characteristics, agricultural production and land use, forest product extraction, social participation, and future plans. In 2002, the same 240 farm properties were revisited and occupants were interviewed using a modified questionnaire, based largely on the 1992 instrument. Property subdivision occurring during the 10-year period necessitated increasing the sample size from 240 to 282 farms in 2002. In the process of paneling the two data sets, a number of questionnaires were purged from the data bases for various reasons (e.g., misidentified properties in 2002, farm abandonment), leading to final samples of 189 properties in 1992 and 228 in 2002. In both surveys, a team of 8–10 Brazilian research assistants was recruited and trained to conduct the interviews during the month of July in both years. All completed questionnaires were checked daily by the field supervisor and were entered onto a spreadsheet software program on laptop computers in the field. The two surveys together enable a unique 10-year comparative and longitudinal analysis of emergent patterns of development and land-use trends in these original frontier settlement areas of Rondônia. In addition, Landsat images of the study sites were analyzed for each year to accurately estimate changes in forest cover during the 1992–2002 period.

There were some significant differences in several survey results between *municipios*, reflecting both the intrinsic heterogeneity of this colonist population and the processes of socio-economic differentiation that followed upon this population's initial settlement. Accordingly, some of the data presented here are disaggregated by *municipio* (Table 1).

Table 1. *Characteristics of project study sites in Rondônia*

Characteristic	Nova União	Alto Paraiso	Rolim de Moura
Location	62°35′W × 10°50′S	63°20′W × 9°35′S	62°47′W × 11°40′S
Altitude[a]	100–225	110–369	250
Average annual rainfall (mm)	1600–1700	2000–2100	2000–2250
Main soil type[b]	PE 3/Re[c]	Pva 13/Rd 3[d]	PE 9/Ce 23[e]
Vegetation cover	TTSMF[f]	TTSMF	TTSMF

[a] Meters above sea level (IBGE, Elevation maps, 1974).
[b] Projeto Radambrasil. Mapa Exploratório de Solos, 1:1000,000, 1979.
[c] Eutrophic yellow–red podsols with patches of eutrophic litolic soils.
[d] Alic yellow–red podsols with patches of distrophic litolic soils.
[e] Eutrophic yellow–red podsols and non-hydromorphic cambisols.
[f] Transitional tropical seasonal moist forest.

5. RESULTS

Several significant changes in general household characteristics occurred in the panel over this 10-year period which shed light upon the theoretical predictions outlined above. To fully understand the spatial and socio-economic complexity of the changes in patterns, the findings of our surveys are presented in two different dimensions—socio-economic stratification and spatial differentiation in selected household level characteristics.

(a) *Socio-economic stratification*

(i) *Changes in land-holdings (H1, H5, and H8)*

Three different trends in rural property ownership occurred in Rondônia during the 10-year study period: property subdivision, consolidation, and retention. To analyze the impacts of these tendencies on socio-economic stratification, land-use change, and income generation, the sample of 282 farmers surveyed in 2002 was classified into three types: Type 1—owners who had retained intact their rural properties since 1992, that is, no change in the size of land-holdings (42.6% of the entire sample); Type 2—farmers who had subdivided/divested some of their land-holdings since 1992 (23.7%); and Type 3—farmers who had expanded the size of their land-holdings since 1992 (33.7%).

In 1992, the mean property size for all three types of farmers was equivalent, averaging 87.9 hectare (ha). By 2002, however, some internal differentiation within the sample frame became apparent, when the average property size of Type 2 (subdividing) farmers dropped by 45.7%, from 85.1 ha to 46.2 ha (Table 2). Meanwhile, the size of Type 1 (no change) property holdings was adjusted from 82.9 ha to 87.6 ha due to necessary sampling modifications.[7]

Table 2. *Land cover, land use, and livestock in 1992 and 2002 by property owner type—areas in hectares (standard deviation)*[a]

	1992 Overall	2002 Overall	2002 Type 1	2002 Type 2	2002 Type 3
Area owned	87.9 (44.4)	96.6 (80.0)	87.6 (56.2)	46.2 (28.3)	147.0 (102.3)
Area deforested	42.6 (23.3)	64.7 (59.9)	57.1 (116.0)	34.0 (21.8)	96.5 (68.3)
Percent of area owned deforested	44.9 (21.9)	69.6 (22.5)	67.4 (20.4)	75.5 (22.5)	68.4 (24.6)
Total area annuals	5.2 (4.5)	2.6 (2.9)	3.0 (2.9)	2.6 (2.6)	2.2 (3.0)
Total area Perennials	7.0 (7.3)	9.1 (9.0)	10.3 (8.5)	6.6 (7.4)	9.5 (10.2)
Total area Pasture	19.1 (30.4)	47.6 (59.4)	35.3 (32.7)	21.5 (18.2)	82.2 (84.4)
Total area secondary growth	5.7 (7.0)	6.1 (8.3)	6.9 (9.9)	4.8 (7.0)	5.7 (6 9)
Average cattle herd	23.3 (38.8)	88.1 (136.6)	72.2 (115.9)	39.2 (47.9)	143.6 (180.0)

Source: John O. Browder, field surveys of 280 farm property owners in Rolim de Moura, Nova União, and Alto Paraiso *municipios* of Rondônia, June–August, 2002.
[a] All area values in hectares. Type 1 = respondents who in 2002 reported no change in the size of their rural holdings since 1992; Type 2 = respondents reporting a net reduction in the size of their rural holdings; Type 3 = respondents reporting a net increase in the size of their rural holdings.

while Type 3 (expanding) farm holdings grew from 77.9 ha (1992) to 147 ha (2002). That these complementary processes of property fragmentation and consolidation have occurred concurrently is not surprising. Taken together, then, more than one-half (57.4%) of the property owners in the sample changed the size of their rural properties during the 10-year study period.

When asked to explain why they acquired more land, a significant proportion of a subsample of Type 3 farmers indicated the intent to increase area in production (27.0%), mainly cattle, while another 18.9% specified "to increase size of pasture" (Table 3A). Another 13.5% indicated "family related reasons" (typically to expand land holdings to accommodate incoming relatives). Another 5.4% indicated that the expansion of holdings was done to settle the debt of others. Overall, Type 3 farmers gave predominantly production-related reasons for increasing their holdings. It can be reasonably inferred that Type 3 farmers had more capital to acquire additional land and were more fully integrated into the formal market economy than either Type 1 or 2 farmers.

Table 3A. *Reasons reported by respondent for enlarging farm property*

Reasons	Total	Percent
Expand area in production (unspecified)	10	27.0
Increase size of pasture	7	18.9
Family related reasons	5	13.5
Opportunity to acquire adjoining land	5	13.5
Debt settlement	2	5.4
Increase annual crop area	1	2.7
Increase perennial crop area	1	2.7
NI	6	16.2

Table 3B. *Reasons reported by respondent for subdividing farm property*

Reasons	Total	Percent
Family (inheritance, divorce settlement)	24	35.3
To settle personal debt	15	22.1
To raise cash for investment (e.g., chainsaw, truck, cattle)	8	11.8
To raise cash for medical emergency	3	4.4
Selling farm to leave Rondônia	2	2.9
To raise cash for unspecified reasons	2	2.9
Other	5	7.4
NI	7	10.3

When asked to explain why they reduced the size of their land holdings, (Table 3B) the predominant reasons given by Type 2 farmers were "family" related (e.g., distribution to heirs, divorce settlement), cited by 36.4% of this sub-sample. The remaining reasons given for sub-dividing holding related to "raising cash" for various reasons: to settle personal debt (22.7%); to purchase equipment or cattle (12.1%); to pay for medical expenses (4.5%). Interestingly, only 3.0% of Type 2 farmers indicated an intent to leave Rondônia as the reason for selling their holdings. Overall, Type 2 farmers cited family related reasons and the need to raise cash to explain their decisions to sub-divide or liquidate their land holdings in Rondônia.

During this study period, the proportion of the sample of farmers surveyed who did not own the land they resided on increased threefold, from 11.7% to 32.2%. This finding suggest some support for H5. More property owners are living off-farm, many in urban areas, and growing proportion of the rural population that persists in the post-frontier are informal workers rather than as property owners.

The emergent patterns of land tenure stratification partially support all three hypotheses. Land consolidation (H1) is clearly occurring, but it is not yet the dominant trend (Type 3 farms). A significant proportion of the rural population continues to hold land (H5) as independent (Type 1) farmers. And, nearly one-quarter of the farmers disposed of at least some of their land-holdings (Type 2), citing mainly "family" life-cycle reasons (H8).

(ii) *Land cover, land-use, and livestock (H4, H7, H10, and H11)*

What impacts does the socio-economic differentiation of the rural population observed over the 10-year study period have on land-use? Several interesting findings again provide mixed support for the four hypotheses outlined above (Table 2).

First, there was clearly no reduction in the rate of deforestation as predicted by the household life-cycle framework (H11). During the study period, the percentage of farm area in the overall sample that had been deforested grew from 44.9% in 1992 to 69.6% in 2002.

Although the average areas deforested were significantly different between property types, the percentages of total farm area deforested were comparable between Types 1 and 3 owners, while Type 2 owners having less land to cultivate had cleared a larger proportion of their holdings by 2002.

Second, in terms of land-use, three important changes occurred during the study period. First, the average area in annual crops (rice, beans, maize) decreased across the board from a combined average of 5.2 to 2.6 ha, challenging the efficacy of the inter-sectoral articulation thesis (H7). While a small portion of these crops are typically consumed on-farm for household subsistence, most of this production is marketed. The drastic drop in this labor intensive annual crop production signifies some degree of market contraction for these crops, although household labor reductions could also have been important (as asserted in the household life-cycle thesis).

Third, the slight increase in perennial crop production over the study period, especially among Type 1 farmers, which is also seasonally labor-intensive, raises some doubt about the household life-cycle prediction of production shifts away from labor intensive activities (H10). Overall, the average total area per farm cultivated in perennial crop production increased from 7.0 to 9.1 ha (Type 1 farmers increased to 10.3 ha). It is noteworthy that during the study period (mid-1990s), many roads within the study area were connected to Rondônia's expanding electrical power grid, enabling some farmers to refrigerate perishable perennial crops like *cupuaçu* (*Theobroma grandiflorum*), *pupunha* palm (*Bactris gasipaes*), and *acerola* (*Malphighia punicifolia*), to name a few. To the extent that this factor explains some of the slight increase in perennial crop output, a case for the capitalist penetration model might be advanced.

Fourth and most significant change in land-use during the 1992–2002 study period was the tremendous expansion in total pasture area and cattle herd size especially on Type 3 farms. Overall, the average area in pasture more than doubled and the average herd size nearly quadrupled per farm. The forces driving this remarkable expansion in Rondônia's livestock sector and the manner in which it is linked to the national cattle industry and global markets remain to be investigated.

While the empirical findings presented here do not irrefutably support any of the three theoretical formulations outlined earlier, four preliminary conclusions could be advanced. First, during this 10-year study period, an emergent pattern of socio-economic stratification associated with changes in size of land-holdings (assets) is clearly evident resulting in three different classes of farmers: those that retained their same properties (Type 1); those that subdivided their properties (Type 2); and those who increased their rural holdings (Type 3). Second, significant differences in land-cover and land-use changes are associated with these different farmer types. Type 3 farmers have deforested significantly larger areas than either of the other two types, and have vastly exceeded the other two types in the growth of pasture areas and cattle herds. Third, Type 1 farmers appear to have struck a more even balance in land-use activities, retaining larger areas in annual and perennial crops than either of the other two types. The average area in pasture and herd size of Type 1 farmers is closer to the sample means than either of the other two types. Finally, Type 2 farmers, having reduced their land assets during this 10-year period have deforested a greater proportion of their land holdings than either of the other two types the largest and, therefore, have less "natural capital" left to support future expansion of production. Type 2 farmers were the only group to reduce the areas in production of both annual and perennial crops, and their increases in pasture area and cattle herds were significantly lower than the sample mean for these variables. Like the other two types, Type 2 farmers appear to be specializing in cattle production, but are constrained by their smaller land holdings from advancing with the other two farmer types. With less natural capital and smaller land holdings to cultivate, Type 2 farmers would appear to be the most economically vulnerable of the three farmer types, and the most likely to be adversely affected by both changes in household life-cycle characteristics and the increasing encroachment of capitalist farming systems, mainly represented by Type 3 farms. The predominant reasons given by Type 2 farmers for subdividing their land holdings, to raise cash, suggest that they have few other liquid assets (e.g., savings) to draw upon, and are the most likely to join the class of dispossessed peasants predicted by both structuralist theories.

While these findings clearly point to a process of socio-economic differentiation occurring within the farming population of Rondônia

during this 10-year study period, the evidence does not definitively support the household life-cycle, capitalist penetration, or inter-sectoral articulation theses. Rather, it appears that the selected elements of these arguments operate simultaneously in the frontier, but affect different socio-economic subgroups of the rural population in significantly different ways. The effects of this socio-economic segmentation of the rural population are also reflected in the value of agricultural production occurring during the study period.

(iii) *Value of production (H3, and H12)*

Both structuralist theories predict the progressive impoverishment of the peasantry leading to either a "hollow frontier" (capitalist penetration) or a relict subsistence farming sector (inter-sectoral articulation). Does the differentiation between farmer types have implications for income generation? A detailed financial analysis of each farm was conducted based on the 1992 and 2002 survey data to estimate the total value of production (VOP) in the preceding years. Respondents reported the volume of production for each of 11 products (banana, beans, cacao, coffee, *cupuaçu*, guarana, livestock, *mandioc*, maize, milk, and rice), the quantity sold and consumed on-farm, and the price received per unit of output. Official prices at the *municipio* level obtained from the national agricultural extension service

Table 4. *Estimated gross value of production (VOP) in Brazilian Reais*[a] *(adjusted real values) by property owner type, 1991 and 2001*

	Marketed VOP	Consumed VOP	Total VOP
(a) 1991 (standard deviation)			
Type 1 (no change)			
Mean (standard deviation)	7,522 (7,445)*	3,026 (2,939)*	10,548 (8,601)*
Median	5,792	2,252	8,667
N	114		
Type 2 (subdivided)			
Mean (standard deviation)	6,775 (7,099)*	2,018 (1,747)*	8,793 (7,802)*
Median	4,879	1,752	6,963
N	44		
Type 3 (enlarged)			
Mean (standard deviation)	2,204 (2,704)*	1,571 (1,249)*	3,775 (3,629)*
Median	1,501	1,472	3,207
N	13		
Total VOP (standard deviation)	*6,255 (5,686)*	*2,843 (2,618)*	*9,098 (7,402)*
Median	*4,783*	*2,307*	*6,819*
(b) 2001 (standard deviation)			
Mean (standard deviation)	14,031 (20,960)*	833 (1,419)	14,864 (20,920)*
Median	6,339	348	7,673
N	114		
Type 2 (subdivided)			
Mean (standard deviation)	6,947 (8,212)*	781 (1840)	7,728 (8,563)*
Median	3,464	291	3,902
N	64		
Type 3 (enlarged)			
Mean (standard deviation)	28,292 (46,754)*	729 (1,226)	29,021 (46,648)*
Median	12,357	54	14,683
N	66		
Total VOP (standard deviation)	*10,807 (19,202)*	*825 (1,438)*	*11,633 (19,322)*
Median	*5,208*	*397*	*6,062*

Source: John O. Browder and Marcos A. Pedlowski. Field surveys conducted in Rolim de Moura, Nova União, and Alto Paraiso *municipios*, Rondônia, June–August 1992 and 2002.

[a] Exchange rate: US $1.00 = R $2.35 (average 2001).

* Significant at $p = 0.05$ or lower.

(EMATER) were also used to verify farmer self-reported prices. Since the difference between self-reported and official prices was less than 5.0% for all crops, we present the results using self-reported prices. Output consumed on-farm ("consumed VOP") was shadow-priced also using self-reported prices. In addition to cultivated farm products, the financial analysis included forest products (timber, wild palm, and Brazil nut) that were extracted by a total of 56 farmers (24.5% of the sample). The "value of production" is not equivalent to total household income. Off-farm income earned by household members (reported by 34.9% of the overall sample in 2002) and income remittances from relatives outside the household were not considered in this analysis because farmers generally declined to accurately report the value of such an income. The sub-samples providing useful information for the financial analysis in 1991 and 2001 were constituted by 171 and 191 farmer respondents, respectively. The results were grouped by property owner type (Table 4, below).

During the study period, average VOP per household for the overall sample increased modestly in real (inflation adjusted) terms. Three observations are noteworthy. First, there was a significant variation in average VOP by farmer type. The VOP of Type 1 farmers increased by 41% over this 10-year period, while Type 2 farmers saw a 12% drop in real VOP. Type 3 farmers saw a whopping eightfold increase in VOP during the study period, to R $29,021 (US $12,349) in 2001. Only one socio-economic group (Type 2 farmers) suffered a reduction of income as predicted by both structuralist models. The majority of farmers in the sample saw their incomes increase in real terms over the study period! Second, there was a dramatic reduction in the portion of production consumed on the farm. In 1991, the (shadow-priced) value of farm production consumed by households was equivalent to R $2,843, dropping to R $825 in 2001. The decline in the proportion of total output consumed by the household also reflects the progressive integration of the post-frontier into the national market economy. As farmers gradually moved away from subsistence to cash-oriented crop production, a growing share of their consumption constituted food products purchased from local grocery stores. However, the decline in subsistence production contradicts the premise of the inter-sectoral articulationist perspective that an increasingly impoverished rural population would rely on its own production to meet subsistence needs. Finally, there was a significant shift in source of the income. In 1991, annual and perennial crop production accounted for 82% of the VOP for the sample overall, while cattle only represented 16% (Figure 2). By 2001, annuals and perennials had dropped to 32% of VOP, while cattle sales constituted 68%.

The findings of this study, contrary to the structuralist predictions, clearly indicate that for the majority of migrants to Rondônia, the frontier experience paid off with higher values of production. Farmers who were able to maintain or expand the size of their land holdings increased their VOP, consistent with one household life-cycle prediction (H12), while those who subdivided portions of their farms saw farm VOP decline. The progressive impoverishment of the peasantry predicted by both structuralist theories appears to be a more selective process closely associated with the socio-economic stratification of the rural population.

While the patterns of development predicted by both household life-cycle and the structuralist

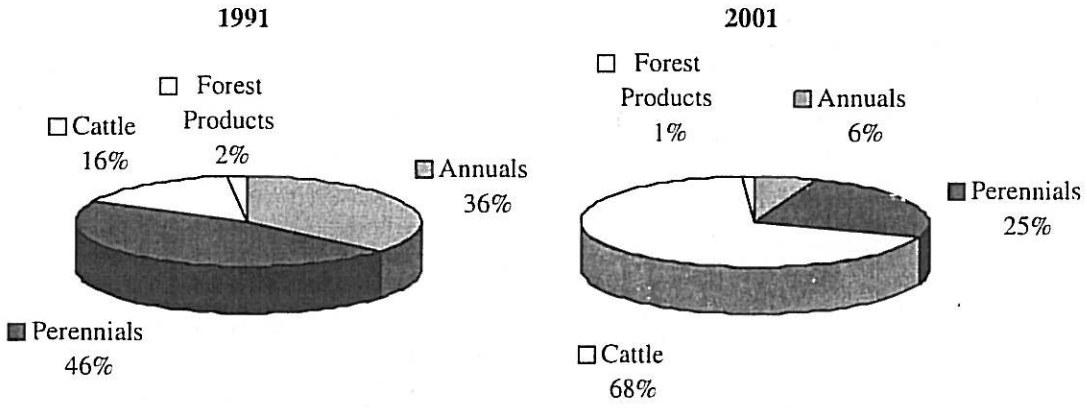

Figure 2. *Value of Production by Land-Use, 1991-2001.*

Table 5. *Distribution of property types by study site, 2002 (percent of total)*

Type/site	AP (%)	NU (%)	RM (%)	Total (number) (%)
Type 1	62	58	56	115
Type 2	34	36	25*	65
Type 3	4	5	19**	11
Total (number)	82	77	32	191

Pearson Chi-Square test significant at $p = 0.05$ for types.
Note: AP = Alto Pariaso, NU = Nova União, RM = Rolim de Moura.
* Significant at $p = 0.05$ between sites.
** Significant at $p = 0.01$ between sites.

theories are not wholly validated by the survey findings here, parts of each theory are manifest in the survey data analysis. Rather than a dominant emergent master theory, the "big picture" of frontier change patterns suggests a mosaic of local factors influencing socio-economic differentiation that is disarticulated from any single theoretical explanation. This suggestion encourages a conceptually more pluralistic framework for understanding the processes of change Amazônia and necessitates some consideration of the spatial heterogeneity of the farming population, to which we now turn.

(b) *Spatial differentiation*

While there is clearly socio-economic stratification of the rural population, there was also some degree of spatial differentiation among the three research sites. In shifting the unit of analysis from the "farmer" to the "property" and adapting the typology accordingly, we found no significant differences in the proportions of farms distributed by Types 1–3, with one exception (Table 5). Only Rolim de Moura stands out having significantly lower proportion of Type 2 properties and substantially higher percentage of Type 3 properties than the other two study sites. With these two exceptions the spatial distribution of property types is comparable among the study sites, signifying that the process of socio-economic differentiation is generalized (uniform) across Rondônia's settlement frontier. However, there are important spatial differences in certain key characteristics of this rural population that prevent us from concluding that this is a homogeneous population.

(i) *Changes in the value of production by study site (H3, and H12)*

It was observed above that only Type 2 farmers suffered a decrease in the gross real value of production (Table 4). In 1991, there was no sig-

Table 6. *Net VOP by site, 1991–2001 in Brazilian Reais ($R)*

	AP		NU		RM		Aggregated		
	Mean	*N*	Mean	*N*	Mean	*N*	Median	Mean	*N*,
Total $R 1991	5,871	72	5,423	69	7,748	30	3,976	6,019	171
	(5,706)		(7,052)		(8,262)			(6,768)	
Total $R 2001**	5,907	82	10,881	77	16,485	32	3,221	9,685	191
	(8,613)		(19,848)		(32,958)			(19,518)	
$R per hectare 1991	201	72	208	69	287	30	152	219	171
	(206)		(299)		(307)			(266)	
$R per hectare 2001**	159	80	176	76	392	30	94	204	186
	(227)		(243)		(769)			(381)	
$R *per capita* 1991	1,206	70	1,292	67	1,896	30	705	1,364	167
	(1,657)		(1,825)		(2,316)			(1,862)	
$R *per capita* 2001	1,846	57	3,317	60	3,381	23	844	2,728	140
	(4,788)		(6,476)		(4,496)			(5,548)	

*Significant at $p = 0.10$.
**Significant at $p = 0.05$.
***Significant at $p = 0.001$.
Standard Deviations in parenthesis.

nificant difference in the mean net VOP between Alto Paraiso and Nova União; only Rolim de Moura's average net VOP was significantly higher (Table 6). By 2001, however, average net VOP diverged between all three sites, ranging from $R 5,907 (Alto Paraiso) to $R 16,485 (Rolim de Moura). In terms of VOP per unit of land input (ha), productivity actually declined in both Alto Paraiso and Nova União, but increased significantly in Rolim de Moura. This financial analysis indicates a significant degree of variability in the value of production between the three study sites reflecting some spatial heterogeneity in the farming population, with one site (Rolim de Moura) standing out with its higher rate of land consolidation and higher than average VOP.

(ii) *Demographic changes by study site (H2, H6, and H9)*

All three interpretative frameworks predicted a decline in rural population over time, but for different reasons. Consistent with the applicable hypotheses, the total household population of the sample frame dropped by 38.4%, from 1,048 to 647 members. The drop was especially precipitous in Rolim de Moura (−54.6%), while the decreases in Alto Paraiso and Nova União (−33.41% and −36.25%) were roughly comparable for all age and gender classes, except for the higher growth rate of seniors in Alto Paraiso (Table 7A). The most notable demographic change occurring during the study was the drastic reduction (by −86%) of dependent children in Rolim de Moura. While dependency ratios were statistically equivalent for all three study sites in 1992, the ratio for Rolim de Moura dropped the lowest, to 0.13 (Table 7B).

The survey data clearly indicate a changing population profile as the number of children decline (from 63.4% to 17.3% of the sample population) and the population of seniors increases (from 1.8% to 3.5% of the sample population). The household life-cycle thesis predicts that the rate of depopulation would vary in direct relation to the year of initial settlement (i.e., older settlements-higher rate of depopulation). The survey findings partially confirm this prediction: in 2002, Rolim de Moura (est. 1977) had lost 54.6% of its 1992

Table 7A. *Demographic changes in rural households by study site, 1992–2002*

Characteristic	Alto Paraiso			Nova União			Rolim de Moura			Total	
Year	1992	2002	% Change	1992	2002	% Change	1992	2002	% Change	1992	2002
Total household population	452	301	−33.41	411	262	−36.25	185	84	−54.59	1,048	948
Total females (ages 15–65)	116	89	−23.28	108	81	−25.00	49	33	−32.65	273	203
Total males (ages 15–65)	151	112	−25.83	127	100	−21.26	60	35	−41.67	338	247
Total children (under 15 yrs)	179	86	−51.96	167	68	−59.28	72	10	−86.11	665	164
Total seniors (over 65 yrs)	6	14	133.33	9	13	44.44	4	6	50.00	19	33

Table 7B. *Summary of demographic changes by study site*

Characteristic	Alto Paraiso			Nova União			Rolim de Moura			Total		
Year	1992	2002	Sig.	1992	2002	Sig.	1992	2002	Sig.	1992	2002	Sig.
Mean household size (persons/household)	5.72	4.63	.011	5.41	3.97	.001	5.44	2.90	.000	5.54	4.04	.000
Dependency ratio	0.89	0.66	.069	0.91	0.56	.010	0.87	0.13	.000	0.89	0.52	.000
Mean age of household head (years)	45.7	51.8	.004	48.58	53.24	.021	46.6	50.5	.163	46.96	52.14	.000
Percent of farms with multiple households	48.1	38.4	.198	62.7	38.2	.002	23.5	17.9	.556	49.7	34.8	.001

population, the Alto Paraiso (est. 1985) population was down 33.4% and Nova União (est. 1988) saw a 36.2% drop in its 1992 population. Yet, the pattern of demographic change occurring in Rolim de Moura also resembles the "hollowing" out of the frontier predicted by the capitalist penetration thesis (H2), a quandary that will be resolved in the "Discussion" section, below.

A final observation on demographics: a significant share of the decline in population in the study sites was due not only to predictable life-cycle changes in household composition, but also to a reduction in the number of separate households residing on the same properties. Consistent with findings from other settlement fronts in Amazônia (e.g., Schmink & Wood, 1992), many of the first generation migrants to the Rondônia study sites found no available unclaimed land upon arrival and it was common for multiple households to share a single 100-ha farm plot under a variety of informal land tenure and labor sharing arrangements. In 1992, nearly one-half of the households surveyed shared the same property with other households. By 2002, this proportion dropped to 35%, as farmers gradually consolidated their property holdings. While in many instances this land consolidation might signify an "expulsion" of peasants (as predicted by capitalist penetration theory), it is not at all clear that this consolidation process was the result of capitalist penetration (H2), or other more locally specific factors.

While a depopulation process on the frontier is clearly evident in all 3 study sites, it is a demographically and geographically selective process mostly affecting children and particularly intense in the one study site (Rolim de Moura) that had undergone a more thorough incorporation into the national and global economies (Browder, 1987, 1989).

(iii) *Urbanization and household economic integration*

Several other changes in household patterns worth noting reflect the degree of market integration of the first generation of the pioneer population after 25 years on the frontier and add some texture to this comparative theoretical analysis (Table 8): for example, during the 10-year study period absentee farm property ownership increased from 11.8% to 32.2% of the sample with

Table 8. *General household characteristics, 1992 and 2002 disaggregated by municipio*

Characteristic	AP			RM			NU			Total		
Year	1992	2002	Sig.	1992	2002	Sig.	1992	2002	Sig.	1992	2002	Sig.
Sample size	79	99		34	39		76	90		189	228	
Mean farm property size	86.23	68.87	.000	84.29	72.53	.179	75.88	64.4	.036	81.74	67.73	.412
Mean number of persons/ household F1	5.72	4.63	.011	5.44	2.90	.000	5.41	3.97	.001	5.54	4.04	.004
Dependency ratio F1	0.89	0.66	.069	0.87	0.13	.000	0.91	0.56	.010	0.89	0.52	.003
Mean age of household head (years)	45.7	51.85	.004	46.59	50.49	.163	48.58	53.24	.021	47.01	52.14	.557
Wealth index	2.80	6.02	.000	3.44	6.38	.000	1.88	5.35	.000	2.56	5.83	.170
Percent of farms with multiple households	48.1	38.4	.198	23.5	17.9	.556	62.7	38.2	.002	49.5	34.8	.052
Percent of resident owner farms	91.1	67.7	.000	73.5	56.4	.128	91.9	73.0	.002	88.2	67.8	.179
Percent of farms with urban-based owner	6.3	32.3	.000	8.8	43.6	.001	5.4	27.0	.000	6.4	32.2	.179
Percent of households with members working off-farm F1	27.8	41.8	.066	14.7	25.7	.256	23.7	32.1	.241	23.8	34.9	.200
Percent of households with definitive land title	65.8	51.0	.051	53.3	74.4	.069	50.0	62.1	.124	57.2	59.4	.035
Percent of households owning more than 1 rural property	19.0	34.1	.028	18.2	40.0	.048	12.0	22.8	.079	16.0	30.7	.121
Percent of households obtaining bank credit in previous year	0	18.1	.000	5.9	20.5	.070	1.4	29.6	.000	1.6	22.9	.179
Percent of farmers with savings account	15.2	10.7	.394	26.5	11.4	.110	14.9	9.2	.287	17.1	10.3	.922

the highest rate of absentee ownership (43.6%) occurring in Rolim de Moura. Much of this shift was represented by owners moving to nearby urban areas. Indeed, the percentage of farm households whose owners resided in urban areas increased from 6.4% to 32.2%, suggesting growing functional linkages between rural and urban sectors over time. While this finding may provide partial support for the inter-sectoral articulation "cities of peasants" hypothesis (H6), in other migration research in Rondônia we found that nearly three-quarters of the urban population in this frontier area reported living in an urban center as place of either last or second-to-last residence (Browder & Godfrey, 1997, pp. 257–259). On the other hand, the increase in absentee land ownership, when combined with the pattern of land consolidation and depopulation, especially pronounced in Rolim de Moura, suggests a significant "hollowing-out" of the certain sections of frontier as predicted by the capitalist penetration thesis (H1, H2).

Further evidence of capitalist penetration and household life-cycle patterns of development was represented by the increase in percentage of households with members working off-farm, from 23.8% to nearly 34.9%. Rather than viewing these as mutually exclusive theories, a certain positive synergy between the processes they describe is more likely to be the case. As children become young adults some may remain on the farm, others leave (perhaps temporarily) to work on other farms on in the gold mines (*garimpo*), or in the urban informal sector of the frontier. All these "off-farm" activities strengthen the linkages between the rural household and the growing regional economy.

Further evidence of capitalist penetration is found in the significant increase in the percentage of households obtaining bank credit in the previous year (from 1.6% to 22.9%), although the majority (77%) did not receive any financing and only 10% held commercial savings accounts, down from 17.5% in 1992. Curiously, there was no significant change in the percentage of the sampled farmers holding definitive land titles to farms, 57.5% and 59.4%, respectively, which may reflect a high rate of property turnover (hence titles in transference) or, simply, the possibility that informal, unofficial forms of land tenure are widely recognized and enable secure property ownership over the long term. However, definitive land title ownership rates were significantly higher in Rolim de Moura than in either of the other two study sites in 2002, further indicating a greater degree of market integration in Rolim de Moura than in Nova União or Alto Paraiso. Only one of the study sites (Nova União) had a significantly higher rate of collective land tenure arrangements in 1992, but multiple household properties dropped there by 39% in 2002. In 2002, only 17.9% of the properties in the Rolim de Moura sub-sample included multiple households, indicating that rural property there had become more thoroughly privatized into single owner properties. One important indicator of the capitalist penetration thesis, and the degree of economic integration, is the rate of household borrowing from commercial lending institutions. In 1992, Rolim de Moura's residents enjoyed a significantly higher rate of bank loan use, although very small in any case (5.9%). However, by 2002 the percentage of households acquiring bank loans increased dramatically across the three study sites, with the highest rate of borrowing unexpectedly occurring in Nova União. It is important to note that farmers throughout the State of Rondônia were eligible for various government credit programs brokered through private banks, some financed by the World Bank's PLANAFLORO program. Therefore, the growth in the rate of financial participation of the rural population may not reflect capitalist penetration as much as government involvement in credit markets. In general, however, the spatial differences in these household indicators tend to indicate that Rolim de Moura more closely fits the outcomes predicted by the capitalist penetration thesis, while household life-cycle factors are more frequently indicated in the other study sites.

6. DISCUSSION

The purposes of this paper are to describe general patterns of development that have emerged in Brazil's Amazonian "post-frontier" and to offer a preliminary assessment of the validity of the predictions offered by three distinct theoretical perspectives, some now more than 30 years old. Has the frontier changed as predicted by one brand of neo-Marxist scholars toward progressive penetration of capitalism, displacing traditional forms of production, and ultimately imploding into a "hollow frontier" controlled by local oligarchs linked to national capitalist elites, and occasionally global