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The Complex Evolution of Cattle Ranching Development Amid Market Integration and Policy Shifts in the Brazilian Amazon

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This article provides an integrated analytical framework to explain the factors and trends shaping cattle ranching development in the Brazilian Amazon and its implications for deforestation. The two most important factors currently shaping cattle ranching evolution in this region are gradual market integration and the associated shifting policy contexts. Based on these two broader contextual factors, this article analyzes four main specific trends shaping the production and trade dynamics in the cattle sector. The first trend is growing investment in beef and dairy processing facilities situated closer to production zones. The second trend is gradual improvement in cattle herds and management systems alongside persistently extensive cattle ranching. The third is simultaneous fragmentation and concentration of landholdings. The fourth is widespread adoption of ranching by smallholders. These four trends are not isolated from each other; instead, they interact in complex ways to influence the dynamics of cattle expansion and associated land use outcomes. This article also discusses the complexities underlying any policy responses that aim to reduce environmental impacts of cattle ranching without hindering regional development and harming the well-being of the rural poor. This article adopts a three-step methodology that begins by formulating an analytical framework based on literature review and interview data to understand the factors shaping the development of cattle ranching, then it uses secondary data to depict the primary trends of production and trade in the cattle sector and, finally, the previous analysis is linked with observed deforestation trends. **Key Words:** *beef markets, Brazilian Amazon, cattle ranching, deforestation, land use change.*

本文提供一个综合的分析框架，来解释塑造巴西亚马逊地区养牛业的发展和其对毁林影响的因素和趋势。目前在这一地区影响养牛业演变的两个最重要的因素为渐进的市场整合和相关的变化的政策背景。在这两个更广义背景因素的基础上，本文分析了塑造牛业生产和贸易动态的四个主要的趋势。第一个趋势是对临近生产区的牛肉和乳品加工的设施的越来越多的投资。第二个趋势是对牛群和管理系统，以及持续广泛的养牛业的逐步改善的制度。第三是土地所有权的同时分散和集中。四是广泛地采用小农牧场。这四个趋势不是相互隔离的；相反，它们以复杂的方式相互作用，从而影响牛业的扩张和相关土地使用结果的动态。本文还讨论了政策反应背后的复杂性，这些政策旨在减少养牛业的环境影响，并且不阻碍区域发展和损害农村贫困人口福祉。本文采用三步走的方法，通过从制定基于文献评论和访谈资料的分析框架开始，以了解塑造养牛业发展的因素，然后使用辅助数据，描绘牛业部门的生产和贸易的主要趋势，最后，把前面的分析与观察到的毁林趋势联系起来。**关键词：**牛肉市场，巴西亚马逊河流域，养牛业，森林砍伐，土地利用变化。

Este artículo provee un marco analítico integrado para explicar los factores y tendencias que están configurando el desarrollo de la ganadería de rancho en la Amazonia brasileira, y las implicaciones que esto tiene para la deforestación. Los dos factores más importantes que en la actualidad caracterizan la evolución de la ganadería ranchera en esta región son la integración gradual del mercado y los contextos asociados de políticas cambiantes. Con base en estos dos mayores factores contextuales, este artículo analiza cuatro tendencias específicas que configuran la producción y las dinámicas del intercambio comercial en el sector ganadero. La primera tendencia es el crecimiento de la inversión en instalaciones para el procesamiento de carne y productos de lechería situadas más cerca de las zonas de producción. La segunda tendencia es el gradual mejoramiento del hato ganadero y de los sistemas de manejo junto con el persistente carácter extensivo de la ganadería ranchera. La tercera es la fragmentación y concentración simultáneas de los predios. La cuarta es la adopción generalizada del rancho por los pequeños propietarios. Estas cuatro tendencias no aparecen aisladas entre sí; en vez de eso, ellas interactúan entre sí de modos muy complicados para influir en la dinámica de la expansión del sector ganadero y los resultados asociados del uso del suelo. Este artículo discute también las complejidades que están detrás de toda política de

respuesta que se oriente a reducir los impactos ambientales de la ganadería ranchera, sin obstaculizar el desarrollo regional o sin dañar el bienestar de los pobres del campo. Este artículo adoptó una metodología de tres etapas que empiezan con la formulación de un marco analítico basado en la revisión de la literatura y datos de entrevistas, para comprender los factores que configuran el desarrollo de la ganadería ranchera; luego utiliza datos secundarios para caracterizar las tendencias primarias de la producción y el comercio en el sector ganadero, y, finalmente, el análisis anterior se enlaza con las tendencias de deforestación observadas. *Palabras clave:* mercados de carne, Amazonia brasileira, ganadería ranchera, deforestación, cambios de uso del suelo.

In the Brazilian Amazon, frontier development is inextricably linked to the evolution of cattle ranching, which continues to be the single most important factor driving landscape change in this region (Margulis 2004), despite the relatively recent expansion of soybean production (Nepstad, Stickler, and Almeida 2006). Cattle ranching induces the removal of forest for pasture, initiating land conversion processes with critical implications for economic growth, local livelihoods and biodiversity conservation, and associated impacts on local and global environmental change. As such, revisiting the role of cattle ranching in regional development in the tropics, and understanding the human–environment interactions involved, is of paramount importance (Swart, Robinson, and Cohen 2003; Walker et al. 2009). This role is becoming increasingly complex for two reasons: (1) growing competition for land for food and feed production, which places heightened pressure on forests; and (2) conservation efforts linked to options for climate change mitigation are increasing in scope and influence (Zimmerer 2006, 2011; Angelsen 2008; Wertz-Kanounnikoff and Angelsen 2009).

Understanding the factors and processes shaping cattle ranching development in the Amazon is therefore crucial for devising policy responses able to effectively manage the trade-offs between development and forest conservation. The two main factors shaping cattle ranching in the region are related to market integration and policy shifts. In turn, these broad-scale factors are shaping four main interacting specific trends: (1) the arrival of processing industries in production zones, (2) shifts in pasture and livestock management systems, (3) rapid changes in land-tenure structure, and (4) widespread adoption of ranching by smallholders.

Significant efforts have been spent, using various approaches, to explain the drivers of cattle sector expansion and their impacts on regional development and forest conservation. These include political economy perspectives (Hecht 1982, 1985), neoclassical economic views focused on cost–benefit analysis (Mattos and Uhl 1994; Arima and Uhl 1997), agronomic perspectives looking at livestock and pasture management practices (Serrão and Toledo 1992), spatial analyses

focused on the influence that biophysical factors and infrastructure have on pasture expansion and land use change (Chomitz and Thomas 2001; Mertens et al. 2002; Alves 2003), and value chain analyses of beef and dairy markets (Poccard-Chapuis 2004). Each of these perspectives, however, offers only a partial explanation for cattle expansion processes in the Brazilian Amazon.

Previous research, undertaken from the 1970s to 1990s, documented that the main factors encouraging livestock expansion and deforestation in the Amazon were associated with policy incentives and institutional rents linked to land speculation (Hecht 1993; Schneider 1993; Alston, Libecap, and Mueller 1999). Since the early 2000s, however, it has been more commonly argued that market-driven forces constitute the most important trigger for ranching development (Margulis 2004; Nepstad, Stickler, and Almeida 2006). Market forces, such as growing urban demand for beef along with more developed value chains, have marked effects on the growth of cattle herds and pasture expansion as well as on the Amazon cattle sector's gradually increasing articulation to domestic and global beef markets (Kaimowitz et al. 2004).

In addition, despite a growing body of literature acknowledging the interactions between local and regional cattle ranching dynamics on the one hand and global market changes on the other (Kaimowitz et al. 2004; Nepstad, Stickler, and Almeida 2006; Walker et al. 2009), there has been little effort to disentangle their differentiated effects on cattle production, especially those effects associated with changes in production systems, land tenure, and actor types across landscapes. Only a few researchers have adopted integrated perspectives to elucidate the multiple interactions shaping economic and landscape change (Faminow 1998; Margulis 2004).

This article builds on such integrated perspectives in two innovative ways. First, it provides an analytical framework that links policies and markets shaping cattle production dynamics with local socioeconomic conditions influencing land use change. This integrated framework, which contributes to understanding the human–environment interactions in the Amazon, is linked to the nature–society tradition in geography

(Zimmerer 2010). Second, it analyzes trends of ranching expansion in the Brazilian Legal Amazon¹ based on comparison of data from the most recent Brazilian Institute of Geography and Statistics (IBGE) agricultural census (IBGE 2006) with that of a previous census (IBGE 1996).

This article provides consistent empirical evidence showing that (1) the establishment of the beef and dairy industry in production zones has contributed to improved market value chains; (2) gradual improvements in pasture and herd management systems have led to gains in productivity; (3) large-scale landholdings have tended to decrease in size, probably to achieve more efficient production scales, while some land concentration has taken place in areas dominated by smallholders; and (4) cattle raising, for either beef or milk production, is increasingly important within small-scale farming systems. Although some of these trends have already been explored in the literature, they have been analyzed in isolation. This article offers a comprehensive analytical framework that relates each trend to the others and documents empirical evidence about their magnitudes through adopting a wide regional approach. Our main objective with this analysis is to contribute toward understanding the evolving dynamics of cattle ranching expansion in the Brazilian Amazon as influenced by economic and institutional conditions.

This article begins by describing the research methods used and assessing the advantages and shortcomings of the data analyzed. It then describes a conceptual framework that explains the drivers of landscape change in the Amazon associated with cattle ranching expansion and reviews the main theoretical views to understand their interactions and likely implications. It then presents a review of the policy frameworks and broader market conditions shaping cattle ranching development. This is followed by an analysis of the main production dynamics in cattle ranching linked to policy and market changes, with an emphasis on trends in the growth of the beef and dairy industries, pasture and herd management, fragmentation and concentration of landholdings, and changes in the adoption of cattle ranching by smallholders. Finally, it assesses the implications of these dynamics for deforestation, and offers conclusions.

Methods and Data Sources

Our analysis employs several methods and data sources. It includes a systematic literature review and

analysis of secondary statistical information from several sources, mainly data from agricultural censuses carried out by the IBGE in 1995–1996 and 2006, as well as land use change data from remote sensing analysis performed by the National Institute of Spatial Research (INPE). We interpret official statistics based on knowledge acquired during previous fieldwork, which included conducting interviews with key stakeholders at several times and locations across the Amazon. Although our fieldwork concentrated on the eastern Amazon, mainly the state of Pará, we have also conducted interviews in the states of Acre, Roraima, and Amazonas. In early 2000, we carried out a series of semistructured interviews to understand the dynamics of cattle ranching expansion in several contrasting landscapes (see Pacheco 2005) and interviewed select groups of landholders and industry managers to understand the influence of market conditions on the livestock sector in the Amazon (see Poccard-Chapuis 2004). We also participated in broader research to understand the interactions among landholder behaviors, public incentives, and institutional change (see Wood forthcoming). Additional interviews with key stakeholders were conducted in Pará in 2009. Many of the reflections on the official data from the IBGE and INPE draw on findings from these research activities, which are critical for interpreting this information on a region-wide scale, thus making it possible to provide a refined analysis of the processes and interactions explaining cattle ranching development.

The methodology adopted consists of three steps. The initial step of our research design was to formulate an analytical framework drawn from the literature review and previously mentioned interviews that accounts for three groups of issues. The first group includes the factors shaping cattle ranching expansion in the Amazon; these factors are primarily linked to policies and market forces. In the second group are the resulting processes and their interactions with regard to investments in processing facilities, production dynamics related to intensification versus extensification of cattle ranching, and changes in land tenure structures due to simultaneous fragmentation and concentration of landholdings. The third group is related to the implications of previous processes and interactions for land use change, mainly related to pasture expansion, and their effects on deforestation. We explain this analytical framework in detail in the next section, and provide an exhaustive review of its main theoretical foundations.

Our second step was to analyze secondary data from several sources to provide the main empirical evidence for our analysis of trends. We used data from FAO-STAT and from two Brazilian ministries, the Ministry of Industry and Trade (MDIC) and the Ministry of Agriculture (MAPA), to depict the main trends of production and trade in the cattle sector in Brazil. We used data from the Federal Inspection Service (Serviço de Inspeção Federal [SIF] 2011) within MAPA to identify investments in processing facilities (i.e., slaughterhouses and dairy plants) in the Brazilian Amazon. We also processed and analyzed data from the two most recent agricultural censuses conducted in Brazil by the IBGE (1996, 2006), which provide information to identify changes in cattle production systems, herd densities, land tenure, and land use at the municipal level, which is the lowest unit of aggregation on which these data are being made available.

The data from the agricultural censuses constitute the most comprehensive source of information for determining socioeconomic trends for the whole Brazilian Amazon. These data exhibit some shortcomings, however, mainly possible gaps in the agricultural census coverage, because some landholdings might not have been included, particularly holdings in remote areas. Although in theory the agricultural census constitutes a complete enumeration of all agricultural holdings, this is not necessarily true in practice. Suspected gaps are difficult to confirm. The actual coverage of the agricultural censuses is difficult to determine due to the lack of reports on this issue.

Finally, as the third step, we compare the census data from the IBGE with land use change data from the INPE, which is based on remote sensing analysis. The latter is undertaken with the aim of providing the most accurate assessments of deforestation as possible. The INPE defines deforestation as all conversion of primary forest by anthropogenic activity to other land uses (Câmara, de Morisson, and Soares 2006). The main limitation of the INPE data set is that it overestimates net deforestation; because areas classified as deforested retain that classification, the data set fails to capture forest regrowth. Furthermore, the INPE analysis is based on Landsat imagery with a resolution of 30 m; as such, the results tend to underestimate deforestation in very small plots and overestimate deforestation in areas with remaining small patches of forest. Another limitation is related to cloud cover in certain locales.

Theory: Drivers of Cattle Ranching and Landscape Change

A Conceptual Framework for Explaining Ranching Development

Figure 1 provides a simplified framework for analyzing the factors that influence cattle production and associated pasture expansion. In practice, there is tension between the factors shaping cattle development, depicted by the plus and minus signs assigned to the drivers. In the upper left of Figure 1 is a list of the main public policies that the government uses as incentives for developing the cattle sector; to the right are the variables that influence export volumes. At the center of the top panel are those factors that underpin the structure of domestic demand for beef and dairy products. Macroeconomic conditions and expanding national and external demand largely favor investments in processing (i.e., slaughterhouses and dairy plants). Growing demand from industry in turn further stimulates cattle production.

Production dynamics, derived from the growth of cattle production, occupy the second level in Figure 1. This growth can take place through either extensive or intensive systems. On the one hand, extensive systems rely on expanding the pastureland, often with a low stocking ratio (head of cattle per unit of land). On the other hand, intensive systems enhance pasture and herd management to increase production without expanding the area of pasture. These two systems tend to be interconnected. Both are linked to changes in land tenure arising from two simultaneous processes of fragmentation and concentration of landholdings.

The lower panel of Figure 1 depicts the land use dynamics driven by pasture expansion. These dynamics mainly involve the conversion of primary forest, as well as subsistence cropland or secondary forest, to pasture. Extensive systems of cattle production often lead over time to pasture degradation, prompting expansion into new pastureland to maintain production levels. In some cases, however, pasture degradation, with its implied shrinkage of economic profit, can also justify the recovery of pastureland. This recovery reinforces intensification trends and fragmentation of landholdings in a bid to improve efficiency through the adoption of better pasture and herd management techniques. In the following section, we discuss in detail the interactions that occur at these three levels.

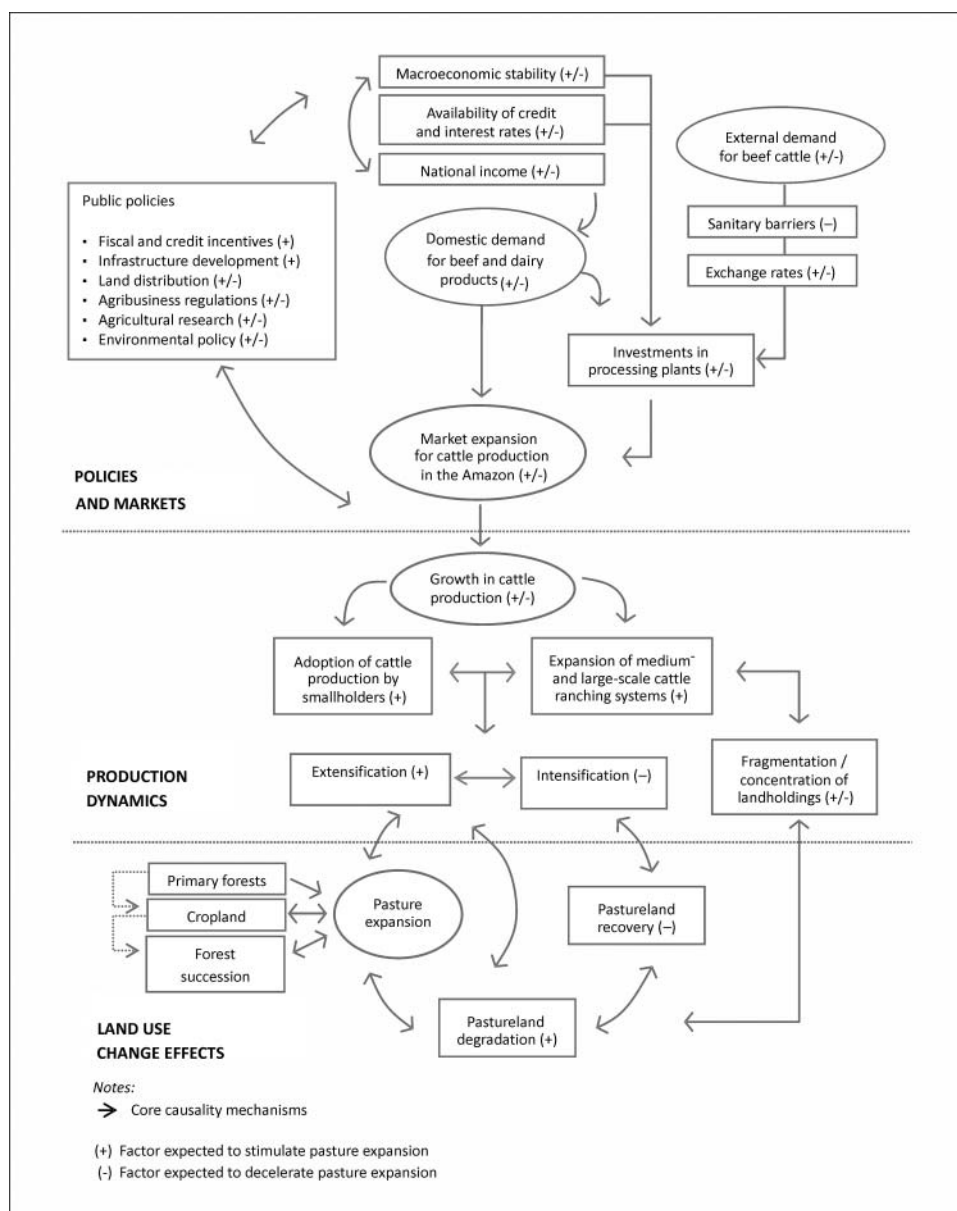


Figure 1. Simplified diagram of the causal factors driving pasture expansion in the Brazilian Amazon.

Policies and Markets That Shape Expansion of Cattle Ranching

A wide-ranging set of national policies influence, directly and indirectly, the expansion of cattle ranching in the Brazilian Amazon. These policies range from macroeconomic policies (e.g., taxes, exchange rates) to sector-oriented policies (e.g., infrastructure development, subsidized credit, commercial tariffs, land tenure distribution, environmental policy).

Macroeconomic policies have a central role in forest clearing because of their effect on macro prices, which influence the competitiveness of production in external

markets and private investment decisions (Wunder 2004). For example, policies such as real exchange rate depreciation, reduction of tariffs and trade restrictions, and lowering of agricultural export taxes lead to more competitive prices for agricultural products in external markets (Repetto and Gillis 1988; Kaimowitz and Angelsen 1998). Expansive macroeconomic policies (increasing public spending and money supply) often foster economic growth by stimulating demand for agricultural products, hence accelerating deforestation. By contrast, deflationary policies (reducing public spending and money supply) have the opposite effect, to the extent that they depress the economy and

consequently reduce people's incomes and spending on agricultural goods, thus placing less pressure on forest conversion due to agricultural expansion (Kaimowitz and Angelsen 1998). Domestic demand for beef and dairy products is determined not only by total demand as a function of people's income, but also by the proportion of total income that people want to spend on these products, which is related to their structure of consumption (Gunderson, Lusk, and Norwood 2009). Higher household income often translates into the allocation of a greater proportion of total income for beef and dairy consumption.

Macroeconomic stability also stimulates private investment because it reduces uncertainty (Bleaney 1996). Interest rates are another key variable affecting the level of investment in beef and dairy food production and processing, because low interest rates imply lower financial costs for companies (Stiglitz and Weiss 1981). Interest rates are, however, tightly linked to inflation because low interest rates might encourage the buildup of inflationary pressure, which tends to increase spending and hence expand domestic demand (Mishkin 1993). Low interest rates coupled with increasing demand for dairy and beef cattle, in either domestic or foreign markets, create a strong incentive for increasing the capacity of slaughterhouses or meat-packing plants, thus leading to increased dairy and meat supply.

The effect of sector-oriented policies is less ambiguous, as suggested by Kaimowitz and Angelsen (1998). These policies have a more direct impact on investment in agriculture or livestock and hence on land use decisions. For instance, policies aimed at subsidizing agricultural or livestock inputs or allocating financial resources with lower interest rates are likely to have a direct impact on reducing the costs of production, as are policies such as tax incentives or the artificial control of high agricultural prices. These latter policies improve the competitiveness of the cattle sector, thus stimulating pasture expansion (Brown and Pearce 1994; Contreras 1999). This expansion is most evident in the presence of specific fiscal and credit policies aimed at promoting beef cattle production (Hecht 1993). Agricultural research and technological development can lead to increases in agricultural land use, particularly when they promote innovations that are capital intensive and apply to export products (Angelsen et al. 2001).

Production Dynamics That Affect Cattle Ranching Development

Cattle ranching expansion takes place in medium- and large-scale landholdings as well as small-scale

farming systems. In tropical regions, cattle production constitutes an attractive option for landholders, even for smallholder farmers. This is due to several factors, including the extensive area needed for beef production coupled with the availability of cheap land; the low labor and supervision requirements; the easier transportability and limited risk compared with agricultural activities; the minimal use of purchased inputs; the biological and economic flexibility; low costs of production and banking services; and indirect financial benefits, such as wealth maintenance and secure cash flow (Hecht 1992; Kaimowitz 1995; Sunderlin and Rodríguez 1996; Walker, Moran, and Anselin 2000; Pacheco 2009c). In addition, cattle farming can assist producers in slowing spontaneous forest regeneration after slash-and-burn agriculture, which leaves smallholders with large areas of cleared land that is suitable only for cattle (Vosti et al. 2000).

Large-scale landholders view cattle as a financial investment and thus base their decisions on financial returns, profit margins, land value increases, eventual subsidies, and tax benefits, among other factors (Hecht 1993; Kaimowitz 1995; Faminow 1998). Ranching offers further advantages because the productivity of labor is generally higher than that in crop cultivation, the risk of product loss is low, transport and commercialization are simple, and the sale price of animals usually tracks inflation (Hecht 1993; Arima and Uhl 1997). In contexts in which returns from cattle are lower than cash crop production, ranchers might still prefer to invest in cattle ranching because of risk considerations or merely because they typically have few alternative investment options (Kaimowitz and Angelsen 2008). In addition, ranchers appear to have continued to expand pasture, encroaching onto public lands, because demonstrating the land is being used serves as a cheap and effective way of justifying land ownership, thus helping landholders to defend their land possession (Alston, Libecap, and Mueller 1999; Lele et al. 2000; Fearnside 2001).

Smallholder decisions to invest in cattle consider returns from beef and dairy production as well as integration of livestock into a diversified system of production, which allows producers to obtain more secure returns (Tourrand et al. 1995). Smallholders produce a diversified portfolio of agricultural products depending on price variations (Faminow et al. 1999). Those who are risk averse often prefer to develop dual-purpose livestock systems (milk and meat). Some producers, however, choose to specialize in milk production because the payoff from the investment in cattle is steadier and occurs much sooner, and the returns can be

higher (Faminow 1998). Usually farmers focus on milk when they have accessible, guaranteed milk markets. Income from the sale of calves has the advantage of being relatively concentrated in one period of the year, allowing investments in property, whereas milk income is better suited for covering daily domestic expenses (da Veiga et al. 2001). Smallholders who can accumulate capital prefer to invest it in livestock because it is less risky, easier to market, and requires less labor than annual crops (Kaimowitz 1995). Cattle production also serves an important function in wealth accumulation, because it helps owners endure economic shocks (Pacheco 2009c).

Different production systems can coexist in frontier areas.² Whereas some ranchers adapt their systems of production according to changing conditions, others are not in a position to adopt new technologies, particularly smallholder farmers and cattle ranchers with little access to investment capital. In most cases, adoption of improved technologies, which could include more fences, recovery of degraded pastures, and the purchase of more productive animals, leads to the development of semi-intensive systems of range fattening or specialized systems of calf production (Arima and Uhl 1997; Faminow 1998). Smallholders who adopt these livestock production technologies tend to transition from low-productivity range fattening to more profitable semi-intensive systems of dairy production (da Veiga et al. 2001).

Although no clear relationship between changes in production systems and land tenure dynamics is evident, two simultaneous trends are expected to emerge. First, growing demand for land as extensive cattle production systems expand could lead to land concentration, as documented in the 1980s in the eastern Amazon, particularly around Altamira and Marabá (Schmink and Wood 1992). Second, large-scale landholdings might become fragmented, often in areas with increasing land values, in part related to road development and greater market integration, as documented for some ranching frontiers in the early 2000 decade in southern Pará (Pacheco 2009a).

Land Use Effects of Cattle Production Expansion

Pressure to increase cattle production can induce three types of land use responses, either alone or in combination (Faminow 1998) and depending on the specific conditions: (1) the expansion of pasture ar-

reas within existing establishments or occupied lands; (2) the opening up of pasture areas in new frontiers or lands that were not previously occupied; and (3) the improvement of production in existing pasture areas through enhanced pasture and cattle herd management techniques. The first two are examples of *extensification* of production, whereas the third is an example of *intensification*.

The conventional wisdom that improvements in livestock technology will reduce pressure on forests is based on the simple assumption that if ranchers can raise the same number of cattle on less land, they will not need to convert as much forest to pasture. This position therefore holds that technologies that reduce pasture degradation will allow farmers to stop abandoning their pastures and clearing additional forest for new pasture. Kaimowitz and Angelsen (2008), however, argued that, in reality, the opposite might occur, as the effects of capital- and labor-intensive technologies depend on the timescale involved. In the short run, according to these authors, new technologies will tend to reduce deforestation as long as land managers concentrate their available capital and labor in a smaller area, obtaining higher benefits. Over time, however, higher profits will attract additional labor and capital into agricultural production, which can lead to expanded pressure on forests, thus increasing net deforestation (see Arima et al. 2011). This trend is not linear because it depends on land availability, and some land might not be suitable for agriculture and ranching due to several factors (i.e., soil composition, weather conditions, terrain structure; Schneider et al. 2000).

An additional issue is that soils in land frontier areas can be exhausted wherever nutrient mining is intense and abandoned rapidly. Hecht (1992) documented that pasture degradation is more likely to occur under extensive production systems, thus drastically reducing the pasture productivity needed to support cattle herd reproduction (note, however, that there are no reliable estimates on the extent of degraded pasture in the Amazon). To sustain production levels, cattle ranchers tend to clear forest areas to establish new pastureland, leading to further extensification of production (Schneider 1993). In other situations, economic incentives designed to encourage market development might favor the transition to more intensive systems, thus leading to pastureland recovery. Yet, additional research is required with regard to the latter trend mentioned.

Table 1. Profile of the livestock sector in Brazil for six years between 1961 and 2008

	1961	1970	1980	1990	2000	2008
Population of Brazil (thousands) ^a	72,744	95,991	121,618	149,527	174,167	192,004
Cattle (thousand head) ^b	56,041	75,447	118,971	147,102	162,600	169,876
Beef production (thousand tons) ^c	1,369	1,845	2,850	4,115	6,580	9,024
Beef exports (thousand tons) ^d	31	116	80	123	316	1,441
Milk production (thousand tons) ^c	5,227	7,353	11,956	14,933	20,380	27,579
Milk exports (thousand tons) ^e	0.0	0.0	0.5	0.1	0.1	3.9

^aCEPALSTAT (2011).^bData taken from Brazilian Institute of Geography and Statistics (IBGE) municipal livestock surveys from 1961 to 1990. Data for 2000 taken from Informa Economics FNP (2004), and data under column 2008 corresponds actually to data from year 2006 based on IBGE (2006).^cProduction and export data are taken from FAOSTAT (2011).^dIncludes cattle meat, dried meat, meat extracts, meat of beef, boneless cattle meat, and preparations of beef meat.^eIncludes butter, butter oil, fresh milk, and skim milk, all from cows.

Policy and Market Changes in the Brazilian Amazon

Evolution of Cattle Production in Brazil

Brazil holds one of the largest cattle herds in the world (FAOSTAT 2011). According to the 2006 IBGE agricultural census, the total cattle herd was about 170 million head, of which 56 million head were located in the Amazonian states³ (Table 1). Cattle herds have primarily been located in southern Brazil, an area that has experienced significant intensification of livestock production. For more than a decade, however, the cattle population in the south has stagnated, mainly because of the lack of available land. Pressures from cattle industry growth have therefore been displaced to west-central and northern Brazil. As a result, the annual rate of growth of the cattle population in the Brazilian Amazon was 4.59 percent in the 10-year period from 1995–1996 to 2006, when the agricultural censuses were conducted. By contrast, the annual rate of cattle population growth for the whole country was 1.14 percent and was negative in both the south and the southeastern states (–1.15 percent and –0.54 percent, respectively).

Policies with Implications for Cattle Ranching

Brazil's policies have undergone a gradual shift from heavy reliance on state intervention toward liberalization. After a period of economic expansion in the 1970s, the economy experienced an acute crisis in the 1980s that triggered macroeconomic instability until the mid-1990s. This was partially reversed after the second half of the 1990s and, currently, the country's macroeconomic indicators are relatively stable. During this period, several policies targeted the Amazon region.

The most relevant are credit incentives, land policies, livestock-related policies, and conservation and land use policies, as overviewed next.

The fiscal and credit incentive policies encouraging cattle ranching expansion to the detriment of forests in the Brazilian Amazon have been widely documented (Hecht 1985; Browder 1988; Binswanger 1991). There are no complete historical records about the money allocated through fiscal incentives. Available estimates indicate that the livestock sector in the Amazon received in total US\$5.1 billion (in 1990 US\$), including fiscal incentives and subsidized credit, from 1971 to 1987, an average of US\$300 million per year⁴ (Schneider 1995). Subsidized credit for pasture implementation was removed in the late 1980s, but credit supply has remained important in supporting livestock production in the Brazilian Amazon (Lele et al. 2000; Kaimowitz 2002). By the end of the 1990s, credit was also oriented toward supporting smallholders. Arima, Barreto, and Brito (2005) noted that from 1989 to 2002, the Amazon Bank (BASA) allocated US\$2.4 billion for cattle production in the northern regions (excluding Mato Grosso and Maranhão).⁵ According to Pacheco (2002), the total amount of credit targeted to the northern states from public sources in the period from 1998 to 2001 was about US\$92 million (in 2001 US\$).

In the past, land policies favored a bimodal distribution of land, which benefited both smallholders and corporate ranches (land policies have been explored elsewhere; see Binswanger 1991; Alston, Libecap, and Mueller 2000; Fearnside 2001). In the period from 1970 to 1984, the state differentiated between public and private lands, and it legally registered public lands in the name of the federal government to identify public lands for colonization programs. After 1985, the government placed greater emphasis on expropriation and

redistribution of private lands when landholdings did not serve a social or economic function rather than on the allocation of public lands to settlers (Fearnside 2001). The expropriation of landholdings has proceeded slowly, however, despite the implementation of a National Plan of Agrarian Reform (PNRA), and it has depended on the initiative of social movements (Simmons et al. 2010).

It was not until 1993, however, that the government made agrarian reform a priority with the passing of Law No. 8629. The Cardoso government established ambitious goals for agrarian reform and made some progress in expropriating and allocating land to settlements sponsored by the National Institute of Colonization and Agrarian Reform (INCRA). Cardoso's administration settled 90,000 families per year between 1995 and 2002, much more than the average of about 7,200 families per year settled between 1964 and 1994 (INCRA 2002, 2007). The Lula administration continued to implement agrarian reform but amid much criticism of its achievements (Domingos 2003). Pacheco (2009b) provided a more detailed assessment of progress in implementing agrarian reform policies in the Brazilian Amazon.

The most contentious issue regarding land use policies is the legal obligation for rural landholders to maintain legal forest reserves within forestlands occupied by agricultural establishments. This mechanism was adopted in the 1934 Forest Code, which stipulated that one fourth of each property's forest area had to be conserved. Under the 1965 version of the Forest Code, half the area of each property in the northern region could be converted to agricultural uses, with the other half to be maintained as legal forest reserve. By comparison, the proportion of legal reserve in other regions of the country (which included some *cerrado* areas) was set at 20 percent. In 1996, the proportion of legal forest reserves was set to be not less than 80 percent of an establishment's total area, allowing for forest conversion in the remaining 20 percent. In 1998, regulations allowed landholders to maintain a legal forest reserve in areas outside of their establishments but with the same ecological relevance. These regulations also reduced the proportion for the *cerrado* areas in the northern region to 20 percent (Oliveira 2000).

Some current legislation indicates that legal reserves, such as in the state of Pará, could be reduced to 50 percent with respect to the total landholding size but only on those lands that have been classified in the state's Land Use Zoning Plan as lands for agricultural consolidation and expansion.⁶ In May 2011, the Brazil-

ian House of Representatives approved a new version of the Forest Code, which at the time of writing was awaiting consideration by the Senate. The main relevant points of this version are that it condones illegal deforestation carried out before July 2008 and allows for agricultural uses in protected areas on private property that are already occupied (Câmara dos Deputados 2011). Assessing the impacts of the new Forest Code, if approved, is beyond the scope of this article (see Instituto de Pesquisa Economica Aplicada 2011).

The government recently issued some regulations for the cattle sector linked to compliance with environmental regulations. The most important was Presidential Decree No. 7029, issued in December 2009, which establishes a program for the environmental regularization of rural landholdings (*Programa Mais Ambiente*) to encourage landholders to comply with environmental laws by maintaining or restoring permanent preservation forests and the forested legal reserve. As part of the program, the government environmental agency has developed Terms of Accession and Commitment (TAC). Landholders who subscribe to a TAC are registered in the Rural Environmental Cadastre (CAR) and, from the date of subscription, are immune from sanctions for destroying or damaging forests or natural vegetation. The Federal Public Prosecutor's Office is supporting a program with the beef industry to certify "legal beef" bought from landholders with a signed TAC.⁷

Also associated with livestock-related regulations are the programs for the eradication of foot and mouth disease (FMD), which date from 1965 in southern Brazil. International cooperation supported other such programs in the 1980s, but it was not until 1992 that the government implemented a program aimed at eradicating this disease from the entire country. In 1995, this state-run program was consolidated in partnership with the private sector and in the mid-1990s, these national programs began to be implemented in the Amazon region. Such programs involve delimitation of livestock circuits, which impedes herd transportation from FMD-infected zones to disease-free zones and forbids the exchange of animals (except for deboned meat, which is permitted to cross the zone boundaries). In 2001, all of the southern states including Mato Grosso and Tocantins were declared FMD-free zones. Rondônia was included as an FMD-free zone in 2003, Acre in 2005, and the south-central region of the state of Pará in 2007 (Programa Erradicação e Prevenção da Febre Aftosa 2009).

In addition, the federal government has introduced measures to improve the efficiency of monitoring

systems of slaughterhouses and meat-packing plants. In 1989, some monitoring functions were transferred to state and municipal governments, with the federal government retaining oversight of large slaughterhouses. The standards in the municipal systems of control are lower than in the state and federal systems. In 1996, a ministerial decree established standards for beef cattle commercialization in terms of temperature, packing, and labeling, forcing the expansion of the refrigerated beef supply. Furthermore, in 1998, another decree standardized sanitary regulations for the livestock sector across the entire country, thus requiring all slaughterhouses and meat-packing plants, independent of their processing capacity, to comply with the same sanitary rules. These regulations have largely favored large-scale beef companies (Poccard-Chapuis et al. 2001; Poccard-Chapuis 2004).

Market Development for Dairy and Beef Cattle

Demand for beef and dairy products is mainly determined by the size of the Brazilian population and its income levels. Domestic demand tends to increase in correlation with population growth; thus, any policy designed to improve people's income levels will also likely increase domestic meat consumption. The livestock sector in Brazil has traditionally been a nontraded sector because production has largely been driven by domestic demand. Hence, production and prices of beef and dairy products have primarily been determined by fluctuations in demand within the Brazilian market. Nonetheless, as exports become more important over time, it is likely that international prices will increasingly influence production.

In Brazil, domestic demand for beef and dairy products has tracked closely with population growth (from 73 million people in 1961 to 192 million in 2008), although in the last few years of this period, the annual rate of beef consumption grew faster than the population growth rate. This means that domestic consumption of cattle products has expanded not only because of an inertial expansion of the internal market but also, and importantly, because people have been increasing their consumption of beef and dairy products. Per capita beef consumption rates increased from 17 kg per year in 1961 to 37 kg per year in 2007, with corresponding rates for milk growing from 53 to 119 liters per year in the same period (FAOSTAT 2011).

The dynamics of beef production in the late 1980s mirrored the deteriorating macroeconomic conditions. Overall, this period saw a decline in people's purchas-

ing power, which in turn led to a decrease in domestic demand. Slaughter rates were relatively low from the late 1980s to early 1990s. Economic stabilization following the Plano Real (1994) led to the recovery of the Brazilian beef industry, in part because of increasing domestic demand, as reflected in the slight growth in per capita consumption from 1995 to 1997. Meat production in this period depended on the expansion of the domestic market, which exceeded 6 million tons (Informa Economics FNP 2004). The economic stabilization had a contradictory influence on the dairy sector. It expanded the domestic demand but also reduced the cost of importing dairy products; thus, producers had to compete with dairy imports in a context of low prices (Primo 2000). Macroeconomic conditions influence external demand primarily through exchange rates, which have influenced exports in Brazil to varying degrees over time. The first increase in beef exports occurred during the early 1980s, when the government stimulated exports and applied a system of minidevaluations to tackle the economic crisis. After a short cycle of expanding beef exports in the early 1990s, exports skyrocketed at the end of the 1990s, following the drastic devaluation of the Brazilian currency (real) in 1999 (Kaimowitz et al. 2004). The same exchange rates led to a severe reduction in milk imports because of the high cost of importing dairy products.

Meat exports in the late 1990s exceeded the peak of 1985, but the volume did not near 1 million tons until 2003. This boom in meat exports was linked primarily to the devaluation of the Brazilian real against the U.S. dollar. Under the reforms of the early 1990s, the real was closely linked to the U.S. dollar. A rapidly strengthening U.S. dollar resulted in inflated real-priced commodities in international markets. In January 1999, the Brazil government delinked the real from the U.S. dollar and allowed it to float freely. As a consequence, the real depreciated against the strengthening dollar (Schnepf, Dohlman, and Bolling 2001), which made Brazilian exports more competitive in the world market. The Brazilian real has tended to appreciate since the second half of the 2000s, yet this trend did not affect the competitiveness of the Brazilian beef industry. Only since 2008 have beef exports begun to show a declining trend, associated with contracting foreign demand due to the global financial crisis and growing domestic demand in a context of declining beef production (Gonçalves 2008). Furthermore, some major importers of Brazilian beef (e.g., the European Union, Russia) have begun to impose trade conditions on beef imports originating from Brazil with effects on export

dynamics (Instituto de Estudos Econômicos Sociais e Políticos [IDESP] 2010).

The sanitary barriers that many countries have imposed on beef imports are designed to limit imports from countries with prevailing animal diseases, particularly FMD. Historically, these barriers limited beef exports from Brazil, but the country's FMD-free area has been gradually expanding from south to west-central Brazil, including the most important production zones in the Brazilian Amazon, mainly in Mato Grosso and the south of Pará.⁸ Currently, fresh or chilled and frozen beef originating from FMD-free areas accounts for approximately three fourths of Brazilian exports. Maintaining this condition is a challenge for the Brazilian sanitary system because of outbreaks, such as that in 2005.

The Brazilian Amazon states contribute little to Brazil's beef exports, although that contribution is increasing slowly, mainly from the states of Mato Grosso, Pará, and Tocantins. The Amazonian states combined contributed 5.6 percent of total exports in 2000, which increased to 15.4 percent in 2006, based on our own estimates drawing on MDIC data. A larger share of national exports originates in southeast and west-central Brazil. The contribution from the Amazonian states is expected to expand in the future because of increasing investments in meat-packing plants and slaughterhouses, efforts to eradicate FMD, and the likelihood that this region will offer more competitive international freight fares from its northern ports. Kaimowitz et al. (2004) argued that the export of higher quality Brazilian beef from the southern states creates a gap in the domestic market, mainly in the southern states, which is filled by beef from the Amazon. This interaction between domestic and export beef markets has been described as the "hamburger connection in the Amazon" (see Kaimowitz et al. 2004, 2), but this trend is expected to wane as more beef is exported directly from the Amazon.

In addition, the three largest supermarket chains operating in southern Brazil's main cities (Wal-Mart, Carrefour, and Pão de Açúcar) agreed in 2009 to suspend contracts with suppliers found to be involved in Amazon deforestation. This came as a result of environmental campaigns to prevent beef markets from driving illegal deforestation in the Amazon.⁹ The latter decision has been linked with the Amazon states' express policies that only cattle ranchers proven to be complying with environmental laws can sell their products to the beef industry. In this regard, in the states of Mato Grosso and Pará, beef companies signed an agreement with the Federal Public Prosecutor's Office stating

that only landholders that have signed a TAC and are registered in the CAR can supply beef to industry. The main norms pertaining to environmental regularization were discussed earlier in the section on policies.

Trends in Investments, Production Systems, and Tenure Changes

Investments and Development in the Cattle Industry

The dramatic growth in Brazil's cattle population has been accompanied by a significant expansion of the cattle industry during the past two decades. The federal government has certified 300 slaughterhouses across the country, and states and municipalities have certified 1,500 small-scale abattoirs (Franco 2004). Most of Brazil's cattle industry is located in the southeast and west-central regions of the country (Instituto Euvaldo Lodi [IEL]/Confederação Nacional da Agricultura [CNA]/Serviço Brasileiro de Apoio às Micro e Pequenas Empresas [SEBRAE] 2000). Thirty-five of the ninety-one slaughterhouses in the Brazilian Amazon were established in the 1990s, with a further thirty-eight slaughterhouses set up in the 2000s (Table 2). Hence, the Amazon's meat-processing capacity has expanded enormously since the 1990s, matching the increase in cattle population.

A two-way interaction exists between the increase in processing capacity and cattle sector expansion. On

Table 2. Number of slaughterhouses and dairy processing plants in the Brazilian Amazon states by industrial capacity and year established

	Year established				
Industrial capacity	Until 1980	1981–1990	1991–2000	2001–2008	Total
Slaughterhouses (capacity in cattle/hour)					
< 20	0	3	5	7	15
20–40	0	5	13	18	36
41–80	1	5	10	10	26
> 80	3	1	7	3	14
Total	4	14	35	38	91
Dairy plants (capacity in thousands of liters)					
< 5	0	4	54	9	67
5–10	0	1	17	19	37
11–50	2	1	14	15	32
>50	0	0	3	2	5
Total	2	6	88	45	141

Note: Data adapted by the authors based on data from the Federal Inspection Service (SIF) and Ministry of Agriculture (MAPA).

the one hand, slaughterhouses are set up in areas with a relatively sizable local supply of beef cattle and, on the other hand, landholder investors are attracted to areas with processing capacities already in place and a secure local demand for live cattle. There has been little study of this interplay in the Amazon, although Mertens et al. (2002) documented some of these interactions in São Felix de Xingu, Pará. In this vein, Pocard-Chapuis et al. (2005) suggested that this interaction has led to an increase in the competitiveness of cattle raising in the Amazon and the attractiveness of the Amazon for bovine production.

With changes in beef supply from live cattle to packed meat enabling industrial producers to reach more distant markets, some of the largest Brazilian beef industries have begun to play a significant role in the expansion of the Amazon's meat-processing capacity. Nine groups in the beef sector in Brazil, taken together, own about 40 percent of the slaughterhouses established in the region (Smeraldi and May 2009).¹⁰ Pocard-Chapuis (2004) identified three types of meat commercialization circuits: meat supply to local markets, meat supply to meet demand from proximate urban centers, and circuits that supply beef to more distant markets, often located in other states of Brazil. A large proportion of the meat produced in the Brazilian Amazon reaches markets in the main cities in the northeast states, and much of the Mato Grosso production is sold in Brazil's southern cities (Arima, Barreto, and Brito 2005). As mentioned, although a small proportion of meat is exported directly from the slaughterhouses in the Amazon states, this trend will reverse to the extent that FMD is controlled in the production zones in the Amazon and the road network improves. Industrial producers might benefit from lower transportation costs to the Atlantic seaports. Exports of live cattle, originating in Pará, to Venezuela, Egypt, and Lebanon began in 2005, although this relatively recent trend accounts for only a small fraction of total beef exports and it is not clear whether it will continue into the future (IDESP 2010).¹¹

The situation for investments in milk production is slightly different. Brazil has 828 dairy-processing plants, most of which are small and heavily concentrated in urban centers in the country's southeast. Since the Plano Real, a process of concentration has been underway in the dairy sector (Jank, Farina, and Galan 1999). In this context, the Amazon region emerged as a reserve for potential milk producers seeking to grow their operations, some of which were companies with headquarters in southern Brazil aiming to expand their operations across

the country (da Veiga et al. 2001). From 1990 to 2008, more than 100 new plants were installed in the Amazon region, mostly of low processing capacity and mainly in the states of Mato Grosso, Pará, and Rondônia, following the expansion of their main urban centers (Table 2). The expansion of a network of dairy-processing plants close to production areas in Rondônia and southern Pará, similar to the trends noted for the beef industry, has allowed industrial milk producers to reach distant markets, particularly in the northeast (Pocard-Chapuis et al. 2003).

Improvements in Cattle Herds and Management Systems

The growth in cattle herds in the Brazilian Amazon has been explosive, particularly since the mid-1970s: The cattle population in the northern states was about three times larger in the late 1980s than in the mid-1970s, and it had doubled again by the early 2000s. In absolute numbers, the cattle population in the Amazon reached 35 million head in 1995–1996 and nearly 56 million head in 2006 (Table 3). Furthermore, the proportion of cattle in the Brazilian Amazon relative to the cattle herds in Brazil grew from 23 percent in 1995–1996 to 33 percent in 2006. Growth was particularly significant in southern Pará, around the Trans-Amazon highway in Pará, in northwest Mato Grosso, and in Rondônia (Figure 2). Overall, the cattle population on the margins of the Amazon region has decreased; this could be associated with agricultural expansion that tends to make use of degraded pastures, the analysis of which is beyond the scope of this article.

According to IBGE data, cattle raising has gradually intensified in the Brazilian Amazon, particularly in older frontier areas better connected to infrastructure. Although the increase in the cattle herd is partly due to the expansion of cultivated pastures at the expense of forestland, a larger part is the result of cattle intensification. The stocking ratio (the number of head per hectare of pasture) in the region grew from 0.7 in 1995–1996 to 1.0 in 2006 (Table 3), a trend observed across Brazil as a whole. Nevertheless, the extent of pasture grew from 50.4 million ha to 53.4 million ha during the same period. Without the increase in stocking ratios, an additional 20 million ha of pasture would have been needed to raise the same number of cattle. Stocking ratio trends are shown in Figure 3.

Several parameters have been used to describe and compare cattle production systems. Table 4 summarizes fifteen herd parameters presented by Faminow (1998),

Table 3. Comparison of growth in cattle production and pasture by landholding size in the Brazilian Legal Amazon, between 1995–1996 and 2006

Landholding size (ha)	Number of landholdings (thousands)	Average size (ha)	Pasture (thousand ha)	Head of cattle (thousands)	Stocking ratio (head/ha)
1995–1996					
< 50	534	11.4	1,645	2,866	1.7
50–100	109	65.6	2,502	2,946	1.2
101–500	112	182.4	9,288	8,509	0.9
501–1,000	15	674.4	5,239	3,811	0.7
> 1,000	18	4,190.3	31,796	16,986	0.5
Total	788	150.1	50,469	35,117	0.7
2006					
< 50	451	14.8	3,472	6,325	1.8
50–100	121	65.6	4,082	5,796	1.4
101–500	109	189.0	11,322	14,060	1.2
501–1,000	15	659.9	5,550	5,984	1.1
> 1,000	18	3,372.5	29,016	23,277	0.8
Landless	77	—	—	108	—
Total	792	134.7	53,443	55,550	1.0
Growth in% (1995/1996–2006)	0.1	(1.1)	0.6	4.6	4.0

Note: Elaborated by authors based on data in agricultural censuses conducted in 1995–1996 and 2006 by the Brazilian Institute of Geography and Statistics (IBGE 1996, 2006). The IBGE collected data for 760 municipalities in the states of Acre, Amapa, Mato Grosso, Pará, Rondônia, Roraima, Maranhão, and Tocantins.

Table 4. Comparison of Amazon beef herd production parameters

Herd parameters	Mattos and Uhl (1994), eastern Pará, 1990–1991 ^a	Faminow et al. (1999), Rondônia and Acre ^b	Expert estimate, EMBRAPA, typical Pará, 1997 ^c	Expert estimate, EMBRAPA, high Pará, 1997 ^c	Authors' estimates, Trans-Amazon, Pará (2002) ^d	Authors' estimates, southern Pará (2003) ^d
Calving rate	70%	72–80%	50–70%	> 90%	80–90%	80–90%
Calf mortality	8%	5–20%	> 10%	1%	3–5%	3–5%
Adult mortality	1–3%	3–4%	5%	< 1%	1–2%	1%
Culling rate, bulls	20%	20–25%	20%	25–30%	—	—
Culling rate, cows	10%	0–12.5%	< 10%	25%	13–22%	15–20%
Culling rate, heifers	—	—	0–15%	25%	—	—
Bull:cow ratio	1:20	1:30	1:30	Use AI	1:30–50	1:30–50/use AI
Age of first conception	24–36 months	30–40 months	26–27 months	16 months	16–24 months	16 months
Age of cows culled	10 years	10 years	8–10 years	6 years	6–8 years	6 years
Weaning age	—	8–12 months	—	—	—	8 months
Slaughter age	3 years	—	—	—	3 years	2.5–3 years
Weight at slaughter	478 kg	—	—	—	470–500 kg	510–520 kg
Stocking rate	< 0.5–0.6 AU ha ⁻¹	0.8–2.0 AU ha ⁻¹	< 1 AU ha ⁻¹	> 1 AU ha ⁻¹	0.8–1.3 AU ha ⁻¹	0.4–1.3 AU ha ⁻¹
Mean pasture life	5–10 years	8–15 years	—	—	—	15 years
Mineral supplementation	Yes	Yes	—	—	Yes	Yes

Note: All data are taken from Faminow (1998) unless otherwise indicated. EMBRAPA = Empresa Brasileira de Pesquisa Agropecuária; AI = artificial insemination; AU = animal unit.

^aData from Mattos and Uhl (1994) are based on a survey carried out in Paragominas, although some parameters are drawn from secondary sources.

^bData collected in interviews and focus groups at several sites in Rondônia and Acre.

^cEstimates are taken from interviews with cattle production experts at stations at EMBRAPA. These expert assessments include both a typical situation for cattle ranching and estimates for high herd production, reflecting ranches with above-average performance indicators.

^dBased on author surveys of cattle ranchers and interviews with key informants in 2002 and 2003.

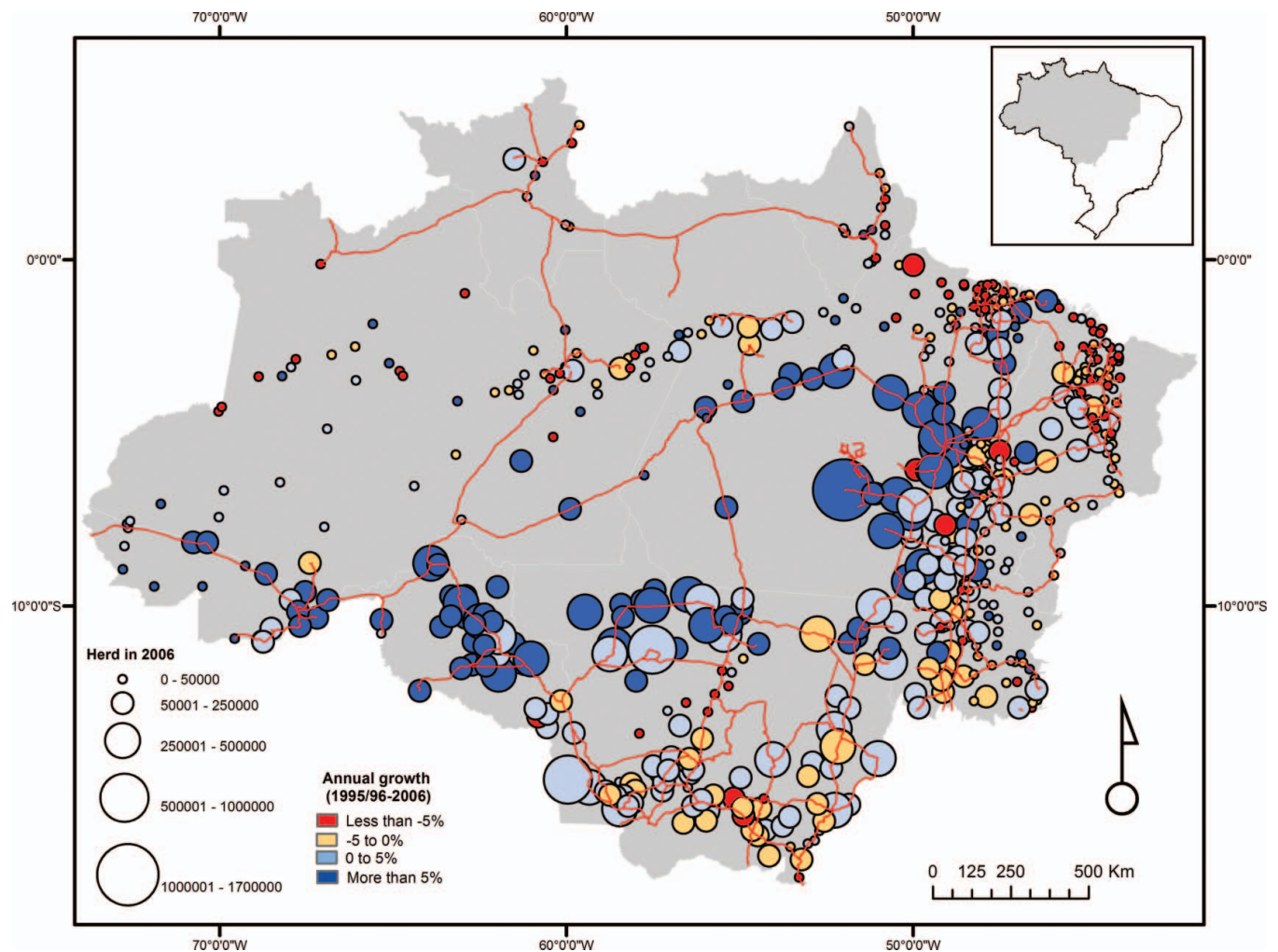


Figure 2. Cattle population by municipality in the Brazilian Legal Amazon. Authors' elaboration based on data from agricultural censuses conducted in 1995–1996 and 2006 by the Brazilian Institute of Geography and Statistics (IBGE 1996, 2006). (Color figure available online.)

corresponding to the early and mid-1990s, and compares them with information gathered in the field in 2002 and 2003. Despite the difficulties arising from comparing data collected in different locations, these data provide relevant indicators showing that most herd parameters in the Amazon have improved in recent years. It is noteworthy that these indicators relate to cattle herd management practiced chiefly by medium- and large-scale cattle ranchers and not necessarily by smallholders.

A first glance suggests improvements in pasture and cattle herd management in the Amazon, at least in areas with longer occupation, which now constitute the most consolidated frontiers. The cattle sector has not been operating in a technological vacuum. Planting of improved pasture grasses and adoption of better management techniques have resulted in higher stocking

ratios. Increasing concern with productivity has led to the adoption of improved breeds and attention to the genetic quality of the herd. The fact that cattle ranching has often been adapted to local environmental conditions contradicts the argument by Schneider and colleagues (2000) that rainfall and humidity could work as barriers to livestock expansion.

Most herd parameters provided for the early and mid-1990s in Table 4 show close agreement. Likewise, most data provided for high herd production are much closer to the situation typical in early 2000. This suggests that most indicators show improvement: increased calving rates, reduced mortality rates, reduction of the age of first conception or improvement in the precocity of cows' first conception, younger weaning age, and reduced slaughter age of calves with a higher weight. Pasture productivity, which can be

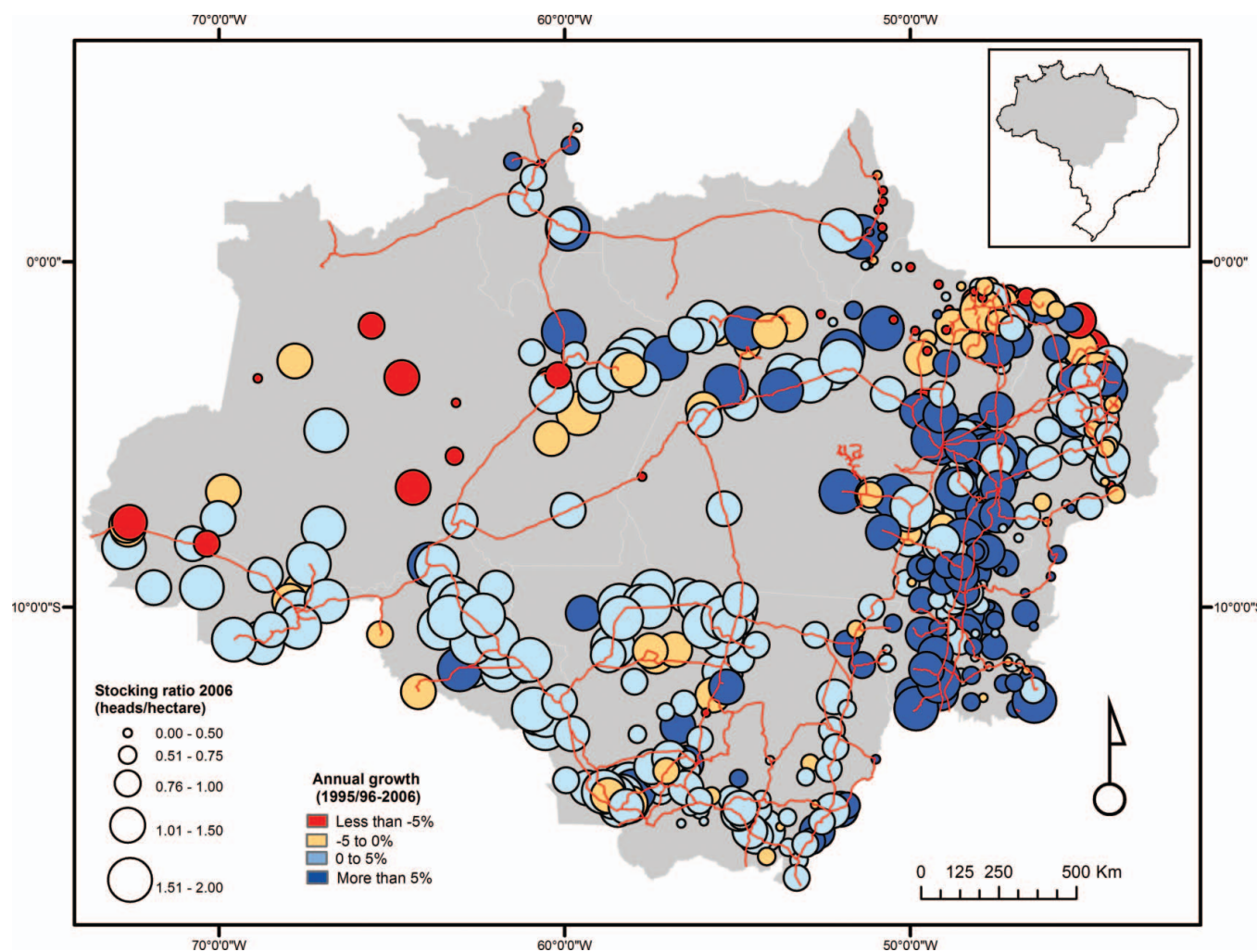


Figure 3. Cattle stocking ratio (head/ha) by municipality in the Brazilian Legal Amazon. Authors' elaboration based on data from agricultural censuses conducted in 1995–1996 and 2006 by the Brazilian Institute of Geography and Statistics (IBGE 1996, 2006). (Color figure available online.)

estimated indirectly using the stocking ratio, shows high variability, although the data in Table 4 suggest that it has improved over time. Furthermore, pasture life and productivity continue for longer than in the past because of more careful pasture management practices. In recent years, however, a fungus that affects *Bracharia* pasture grasses has spread, and many landholders have had to resow their pasture areas.

Cost–benefit analyses of cattle ranching in recent years suggest that it has become more profitable, depending on the system type. The different estimates of cattle ranching profitability are not directly comparable because the various sources make different assumptions. In the 1990s, Mattos and Uhl (1994) and Arima and Uhl (1997) estimated relative internal rates of return (IRR) for cattle ranching in self-reproducing herds and calf production, which ranged from 3 to

5 percent, except for range-fattening ranches, for which the IRRs were on the order of 7 to 8 percent. Neither of these estimates accounted for increases in land prices. Margulis (2004), drawing on data taken from Camargo et al. (2002), estimated a relatively high IRR of 9 to 14 percent, also disregarding land prices. Pacheco (2005), drawing on estimates from a diverse range of cattle ranching systems in Uruará and Redenção (i.e., self-reproducing herds, calf production, and range fattening), estimated the IRR in a range of 2.5 to 9.7 percent, without considering increments in land prices, suggesting a wide range of situations in which modernized cattle ranching is much more profitable than traditional ranching systems. Issues of scale also matter. Barreto and Silva (2009), based on information from ANUALPEC (Anuário da Pecuária Brasileira [Yearbook of the Livestock Sector in Brazil];

see also Informa Economics FNP [2004]) for 2002 through 2008, suggested that large-scale cattle ranching operations (with about 5,000 head) tend to obtain greater benefits than operations without economies of scale (those with no more than 500 head).

Two Simultaneous Processes of Land Tenure Change

Land distribution in the Brazilian Amazon is skewed: Most landholders own a small portion of the land and most land is owned by a few large-scale landholders. According to the 1995–1996 IBGE agricultural census, 81.2 percent of the total number of agricultural establishments are smallholdings of less than 100 ha. These smallholders account for only 11.2 percent of total land in landholdings. By contrast, 2.3 percent of the total number of establishments larger than 1,000 ha accounted for 63.2 percent of all land. In the past decade, however, this situation has changed slightly. According to the most recent IBGE agricultural census, the same classification of large-scale landholders controlled just 57.5 percent of all land in 2006. Although the average size of small-scale landholdings has not changed significantly, the average size of medium-scale landholdings is increasing slowly and that of large-scale landholdings has shrunk (Table 3). The latter results from two land tenure changes taking place in the region. The first is related to fragmentation of large-scale landholdings in areas with previously notable land concentration for extensive cattle ranching. The second is land concentration that is linked to persistent encroachment of public lands in remote areas, although it is also evident in already consolidated frontiers with greater presence of smallholders (Figure 4).

These tenure changes have been documented at the local scale in some locations in the Amazon region (Browder, Pedlowski, and Summers 2004; Pacheco 2005; Aldrich et al. 2006). Fragmentation of large-scale landholdings is evident to the extent that these landholdings are becoming smaller over time, which is associated with the previously mentioned trend toward intensification. The latter is also partly due to increasing land values, which tend to be higher in the more consolidated frontiers closer to roads, particularly in eastern and west-central Mato Grosso and southern Pará. Land fragmentation mostly takes place through transactions in the land market, which is relatively vigorous. As suggested by Pacheco (2009a) in assessing the development of cattle ranching in southern Pará, the fragmentation of landholdings is largely associated with more developed markets for beef production,

which tend to stimulate improvements in pasture productivity as a way of increasing profits from beef production. This leads to increased land values, thus fostering the fragmentation of large-scale landholdings.

Many farmers operating at a large and extensive scale do not have enough capital to make improvements in pasture maintenance because of agronomic pasture degradation processes and are thus prevented from competing in a market that demands higher quality and productivity. Many large-scale landholders built and maintained extensive properties as a form of financial saving activity and to build a heritage, rather than as a means of creating an economically efficient business (Hecht 1993). Nowadays, in a context of increasing land values, selling part of the land tends to be a solution for reforming the pasture and improving productivity. Intergenerational transmission can promote land fragmentation between heirs and could provide rents to finance nonagricultural projects. Additional research is required for more in-depth understanding of this dynamic.

In some cases, fragmentation of large-scale landholdings results in the encroachment of large-scale landholdings by landless people as a way to put pressure to the federal agrarian reform agency (INCRA) for the creation of agrarian reform settlements. This process has been analyzed in some detail elsewhere (see Pacheco 2009b; Simmons et al. 2010).

With regard to land concentration, large-scale landholders are concentrating land in more remote areas such as in northeast and central Mato Grosso, along the BR-163 highway in Pará, and in the eastern part of the state of Amazonas. This is likely the result of persistent land speculation aimed at reaping profits from expected increases in land prices (Carrero and Fearnside 2011). Assessing the rationales behind land speculation is beyond the scope of this article; for an analysis, see Alston, Libecap, and Mueller (1999). A different process of land concentration takes place when better-off farmers purchase additional tracts of land to expand cattle production in locales where small-scale agriculture has been consolidated and ranching is widely adopted as a source of income (Pacheco 2005; Aldrich 2006). The latter process is evident along the Trans-Amazon highway and in the eastern part of Maranhão (Figure 4).

Increased Adoption of Cattle Production in Small-Scale Farming Systems

Small-scale farming systems in the Amazon are increasingly adopting cattle ranching, a trend related to

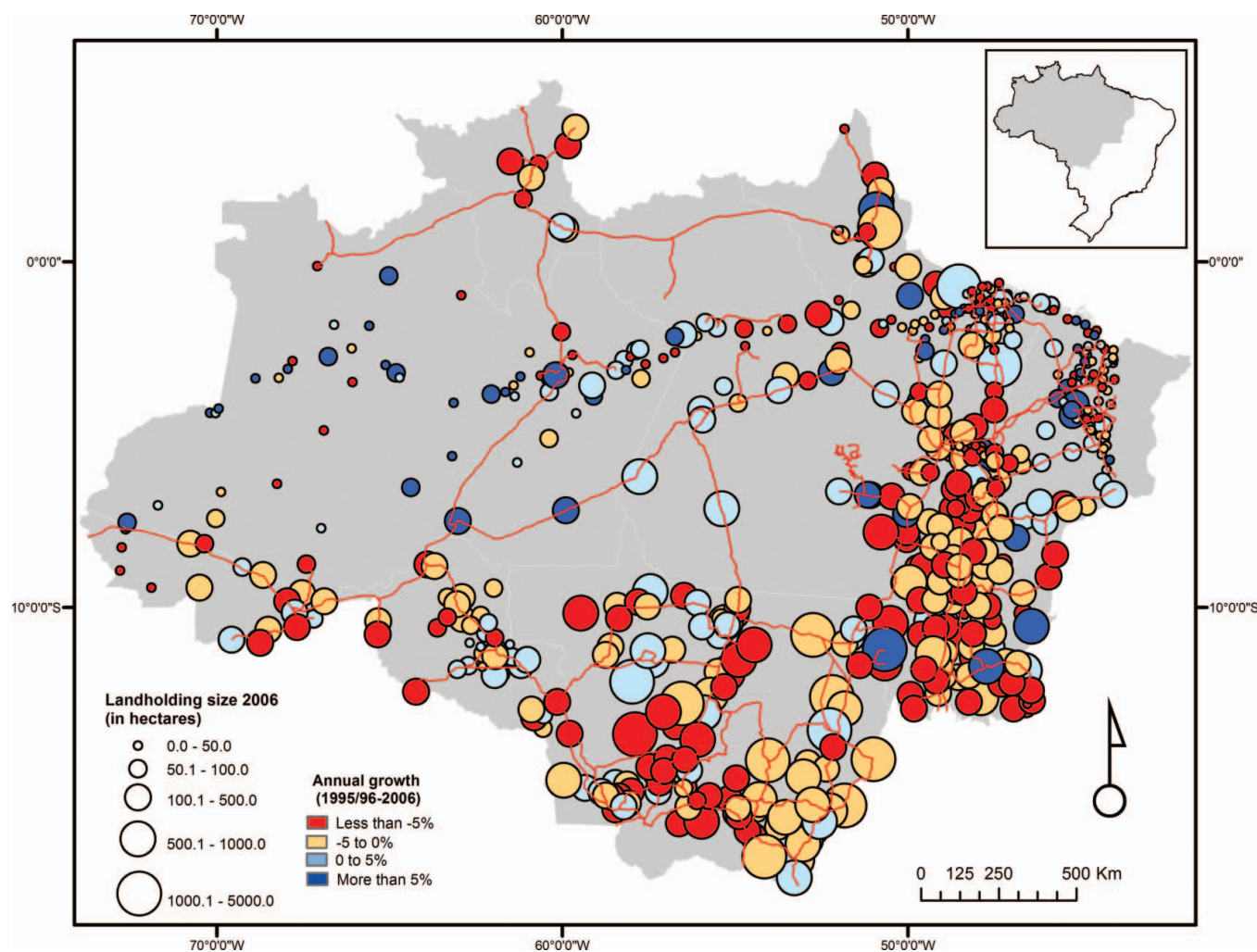


Figure 4. Trends in landholding size by municipality in the Brazilian Legal Amazon. Authors' elaboration based on data from agricultural censuses conducted in 1995–1996 and 2006 by the Brazilian Institute of Geography and Statistics (IBGE 1996, 2006). (Color figure available online.)

smallholders' occupation of frontier land. Hence, smallholders are allocating more of their plots to pasture, thus stimulating land concentration, as discussed earlier. Increasing cattle production in areas dominated by smallholders has been documented in the Trans-Amazon (Tourrand et al. 1995; da Veiga, Tourrand, and Quanz 1996; Castellanet, Simões, and Filho 1998), Acre (Vosti, Witcover, and Carpentier 2003), and Rondônia (Browder, Pedlowski, and Summers 2004). The rationales behind smallholders' decisions to invest in cattle are discussed in the section on production dynamics.

Data from the two most recent IBGE agricultural censuses (1995–1996 and 2006) reveal that cattle herds expanded significantly in small-scale landholdings during that ten-year period. The cattle population increased by about 20 million head during that decade,

with a third of that increase (6.5 million head) taking place in landholdings smaller than 100 ha (Table 3). In 1995–1996, smallholders owned about 16.5 percent of the total cattle herd. This proportion had increased to 21.8 percent by 2006. Smallholders were encouraged to take up ranching by the availability of financial subsidies, as mentioned earlier (Arima 2000; Arima, Barreto, and Brito 2005). In addition, smallholders tend to benefit from expanding markets and networks largely developed by traders, large-scale ranchers, and industry (Poccard-Chapuis et al. 2005).

Furthermore, smallholdings are often characterized by higher stocking ratios. There is an inverse relationship between the density of cattle head per hectare and landholding size: Stocking ratios on small-scale landholdings are almost double those on large-scale landholdings. This evidence is consistent with the

precept about farming systems that land scarcity induces more intensive production practices. As smallholders grow to depend on cattle production, raising cattle is becoming an important livelihood strategy for people living on the Amazonian forest frontiers. This trend has important implications for policies aiming to reduce deforestation.

Implications for Deforestation Dynamics

Estimates from the INPE indicate that deforestation in the Brazilian Legal Amazon, driven by frontier expansion, increased continuously until 2004, when it peaked at 2.7 million ha in the year. Since then, deforestation has tended to decrease, to 764,000 ha in 2009 (INPE 2011b), but a slight increase of 27 percent in the rate of deforestation was reported between August 2010 and April 2011 (INPE 2011a).

Deforestation trends are increasingly linked to fluctuations in commodity markets, especially for beef and soybeans (see Kaimowitz et al. 2004; Nepstad, Stickler, and Almeida 2006). In the Brazilian Amazon, expansion of deforestation in the mid-2000s has likely responded to increases in prices and demand from global markets in a context of weak enforcement of environmental regulations. In the same vein, its decline has also been affected by the global economic downturn in 2008. In addition, deforestation decline is also associated with conservation policies aimed at expanding forest areas under protection as well as strengthening—at the federal and state level—government enforcement of environmental regulations through improved monitoring and sanctioning systems (Astill 2010; Barreto and Silva 2010; see also Zimmerer 2011).

As mentioned in the introduction, cattle ranching development, with the consequent pasture expansion, is the main proximate cause of deforestation in the Brazilian Amazon (Hecht 1982; Faminow 1998; Kaimowitz et al. 2004; Margulis 2004). Where and when the deforestation occurs has shifted over time, however, and uncertainties remain with regard to its eventual stabilization. Margulis (2004), drawing on data from the IBGE's 1995–1996 agricultural census, indicated that 70 percent of total forest conversion by that time was devoted to planted pasture.

Table 5, based on the 2006 agricultural census, confirms that, by 2006, pasture accounted for 75 percent of total accumulated deforestation. It is noteworthy that these estimates include only landholdings accounted for in the censuses. The remaining forest

conversion is linked with subsistence agriculture and soybean cultivation. In this regard, Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA) and INPE (EMBRAPA/INPE 2011), based on remote sensing analysis, estimated that, of the 71.9 million ha of the Brazilian Amazon deforested by 2008, 62 percent is now pasture, 5 percent agriculture, and 21 percent forest regrowth. Assessing agricultural expansion is not the focus of this article and is discussed elsewhere (Nepstad, Stickler, and Almeida 2006; Vera et al. 2008).

It is not yet clear which actors are making the largest contribution to deforestation for pasture expansion, although a few estimates of actors' contributions to total deforestation have been made. Among the most relevant studies estimating different landholders' contributions to deforestation, Fearnside (1993) suggested that 70 percent of deforestation is attributable to large-scale ranching operations, but Homma et al. (1995) argued that half of the deforestation in the Amazon is due to shifting cultivators. Börner et al. (2010) suggested that about 80 percent has been caused by large landholders, on lands dominated by agribusiness and cattle ranching.

According to the 1995–1996 agricultural census, only 14.8 percent of land clearing was attributable to landholders with less than 100 ha, 29.0 percent occurred on establishments of between 100 and 1,000 ha, and the remaining 56.2 percent took place on landholdings larger than 1,000 ha. The 2006 census data give similar proportions: 16.1, 30.8, and 53.1 percent, respectively. This suggests that there has been no significant change over time in different actor types' contributions to deforestation. It is noteworthy to highlight the contribution to deforestation of medium-scale landholders, which has often been neglected in previous assessments. These sources also show that the proportion of deforested land is inversely correlated to landholding size, but it is growing across all actor types. The average portion of total cleared land in landholdings reached 40 percent in 1995–1996 and 51 percent in 2006.

Although the estimates from the IBGE agricultural censuses given in Table 5 suggest that only about 7 million ha was cleared from 1995–1996 to 2006, forest loss actually amounted to 9 million ha. This discrepancy might be due to changes in land use categories in the two censuses. In addition, the INPE reports on deforestation indicate that about 20 million ha of forest was removed from 1996 to 2006 (INPE 2011b). The INPE data suggest not only that significant land use change has been taking place outside of landholdings reported by the IBGE but also that there are methodological

Table 5. Land use in landholdings in the Brazilian Legal Amazon in 1995–1996 and 2006

Landholding size (ha)	Land use (in thousand ha)					Total area cleared (thousand ha) ^c	Deforestation indicators (in%)		
	Total	Crops ^a	Pasture ^b	Forest ^c	Others ^d		Cleared land/total land	Contribution to total cleared	Planted pasture/total cleared
1995/1996									
< 50	6,075	1,602	1,645	1,855	973	3,596	59.2	7.6	35.1
50–100	7,158	833	2,502	2,997	826	3,393	47.4	7.2	56.6
101–500	20,382	1,424	9,288	7,634	2,036	9,163	45.0	19.4	68.8
501–1,000	9,964	650	5,239	3,171	904	4,517	45.3	9.6	72.9
> 1,000	74,684	3,335	31,796	33,818	5,735	26,572	35.6	56.2	74.9
Total	118,262	7,844	50,469	49,475	10,474	47,240	39.9	100.0	69.2
2006									
< 50	6,690	1,133	3,472	1,821	264	4,282	64.0	7.9	62.7
50–100	7,964	845	4,082	2,794	243	4,504	56.6	8.3	72.3
101–500	20,590	1,886	11,322	6,756	625	11,373	55.2	20.9	76.0
501–1,000	10,055	890	5,550	3,351	263	5,389	53.6	9.9	78.0
> 1,000	61,373	6,186	29,016	24,905	1,266	28,873	47.0	53.1	75.2
Total	106,672	10,941	53,443	39,627	2,660	54,420	51.0	100.0	74.4

Note: Authors' elaboration based on data from agricultural censuses conducted in 1995–1996 and 2006 by the Brazilian Institute of Geography and Statistics (IBGE 1996, 2006). The IBGE collected data for 760 municipalities in the states of Acre, Amapá, Mato Grosso, Pará, Rondônia, Roraima, Maranhão, and Tocantins.

^aIncludes permanent and annual crops.

^bIncludes planted pasture and natural grasslands.

^cIncludes primary and planted forests.

^dIn 1996, refers to abandoned productive lands and nonproductive lands, and in 2006 includes water bodies, degraded land, and nonproductive lands.

^eIncludes permanent and annual crops, fallow lands, planted pasture, planted forests, and abandoned and degraded lands.

differences in the IBGE census. INPE estimates do not consider forest regrowth, which, as mentioned earlier, is relatively important (EMBRAPA/INPE 2011).

Conclusions: Trends and Trajectories of Cattle Ranching Development in the Brazilian Amazon

No land use in any tropical forest zone has received as much attention, with such varied interpretations, as cattle ranching in the Brazilian Amazon. The polarization of perspectives on ranching in the Amazon is acute and appears to be led as much by ideological views as by evidence of its social and environmental impacts. Environmentalists emphasize that the Amazon sustains the Earth's global biogeophysical systems and biodiversity that is undermined by the amount of forest loss due to ranching. Development critics highlight that cattle ranching raises concerns about unsustainable agricultural land use in the Amazon and uneven distribution of benefits. By contrast, for development advocates and rural elites, cattle ranching constitutes a valid way of promoting regional economic development with mul-

tiplier economic effects. For these groups, the benefit more than compensates for the negative effects of forest removal.

This article systematizes existing knowledge and brings additional evidence to the debate about cattle ranching dynamics, focused in the Brazilian Amazon, with implications for its future development. It does so by examining the broader human–environment relationships driving cattle expansion and offering an integrated analysis of the economic and political factors, working at different scales, that shape land use change and consequent deforestation.

We observe that important changes in beef and dairy markets along with shifts in policy incentives over time have influenced the expansion of cattle ranching in the Brazilian Amazon. These policy shifts interact with several local socioeconomic and ecological conditions, resulting in disparate trends in cattle expansion with differential outcomes for land use and socioeconomic development. More specifically, persistent expansion of cattle ranching is linked to variables operating at different levels. Specific public policies (e.g., subsidized credit, FMD eradication, monitoring of the cattle industry) and market conditions linked to both

domestic and external demand—affected by exchange rates and sanitary barriers—set the major trends that influence cattle ranching expansion. Other related key factors shaping this expansion include public investments in road development as well as private investments in the expanding beef- and dairy-processing industry. Finally, specific local conditions such as land tenure and access to finance and technologies also influence cattle ranching expansion in the Brazilian Amazon.

Four simultaneous trends associated with cattle ranching development are identified in this region. The first trend is the arrival of investments in the Amazon region, mainly to set up processing facilities for beef and dairy production, which have led to a significant restructuring of the market value chains. The second trend is a gradual improvement in cattle production systems, which is leading to a significant but geographically differentiated increase in the head of cattle per hectare of pasture. Although higher stocking ratios predominate in older frontiers with better access to markets, they do not necessarily lead to a reduction in the expansion of pasture areas in more distant frontiers. The third trend is a two-faceted process of land tenure change by which landholdings tend to concentrate in areas dominated by smallholders and fragment in areas with previously notable land concentration often for extensive cattle ranching. Yet, significant land concentration persists in the region as a whole. The fourth trend constitutes the gradual adoption of ranching activities by smallholders, enabling them to make more productive use of their land and benefit from regular income streams from dairy and beef meat production.

The interactions established among each of these four trends contribute to shape two main trajectories of cattle ranching development. The first trajectory is linked to cattle expansion through more modernized systems of production. This often occurs in older agricultural frontiers, in part stimulated by the processing industry and the need to reduce production costs to compete with other production zones. The second trajectory is associated with the persistent development of low-productivity cattle ranching in the context of cheaper land prices linked to greater availability of land. Important interactions exist between these two different trajectories. For example, in many cases, economic incentives that encourage intensification lead indirectly to the expansion of extensive cattle ranching and thus to the reallocation of investment capital to more distant frontiers, given the lack of effective policies to “close” the frontier.

Three main policy mechanisms could contain the expansion of extensive cattle ranching as a way to close the frontier: (1) designation of public lands as protected areas and production forest; (2) land use constraints defined through economic and ecological zoning; and (3) promotion of cattle ranching outside the Amazon biome. The first policy has efficiently halted the expansion of extensive ranching into public forestland. The second has been more difficult to implement because it depends on political negotiations between actors and state enforcement capacity. Efforts to halt deforestation in recent years have proven that it is possible to reduce the expansion of cattle ranching into unauthorized forestland. The third policy option will serve only to displace the problem to the *cerrado* ecosystem, which is also under intense pressure. In a complementary approach, environmental actors are putting pressure on the industrial private sector to ban the purchase of cattle raised on illegally cleared forestland.

Key questions that remain unanswered pertain to the costs and benefits of such efforts for the environment and for the rural economy and the amount of public spending required to sustain such efforts over time. In addition, as part of state and civil society efforts to halt deforestation linked to ranching, mechanisms to compensate landholders for avoiding forest conversion are under consideration as a new panacea. Such mechanisms are being embedded in institutional schemes aimed at reducing deforestation and forest degradation, and enhancing carbon stocks (REDD+). The assumption is that compensating cattle producers for avoiding deforestation could generate relatively large carbon gains for a small opportunity cost. Nonetheless, the effectiveness and the efficiency of these mechanisms are still under scrutiny (Börner et al. 2010; Pacheco et al. 2011). It is unlikely that compensation or reward mechanisms will work as expected because a large amount of deforestation in the Amazon occurs on poorly delimited private lands and regularization processes are still in progress. Furthermore, it is not clear whether conservation policies will be enough to counter the effects of market-led pressures in the face of growing market integration (Nepstad, McGrath, and Soares-Filho 2011). In this context, command-and-control measures will continue to be important in achieving land use governance.

The study undertaken here highlights some major trends and trajectories with regard to cattle ranching development in the Amazon involving disparate actors and landscapes, with implications for both economic development and environmental conservation. We argue that it is misleading either to defend or to criticize

cattle ranching expansion without considering the whole range of differentiated social and economic effects for the diverse actor types involved in the cattle sector, as well as its disparate ecological implications for the various landscapes across different stages of frontier occupation and transformation. In this regard, there are important trade-offs to take into account between conservation and development. Whereas in some cases cattle ranching can be justified due to its benefits for local development and smallholder livelihoods, in others it cannot due to its significant irreversible environmental effects.

Environmentalists and development advocates could possibly agree that the best scenario for cattle ranching development in the Amazon would be to close the frontiers and promote high-productivity herd management in already deforested lands. Remaining questions concern identifying ways to more effectively stabilize cattle production to promote forest conservation without compromising either economic growth or opportunities to enhance the livelihoods of the large group of smallholders who increasingly depend on cattle production. The incentives required to achieve frontier stabilization must consider the different range of actor types engaging in the cattle sector across differentiated landscapes, thus prioritizing those locales in which better trade-offs can be achieved in terms of economic growth, reduction of social disparities, and forest conservation. The latter will likely require hybrid approaches that combine enforcement of land use regulations with market-based approaches that promote a more sustainable supply of beef and dairy, along with incentives for avoiding deforestation. Although steps have been taken in this direction, there is a need for greater policy harmonization to balance conservation and development aims in the context of larger market integration.

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Notes

1. The Amazon Basin of Brazil was defined by government decree in 1953; it is referred to as the Brazilian Legal Amazon (BLA). It covers an area of 5,000,000 km² encompassing six "northern" states (Acre, Amapá, Amazonas, Pará, Roraima, and Rondônia), plus part of

three others (Tocantins, north of the 130 parallel; Mato Grosso, north of the 160 parallel; and Maranhão, west of the 440 meridian). The entire state of Mato Grosso was included in the BLA by complementary Law No. 31 issued in October 1977 (art. 45; cf. Faminow 1998; Fearnside 1993).

2. There are a diverse range of cattle ranching systems in the Amazon. Extensive systems are normally based on free ranging, whereas semi-intensive systems adopt a subdivision of large pastures into smaller paddocks to facilitate more uniform grazing patterns and pasture rotation, along with an improved use of mineral supplements, vaccination, and artificial insemination. More traditional systems consist of self-reproducing herds and others specialize in cow-calf production. Heifer calves can be retained for herd expansion or sold to other operators who specialize in calf production and finish them for slaughter. These different systems can be dedicated only to beef production or to both beef and dairy production.
3. This estimate corresponds to the 2006 agricultural census conducted by the IBGE. It is lower than previous estimates in the Municipal Livestock Survey (PPM), which are widely quoted in the literature. The PPM estimates indicate that the total cattle herd in Brazil in 2006 was 205.8 million head—35.9 million head more than the figure in the 2006 agricultural census. The PPM estimates indicate that the cattle herd in the Amazon was equivalent to 73.1 million head—17.5 million more than the figure provided by the 2006 agricultural census. This article considers the agricultural census to be a more reliable source than the PPM.
4. Schneider (1995) employed some proxy measures to estimate the implications of incentives for the expansion of cattle herds in the north. The author estimated the effects of subsidized credit and fiscal incentives in 1980 and 1985 (years for which agricultural census data are available) assuming that such incentives discriminated against small landholders, and hence that large-scale farmers captured subsidized credit and fiscal incentives first.
5. Some government-sponsored credit lines are helping farmers access cheap credit, often used to plant pasture and increase cattle herds. The more influential programs for farmers in the Amazon states are (1) the Constitutional Fund to finance the north region of Brazil (FNO), administered by BASA and in operation since 1988; (2) the National Program to Strengthen Family Agriculture (PRONAF), created in 1995 for low-income rural producers; and (3) specific credit lines from the Bank of Brazil (BB). Other credit lines support investments in equipment and machinery (MODERFROTA) and the recovery of degraded pastures (PROPASTO), both with low interest rates. For additional information on credit programs established in Brazil, see Lele et al. (2000) and Pacheco (2002).
6. Presidential Decree No. 7130, issued 11 March 2010, applies only to lands classified as productive areas in ecological and economic zoning in the area of influence of the BR-163 highway (Cuiabá-Santarém) and the western zone of the BR-230 highway (Trans-Amazon).
7. See the program "Legal Beef" sponsored by the Federal Public Ministry, <http://www.carnelegal.mpf.gov>.

- br/historico/ajuste-de-conduta (last accessed 27 September 2011).
8. Fresh beef exports to some countries (mainly the European Union and the United States) are prohibited. (Exports of canned, processed, and dried beef products not subject to FMD restrictions are permitted.) Brazil has sought to work with U.S. animal health officials to gain approval for FMD-free states to begin exporting fresh, chilled, or frozen beef. Regional FMD-free status was accepted by several countries in 2002, including China, Egypt, and Russia (U.S. Department of Agriculture 2004).
 9. For example, see “Wal-Mart bans beef” (2009).
 10. The main economic groups operating in the beef sector in Brazil are Bertin, Independência, JBS Friboi, Marfrig, Margen, Minerva, Perdigão, Quatro Marcos, and Sadia.
 11. The relative increase in exports of live cattle is likely occurring because of growing constraints on selling cattle originating from unauthorized deforested lands to the beef industry.
- ## 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 (3): 265–88.
- Alston, L. J., G. D. Libecap, and B. Mueller. 1999. *Titles, conflict, and land use: The development of property rights and land reform on the Brazilian Amazon frontier*. Ann Arbor: University of Michigan Press.
- . 2000. Land reform policies, the sources of violent conflict, and implications for deforestation in the Brazilian Amazon. *Journal of Environmental Economics and Management* 39 (2): 162–88.
- Alves, D. 2003. An analysis of the geographical patterns of deforestation in Brazilian Amazônia in the 1991–1996 period. In *Patterns and processes of land use and forest change in the Amazon*, ed. C. Wood and R. Porro, 95–106. Gainesville: University of Florida Press.
- Angelsen, A. 2008. *Moving ahead with REDD: Issues, options, and implications*. Bogor, Indonesia: Center for International Forestry Research.
- Angelsen, A., D. van Soest, D. Kaimowitz, and E. Bulte. 2001. Technological change and deforestation: A theoretical overview. In *Agricultural technologies and tropical deforestation*, ed. A. Angelsen and D. Kaimowitz, 19–34. New York: CABI Publishing, Center for International Forestry Research.
- Arima, E. 2000. *Incentivos fiscais e de crédito para pecuária na Amazônia Legal* [Fiscal and credit incentives for livestock in the Legal Amazon]. Belém, Brasil: Instituto do Homem e Meio Ambiente na Amazônia.
- Arima, E., P. Barreto, and M. Brito. 2005. *Pecuária na Amazônia: Tendências e implicações para a conservação ambiental* [Livestock in the Amazon: Trends and implications for environmental conservation]. Belém, Brazil: Instituto do Homem e Meio Ambiente na Amazônia.
- Arima, E., P. Richards, R. Walker, and M. Caldas. 2011. Statistical confirmation of indirect land use change in the Brazilian Amazon. *Environmental Research Letters* 6 (2): 024010.
- Arima, E., and C. Uhl. 1997. Ranching in the Brazilian Amazon in a national context: Economics, policy, and practice. *Society and Natural Resources* 10 (5): 433–51.
- Astill, J. 2010. A special report on forests: Seeing the wood. *The Economist* 23 September 2010. <http://www.economist.com/node/17062713> (last accessed 27 September 2011).
- Barreto, P., and D. Silva. 2009. *Os desafios para uma pecuária mais sustentável na Amazônia*. [Challenges for more sustainable cattle ranching in the Amazon]. Belém, Brazil: Instituto do Homem e Meio Ambiente na Amazônia.
- . 2010. Will cattle ranching continue to drive deforestation in the Brazilian Amazon? Paper presented at the conference on Environment and Natural Resources Management in Developing and Transition Economies, Clermont-Ferrand, France.
- Binswanger, H. P. 1991. Brazilian policies that encourage deforestation in the Amazon. *World Development* 19 (7): 821–29.
- Bleaney, M. F. 1996. Macroeconomic stability, investment and growth in developing countries. *Journal of Development Economics* 48 (2): 461–77.
- Börner, J., S. Wunder, S. Wertz-Kanounnikoff, M. R. Tito, L. Pereira, and N. Nascimento. 2010. Direct conservation payments in the Brazilian Amazon: Scope and equity implications. *Ecological Economics* 69 (6): 1272–82.
- Browder, J. O. 1988. Public policy and deforestation in the Brazilian Amazon. In *Public policy and the misuse of forest resources*, ed. R. Repetto and M. Gillis, 247–97. New York: Cambridge University Press.
- Browder, J. O., M. Pedlowski, and P. M. Summers. 2004. Land use patterns in the Brazilian Amazon: Comparative farm-level evidence from Rondônia. *Human Ecology* 32 (2): 197–224.
- Brown, K., and D. W. Pearce. 1994. *The causes of tropical deforestation*. London: UCL Press.
- Câmara dos Deputados. 2011. PL 1876/1999. Projeto de Lei. <http://www.camara.gov.br/proposicoesWeb/fichadetramitacao?idProposicao=17338> (last accessed 27 September 2011).
- Câmara, G., D. de Morisson, and J. V. Soares. 2006. *Metodologia para o cálculo da taxa anual de desmatamento na Amazônia Legal* [Methodology for estimating the annual deforestation rate in the Legal Amazon]. São José dos Campos, Brazil: Instituto Nacional de Pesquisas Espaciais.
- Camargo, G. S., S. D. Zen, S. M. Ishihara, and M. Osakaki. 2002. *Economia da pecuária de corte e o processo de ocupação da Amazônia* [Economy of beef production and the process of occupation in the Amazon]. Piracicaba, Brazil: Centro de Estudos Avançados em Economia Aplicada, University of São Paulo.
- Carrero, G. C., and P. M. Fearnside. 2011. Forest clearing dynamics and the expansion of landholdings in Apuí, a deforestation hotspot on Brazil's Transamazon Highway. *Ecology and Society* 16 (2): 26.
- Castellanet, C., A. Simões, and P. C. Filho. 1998. *Diagnóstico preliminar da agricultura familiar na Transamazônica: Indicações para pesquisa e desenvolvimento* [Diagnostic of

- the smallholder agriculture in the Transamazon: Guidance for research and development]. Belém, Brazil: Empresa Brasileira de Pesquisa Agropecuária.
- CEPALSTAT. 2011. *Databases and statistical publications*. Santiago, Chile: Economic Commission for Latin America and the Caribbean. <http://websie.eclac.cl/infest/ajax/cepalstat.asp?idioma=i> (last accessed 25 September 2011).
- Chomitz, K. M., and T. S. Thomas. 2001. *Geographic patterns of land use and intensity in the Brazilian Amazon*. Washington, DC: World Bank, Development Research Group, Infrastructure and Environment.
- Contreras, A. 1999. Underlying causes of deforestation. Occasional paper, Center for International Forestry Research, Bogor, Indonesia.
- da Veiga, J. B., R. Poccard-Chapuis, M. G. Piketty, and J. F. Tourrand. 2001. *Milk production, regional development and sustainability in the Eastern Amazon*. Belém, Brazil: Agricultural Research for Development, Empresa Brasileira de Pesquisa Agropecuária.
- da Veiga, J. B., J. F. Tourrand, and D. Quanz. 1996. *A pecuária na fronteira agrícola da Amazônia: O caso de município de Uruará, PA, na região da Transamazônica* [Cattle production in the Amazon agricultural frontier: The case of the municipality of Uruará, PA, in the Transamazon]. Belém, Brazil: Empresa Brasileira de Pesquisa Agropecuária.
- Domingos, M. 2003. *Backgrounder part I: Land reform in Brazil*. Ceara, Brazil: Federal University of Ceara.
- Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA)/Instituto Nacional de Pesquisas Espaciais (INPE). 2011. *Levantamento de informações de uso e cobertura da terra na Amazônia* [Analysis of information on land use and cover in the Amazon]. Brasília, Brazil: EMBRAPA/INPE.
- Faminow, M. D. 1998. *Cattle, deforestation, and development in the Amazon: An economic, agronomic, and environmental perspective*. New York: CAB International.
- Faminow, M. D., C. Dahl, S. Vosti, J. Witcover, and S. Oliveira. 1999. *Smallholder risk, cattle and deforestation in the western Brazilian Amazon*. Washington, DC: International Development Research Center, International Food Policy Research Institute, Empresa Brasileira de Pesquisa Agropecuária.
- FAOSTAT. 2011. *Statistical database, live animals*. Rome, Italy: Food and Agriculture Organization of the United Nations. <http://faostat.fao.org/site/573/default.aspx#ancor> (last accessed 27 September 2011).
- Fearnside, P. M. 1993. Deforestation in the Brazilian Amazon: The effect of population and land tenure. *Ambio* 22 (8): 537–45.
- . 2001. Land-tenure issues as factors in environmental destruction in Brazilian Amazonia: The case of southern Pará. *World Development* 29 (8): 1361–72.
- Franco, M. 2004. Da marginalidade à carne com griffe [From marginalized to trademarked beef]. *DBO* 287 (23): 90–104.
- Gonçalves, R. 2008. *Exportação de bovino vivo: Problemas, riscos e soluções* [Beef exports: Problems, risk and solutions]. Rio de Janeiro, Brazil: Universidade Federal do Rio de Janeiro.
- Gunderson, M., J. Lusk, and B. Norwood. 2009. Getting something from nothing: An investigation of beef demand expansion and substitution. *Review of Agricultural Economics* 31 (1): 68–87.
- Hecht, S. 1982. Cattle ranching development in the eastern Amazon: Evaluation of development strategy. PhD dissertation, University of California, Berkeley.
- . 1985. Environment, development and politics: Capital accumulation and the livestock sector in eastern Amazonia. *World Development* 13 (6): 663–84.
- . 1992. Valuing land uses in Amazonia: Colonist agriculture, cattle and petty expansion in comparative perspective. In *Conservation of neotropical forests: Working from traditional resource use*, ed. K. H. Redford and C. Padoch, 379–99. New York: Columbia University Press.
- . 1993. The logic of livestock and deforestation in Amazonia. *Bioscience* 43 (10): 687–95.
- Homma, A. K. O., R. T. Walker, F. N. Scatena, A. J. de Conto, R. de A. Carvalho, C. A. P. Ferreira, and A. I. M. dos Santos. 1995. Redução dos desmatamentos na Amazônia: Política agrícola ou ambiental? [Reduction of deforestation in the Amazon: Agricultural or environmental policy?]. Paper presented at the 33rd Congresso Brasileiro de Economia e Sociologia Rural, Curitiba, Brazil.
- Informa Economics FNP. 2004. *ANUALPEC 2004: Anuário da pecuária Brasileira* [Yearbook of the livestock sector in Brazil]. Rio de Janeiro, Brazil: Instituto FNP.
- Instituto Brasileiro de Geografia e Estatística (IBGE). 1996. *Agricultural census 1995/96*. Rio de Janeiro, Brazil: IBGE. http://www.ibge.gov.br/home/estatistica/economia/agropecuaria/censoagro/1995_1996/ (last accessed 27 September 2011).
- . 2006. *Agricultural census 2006*. Rio de Janeiro, Brazil: IBGE. <http://www.sidra.ibge.gov.br/bda/pesquisas/ca/default.asp> (last accessed 27 September 2011).
- Instituto de Estudos Econômicos Sociais e Políticos (IDESP). 2010. *Tendências e perspectivas da pecuária de corte no Pará: Boletim de conjuntura* [Trends and perspectives of the beef livestock sector]. Belém, Brazil: IDESP.
- Instituto Euvaldo Lodi (IEL)/Confederação Nacional da Agricultura (CNA)/Serviço Brasileiro de Apoio às Micro e Pequenas Empresas (SEBRAE). 2000. *Estudo sobre a eficiência econômica e competitividade da cadeia agroindustrial da pecuária de corte no Brasil* [Study on the economic efficiency and competitiveness of agroindustrial beef production in Brazil]. Brasília, Brazil: IEL/CNA/SEBRAE.
- Instituto Nacional de Colonização e Reforma Agrária (INCRA). 2002. *Balanco da reforma agraria 2002* [Balance of the agrarian reform 2002]. Brasília, Brazil: Secretaria de Reforma Agraria, Ministerio do Desenvolvimento Agrario.
- . 2007. *Numeros da reforma agraria 1995–2006* [Figures of the agrarian reform 1995–2006]. Brasília, Brazil: Secretaria de Reforma Agraria, Ministerio do Desenvolvimento Agrario.
- Instituto Nacional de Pesquisas Espaciais (INPE). 2011a. *DETER Março/Abril de 2011—Relatório de avaliação* [DETER March/April 2011, Evaluation report]. São José dos Campos, Brazil: INPE. <http://www.obt.inpe.br/deter/avaliacao/> (last accessed 27 September 2011).
- . 2011b. *Monitoramento da floresta Amazônica Brasileira por satélite* [Satellite monitoring of the Brazilian

- Amazon Forest]. São José dos Campos, Brazil: INPE. http://www.obt.inpe.br/prodes/prodes_1988_2010.htm (last accessed 27 September 2011).
- Instituto de Pesquisa Economica Aplicada. 2011. Código Florestal: Implicações do PL 1876/99 nas Áreas de Reserva Legal [Implications of PL 1876/99 in the legal forestry reserves]. Comunicado No. 96, IPEA, Rio de Janeiro, Brazil.
- Jank, M. S., E. Q. Farina, and V. B. Galan. 1999. *O agribusiness do leite no Brasil* [Agriculture in the milk sector in Brazil]. São Paulo, Brazil: USP/FIA/PENSA/IPEA, Editions Milkbuzz.
- Kaimowitz, D. 1995. *Livestock and deforestation in Central America in the 1980s and 1990s: A policy perspective*. Washington, DC: International Food Policy Research Institute, Inter-American Institute for Cooperation on Agriculture.
- . 2002. Amazon deforestation revisited. *Latin American Research Review* 37 (2): 221–35.
- Kaimowitz, D., and A. Angelsen. 1998. *Economic models of tropical deforestation: A review*. Bogor, Indonesia: Center for International Forestry Research.
- . 2008. Will livestock intensification help save Latin America's forests? *Journal of Sustainable Forestry* 27 (1–2): 6–24.
- Kaimowitz, D., B. Mertens, S. Wunder, and P. Pacheco. 2004. *Hamburger connection fuels Amazon destruction: Cattle ranching and deforestation in Brazil's Amazon*. Bogor, Indonesia: Center for International Forestry Research.
- Lele, U., V. M. V. Verissimo, S. Vosti, K. Perkins, and S. A. Husain. 2000. *Brazil, forests in the balance: Challenges of conservation with development*. Washington, DC: World Bank.
- Margulis, S. 2004. Causes of deforestation of the Brazilian Amazon. Report No. 22, 107, World Bank, Washington, DC.
- Mattos, M. M., and C. Uhl. 1994. Economic and ecological perspectives on ranching in the Eastern Amazon. *World Development* 22 (2): 145–58.
- Mertens, B., R. Pocard-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 Pará. *Agricultural Economics* 27 (3): 269–94.
- Mishkin, F. S. 1993. *Is the Fisher effect for real? A reexamination of the relationship between inflation and interest rates*. New York: National Bureau of Economic Research (NBER), Columbia University.
- Nepstad, D., D. McGrath, and B. Soares-Filho. 2011. Systemic conservation, REDD, and the future of the Amazon Basin. *Conservation Biology* 25 (6): 1113–16.
- Nepstad, D., C. Stickler, and O. Almeida. 2006. Globalization of the Amazon soy and beef industries: Opportunities for conservation. *Conservation Biology* 20 (6): 1595–1603.
- Oliveira, V. V. 2000. *A eficácia dos instrumentos de preservação ambiental: Uma análise da Reserva Legal, das Áreas de Preservação Permanente e do EPIA/RIMA ante a pecuária extensiva nos municípios que integram a Comarca de Redenção* [The effectiveness of the instruments of environmental preservation: An assessment of the legal reserve, permanent protection areas and EPIA/RIMA in the face of extensive ranching]. Belém, Brazil: Núcleo de Altos Estudos Amazônicos, Universidade Federal do Pará.
- Pacheco, P. 2002. *Revisiting the role of fiscal incentives on driving livestock expansion in the Brazilian Amazon*. Brasília, Brazil: The World Bank Group.
- . 2005. Populist and capitalist frontiers in the Amazon: Dynamics of agrarian and land-use change. PhD dissertation, Graduate School of Geography, Clark University, Worcester, MA.
- . 2009a. Agrarian change, cattle ranching and deforestation: Assessing their linkages in southern Pará. *Environment and History* 15 (4): 493–520.
- . 2009b. Agrarian reform in the Brazilian Amazon: Its implications for land distribution and deforestation. *World Development* 37 (8): 1337–47.
- . 2009c. Smallholder livelihoods, wealth and deforestation in Eastern Amazon. *Human Ecology* 37 (1): 27–41.
- Pacheco, P., M. A. Aguilar-Støen, J. Börner, A. Etter, L. Putzel, and M. del C. Vera-Díaz. 2011. Landscape transformation in tropical Latin America: Assessing trends and policy implications for REDD+. *Forests* 2 (1): 1–29.
- Pocard-Chapuis, R. 2004. *Les réseaux de la conquête filière bovine et structuration de l'espace sur les fronts pionniers d'Amazonie orientale Brésilienne* [Livestock evolution and spatial structuring of the pioneer frontiers in the Brazilian western Amazon]. Department of Geography, University of Paris X, Nanterre, France.
- Pocard-Chapuis, R., J. da Veiga, M. G. Piketty, C. Morelly, and J. F. Tourrand. 2003. *A cadeia produtiva do leite: Alternativa para consolidar a agricultura familiar nas frentes pioneiras da Amazônia* [The milk value chain: Alternative to consolidate family agriculture in the pioneer frontiers in the Amazon]. Belém, Brazil: Embrapa Amazônia Oriental.
- Pocard-Chapuis, R., M. Thales, A. Venturieri, M. G. Piketty, B. Mertens, J. da Veiga, and J. F. Tourrand. 2005. *Cadeia produtiva da carne: Uma ferramenta para monitorar as dinâmicas nas frentes pioneiras na Amazônia brasileira* [The beef value chain: A tool for monitoring the dynamics in pioneer frontiers in the Brazilian Amazon]. *Cadernos de Ciencia & Tecnologia* 22 (1): 125–38.
- Pocard-Chapuis, R., J. F. Tourrand, M. G. Piketty, and J. B. da Veiga. 2001. *Cadeia produtiva de gado de corte e pecuarização da agricultura familiar na Transamazônica* [Livestock value chain and small-scale cattle ranching in the Transamazon]. Documentos No. 106, Empresa Brasileira de Pesquisa Agropecuária, Belém, Brazil.
- Primo, W. M. 2000. Impactos da década de 90 para a indústria de laticínios [Impacts of the 1990 decade for the dairy industry]. Paper presented at the 17th Brazilian Congress of Dairy Industry, Minas Gerais, Brazil.
- Programa Erradicação e Prevenção da Febre Aftosa. 2009. *Evolução geográfica do processo de implantação de zona livre de febre aftosa no Brasil* [Geographic evolution of the implementation process for achieving a foot-and-mouth disease-free zone]. Belém, Brazil: PNEFA.

- Repetto, R. C., and M. Gillis. 1988. *Public policies and the misuse of forest resources*. Cambridge, UK: Cambridge University Press.
- Schmink, M., and C. H. Wood. 1992. *Contested frontiers in Amazonia*. New York: Columbia University Press.
- Schneider, R. 1993. Land abandonment, property rights, and agricultural sustainability in the Amazon. Dissemination Note No. 3, World Bank, Washington, DC.
- . 1995. *Government and the economy on the Amazon frontier*. World Bank Environment Paper No. 11, World Bank, Washington, DC.
- Schneider, R., E. Arima, C. Santamaria, P. Barreto, and A. Veríssimo. 2000. *Sustainable Amazon: Limitations and opportunities for rural development*. Belém, Brazil: World Bank, Instituto do Homem e Meio Ambiente na Amazônia.
- Schnepf, R. D., E. Dohlgan, and C. Bolling. 2001. *Agriculture in Brazil and Argentina: Developments and prospects for major field crops*. Washington, DC: Market and Trade Economics Division, Economic Research Service, U.S. Department of Agriculture, Agriculture and Trade Report.
- Serrão, A., and J. M. Toledo. 1992. Sustainable pasture-based production system in the humid tropics. In *Development or destruction: The conversion of tropical forest to pasture in Latin America*, ed. T. E. Downing, S. B. Hecht, H. A. Pearson, and C. Garcia-Downing, 257–80. Boulder, CO: Westview.
- Serviço de Inspeção Federal (SIF). 2011. *Estabelecimento Registrados no Sistema de Informações Gerenciais do Serviço de Inspeção Federal* [Establishments registered in the Information System of the Federal Inspection Service]. Brasília, Brazil: Ministério da Agricultura, Pecuária e Abastecimento. <http://www.agricultura.gov.br/portal/page/portal/Internet-MAPA/pagina-inicial/servicos-e-sistemas/sistemas/sif> (last accessed 15 January 2011).
- Simmons, C., R. Walker, S. Perz, S. Aldrich, M. Caldas, R. Pereira, F. Leite, and E. Arima. 2010. Doing it for themselves: Direct action land reform in the Brazilian Amazon. *World Development* 38 (3): 429–44.
- Smeraldi, R., and P. May. 2009. *A hora da conta: Pecuária, Amazônia e conjuntura* [Time to pay the bill: Livestock, Amazonia and conjuncture]. São Paulo, Brazil: Amigos da Terra.
- Stiglitz, J. E., and A. Weiss. 1981. Credit rationing in markets with imperfect information. *American Economic Review* 71 (3): 393–410.
- Sunderlin, W. D., and J. A. Rodríguez. 1996. *Cattle, broadleaf forests and the agricultural modernization law of Honduras*. Bogor, Indonesia: Center for International Forestry Research.
- Swart, R., J. Robinson, and S. Cohen. 2003. Climate change and sustainable development: Expanding the options. *Climate Policy* 3 (1): 19–40.
- Tourrand, J. F., J. B. da Veiga, A. P. O. M. Guia, S. A. Carvalho, and R. O. Pessoa. 1995. *Stratégies et pratiques d'élevage en Amazonie Brésilienne: Dynamisme e diversité dans l'agriculture familiale* [Strategies and practices of cattle production in the Brazilian Amazon: Dynamics and diversity of smallholder agriculture]. Montpellier, France: Agricultural Research for Development.
- U.S. Department of Agriculture. 2004. *World beef trade overview*. Washington, DC: USDA, Foreign Agricultural Service.
- Vera, M. C., R. Kaufmann, D. Nepstad, and P. Schlesinger. 2008. An interdisciplinary model of soybean yield in the Amazon Basin: The climatic, edaphic, and economic determinants. *Ecological Economics* 65 (1): 420–31.
- Vosti, S., C. L. Carpentier, J. Witcover, and J. F. Valentin. 2000. Intensified small-scale livestock systems in the western Brazilian Amazon. In *Agricultural technologies and tropical deforestation*, ed. A. Angelsen and D. Kaimowitz, 113–34. New York: CABI Publishing, Center for International Forestry Research.
- Vosti, S., J. Witcover, and C. L. Carpentier. 2003. *Agricultural intensification by smallholders in the western Brazilian Amazon: From deforestation to sustainable land use*. Washington, DC: International Food Policy Research Institute.
- Walker, R., J. Browder, E. Arima, C. Simmons, R. Pereira, M. Caldas, R. Shiota, and S. de Zen. 2009. Ranching and the new global range: Amazônia in the 21st century. *Geoforum* 40 (5): 732–45.
- Walker, R., E. Moran, and L. Anselin. 2000. Deforestation and cattle ranching in the Brazilian Amazon: External capital and household processes. *World Development* 28 (4): 683–99.
- Wal-Mart bans beef illegally produced in the Amazon rainforest. 2009. [news.mongabay.com](http://news.mongabay.com/2009/0612-abras_beef_wal-mart.html), 12 June 2009. http://news.mongabay.com/2009/0612-abras_beef_wal-mart.html (last accessed 27 September 2011).
- Wertz-Kanounnikoff, S., and A. Angelsen. 2009. Global and national REDD+ architecture: Linking institutions and actions. In *Realising REDD+: National strategy and policy options*, ed. A. Angelsen, 13–24. Bogor, Indonesia: Center for International Forestry Research.
- Wood, C. Forthcoming. *Cattle ranching, land use and deforestation in the Amazon: A comparative study of Brazil, Ecuador, and Peru*. Brasília, Brazil: University of Brasília.
- Wunder, S. 2004. Oil, macroeconomics, and forests: Assessing the linkages. *World Bank Research Observer* 19 (2): 231–57.
- Zimmerer, K. S. 2006. Cultural ecology: At the interface with political ecology—The new geographies of environmental conservation and globalization. *Progress in Human Geography* 30:1–16.
- . 2010. Retrospective on nature–society geography: Tracing trajectories (1911–2010) and reflecting on translations. *Annals of the Association of American Geographers* 100 (5): 1076–94.
- . 2011. Conservation booms, land use transitions and environmental governance in Latin America, 1985–2008 (Mexico, Costa Rica, Brazil, Peru, Bolivia). *Latin American Research Review* 46 (3): 82–114.