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Extensive Production Practices and Incomplete Implementation Hinder Brazil's Zero-Deforestation Cattle Agreements in Pará

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Abstract

Global attention to the role of cattle production in Amazon deforestation led to the development of new public and private-sector supply chain policies designed to control deforestation in Brazil. These zero-deforestation Cattle Agreements (hereafter, CA) are between meatpacking companies and Greenpeace and other nongovernmental organizations, as well as with Brazil's public prosecutors. However, after over a decade of concerted efforts to reduce deforestation linked to the cattle sector, the problem persists. Here, we use field surveys of ranchers, slaughterhouse managers, and key industry personnel to characterize cattle supply chain actors in southeastern Pará and their responses to the CA. We show that loopholes weaken the CA and enable ranchers to evade full compliance, and we highlight strategies and challenges for ranchers seeking to intensify production. We conclude by discussing how the findings presented in this study suggest that ongoing efforts to reduce Amazon deforestation may require both support for improved efficiency in the cattle sector and the tightening of several loopholes currently utilized by ranchers to avoid detection of ongoing deforestation.

Keywords

deforestation, supply chains, land use, Brazil, Amazon, cattle

Over the past decade, pressure to reduce deforestation in the Brazilian Amazon has grown. Most pressure focused on the cattle sector, which is responsible for up to 80% of total deforestation in the region and where improved management of underutilized pastures could allow production of more beef without additional clearing (Cohn et al., 2014; Koch et al., 2019; Latawiec et al., 2014; Strassburg et al., 2014). However, extensive cattle ranching persists as major land-use regime in the Amazon, due to its low labor demands (Garrett et al., 2017; Wilcox, 2017), its potential to secure relatively large tracts of land, which has particular salience in Brazil's historically unstable economy (Bowman et al., 2012; Campbell, 2015; Hecht, 1993), and the elevated status that participation in cattle ranching confers (Hoelle, 2011).

The policy landscape of the Brazilian Amazon includes numerous important initiatives to limit where and how much deforestation can occur, including the federal Forest Code, a wide network of protected areas, and ongoing satellite monitoring for deforestation. Recent efforts to reduce deforestation in Brazil's cattle sector have centered heavily on a pair of agreements struck with slaughterhouses that oblige them to

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identify and block supplying ranches that have deforestation or other forms of noncompliance such as embargoes, forced labor, or that lack registered property boundaries in the nationwide environmental cadaster. These agreements include the Amazon-wide G4 Zero-Deforestation Agreement, which was signed in October 2009 following a Greenpeace report, *Slaughtering the Amazon* (Greenpeace, 2009) that linked clearing in the Brazilian Amazon to international supply chains for leather, tallow, and beef (Barreto et al., 2017; Gibbs et al., 2016). Roughly concurrently, the Federal Public Prosecutor's Office (Ministério Público Federal [MPF]) in Pará state began to pressure ranchers and slaughterhouses to commit to no longer trading cattle from areas with new deforestation by signing Terms of Adjustment of Conduct (TAC) agreements. TACs now cover slaughterhouses in all Amazonian states, though most responses remain concentrated in Pará and Mato Grosso where the commitments began (Barreto et al., 2017). Although there are some differences in the scopes and details of the two agreements, their timing and goals align such that we refer to them collectively as the Cattle Agreements (CA).

Both agreements operate based on the premise that the threat of exclusion from the best markets will incentivize better behavior. However, a decade after they were first initiated, implementation of the CA remains incomplete, and questions remain about how to truly reduce the role of deforestation in Brazil's cattle sector. For example, some slaughterhouses have not yet signed onto the CA or have only recently signed or begun monitoring (Amaral et al., n.d.; Barreto et al., 2017). Furthermore, ongoing leakage and cattle laundering among suppliers to slaughterhouses with CA has further limited the impact of the CA on forest protections (Alix-Garcia & Gibbs, 2017). The delay in extending monitoring to indirect suppliers to slaughterhouses (e.g., those ranches that raise young cattle prior to their arrival at a fattening farm just before slaughter) has facilitated laundering because ranchers can easily register their cattle on a clean property despite raising them on properties with deforestation (Alix-Garcia & Gibbs, 2017). Finally, slaughterhouses also continued to buy directly from properties with deforestation in some circumstances, despite monitoring (Klinger et al., 2018), especially when they competed with nearby nonmonitoring slaughterhouses for cattle (Barreto et al., 2017; Gibbs et al., in press). Meanwhile, broadly accessible alternatives to clearing new areas to increase cattle production have not yet emerged (Garrett et al., 2017; Merry & Soares-Filho, 2017; Rueda et al., 2003).

Considering the land-use habits of producers subject to conservation policies such as the CA can reveal additional pathways for improving compliance and maximizing forest cover on ranches. Research in various fields, including Rural Development Studies, Agricultural Studies, Environmental Studies, Agricultural Economics, Sociology, and Geography, has identified factors that affect how compliance with environmental policies and standards become part of decisions about land use. These include personal characteristics of the farmer, such as age (Burton, 2014; Pereira, 2012), the level of education (Casewell et al., 2001; Ondersteijn et al., 2003; Pereira, 2012), and the farmer's overall "attitude" to the environment (Brannstrom, 2011; Defrancesco et al., 2008) or their preexisting "pro-environmental motivations" (Rueda et al., 2019). Other factors are related to the characteristics of the farm or the business and include the size of landholdings, the level of intensity of current production, whether the farmer has access to credit or capital, and the availability of off-farm income (Wossnik & van Wenum, 2003), which may affect the relative costs to the farmer of compliance. Finally, producers' decisions may be affected by their social networks and the dissemination of information about environmental requirements, which could include alignment of other local institutions with the policy (Brannstrom, 2011), whether neighbors participate and if their participation is known (Defrancesco et al., 2008), and the ease of understanding and adapting to the policy requirements (Rausch & Gibbs, 2016; Wilson & Hart, 2001). Thus, there are many factors that may influence a rancher's response to new requirements to cease deforestation, even when provided a compelling reason to change their land-use practices, such as maintaining market access under well-designed, well-implemented sourcing policies (Garrett et al., 2017; Ribot & Peluso, 2003; Rueda et al., 2019; Wollni & Brümmer, 2012).

In this article, we draw on a novel data set of 131 interviews with ranchers, plus additional interviews with slaughterhouse personnel and other key informants in the cattle sector, and secondary data to characterize cattle production in southeastern Pará. These surveys were conducted in 2013 and 2014, but they describe structural challenges that continue to be faced by ranchers as well as adaptations to land management and position in the supply chain that ranchers continue to use to avoid complying with the CA. The findings presented in this article point to potential adaptations to the CA that could lead to improved outcomes for both forests and ranchers.

Methods

Our study area included 10 municipalities in southeast Pará (Figure 1). In 2017, these municipalities accounted for 30% of Pará's cattle herd and 10% of the herd in the entire Amazon (Instituto Brasileiro de Geografia e Estatística, 2017). The area also holds 70% of Pará's federally inspected (Serviço de Inspeção Federal [SIF])

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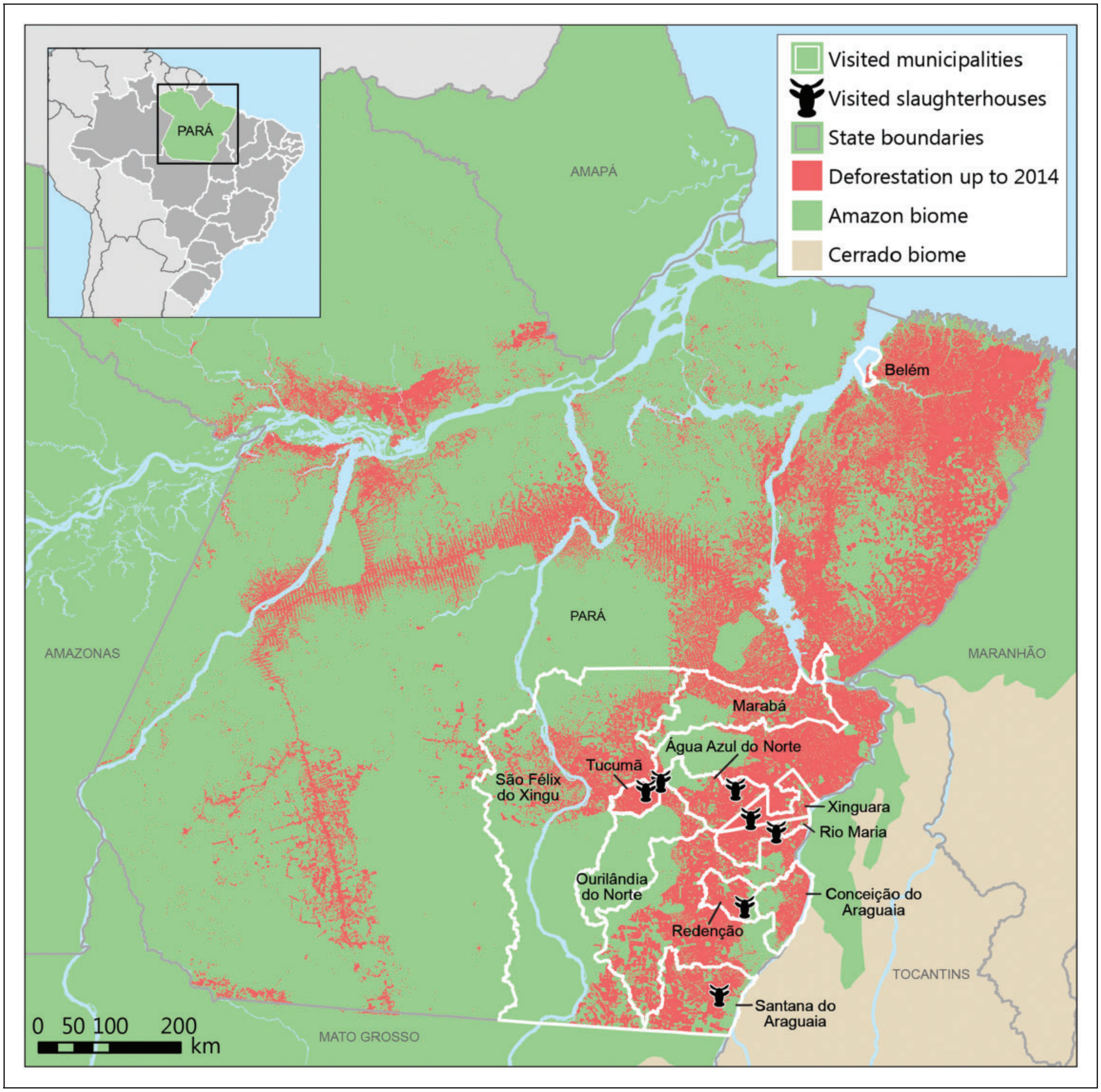

Figure 1. Areas Visited in Pará State.

slaughterhouses and was officially recognized as foot-and-mouth disease (FMD)-free in 2007.

During the summers of 2013 and 2014, we administered semistructured surveys to personnel at seven slaughterhouses, to 131 ranchers, and to representatives of 6 syndicates—ranchers' associations that exert pressure to defend their members' interests and rights. Survey responses were coded and stored in Access.

Slaughterhouse surveys conducted in 2013 were designed to collect data about compliance with the CA and how they translated this into demands on ranchers who supply them. When surveying slaughterhouses, we tried to speak to personnel at all of the SIFs currently active in our study region, as their number was relatively small. In the end, we were able to visit and interview a total of seven of the nine slaughterhouses active in the study area. The rancher surveys conducted during this first year were broader than in the subsequent year and included questions about land-use and production systems, such as stocking rates, life cycles, and transportation (surveys are available as supplementary material). In addition, the surveys probed for responses about requirements generated by the CA.

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Syndicates provided general information about ranching dynamics and the relationship between producers and slaughterhouses, as well as descriptions of the main challenges for maintaining cattle productivity while complying with the agreements. Contact was made first with the syndicate offices; they informed producers about our interest in interviewing them and provided a list of key ranchers who could add information about past and current production systems in the region. This method created a goal-directed sample, in which those people with a long history of cattle activity and who were syndicate members were the main focus. Interviews with 70 additional respondents who have extensive experience in the cattle sector in the Amazon provided supplemental insights on the history and context of local development, particularly regarding the acceptance of environmental and political changes in those regions.

During the second year of field data collection (2014), our sample focused on ranchers who reported FMD vaccination at the State Animal Health office (ADEPARA). FMD vaccination reporting to ADEPARA is a mandatory activity that happens twice a year, and, due to the obligation of all producers to participate, it provided better possibilities for recruitment of ranchers with a range of characteristics throughout our study region, making the sample more randomized. Small and large producers were reached, and during the interview, we identified those who sell directly to slaughterhouses and those who are indirect suppliers. To select the interviewees, we employed a criterion selecting one of every five ranchers who arrived in ADEPARA for an interview. If he or she refused to answer the questions, we selected the next available interviewee and then restarted the criterion of every five ranchers arriving to select next one. This method helped us to reach different types of cattle ranchers, from small to large, and ensured that we had a selection of properties distributed in all evaluated region. Because all ranchers are obligated to report vaccinations and we used a random approach to select ranchers during the second year of data collection, when we surveyed the most ranchers, we believe our sample is generally unbiased.

Results

Property Characteristics and Land-Use Trends

Ranchers in SE Pará are diverse in terms of their land assets and strategies for continued production and for addressing productivity challenges. Property sizes varied considerably; the mean area of our sampled properties was approximately 2,400 hectares (median = 138 ha), with a maximum size of 57,000 hectares and a minimum of 29 hectares. Within our sample, indirect suppliers were much smaller than direct suppliers, with average areas of 276 and 4,836 hectares, respectively.

Table 1. Summary Statistics for Quantity of Animals and Stocking Rate Per Property Reported by Ranchers Surveyed.

	Number of animals	Stocking rate
Mean	1,778	1.61
Standard deviation	7,974	1.04
Median	138	1.38
Minimum	12	0.28
Maximum	80,000	6.25

Among the properties we visited, the minimum stocking rate was 0.3 and the maximum was 6.25 animals per hectare (Table 1). The average reported stocking rate was 1.6 animals per hectare (median 1.38 ha). A given stocking density can mean very different levels of productivity depending on the age of animals and quality of pasture; consequently, many researchers and government offices use animal units (AU) to calculate stocking rate. Because our intent was to use the same method, we initially asked if producers knew and could report the quantity of animals they owned and their average weight. Few could estimate this, which made it impossible for us to calculate stocking rate in AU. In general, the farms we surveyed that had better access to technology, such as information about best practices in pasture rotation, animals with better genetics, and better grass seed, had approximately two animals per hectare, while farms with degraded pasture and no access to technology had only about 0.3 animals per hectare.

However, common issues that affected the majority of our respondents included the inability to legally clear more land on their properties and the desire to increase pasture productivity. More than 95% of surveyed properties reported having less than the area of legal forest reserve[1] that is required by the Forest Code. Properties in our sample were approximately 19% forested, on average, with little land devoted to regrowth (9.6%) or planted to crops (1.7%; Table 2). The majority (69%, on average) of each property was used for pasture. These findings are consistent with the long history of occupation of the region (since the 1970s), and its location within the Arc of Deforestation, or the region in Brazil with the highest levels of deforestation.

Similarly, 76% of respondents reported an interest in increasing pasture productivity; however, many reported that the high cost of improving pasture and low access to technology were limiting factors. For example, the average cost to increase productivity per hectare of pasture in this region is about R$1,474 ($752 in 2009 USD), while conversion of one hectare of forested area to pasture is only R$800 (US$408; Townsend et al., 2009). This cost differential helps to explain why ranchers often

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Table 2. Land-Use Statistics Based on Field Surveys of Properties in Southeastern Pará in 2013 and 2014.

	Property size (ha; $n = 130$)	Pasture (%)	Agriculture (%)	Forest (%)	Secondary growth (%)
Mean	2,423	68.9	1.7	18.6	9.6
Standard deviation	8,861	21.2	6.3	20.5	15.5
Median	137.9	75	0	13.8	0
Minimum	29.0	4.4	0	0	0.0
Maximum	57,064	100.0	40.0	95.6	80.0

choose to clear new areas rather than restore their degraded ones. Lack of routine access to farm machinery or use of extension services necessary for pasture improvement also helps explain why ranchers often choose to clear. Only 11% of farms in our study region (2,748 out of 24,777) had a tractor in 2017, and only 6% (1,571) accessed extension services in the same year (Instituto Brasileiro de Geografia e Estatística, 2017). Statewide totals for Pará are similar (5% of farms had a tractor and 6% accessed extension services statewide in 2017). Thus, our study region is representative of the challenges faced by producers to reconcile productivity gains and environmental concerns (Latawiec et al., 2014, 2017).

A minority of ranchers in this region did not face these challenges and employed alternative land-use models besides expansion via suppression of native vegetation. For example, some ranchers were beginning to invest in crop production, mainly soy and corn, and to a lesser extent rice, alongside their ongoing cattle production. We spoke to 11 ranchers who were planting soy or other crops on the same properties where they were also raising cattle. They cited the need to recover degraded pasture as the main reason to invest in agriculture. They explained that, while the initial capital outlays are high, this is the least expensive option because soy profits will ultimately cover all extra costs for pasture renovation while simultaneously improving the soils through fertilization, soil preparation, and nitrogen fixation after harvesting. Ranchers with areas devoted to agriculture typically had large holdings, with an average property size of 15,000 hectares, which allowed room for continued cattle production even while some of the area was dedicated to crops. The producers who had invested in agriculture on their own properties were all direct suppliers to slaughterhouses.

Another 20 ranchers (15% of our respondents) rented nearby properties to raise their cattle while they rented their own properties out to soy producers arriving from states with high soy production, including Mato Grosso, Mato Grosso do Sul, and Goiás. In these cases, the main goal for the landowner was pasture recovery so that he could eventually return to ranching on his property, but he was unable or unwilling to bear the initial capital outlays that are required to prepare land for and plant soy. Indeed, strategies such as land rentals could make soy production viable for more ranchers interested in increasing productivity. The expectation is that more producers in the region will switch to soy production, at least part time, and that they will employ various strategies to do so depending on their assets and other factors. One local rancher explained that soy production was likely to be significant in the future because the slaughterhouse oligopoly in the region reduces the price paid for cattle and thus the overall profitability of ranching.

Besides using degraded pasture to expand cropping, producers mentioned areas of nondegraded pastures and secondary growth[2] on their properties as sites for new planted areas. Among those who planned to expand cropping ($n = 11$), six said that degraded pasture would be the area used to expand or start soy production, three planned to use nondegraded pasture, and two cited secondary growth. Many producers considered secondary growth to be the same as degraded pasture; thus, producers who plant soy in these areas may be planning to have them revert to pasture as noted earlier.

Land rentals for pasture recovery took place under two types of arrangements. Some ranchers with larger landholdings rented portions of their land under contracts of up to 10 years to soy producers at low cost for areas that are highly suitable for soy production. Other ranchers rented their entire property to soy producers but keep their animals by renting a different parcel of land for pasture in their turn, often within agrarian reform settlements.[3] In this scenario, arrangements to fatten animals on these areas were often informal and short term. Some land rentals occurred under a *sistema de meia* (similar to sharecropping), where the landowner receives a certain percentage of the animals born or fattened on the owner's farm to keep as payment for pasture use. In other cases, the agreement involved pasture restoration at the end of a rental cycle or payment per animal kept on the property. At the time we collected our data (2013–2014), settlers reported renting their pasture for R$20 (R$ 15US$ 7.65 in 2009 values) per animal per month. Another rancher cited intensive feedlot systems as a way to reduce the period of

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extensive cattle grazing that was needed, while opening more land for cropping, thereby increasing productivity and profits.

Rentals for soy production were most common in the municipalities of Santana do Araguaia, Redenção, Santa Maria das Barreiras, and Cumaru do Norte, along Pará's southern border—an area with a long history of ranching and that was widely recognized as part of the new agricultural frontier of the state and home to many recent immigrants from southern Brazil, who arrived with expectations of acquiring cheap available land. Indeed, degraded pastures in this region were available at low cost, when compared with Mato Grosso state, which is the national leader in soy production. For example, in Mato Grosso, land had an average price of R$38,000 per hectare (R$24,040/US$12,265 in 2009 values), while south of Pará land could be bought for much cheaper—around R$6,000 per hectare (R$3,796/US$1,937 in 2009 values; IEG/FNP, 2016).

Beyond taking on soy production or renting to soy producers, ranchers faced other challenges that limit their options and contribute to ongoing extensive production and deforestation. For example, the emergence of an oligopoly of slaughterhouses in this part of the Brazilian Amazon has forced down the price of animals so that it is often lower than that paid in other parts of Brazil; however, most farmers have no option other than to sell regionally, as the cost of transporting animals to another region is too high. The price paid for cattle in Marabá, for example, was 16% lower than in São Paulo in 2016 (Anualpec/FNP, 2017). Ranchers reported that the best way to avoid the oligopoly was to sell animals for live export or for slaughter in other states (this also avoids having to comply with the CA). Most ranchers believed that concentration in the slaughter sector would continue to increase. However, the main change expected by some producers was that cattle production would decrease in the immediate future due to investments in soy and corn production that are needed to recover degraded pasture but would return as the dominate production strategy within 5 years.

Besides oligopoly, other major concerns related to cattle ranching were related to land title regularization and infrastructure. Regarding land titles, ranchers said that the lack of these documents was the reason they failed to invest in reforestation and seek environmental compliance, as their future on the land is uncertain under such situations. Furthermore, infrastructure was cited as a concern because ranchers felt they were doing the government's job when they build roads to enable the transport of animals. Several respondents noted that they received less per head because of slaughterhouse discounts for time and conditions of transportation. According to most ranchers surveyed, it was frustrating to have many new rules about environmental issues being enforced, while solutions for land title regularization and better infrastructure were not forthcoming.

Rancher Responses to the CA

In our study area, the cattle supply chain is complex, and cattle often move among two or three ranches prior to slaughter. The major meatpacking companies, including JBS, Marfrig, and Minerva, have established deforestation monitoring systems that are checked by each slaughterhouse when they make purchasing decisions. However, they only monitor direct sales from the fattening farms that sell to slaughterhouses, which means that many other ranches that are involved in producing the cattle (indirect suppliers) are not monitored.

Ranchers routinely described different ways to sell cattle produced on noncompliant farms with environmental and social problems, that is, noncompliant with agreements signed with Greenpeace and MPF. This happens using information from a compliant property, or by selling to plants or markets that do not monitor for deforestation. We identified five pathways that producers with noncompliance properties in southern Pará used to sell cattle without complying with the agreements: (a) they sell to the live export market where animals stay in quarantine farm before being sent to other countries, (b) they sell to neighboring states that have fewer companies with monitoring systems or to nearby plants that do not monitor origin of animals, (c) they move cattle to a compliant property and make arrangements with owners to sell the cattle from their land, (d) they may rent compliant land to produce cattle or simply to sell from, and (e) they may sell to known middlemen who own a property with no environmental problems (Figure 2). Regarding this information one producer said: "*. . . there are many animals that leave Pará without a GTA to be laundered in other states. Municipalities in the southwest send animals to Mato Grosso while those in the south provide animals to Tocantins and Goiás*" (Personal communication with first author, July 2013).

Leakage occurs when ranchers shift and sell animals to neighboring states, to slaughterhouses that have not implemented the agreements, or to live animal exporters, who are not covered by the MPF-TAC or G4 agreements (Gibbs et al., 2016). In our sample, we visited only SIF slaughterhouses, but company managers and ranchers were candid about the ease of avoiding requirements of the CA. For example, only four of the nine slaughterhouses in the study region operating under federal inspection (SIF), which is required for interstate and international sales, had deforestation monitoring systems. In addition to federal inspection, Brazil has inspection levels at the state (Serviço de Inspeção Estadual [SIE]) and municipal (Serviço de Inspeção Municipal [SIM]) levels. Barreto et al. (2017) identified

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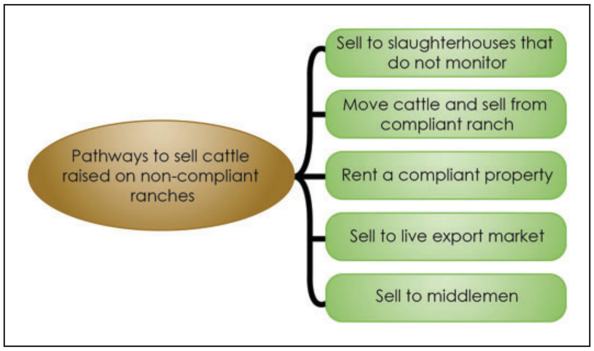

Figure 2. There Are Five Primary Pathways That Ranchers With Noncompliant Properties (i.e., Due to Deforestation, Embargoes, Lack of CAR) Can Sell Cattle Despite the CA.

65 Amazon slaughterhouses under SIE inspection, which are able only to sell beef and by-products within the state where they are registered. All SIE and SIM slaughterhouses also lacked monitoring and, thus, could serve as the destination for animals fattened on *blocked* properties that were unable to sell to those plants that enforced the agreements. Slaughterhouses located in neighboring states, particularly Tocantins, were also identified by ranchers as an option for selling cattle from noncompliant farms. Ranchers with noncompliance on one property could also rent another property with no recent deforestation, thereby expanding their production area and maintaining access to slaughterhouses despite deforestation on part of their productive area. Another challenge was the practice of using so-called middlemen. These ranchers are hired by the slaughterhouses to purchase cattle from many smaller ranchers to increase the efficiency of transaction costs. These middlemen list their own property, often small, as the source of the cattle when selling to the slaughterhouses, thereby rendering the actual sources invisible. In these cases, the ranchers become indirect suppliers and, in doing so, also evade monitoring.

The slaughterhouse managers and owners that we surveyed confirmed that proof of property registration (Cadastro Ambiental Rural - CAR) was mandatory to approve the purchase of animals. Results from our rancher surveys showed that direct suppliers were responding to these slaughterhouse checks and registering their properties in the CAR. However, indirect suppliers that did not interact with slaughterhouses were generally unregistered. For example, 88% of all ranchers ($n = 66$) who had sold directly to slaughterhouses had a property registered in CAR, while only 31% of the indirect suppliers we surveyed ($n = 65$) had registered their properties. Of the direct suppliers, 83% reported they registered to sell animals to slaughterhouses ("market access"). Indirect suppliers said they did not register because they sell only calves, or sell fattened animals to middlemen, and those actions did not require them to have CAR at the time of the surveys.

The indirect suppliers, mainly calving farms where cattle are reared from birth to 8 to 10 months of age, were often smallholders. These ranchers with small pieces of land (mostly settlers) were especially unlikely to have the resources or information to adapt and follow needed changes to comply with agreements. During field surveys, some ranchers noted that smallholder participation in the cattle supply chain may be completely undocumented and that sales occurred even without the required animal movement documentation, meaning that extension of monitoring to cover indirect suppliers could face challenges in capturing movements of animals from smallholder ranches.

Discussion

Our results highlight the importance of improving the current scenario of cattle production in SE Pará to the benefit of both ranchers and forests. The cattle sector in SE Pará is characterized by extensive production practices, and few ranchers in this region can easily transition from relying on deforestation to increase production due to a scarcity of resources for intensifying production via pasture restoration or integration of crop production, in spite of the widespread interest in doing so revealed by our fieldwork. At the same time, major slaughterhouses with commitments to zero-deforestation sourcing under the CA require that suppliers refrain from clearing new areas, though ranchers have devised several ways to persist in these supply chains without modifying their land management strategies to exclude deforestation. Despite political changes in Brazil since the time of our surveys, the CA remain a central pillar of the environmental policy landscape in the cattle sector. To improve forest protections, the CA should be adapted to address the loopholes identified by the surveyed ranchers and in previous studies (Alix-Garcia & Gibbs, 2017; Gibbs et al., 2016). While the issues discussed here are based on evidence from surveys conducted in 2013 and 2014, they remain relevant as the cattle sector has been slow to address even widely known issues related to resources for land users and loopholes in the CA.

For example, the persistence of slaughterhouses without commitments or monitoring systems in place remains a major challenge because if ranchers have access to a nonmonitoring slaughterhouse, they can simply avoid selling to slaughterhouses that do monitor. Alternative buyers are accessible to most producers because as cattle production has expanded rapidly in the region over the past two decades, slaughterhouses have also populated the Amazon landscape. In 1995, there were 13 slaughterhouses operating in the region;

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these increased to 61 just 10 years later (Pereira & Barreto, 2008; Santos et al., 2007). By 2015, the Ministry of Agriculture, Livestock and Supply listed 96 SIF slaughterhouses alone, many of which were not monitoring as of the time of our interviews. SIE slaughterhouses, which can market only at the state level, are even less likely to have a monitoring system, and SIM slaughterhouses under municipal inspection are not even party to the agreements yet.

The development of the Amazon beef sector has corresponded to increasing links between the Amazon beef sector and international markets, which helps explain the emergence of and persistence of the CA even under a challenging political context, but also their limited scope. By 2003, 6 years before the CA were implemented, some parts of the Amazon were already certified as FMD-free, opening up the potential for slaughterhouses in these regions to export (Figure 3; Walker et al., 2009). By 2007, just 2 years before the CA began, our study region in southern Pará was certified FMD-free. Whereas previously, nearly all beef produced in the Amazon had been destined for consumption in Brazil's big coastal cities, by 2015, at least 35% of Amazonian beef was exported (Ministério de Desenvolvimento, Indústria, e Comércio Exterior, 2014) due, in part, to the classification of most Amazon states as being free of FMD[4] by that time, and by 2017, all states were classified as FMD-free. However, only SIF slaughterhouses are eligible to export, reducing the pressure that can be placed on the region's numerous SIE and SIM slaughterhouses.

Live cattle exporters, which may be disproportionately exposed to deforestation, were another outlet for noncompliant cattle (zu Ermgassen et al., 2020). More recently, the sector has seen increased concentration of ownership of processing plants (Vale et al., 2019; zu Ermgassen et al., 2020), which many producers say has driven down carcass prices and reduced their options for market access. Expanding the CA to all SIFs and SIEs could improve rancher compliance by reducing opportunities for avoiding the CA. Since this fieldwork was conducted, Brazil's federal prosecutors have signed TACs with several additional slaughterhouses, and more slaughterhouses have begun monitoring (MPF, 2018), suggesting that some of the needed improvements are already in progress. Widespread adoption of traceability or monitoring systems that cover the entire supply chain, which could eliminate the laundering of animals through use of other properties and stages along the life cycle, remains an important frontier in closing deforestation loopholes in the CA.

However, expansion of the agreements to include more slaughterhouses will not be enough on its own. Ranchers discussed adaptations they have made to continue selling into the supply chains of slaughterhouses that monitor to comply with the agreements. These adaptations essentially amount to presenting as indirect suppliers, which are not yet monitored by any slaughterhouse. Specific strategies include renting another property without violations to sell from themselves, using a middleman for sales to the slaughterhouse, as well as actually changing their role to that of an indirect supplier by selling to other ranchers instead of directly to the slaughterhouse. Thus, from our interviews, it was clear that even monitoring slaughterhouses continue to be exposed to deforestation through their purchases. While laundering would likely continue to be a risk, these findings suggest that expansion of monitoring to cover the first level of indirect suppliers (those that sell to the slaughterhouse's direct suppliers) is an important next step toward discouraging deforestation in cattle supply chains. However, wide-scale monitoring of indirect suppliers may require increased transparency of animal transit records, which may be challenging under Brazil's current political climate (Gardner et al., 2019).

Efforts to improve governance of cattle supply chains may be more effective if accompanied by public or private initiatives that extend material and knowledge-based resources in support of intensification. Cattle ranching in the Brazilian Amazon is characterized by extensive grazing, and animals are almost always raised on pastures for their entire life cycle (Latawiec et al., 2014). Low-intensity grazing is the norm, with an average of about one cow per hectare frequently reported for the region (Valentim & Andrade, 2009), as typical stocking rates range from 0.6 to 2.0 AU per hectare (one AU = 450 kg of live animal; Amigos da Terra, 2009), although stocking rates vary based on soil conditions, technology employed, previous land use, and pasture management (type of grass, age, and quantity of animals raised).

Most producers we interviewed and, indeed, most producers in the Amazon are unable to clear more area under the Forest Code (Gibbs et al., 2015), making a pivot toward intensification even more important. So far, investment in breeding animals that are genetically suited to the Amazon has been credited with the 83% increase in stocking rates between 1975 and 2006 (Valentim & Andrade, 2009), despite the low present rates. There is also some evidence that proximity to SIFs is associated with intensification in cattle production systems, potentially due to more reliable payment systems from these slaughterhouses compared with others (Garrett et al., 2018), though our interviews suggest that this advantage is insufficient for many suppliers to SIFs.

Increasing access to subsidized credit, whether through the Low Carbon Agriculture program ("Programa ABC") or through other avenues, is likely one important step to further increasing efficiency in the

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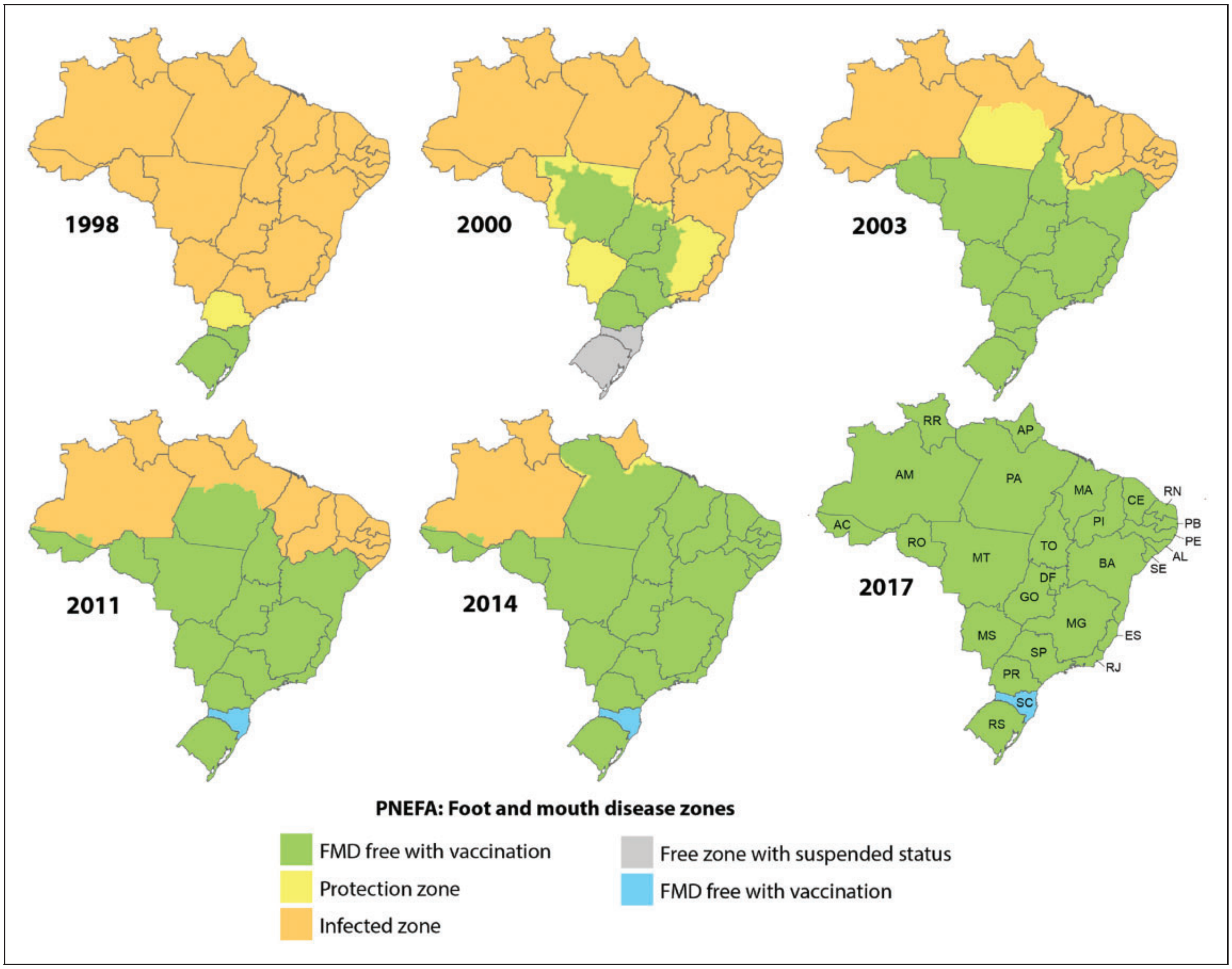

Figure 3. Evolution of Foot-and-Mouth Disease in Brazil, 1998–2014 (Data Source: Ministry of Agriculture, Livestock and Supply/ Programa Nacional de Erradicação e Prevenção da Febre Aftosa, 2014; World Organisation for Animal Health, 2014, 2019). FMD = foot-and-mouth disease.

sector, especially when pasture degradation is a factor (Silva et al., 2017). For example, these loans could support expanded use of soy to recover degraded pastures, a practice that many of our respondents were already undertaking. However, increased access to loans alone is unlikely to solve the common low productivity causes of labor scarcity and lack of access to objective technical assistance (Latawiec et al., 2017). Indeed, Latawiec et al. found that nearly half of technical assistance in their study region in Mato Grosso was provided by pesticide and fertilizer salespersons; it is not hard to imagine that these for-profit extension services could increase costs for producers and limit the dissemination of low-tech solutions. If coupled with strengthened deterrents to deforestation, such as an expanded and fully implemented CA that included both direct suppliers and the indirect suppliers they buy from, efforts to help ranchers to intensify could lead to the sparing of forests that would otherwise be cleared to increase production under conventional, extensive systems (Cohn et al., 2014).

Outside of efforts to intensify, ranchers expressed frustration at difficulties in obtaining documentation of land tenure and about the quality of infrastructure such as roads. Brazil's land tenure system is notoriously byzantine, and it is not uncommon for a land user to spend decades trying to secure title. Lack of land tenure documentation limits access to credit and reduces incentives to invest in conservation strategies and is also associated with increased deforestation (Benatti & da Cunha Fischer, 2018). Increased investment in land tenure regularization efforts could help increase opportunities for ranchers to undertake improved land management approaches that would benefit both the cattle sector and reduce deforestation on privately held lands (Reydon et al., 2020). However, these efforts should be

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carefully calibrated to not promote or legitimize land speculation on state-controlled lands (Reydon et al., 2020), which is a leading cause of deforestation and which currently pending legislation (Provisional Measure 910) would greatly loosen restrictions on (Chiavari & Lopes, 2020). Ranchers also take on maintenance of state-owned infrastructure, such as roads; increased budgets for infrastructure and improved oversight of contracts for infrastructure maintenance could reduce the burden on ranchers. Better-maintained roads would improve the livelihoods of all residents in these regions, though improved forest governance would be needed to ensure that these improvements did not lead to increased deforestation (Pfaff et al., 2018).

Notwithstanding the loopholes and challenges, we noted clear positive changes in the field, including efforts to recover pasture even under challenging conditions, which could spread to other Amazonian states as well as to other parts of the cattle chain through efforts to expand the scope of the agreements. To continue on this positive pathway, steps should be taken to close loopholes, to make consumers more aware about the origin of animals, and to establish agricultural programs that renew open pastures that are degraded. In fact, this article's study region has emerged as the new agricultural frontier as a result of pressure to reduce deforestation and by the need to renew pasture. To understand the land-use dynamics of grain expansion and whether ranchlands are intensifying cattle production or adding pressure on forests is an important research front.

Implications for Conservation

Cattle ranching is a leading cause of deforestation in the Brazilian Amazon (Kaimowitz et al., 2004). Rising rates of deforestation after a decade of reduced rates have created additional urgency around reducing pressure on forests from cattle. The consequences of ongoing deforestation in the Amazon include disturbances in regional rainfall patterns (Zemp et al., 2017), which can in turn lead to diebacks of remaining forest that will lead to further reductions in rainfall (Lapola et al., 2018; Lovejoy & Nobre, 2019), emissions of substantial amounts of carbon (Nogueira et al., 2015), and considerable loss of biodiversity (Barlow et al., 2016).

Recent research suggests that the existence of multiple, complementary policies, including those from both public and private sectors, can be effective at reducing deforestation on private properties (Alix-Garcia et al., 2018; L'Roe et al., 2016). Indeed, the Amazon Soy Moratorium (ASM), which was implemented by the private sector but relies heavily on public data, has been one of the great conservation success stories (Brown & Koeppe, 2013; Gibbs et al., 2015; Kastens et al., 2017). However, the CA, which were in some respects modeled on the ASM, have had only qualified success, causing ranchers to register in the CAR and slaughterhouses to exclude deforestation but leading to no detectable impact on forests (Alix-Garcia & Gibbs, 2017; Gibbs et al., 2016). An important difference between the ASM and the CA is that the ASM covered nearly all buyers and all soy production areas, while the CA have been limited to only certain slaughterhouses and certain ranches, creating opportunities for leakage. Our interviews with ranchers in the field underscored this point, highlighting the importance of expanding the CA to cover more slaughterhouses and indirect suppliers to reduce the pathways for deforestation to enter supply chains.

Under pressure to reduce deforestation, ranchers face substantial obstacles to improve their land-use practices and efficiency on their current lands. Increased support for ranchers, including access to financial resources, improved extension services, regularization of land tenure, and improved infrastructure, could improve land management if implemented in concert with an expanded CA and improved enforcement of other environmental policies to avoid the risk of rebound effects.

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Supplemental Material

Supplemental material for this article is available online.

Notes

1. Brazilian Forest Code mandates that 80% of forested areas must be kept as a legal reserve in all areas inside Amazon Biome.
2. Secondary growth results from a natural process of vegetation regeneration of areas used temporarily in the past for agriculture or pasture, and then after abandonment of economic/subsistence activities, vegetation emerges spontaneously.

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3. Properties inside agrarian reform settlements are managed by National Institute of Colonization and Agrarian Reform (Instituto Nacional de Colonização e Reforma Agrária - INCRA) and are under restrictions related to, for example, no permission of land commerce (land cannot be sold or rented before tittle is issued, which is rare to happen before at least a decade of settlement formation).
4. In the Brazilian Amazon, Mato Grosso and Tocantins were classified as FMD-free with vaccination in 2001, Rondônia in 2003, and state of Acre along with two adjacent municipalities of State of Amazonas in 2005. Pará state FMD-free classification started in 2007, when one zone covering the middle southern was approved, and in 2014, remaining portion of that state was added. Amapá, Amazonas, and Roraima were classified as FMD-free states in 2017 (Ministry of Agriculture, Livestock and Supply/Programa Nacional de Erradicação e Prevenção da Febre Aftosa, 2014; World Organisation for Animal Health,2014, 2019).

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