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Property-level direct and indirect deforestation for soybean production in the Amazon region of Mato Grosso, Brazil

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ABSTRACT

Brazil's Soy Moratorium solidified the world's largest traders' commitment to stop soybean purchases from production areas deforested after July 2006. The aim was to remove deforestation from the soybean supply-chain and halt one of the main drivers of forest loss in the Amazon biome. In this study, we investigated changes in deforestation at the property-level for the period 2004 to 2014. The objective was to examine direct and indirect deforestation, defined as on-property displacement and cross-parcel displacement deforestation for soybean expansion in the Amazon region of Mato Grosso, the leading soy-producing state of the Brazilian Amazon. We used publicly available property and land use data to quantify deforestation associated with cropland expansion. Similar to previous studies, we found that direct deforestation for soybean expansion declined following the implementation of the Soy Moratorium. Moreover, our analysis suggest that indirect deforestation occurred already before the implementation of the Soy Moratorium, and decreased following the first period of analyses. However, slight increases of indirect deforestation in the more recent periods, combined with decreasing direct deforestations rendered indirect deforestation to be responsible for more than half of the deforestation associated with soybean expansion. While we acknowledge the overall reduction of deforestation for soybean, our results suggest, given the increasing trends of deforestation in the Brazilian Amazon since 2013, to address indirect deforestation within the Soy Moratorium. This may be achieved by zero-property-deforestation commitments and by strengthening the integration between supply-chain actors, the soybean and beef purchasing companies and the federal policies aiming to control deforestation.

1. Introduction

Following the rapid deforestation in the Brazilian Amazon of the early 2000s, forest loss has since significantly decreased. Annual rates of deforestation decreased from more than 2.7 million ha in 2004 to 0.5 million ha in 2012. Brazils federal state of Mato Grosso is one of the most active deforestation frontiers in the Amazon during the recent decades (INPE, 2018). Most deforestation was driven by cattle ranching activities and the large-scale expansion of soybean production in the early 2000s (Arvor et al., 2011b; Macedo et al., 2012). The main factors explaining the decreasing deforestation rates are commonly understood as a combination of the implementation of environmental policies, zero-deforestation supply-chain commitments, and decreasing prices for agricultural commodities (Hargrave and Kis-Katos, 2011; Assunção et al., 2015). Policies, including territorial management, increased law enforcement, and strategic allotment of rural credits were streamlined under the Action Plan to Prevent and Control Deforestation in the Legal Amazon (PPCDAm) implemented in 2004 (Assunção et al., 2015; MMA, 2016). Supply-chain commitments were initiated following increasing international attention to deforestation in the Brazilian Amazon associated with soybean production (Soy Moratorium) in 2006, and cattle ranching (MPF-TAC and G4 Agreement) in 2009 (Greenpeace, 2006,2009; Nepstad et al., 2014; Gibbs et al., 2015, 2016). Overall, these strategies are understood to have significantly contributed to a decrease of deforestation, saving approximately 7.3 million ha of Amazonian forest between 2005 and 2009 (Assunção et al., 2015). However, since 2013 deforestation rates in the Brazilian Amazon increased from about 0.5 million ha in 2012 to 0.7 million ha in 2017 (INPE, 2018). Rising global demands for agricultural commodities may fuel additional deforestation, stressing the need to better understand

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current and past deforestation processes (Richards et al., 2012; Garrett et al., 2013; Gasparri and Le Polain de Waroux, 2015; Oliveira and Schneider, 2016).

The Soy Moratorium was the first voluntary zero-deforestation supply-chain commitment implemented in the tropics (Gibbs et al., 2015). It defines the agreement of Brazil's major soybean trading companies not to purchase soybeans produced on areas deforested after June 2006, which was changed to 2008 during the renewal of the Moratorium in 2014 (Gibbs et al., 2015). The Moratorium attracted attention within the research community, on the one hand because as a corporate social responsibility strategy it introduced new actors into conservation policy (Lambin et al., 2018), and on the other hand because it has often been evaluated to be effective in reducing deforestation for soybeans, which makes it a potential blueprint to be transferred to other commodities (Rudorff et al., 2011, 2012; Gibbs et al., 2015; Imaflora, 2016; Costa et al., 2017; Kastens et al., 2017; Silva and Lima, 2018). The commitment was drafted and monitored by the Soy Moratorium Working Group (GTS), a cooperation between industry representatives and high-profile environmental groups (Grupo de Trabalho da Soja (GTS), 2012; Gibbs et al., 2015). With its implementation, a monitoring and reporting system was set up starting for the cropping year 2007/2008 for those municipalities, whose estimated soybean area exceeds 5000 ha (Grupo de Trabalho da Soja (GTS), 2012). Land use on deforestation polygons larger than 25 ha were identified using satellite imagery acquired from the moderate resolution image spectrometer (MODIS) (spatial resolution 250 × 250 m) (Grupo de Trabalho da Soja (GTS), 2016a; Imaflora, 2016) and if croplands were found on post-deforestation land, these polygons were further investigated with high resolution satellite imagery and surveyed by air (Grupo de Trabalho da Soja (GTS), 2012; Gibbs et al., 2015; Imaflora, 2016). In case the identified polygons were used for soybean production the associated properties were added to a blacklist managed by the GTS and excluded from soybean purchases by the committed trading companies (Gibbs et al., 2015).

After the commitment, direct deforestation for soybean production decreased (Rudorff et al., 2011; Macedo et al., 2012; Rudorff et al., 2012; Imaflora, 2016; Kastens et al., 2017), and total deforestation continued to decline until 2012 (INPE, 2018). Despite these measures Mato Grosso has become the leading soybean producing state, rendering Brazil the second-leading country for soybean production worldwide (FAO, 2017; IBGE, 2017). Concerns about the effectiveness of the strategies on curbing deforestation, and interest in better understanding the dynamics of deforestation and soybean expansion in the Amazon grew with the increasing rates of deforestation since 2013 (Rausch and Gibbs, 2016; Kastens et al., 2017; Silva and Lima, 2018). For example, while the GTS monitoring program did not find a single property non-compliant with the Soy Moratorium in 2007/2008 (Grupo de Trabalho da Soja (GTS), 2009) this number increased steadily in the subsequent years to 36,000 ha in 2016/2017 (Figure SI 1), but so far direct deforestation only contributes a small fraction on overall deforestation in Mato Grosso (Grupo de Trabalho da Soja (GTS), 2017).

The discussion and concerns about the effectiveness of the Soy Moratorium addressed potential loopholes in the supply-chain commitment: the potential of leakage to different regions, how non-compliant soybean production might still enter the supply-chain, and how illegal deforestation on soybean producing properties does not necessarily lead to exclusion from commercialization.

The spatial limitation of the Soy Moratorium confined to the Amazon biome, led to the hypothesis of cross-biome leakage. Leakage describes the displacement of the environmental impact of land uses in response to the implementation of environmental policies (Meyfroidt et al., 2013). The hypothesis suggest that following the implementation of the Soy Moratorium, soybean expansion and deforestation were displaced to the Cerrado biome causing an accelerated conversion of native savannah vegetation. Although Macedo et al. (2012) rejected the hypothesis that soybean leakage was driving deforestation in the Cerrado, recent analysis identified a shift of the cropland expansion frontier moving eastwards towards the northern Cerrado region since 2008 where an increasing fraction of croplands are sourced from native vegetation (Noojipady et al., 2017). On average, one quarter of the expansion in the Cerrado occurred at the expense of native savanna vegetation, which partially offsets the averted carbon emissions from reduced deforestation in the Amazon (Noojipady et al., 2017).

Also within the Amazon biome, non-compliant soybean production was potentially able to enter the supply-chain. Gibbs et al. (2015) and Rausch and Gibbs (2016) identified two possible loopholes. First, farmers often own or rent multiple properties, but upon sale, the total harvest could be sold under the registration of those properties listed as deforestation free, while production on the other properties may not be free from deforestation (Gibbs et al., 2015; Rausch and Gibbs, 2016). Second, if soybean farmers engage in illegal deforestation under federal legislation, they are officially prohibited from commercialization of their production (Lei de Crimes Ambientais, 1998; Código Florestal, 2012). However, inconsistencies between the embargoed list under federal legislation and the property cadaster used for the Soy Moratorium, and limited monitoring and enforcement capabilities of the Brazilian environmental protection agency (IBAMA), often allowed soybeans produced on these properties to enter the supply-chain (Gibbs et al., 2015).

Indirect deforestation for soybean might have occurred at farm-level in form of a displacement of deforestation between commodities, namely between soybean and cattle production (Rausch and Gibbs, 2016). A farmer aiming to expand and secure profits from soybean production might expand its soybean area converting pastures to soybean plantation and, at the same time deforest for pasture, to keep the pasture area to support his cattle herd. This land use trajectory suggests that the underlying motivation for deforestation is the expansion of soybean cultivation. If indirect deforestation occurred in response to the implementation of the Soy Moratorium at property-level, we would term this deforestation leakage. Moreover, pastures and sometimes rice plantation play an important role for the preparation of soil for subsequent soybean production (Grupo de Trabalho da Soja (GTS), 2009; Macedo et al., 2012). Deforestation for these land uses might additionally occur in anticipation for amnesty of past deforestation in future renewals of the Moratorium, similar to the amnesty granted for deforestation between 2006 and 2008 agreed on during the renewal in 2014 (Silva and Lima, 2018).

Analyzing and quantifying direct and indirect deforestation for soybean expansion will potentially increase the understanding of deforestation processes in the Brazilian Amazon and may help to inform subsequent policy initiatives to curb further deforestation. In this paper we explicitly addressed indirect deforestation for soybean at property-level. In detail, we analyzed the area of direct conversions from forests to soybean fields, indirect deforestation for soybean expansion measured as the amount of soybean expanding into pastures in combination with deforestation for cattle ranching occurring on the same property and or in its direct neighborhood. The specific research questions were:

How much direct and indirect deforestation for soybean production at property-level occurred in the Amazon biome of Mato Grosso between 2004 and 2014?

Did on-property indirect deforestation increase following the implementation of the Soy Moratorium in the Amazon biome of Mato Grosso?

2. Methods

2.1. Study region

This study focusses on the Amazon biome within the federal state of Mato Grosso (Fig. 1). Extensive cattle ranching with low stocking