



Policy change, land use, and agriculture: The case of soy production and cattle ranching in Brazil, 2001–2012



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ABSTRACT

The Brazilian Amazon has experienced one of the world's highest deforestation rates in the last decades. Cattle ranching and soy expansion constitute the major drivers of deforestation, both through direct conversion and indirectly by land use displacement. However, deforestation rates decreased significantly after the implementation of the action plan to prevent and control deforestation in 2004. The aim of this study is to quantify the contribution of cattle and soy production with deforestation before and after the implementation of the action plan in the two states Mato Grosso and Pará along the BR-163. Specifically, we aim to empirically test for land use displacement processes from soy expansion in Mato Grosso to the deforestation frontier between 2001 and 2012. First, we calculated the relationships between deforestation rate and the change in cattle head and planted soy area respectively for the BR-163 region. Second, we estimated different panel regression models to test the association between processes of land use displacement. Our results indicate a close linkage between cattle ranching and deforestation along the BR-163 between 2001 and 2004. Soy expansion in Mato Grosso was significantly associated with deforestation during this period. However, these relations have diminished after the implementation of the action plan to control and prevent deforestation. With the decrease in deforestation rates in 2005, cattle ranching and deforestation were not directly linked, nor was soy expansion in Mato Grosso and deforestation at the forest frontier. Our analysis hence suggests that there was a close coupling of processes and spatial displacement until 2004 and a decoupling has taken place following the political interventions. These findings improve the understanding of land use displacement processes in Brazil and the methods offer potential for exploring similar processes in different regions of the world.

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Introduction

The Brazilian Amazon has been subjected to one of the world's highest deforestation rates in the last decades (INPE, 2014b). Deforestation rates in the Legal Amazon increased from 2000 to 2004 from 18,226 km²/year to 27,772 km²/year respectively. Since then rates have been decreasing to 4571 km²/year in 2012 (INPE, 2014b).

Understanding causes of deforestation and land use changes is crucial to curb deforestation. There are a large number of studies linking socio-economic and biophysical factors to deforestation in the Amazon region typically identifying drivers on municipal or grid level (Aguilar, Câmara, & Escada, 2007; Andersen & Reis, 1997;

de Espindola, Aguiar, Pebesma, Câmara, & Fonseca, 2012; Laurance et al., 2002; Pfaff, 1999). Most commonly, a combination of proximate and underlying causes have been identified as the main drivers of deforestation, i.e., cattle farming, road building, and accessibility to markets and ports (Lambin & Geist, 2006; Margulis, 2004). These drivers describe the local circumstances influencing deforestation. However, underlying causes on regional and global level may influence local drivers and put pressure on land conversions (Meyfroidt, Lambin, Erb, & Hertel, 2013).

A couple of studies on regional and global drivers of deforestation in the Brazilian Amazon concentrate on the effects of global prices for agricultural goods, policy changes, and indirect land use change or land use displacement. Policy changes, especially the implementation of the action plan to prevent and control deforestation (PPCDAm, Plano de Ação para a Prevenção e o Controle do Desmatamento na Amazonia Legal) in 2004, had a significant effect on the decline of deforestation (Assunção, Gandour, & Rocha, 2012, 2013b; Hargrave & Kis-Katos, 2011). The PPCDAm focuses on three

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areas: first, territorial management and land use, e.g., expansion of the protected areas network (PPCDAm I 2004–2007); second, command and control, e.g., improved monitoring, licensing and enforcement of environmental laws (PPCDAm II 2008–2011) and third promotion of sustainable practices, e.g., by credit policies (PPCDAm III 2012–2015) (MMA, 2013). Additional campaigns include the soy moratorium agreed on in 2006 and the cattle moratorium agreed on in 2009. Both have shown promise in changing the patterns of deforestation (Boucher, Roquemore, & Fitzhugh, 2013; Rosa, Souza, & Ewers, 2012; Rudorff et al., 2011).

Understanding processes of land use displacement or indirect land use change as an underlying driver of deforestation has gained special attention since the rapid expansion of export oriented agricultural production (Kim & Dale, 2011; Lapola et al., 2010; Meyfroidt et al., 2013; Searchinger et al., 2008). In Brazil, this discussion mainly focuses on the expansion of soybean and sugarcane production following the increased global and national demand for biofuel and animal fodder within the last decades (Andrade de Sá, Di Falco, Palmer, 2013; Morton et al., 2006). This expansion led to the hypothesis of indirect land use change, i.e., the displacement of cattle ranching to the Amazon rainforest where it drives deforestation (Andrade de Sá et al., 2013; Arima, Richards, Walker, & Caldas, 2011; Barona, Ramankutty, Hyman, & Coomes, 2010; Macedo et al., 2012; Nepstad, Stickler, & Almeida, 2006; Richards, 2012).

Most studies on displacement processes in Brazil focus on the recent expansion of soy area, particularly on Mato Grosso (MT) as one of the world's most important production areas (DeFries, Herold, Verchot, Macedo, & Shimabukuro, 2013). Morton et al. (2006) showed that soybean expansion most often replaced pasturelands. This conversion can be argued to be a process of intensification, since financial returns per area of land increased (Brandão, Castro de Rezende, Da Costa Marques, 2005). However, if the output of the replaced activity faces a relatively inelastic demand, as it is likely for stable food products like meat, the production will probably be reconstituted in another place where it can act as a local driver of land use change (Andrade de Sá, Palmer, Engel, 2012; Andrade de Sá et al., 2013).

In detail, Nepstad et al. (2006) suspected that the expansion of the Brazilian soybean industry drove cattle expansion of the Amazonian cattle herd indirectly. Barona et al. (2010) concluded that the expansion of soy production might have operated as an underlying driver of deforestation displacing pasture further north into the forested areas, where pasture expansion is the predominant proximate cause of deforestation. Using a panel regression approach Arima et al. (2011) and Richards (2012) found soy expansion in Brazil had a significant effect on deforestation in the Amazon forest between 2002 and 2008. However, analyzing the migration history of farmers and ranchers, Richards (2012) could not clearly identify patterns of movement to support the idea of “spatial redistribution of knowledge and capital” from the soy expansion areas to the forest frontier.

This study aims to understand the coupling of cattle production and soy production with deforestation processes within the Amazon region along the BR-163. The BR-163 region has been one of the most dynamic forest frontier regions within the Brazilian Amazon connecting the soy production areas in Mato Grosso (MT) with the forested region in the north of MT and Pará (PA). We analyzed the local evolution of cattle and soy production in relation to deforestation, and the effect of distant soy expansion in Mato Grosso on deforestation at the forest frontier using a fixed effects panel regression. Different from earlier studies, we explicitly focus on the change in displacement processes before and after the implementation of the PPCDAm and aim for statistical evidence for displacement processes.

More specifically our research questions are:

- How does the coupling of land use processes, i.e., cattle and soy production with deforestation, change along the BR-163 between 2001 and 2012?
- Can we find statistical evidence of land use displacement from the soy expansion area in Mato Grosso as source region to the forest frontier areas in the Brazilian Amazon? How does land use displacement change following the implementations of the PPCDAm in 2004?

Material and methods

Study region

This study explores one of the hotspots of deforestation in the Brazilian Amazon: the region along the BR-163 traversing the Brazilian Amazon from Cuiaba, MT to Santarem, PA (INPE, 2014b). We selected those 31 municipalities that intersect with a 150 km buffer along the road starting in the south with the Amazon Biome border and framed in the north with the Transamazonica road (Fig. 1). This area captures the most relevant frontier development following the construction of the highway in 1973 as an export corridor for agricultural productions in MT (Coy & Klingler, 2011; Fearnside, 2007).

The study region comprises 500,580 km² and is dominated by forest area (2001: 411,249 km², 2012: 376,622 km²), cattle ranching (2001: 4,245,462 heads, 2012: 7,436,330 heads), with an estimated stocking density of 0.009 animal per km² in 2006 and 0.01 animal per km² in 2013 (Geraldo, Alves, & Contini, 2012; Walker, Patel, & Kalif, 2013), and soybean production (2001: 3430 km², 2012: 14,884 km²). Other livestock only constitute a minor share of total livestock population (see Appendix Fig. A2). Soybeans as the main crop are increasingly planted in double cropping systems followed by maize, cotton or a non-commercial crop (Arvor, Jonathan, Meirelles, Dubreuil, Durieux, 2011a; Arvor, Margareth, Dubreuil, Bégué, & Shimabukuro, 2011). Deforestation rates increased sharply between 2001 and 2004 from 3995 km² to 6431 km² and decreased until 2012 to 728 km² (INPE, 2014b).

Following the implementation of the PPCDAm in 2004, a number of protected areas, indigenous lands and sustainable use areas were expanded or created within the study region (Fig. 1). Additionally, command and control policies were enforced, e.g., the opening of an IBAMA (Brazil's federal environment protection agency) office in Novo Progresso in 2007, the identification of priority areas for law enforcement, and a rapid response program based on the 15 days DETER (Detecção de Desmatamento em Tempo Real) monitoring interval (Anderson, Shimabukuro, DeFries, & Morton, 2005; Assunção, Gandour, & Rocha, 2013a; INPE, 2014a). In 2008, changes in public credit policies were implemented conditioning the concession of rural credit upon compliance with legal and environmental regulations. This included, among others, legal property rights (Cadastro Ambiental Rural) and limited deforestation per municipality (Governo do Pará). These regulations especially affected those municipalities where cattle ranching is the predominant activity (Assunção et al., 2013b). Additionally, in 2006 the “soy moratorium” and in 2009 the “beef moratorium” were implemented. Both are agroindustry led initiatives with the objective to limit deforestation by direct encroachment of soy fields and pasture areas into forest (Boucher et al., 2011; Rudorff et al., 2011).

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