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UNIVERSIDADE DE BRASÍLIA  
PÓS-GRADUAÇÃO EM GEOGRAFIA

**AMAZÔNIA LEGAL: ESTUDO DA RELAÇÃO DO DESMATAMENTO COM A POSSE DA  
TERRA NO ESTADO DO MATO GROSSO**

**Daniella Tiemi Sasaki Okida**

Dissertação de Mestrado

Brasília-DF: agosto de 2019

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Daniella Tiemi Sasaki Okida

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**Resumo:** Esta pesquisa examina as relações entre a redução das Florestas e a certificação de propriedades no Estado do Mato Grosso. A área de estudo abrange 483.469 km<sup>2</sup> do bioma Amazônia no estado do Mato Grosso, que é inteiramente contido dentro da Amazônia Legal Brasileira, localizada no “Arco do desmatamento”, onde a agropecuária compete com a cobertura vegetal nativa. O monitoramento e os sistemas cadastrais de certificação de propriedades são algumas das políticas públicas que o Brasil tenta implementar para enfrentar esses desafios ambientais. Nesse contexto, cruzamos os dados do Instituto Nacional de Reforma Agrária (INCRA) com o programa anual de monitoramento do desmatamento (PRODES), do Instituto Nacional de Pesquisas Espaciais (INPE). O sistema cadastral que utilizamos é o Sistema de Gestão Fundiária (SIGEF) que foi lançado em 2013. Realizamos a análise de 2013 a 2017 com propriedades públicas e privadas e avaliamos as dinâmicas no comportamento de desmatamento de pequenos proprietários e grandes proprietários. Os resultados mostram que a certificação da terra causa um impacto maior no desmatamento das pequenas propriedades (menores de 100ha ). O SIGEF é relativamente novo e, portanto, é necessário mais tempo para estabelecer uma tendência de conservação consolidada.

**Palavras chave:** Desmatamento, Sistemas Cadastrais, Amazônia Legal, Certificação.

**Abstract:** This research examines the relations between forest decrease and property legal security in Mato Grosso State. The study area encompasses 483.469 km<sup>2</sup> of Amazonian biome in the Mato Grosso State, which is entirely contained within the Brazilian Legal Amazon-BLA, located at the “Arc of deforestation” where agriculture and cattle ranching compete with the native vegetation cover. Cadastral monitoring and certification of productive land plots are some of the public policies Brazil tries to implement to tackle these environmental challenges. In this context, we crossed the data from the National Institute for Agrarian Reform (Instituto Nacional de Colonização e Reforma Agrária - INCRA) with the annually deforestation monitoring program (Programa de Monitoramento da Floresta Amazônica por Satélite – PRODES) from Brazilian National Institute of Space Research (Instituto Nacional de Pesquisas Espaciais - INPE). The cadastral system we used is the SIGEF (Land Management System) and was launched in 2013. We performed the analysis from 2013 to 2017 with public and private land plots and evaluated the differences in the deforesting behavior of smallholders and large landowners. The results show that there is a small impact within the predatory behavior when land tenure security is enforced, and small properties are greater impacted in the deforestation rates. The SIGEF system is relatively new and therefore more time is needed to establish a consolidated conservation trend.

**Keywords:** Forest Cover, Cadastral System, Brazilian Legal Amazon, Land Tenure Security

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**Lista de abreviaturas:**

<b>IBAMA</b>	Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis
<b>IBGE</b>	Instituto Brasileiro de Geografia e Estatística
<b>INCRA</b>	Instituto Nacional de Colonização e Reforma Agrária
<b>INPE</b>	Instituto Nacional de Pesquisas Espaciais
<b>LANDSAT</b>	Land Remote Sensing Satellite
<b>MCTI</b>	Ministério da Ciência, Tecnologia e Inovação
<b>MDA</b>	Ministério do Desenvolvimento Agrário
<b>MMA</b>	Ministério do Meio Ambiente
<b>PRODES</b>	Monitoramento do Desmatamento da Floresta Amazônica Brasileira por Satélite
<b>SIGEF</b>	Sistema de Gestão Fundiária
<b>SUDAM</b>	Superintendência do Desenvolvimento da Amazônia

## CAPÍTULO I – APRESENTAÇÃO GERAL

### 1.1. Introdução

O Brasil enfrenta o desafio de equilibrar o avanço da produção agrícola com as áreas de proteção ambiental (GIL *et al.*, 2015). Nesse contexto, a implementação do Novo Código Florestal de 2012, que flexibiliza as regras em comparação com a lei anterior de 1965, representa um grande desafio para a administração nacional (KROGER, 2017). O Brasil se destaca como parte significativa da produção mundial de produtos agrícolas. Uma preocupação para as próximas décadas é a capacidade de suprir demanda do mercado por alimentos combustíveis e energia, levando em consideração a necessidade de expansão agrícola e pecuária sem ameaçar as áreas de proteção ambiental (NEPSTAD *et al.*, 2009).

Em regiões de floresta tropical, o desenvolvimento tradicional segue o modelo de fronteiras, onde as florestas são substituídas por outros tipos de usos, considerados mais relevantes para a produção e para os ganhos econômicos. (BECKER, 2001). Observa-se que a especulação financeira da terra nesses locais é comum e o mercado não depende da presença da titulação formal do imóvel (HOLLAND *et al.*, 2016; CARRERO e FEARNSSIDE, 2011; MERRY *et al.*, 2008).

Wood *et al.* (2000), em seu estudo, evidencia que a posse de título sobre a terra desestimulava a exploração de madeira e promovia o reflorestamento. L’Roe (2016) demonstra que o registro formal de propriedades levou à diminuição do desmatamento em fazendas de 100ha a 300ha.

Políticas de titulação de propriedades são conceitualmente derivadas de um entendimento mais geral, oriundo das ciências econômicas, conhecido como o “paradigma do direito à propriedade” (ALCHIAN e DEMSETZ, 1973). De acordo com o paradigma do direito à propriedade, o estudo de Wood (2000) entende que a insegurança sobre a posse da terra significa que os fazendeiros não tem certeza se irão colher os benefícios do seu próprio comedito e investimento. Sob estas circunstâncias, espera-se que os fazendeiros sem título da terra prefiram o consumo imediato dos seus recursos, ao invés de um comportamento de investimento a longo prazo. Assim, acabam minando sua terra e extraindo seus recursos (extrativismo de madeira) ao invés de se dedicarem a estratégias de produção sustentáveis.. Brown (2016) indica que o tipo de ocupação da terra e o desmatamento na Amazônia Brasileira estão correlacionados.

Pacheco (2009) pondera que a reforma agrária pode reduzir as taxas de desmatamento quando o pequeno proprietário recebe terras que, em outras circunstâncias, seria rapidamente degradada por médios e grandes fazendeiros, através de plantações de soja e pastos para pecuária. Em contraste, o efeito da reforma agrária no desmatamento é negativo à medida que induz o assentamento em áreas de baixo interesse/pressão de outros agentes de desmatamento. Assim, para Pacheco (2009), o resultado da reforma agrária no desmatamento depende muito da

configuração socioeconômica e geográfica das fronteiras pré-existentes.

## **1.2. Revisão metodológica**

### *1.2.1. Área de estudo*

A área de estudo é composta por 483.469km<sup>2</sup>, referentes à porção do estado do Mato Grosso com o bioma amazônia, conforme o Mapa de Biomas do Brasil (IBGE, 2017) porque o estudo utilizou como elemento de comparação a classificação Floresta do PRODES. O Mato Grosso é o terceiro maior Estado do Brasil, com 903.198,091km<sup>2</sup>, 141 municípios e corresponde a 10,61% da área total do Brasil (IBGE, 2017).

O Novo Código Florestal (BRASIL, 2012) flexibiliza alguns pontos referentes às áreas de reserva legal. As regras determinam que, em imóveis rurais localizados na Amazônia Legal, a reserva será de 80% da propriedade nas áreas de florestas; 35% nas de cerrado; e 20% para os imóveis em áreas de campos gerais.

O Mato Grosso, estado sensível do “Arco de Desmatamento” onde a agricultura encontra-se em rápida expansão e onde os sistemas de produção pecuária local são muito dependentes da terra, com baixa densidade e por isso contribui com o aumento da pressão sobre a terra e sobre sua mudança de uso (COHN *et al.*, 2014). Considerando que o Mato Grosso é o maior produtor de soja e gado do país e se encontra adjacente à porção mais densa da floresta Amazônica, Fearnside (2003) ressalta que as grandes fazendas possuem mais tendência a desmatar para implementar áreas de pastos do que os pequenos fazendeiros, apesar de haver exceções. As evidências encontradas são de que a maior parte do desmatamento é feito pelos médios e grandes fazendeiros. Fearnside (2002) conclui que o investimento em subsídios e na intensificação da pecuária na Amazônia Brasileira não oferece indícios de que resultaria em diminuição de desmatamento e que fatores como a especulação imobiliária da terra e a segurança da posse da terra poderiam ser mais relevantes nas ações de diminuição do desmatamento.

### *1.2.2. SIGEF e PRODES*

O Sistema de Gestão Fundiária (SIGEF) é uma ferramenta eletrônica desenvolvida pelo Instituto Nacional de Colonização e Reforma Agrária (INCRA) e pelo Ministério do Desenvolvimento Agrário (MDA) para auxiliar na governança fundiária do território nacional. O sistema é responsável pela recepção, validação, organização, regularização e disponibilização das informações georreferenciadas de limites de imóveis rurais, públicos e privados.

O estudo utilizou as informações de 1.065 propriedades públicas certificadas/registradas entre 2014 e 2017 e 13.351 propriedades particulares certificadas/registradas entre 2013 e 2017.

A responsabilidade de georreferenciar o imóvel (identificar seus limites e representá-los por meio de coordenadas) é do Profissional Credenciado e a responsabilidade sobre o estabelecimento de direitos reais é do Registro de Imóveis, enquanto a responsabilidade do

INCRA é receber os dados de cada imóvel e certificar que não se sobrepõem e que obedecem ao mesmo padrão técnico.

O projeto PRODES realiza o monitoramento por satélite do desmatamento por corte raso na Amazônia Legal e disponibiliza anualmente as taxas de desmatamento na região. O PRODES utiliza imagens de satélites da classe LANDSAT (20 a 30 metros de resolução espacial e área mínima mapeada de 6,25 hectares). O projeto PRODES conta com a colaboração do Ministério do Meio Ambiente (MMA), do Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA) e é subordinado ao Ministério de Ciência, Tecnologia e Inovação (MCTI). Dados do PRODES foram usados em vários estudos nos últimos anos para pesquisas (BROWN, 2016; JUSYS, 2016; MÜLLER et al., 2016).

### **1.3. Objetivos**

O objetivo deste estudo é analisar a relação entre a certificação da propriedade do banco de dados SIGEF com o desmatamento observado pelo projeto PRODES entre os anos de 2013 a 2017 no bioma amazônia no estado do Mato Grosso.

### **1.4. Estruturação da dissertação**

Esta dissertação foi elaborada no formato de apresentação de artigos científicos segundo as diretrizes estabelecidas para o Programa de Pós-graduação em Geografia da Universidade de Brasília.

No capítulo I foi apresentada uma breve descrição do tema, contendo o problema em questão, o objetivo do trabalho e as fontes de dados utilizadas

No capítulo II será apresentado o artigo intitulado “*Brazilian Legal Amazon: relations between deforestation and land tenure security in Mato Grosso State*”.

No capítulo III serão discutidas algumas conclusões e considerações sobre o desenvolvimento do trabalho juntamente de algumas recomendações finais.

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## **CAPÍTULO II – BRAZILIAN LEGAL AMAZON: RELATIONS BETWEEN DEFORESTATION AND LAND TENURE SECURITY IN MATO GROSSO STATE**

**Abstract:** This research examines the relations between forest decrease and property legal security in Mato Grosso State. The study area encompasses 483.469 km<sup>2</sup> of Amazonian biome in the Mato Grosso State, which is entirely contained within the Brazilian Legal Amazon-BLA, located at the “Arc of deforestation” where agriculture and cattle ranching compete with the native vegetation cover. Cadastral monitoring and certification of productive land plots are some of the public policies Brazil tries to implement to tackle these environmental challenges. In this context, we crossed the data from the National Institute for Agrarian Reform (Instituto Nacional de Colonização e Reforma Agrária - INCRA) with the annually deforestation monitoring program (Programa de Monitoramento da Floresta Amazônica por Satélite – PRODES) from Brazilian National Institute of Space Research (Instituto Nacional de Pesquisas Espaciais - INPE). The cadastral system we used is the SIGEF (Land Management System) and was launched in 2013. We performed the analysis from 2013 to 2017 with public and private land plots and evaluated the differences in the deforesting behavior of smallholders and large landowners. The results show that there is a small impact within the predatory behavior when land tenure security policies are enforced, and small properties are greater impacted in the deforestation rates. The SIGEF system is relatively new and therefore more time is needed to establish a consolidated conservation trend.

**Keywords:** Forest Cover, Cadastral System, Brazilian Legal Amazon, Land Tenure Security

## 2.1. Introduction

Land tenure rules define how property rights to land should be allocated within societies and are an essential part of social, political, and economic structures (FAO, 2002). According to Demsetz (1967), property rights influence land-use choices and practices; for example, the owner of a private right focuses his acts on future benefits and costs opportunities. On the other hand, public land would tend to suffer from hunting and overwork in a short period because no one would privately own the land. Like the idea “no one washes a rental car” attributed to many authors, landowners treat their properties (in terms of improving soil against erosion) more responsibly than tenant farmers (Sklenicka *et al.*, 2015). Land ownership is related to welfare (Rao, 2018) and deforestation rates (Brown, 2016; Nolte *et al.*, 2013). Goldstein *et al.* (2018) evidence that investments affect increased tenure security in the early stages of formalizing land ownership in Benin, West Africa. In Ethiopia, land security/property rights are the most significant factors in farmers’ decision to invest in reforestation (Legesse *et al.*, 2018).

The definition of Brazilian Legal Amazon was by law in 1953, with 5,020,000 km<sup>2</sup> (IBGE, 2014) under the legislation of the Superintendence of the Economic Valorization Plan of Amazon (SPVEA) aimed to promote sustainable development of the Amazon region through the integration of the regional economy. In 1966, the government extinguished SPVEA and created the Superintendence of the Amazon Development (SUDAM) of the Regional Development Ministry (Brazil, 1966). Table 1 present a summary of the Brazilian Legal Amazon legislation.

One of the current challenges in Brazilian Legal Amazon is to balance the expanding agricultural frontier with forest preservation (Gil *et al.*, 2015, Arvor *et al.*, 2016). Sant’Anna (2017) shows that deforestation in the Amazon is related to the process of land inequality and land occupation in Brazil. The 2012 revised Brazilian Forest Code established a series of changes concerning the protection of forests and the flexibilization of the ruling over deforesting farmers, including the amnesty for illegal deforestation in private properties before 2008 (Arima *et al.* 2014, Soares Filho, 2014, Stickler *et al.*, 2013). Besides, the current Forest Code as a governance tool intends to support the agricultural development in already deforested areas while protecting still standing native vegetation through legal reserves (RL), areas of permanent protection (APP), and compulsory rural environmental registry

(CAR) (Arvor *et al.*, 2016; Azevedo *et al.*, 2017, Bircol *et al.*, 2018, Santiago *et al.*, 2018).

Table 1.  
Summary of the Brazilian Legal Amazon Legislation

Date	Law nº	Description
1953, January 6th	1.806	Defines the Economic Valorization Plan of Amazon (SPVEA) and establishes the region considered Brazil's Legal Amazon. Only part of Mato Grosso state is considered into the Legal Amazon region.
1966, October 27th	5.173	Extinguishes the SPVEA and creates the Superintence of the Amazon Development - SUDAM.
1977, October 11th	31 (Supple mentary Law)	Creates the State of South Mato Grosso by dividing the original area of Mato Grosso into two smaller areas: Mato Grosso and South Mato Grosso. Establishes that the new configuration of Mato Grosso is under the regulations of SUDAM and the Legal amazon legislation.
2001, May 4th	2.146-1	Extinguishes the SUDAM and creates de Amazonian Development Fund.
2001, August 28th	10.267	Put into effect the Certificate of Rural Property Registry - CCIR. Creates the National Rural Property Registry - CNIR. Reinforces the National Rural Registry System - SNCR.
2006, July 24th	11.326	Establishes the guidelines for the National Familiar Agricultural Policy.
2007, January 3rd	124 (Supple mentary Law)	Re-establishes the Superintence of the Amazon Development - SUDAM as a financially independent special autarchy, under the National Integration Ministry and part of the Federal Planning and Budget System.
2009, June 25th	11.952	Set the rules for land ownership regularization in the Legal Amazon Territory.
2009, October 28th	6.992	Regulates the law nº 11.952 (June 25th, 2009). Provides the legal mechanisms for land regularization in the Brazilian Legal Amazon where the state of interest - Mato Grosso is located.
2009, Decem ber 29th	12.187	Institutes the National Policy on Climate Change - PNMC.
2012, May 25th	12.651	The Presidency established the current rules for native vegetation protection. This law is also known as the Native Vegetation Protection Law (NVPL).
2017, July 11th	13.465	Institutes mechanisms to enhance the process that enables the disposal of Federal lands. Set the rules for Land Regularization in rural and urban areas.

However, land tenure insecurity problems in Brazil is a challenge for public policies in both urban (Ferreira and Avila, 2018) and rural environments (Duchelle *et al.*, 2014, Araujo *et al.*, 2009, Jepson, 2006), worsening in the Brazilian Legal Amazon because of territorial extension. In this context, the Brazilian National Institute for Colonization and Agrarian Reform (INCRA) and the Ministry for Agrarian Development (MDA) developed a web-based tool named Land Management System (*Sistema de*

*Gestão Fundiária* – SIGEF) to subsidize land governance in the national territory. The SIGEF system manages the information of Brazilian rural properties, receiving, validating, and organizing the data. Therefore, this system controls land regularization processes and provides the georeferenced boundaries of the certified properties (INCRA, 2013). In the Brazilian Legal Amazon, smallholder farmers and large landowners impact differently on land use, and the relationship changes continually with economic and demographic pressures. Large landholders are more sensitive to economic changes (interest rates, financial returns, government subsidies, agricultural credit, inflation rate, and land prices) (Fearnside, 2003). Studies have shown a relationship between land registration with forest preservation in the Brazilian Amazon (Alix-Garcia *et al.*, 2018, L'roe *et al.*, 2016, Araujo *et al.*, 2009).

This research aimed to analyze the dynamics of the land regularization system (SIGEF) with the deforestation rate monitored by the Amazon Deforestation Monitoring Project (PRODES) project from 2013 to 2017 within the Amazon biome in the Brazilian State of Mato Grosso. One of the aims of this study is the verification of the influence of certification in the deforesting behavior within the public and private properties.

## **2.2. Data and methods**

### *2.2.1. Study area*

Mato Grosso State has an area of 903,202 km<sup>2</sup> (IBGE, 2017) and is in the southern Brazilian Legal Amazon within the “Arc of Deforestation”, where occurs the expansion of agriculture and cattle ranching (Stickler *et al.*, 2013, Pacheco, 2012, Fearnside, 2003). The estimated population of the state is of 3.035.122 people with a population density of 3,36 (people per km<sup>2</sup>), according to the latest census (IBGE, 2010). This state has 141 municipalities and harbors springs and rivers from three river basins: (1) *Upper Paraguay*, (2) *Araguaia-Tocantins*, and (3) *Amazon*. The Mato Grosso contains three biomes: (1) Amazon, (2) Cerrado (Brazilian Savannah), and (3) Pantanal (Wetlands). The study area corresponds to the Amazon rainforest areas within the Mato Grosso, covering a total area of 483,469 km<sup>2</sup> (Fig. 1).

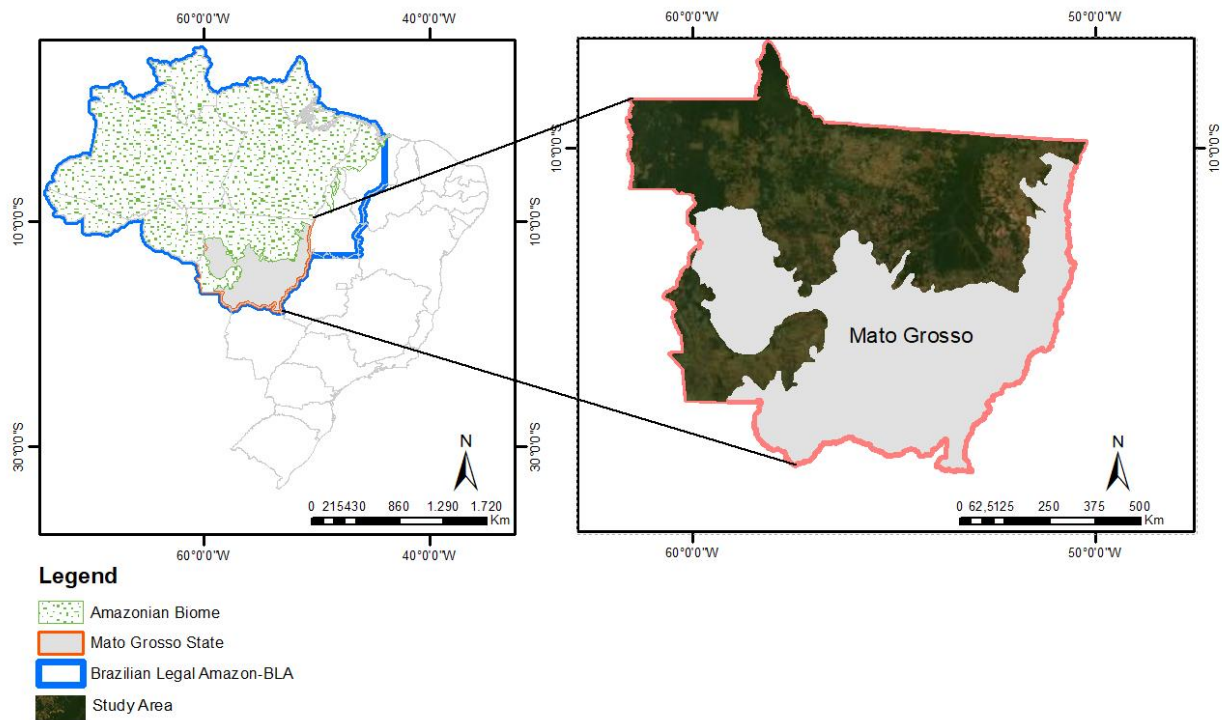


Fig. 1. Location map of the study area.

Mato Grosso State has the largest large farms, with over 75% of the agricultural and livestock areas maintained on farms larger than 1,000 ha (Richards and VanWey, 2015). In the period 1998-2017, the Mato Grosso State deforested about 142,967 km<sup>2</sup> (Fig 2), corresponding to 33.3% of all deforestation in the Brazilian Amazon (PRODES, 2018). The deforestation rates reached a maximum peak in 2004. The launch of the near-real-time deforestation detection system in the Brazilian Amazon (DETER) led to a reduction in rates. Therefore, between 2004 and 2007 occurred a significant deforestation decrease, attributed to the application of public policy enforcement, monitoring systems, and supply chain interventions, slowing down the advance of the agricultural frontier (Nepstad *et al.*, 2014). In 2009 was implemented a program of land regularization in Legal Amazon named Terra Legal Program, coordinated by the Ministry for Agrarian Development and operated by the National Institute for Agrarian Reform (INCRA), whose legal landmark was the establishment of the Law n°11.952/2009.

Cattle ranching, followed by soybean planting, was the main deforestation factor in Mato Grosso (Silva and Lima, 2018, Maranhão *et al.*, 2019). However, the public and private policies have been able to reduce large-scale deforestation in the major soy-and-cattle frontiers of South America (Nolte *et al.* 2017, MacManus *et al.* 2016). Therefore, Mato Grosso's forest conservation reflects the state's

efforts to reduce the loss of its primary forest (Arima *et al.*2014).

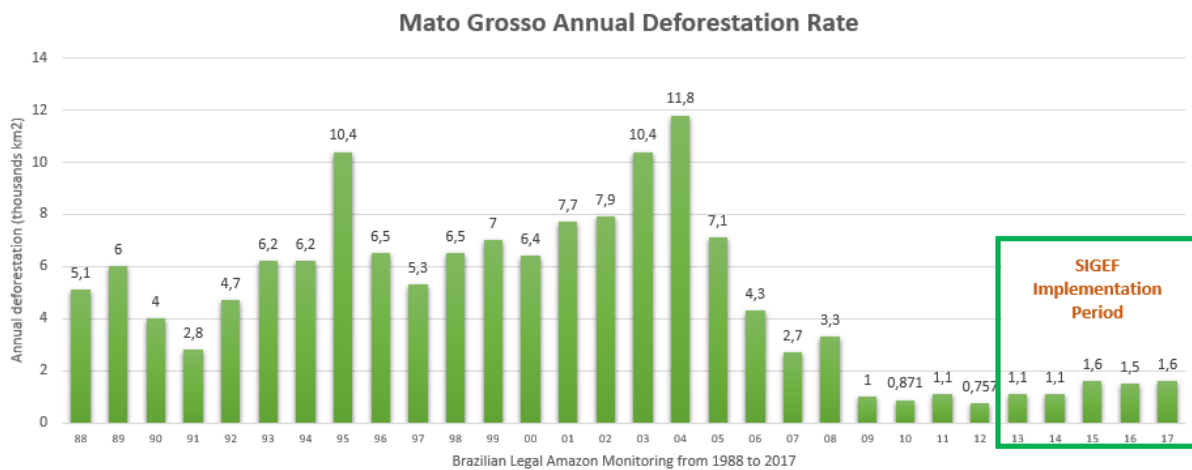


Fig. 2. Mato Grosso Annual Deforestation Rate. (INPE, 2018)

### 2.2.2. SIGEF and PRODES database

The INCRA introduced in 2013 the Land Management System (SIGEF) to process and validate land regularization protocols and publish georeferenced data on a web-based platform (Fig.3). The extinct Ministry for Agrarian Development coordinated the development of the SIGEF project with a partnership with INCRA, which contributed the previously accumulated knowledge to the automated certification (*e-Certifica*). The SIGEF certifies the properties boundaries (Brazil, 1973) and manages georeferencing contracts within the public administration. SIGEF documents have digital signatures and certificates used in the registry, which configures a further property legal security to the landowner. The rural land certification is an exclusive activity of the INCRA (Brazil, 2001), ensuring the legal and technical requirements of property limits and eliminating overlap. Management through the SIGEF system (Fig. 3) englobes: (i) professional accreditation for rural certification; (ii) digital authentication within the platform; (iii) standardized georeferenced data; (iv) automatized validation of the information in compliance with the technical requirements; (v) automatized generation of technical documents; (vi) electronic management of rural plot of land requirement files; (vii) possibility of online updated information inclusion; (viii) georeferencing services and contract management with the public administration; and (ix) open access to information about certified land plots and accreditation procedures.

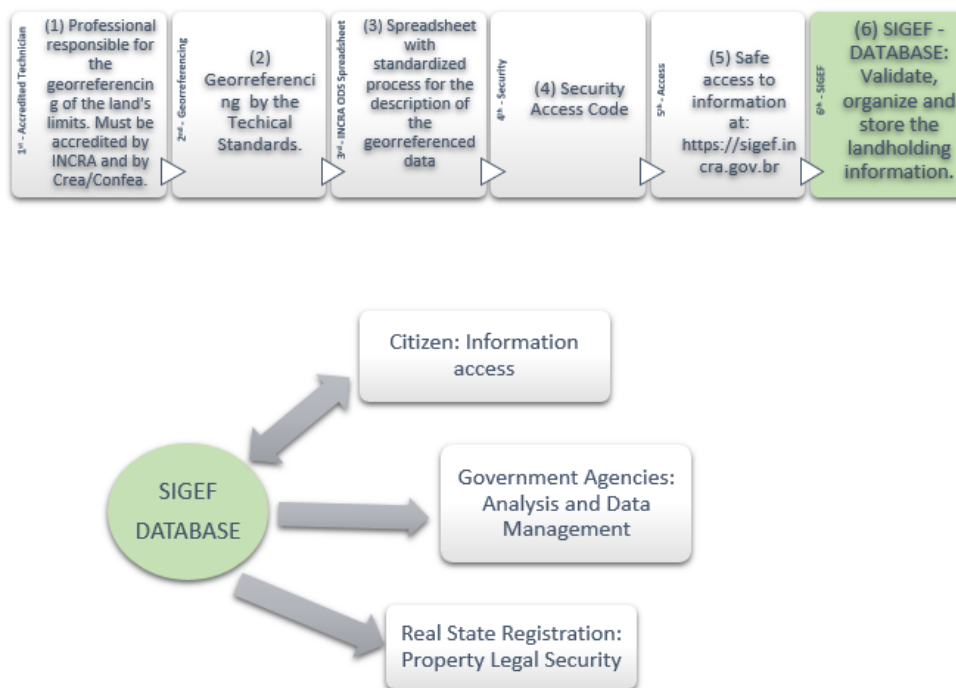


Fig. 3. SIGEF Processes (INCRA, 2013).

Since 1988, the Brazilian National Institute of Space Research has provided annual clear-cut deforestation data for every State of the Brazilian Legal Amazon. PRODES data production uses Landsat satellite imagery (30-meter resolution and revisiting each 16 days), measuring increments higher than 6.25 ha, and disregarding forest growth after deforestation (Câmara, 2001).

In the present study, the class named 'Forest' by PRODES was used, including the following vegetations: (i) Dense Ombrophilous Forest; (ii) Open Ombrophylous Forest; (iii) Seasonal Deciduous Forest; (iv) Alluvial Vegetation; (v) *Campinarana*; and (vi) Ecological Tension Areas (forest/savanna) with predominance of Forest Physiognomy (Mines and Energy Ministry, 1978). The high accuracy of PRODES data (Hansen *et al.*, 2013; Valeriano *et al.*, 2012) allows its extensive use in social and natural surveys (Brown, 2016; Jusys, 2016; Müller *et al.*, 2016). Therefore, these data had applications in the following programs: (i) agribusiness supply chain certification, for example the soy moratorium; (ii) international agreements such as the UN Climate Change Conference in Paris (COP21); and (iii) supporting information for financial aid through the Amazon Fund (Brazilian Ministry of Environment, 2016).

### 2.2.3. Data Processing

This research used the SIGEF data of certified rural plots during the period 2013-2017 of the Mato Grosso State, evaluating the following characteristics: public and private plots, land plot size (<100 ha, 100–250 ha, 250–1,000 ha; 1,000–5,000 ha, and >5,000 ha) (Richards *et al.*, 2015), and certification year within the land regularization system. Besides, the methodology considered the preservation condition of the area: (i) evolution of deforestation in the period 2012-2017; (ii) forest cover rate inside and outside certified public/private plots between 2013 and 2017; and (iii) deforestation by the size of certified parcels in the period 2013-2017. Table 2 shows the evolution of certification in the SIGEF from 2013 to 2017. In the SIGEF system, there is a difference between certification and registration terms. Registered status has fully complied with the Public Registry requirements. However, the certified status already means that the land has been successfully in identification and processing steps, and there is legal property security.

Table 2. Properties certified from 2013 to 2017 in the SIGEF.

Year	Number of Certified properties - Private	Number of Certified properties - Public	Certified properties - Private - without Forest in 2013 (%)	Certified properties - Public - without Forest in 2013 (%)	Area of Certified properties - Private (km <sup>2</sup> )	Area of Certified properties - Public (km <sup>2</sup> )	Area of Certified properties - Private -without Forest in 2013 (km <sup>2</sup> )	Area of Certified properties - Public -without Forest in 2013 (km <sup>2</sup> )
2013	186	0	18.82	0.00	1988.31	0	1877.21	0
2014	3733	59	31.10	38.98	28914.52	4419.83	26749.42	4181.55
2015	2811	920	25.86	20.11	21664.06	11937.96	20079.44	11791.07
2016	3059	46	27.13	28.26	18632.79	3404.04	16894.86	3214.68
2017	3562	40	25.07	22.50	20552.47	8473.18	18666.65	8323.91
Sum:	13351	1065			91752.15	28235.01	84267.58	27511.21

The number of public and private properties registered in SIGEF are different, while privately owned land corresponds to 13.351 inputs in the system, public plots correspond to 1.065 properties with 7% of the total (Table 2). The deforestation impact of the public property area is also smaller when compared with the area of private land plots. The total area of certified private properties from 2013 to 2017 is 91.752,15km<sup>2</sup>, and the total area of public lands within the program is 28.235,01km<sup>2</sup>, which corresponds to 23% of the total. Although public units have smaller quantities, they are considerably larger. The number of entirely deforested properties ranged from 18% to 38%, a considerable amount for the Amazon Biome, where the Brazilian Forest Code (2012) establishes a



Legal Reserve of 80% (or maximum of 20% of deforestation permitted per plot).

## 2.3. Results

### 2.3.1. Forest cover from 2012 to 2017

In the period 2012-2017, there was a forest loss of 5963km<sup>2</sup>. In 2017, the forest cover corresponded to 52% of the study area. Figure 4 shows the forest cover decrease detected from 2012 to 2017 in the study area and within the certified properties during the SIGEF implementation process.

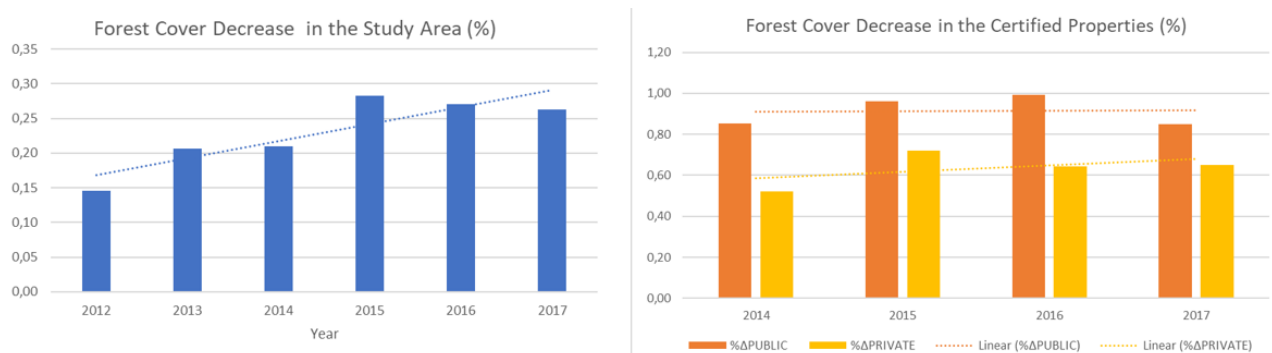


Fig. 4. Variation of Forest Cover Decrease from 2012 to 2017 in the Study Area and in the certified properties (%).

### 2.3.2. Forest cover within and outside the certified properties

Between 2013 and 2017, deforestation was 240,70 km<sup>2</sup> inside certified public plots and 14771,39 km<sup>2</sup> inside certified private plots. We observe a consistent and regular deforestation rate through the years in the public plots. In the private plots, there was a slight increase in the deforestation rate from 2014 to 2017. Whilst 2015 had the highest record of deforestation in the study area, deforestation within the public plots found its peak at 2016. In private properties, the highest deforestation record was in 2015, which is consistent with the overall data. In 2015, private plots certified in 2015, 2016 and 2017 presented a deacceleration in the monitored deforestation behavior.(Fig. 5).

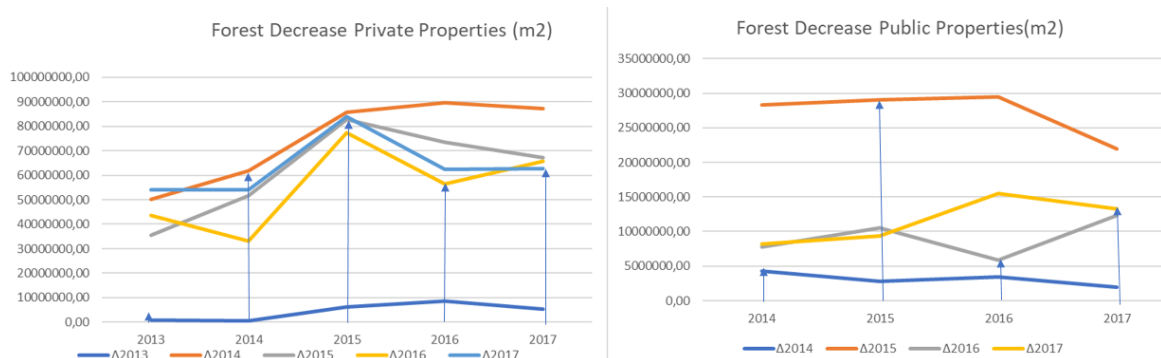


Fig. 5. Variation of Forest cover (m<sup>2</sup>) by year of certification in private and public properties.

We verify that private plots certified in 2015 slowed down the deforestation process after obtaining the certification. Private plots certified in 2013 maintained a stable behavior, while private plots certified in 2014 and 2016 had accelerated deforestation. Certification of public plots only showed a decline in deforestation in 2014. In 2015, public plots that received certification in 2016 slowed deforestation but resumed the increased deforestation rate in the following years. Figure 6 shows the evolution of forest cover degradation from 2013 to 2017 in the study area. Public plots only showed signs of the relation between certification and a decrease in deforestation in 2014.

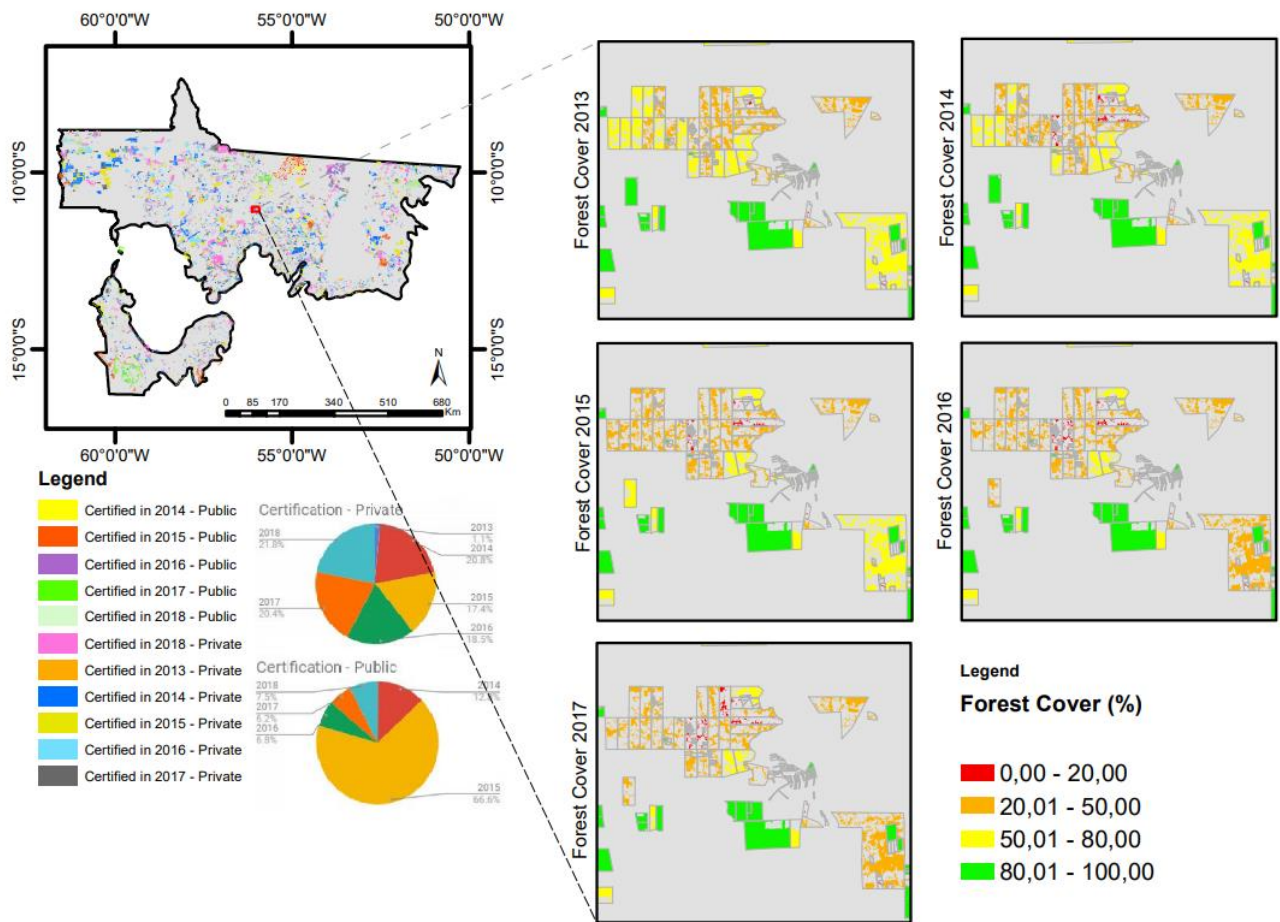


Fig. 6. Example of Forest Cover evolution from 2013 to 2017

### 2.4.3 Forest cover by property size

Table 3 presents the area deforested in the period 2013-2017 by the size of the rural property. Property size distribution is not homogeneous, especially in public properties, where the smallest properties (<100 ha) corresponds to around 80% of the total. The percentage of deforestation on the

smallest public properties is more than eight times the largest public properties (>5,000 ha). However, the deforested area on the largest properties is five times bigger than the smallest properties in the analyzed period.

Figure 7 shows the variation of forest cover by size and year after the certification. Most properties maintained stable deforestation behavior in the first years after certification. Private property sizes 2, 3, 4, and 5 have accelerated deforestation over the years. Size 1 was the only identified case where certification and decrease in deforestation had a positive relation. In public plots, Size 1 was the only case where we found a sharp decline in deforestation between the first and second years after certification. Figure 8 brings the frequency distribution of Forest cover (from 0% total deforestation to 100% entire forest cover). Most property categories have a peak concentration in forest cover from 0%-10%, which is alarming within the Brazilian Legal Amazon territory. The private and public properties of size 5 behave very differently, with strong indications that most of the large public land plots do not comply with the preservation of native vegetation. Small landowners (private or public) had a higher rate of deforestation over the years analyzed than the large landowners, although the total area deforested be higher in large owners.

Table 3. Forest cover variation by property size from 2013 to 2017

PRIVATE						
Size (ha)	Forest (ha) 2013	nº properties	Forest (ha) 2017	nº properties	Forest Decrease (ha)	Deforestation (%)
Size 1 (<100)	38959,94	2312	35986,37	2283	2973,57	7,63
Size 2 (100-250)	169475,96	2805	158605,71	2791	10870,25	6,41
Size 3 (250-1000)	1011083,24	4300	975926,36	4287	35156,89	3,48
Size 4 (1000-5000)	3087349,85	2583	3012072,59	2582	75277,26	2,44
Size 5 (>5000)	1576460,85	271	1553024,85	271	23435,99	1,49
PUBLIC						
Size (ha)	Forest (ha) 2013	nº properties	Forest (ha) 2017	nº properties	Forest Decrease (ha)	Deforestation (%)
Size 1 (<100)	12925,32	682	8685,44	640	4239,87	32,80
Size 2 (100-250)	1670,89	14	1659,77	14	11,13	0,67
Size 3 (250-1000)	6290,79	24	6221,68	24	69,11	1,10
Size 4 (1000-5000)	65406,52	62	64120,01	62	1286,50	1,97
Size 5 (>5000)	581038,12	68	562574,15	68	18463,97	3,18



Fig. 7. Forest Cover (%) by size per year after certification. Note: y-axis in logarithmic scale.

In 2016 and 2017, there was no difference in the public land plots forest cover observed within the PRODES database for Size 1 farms. The positive relation with the deforestation rate is resumed after 2017.

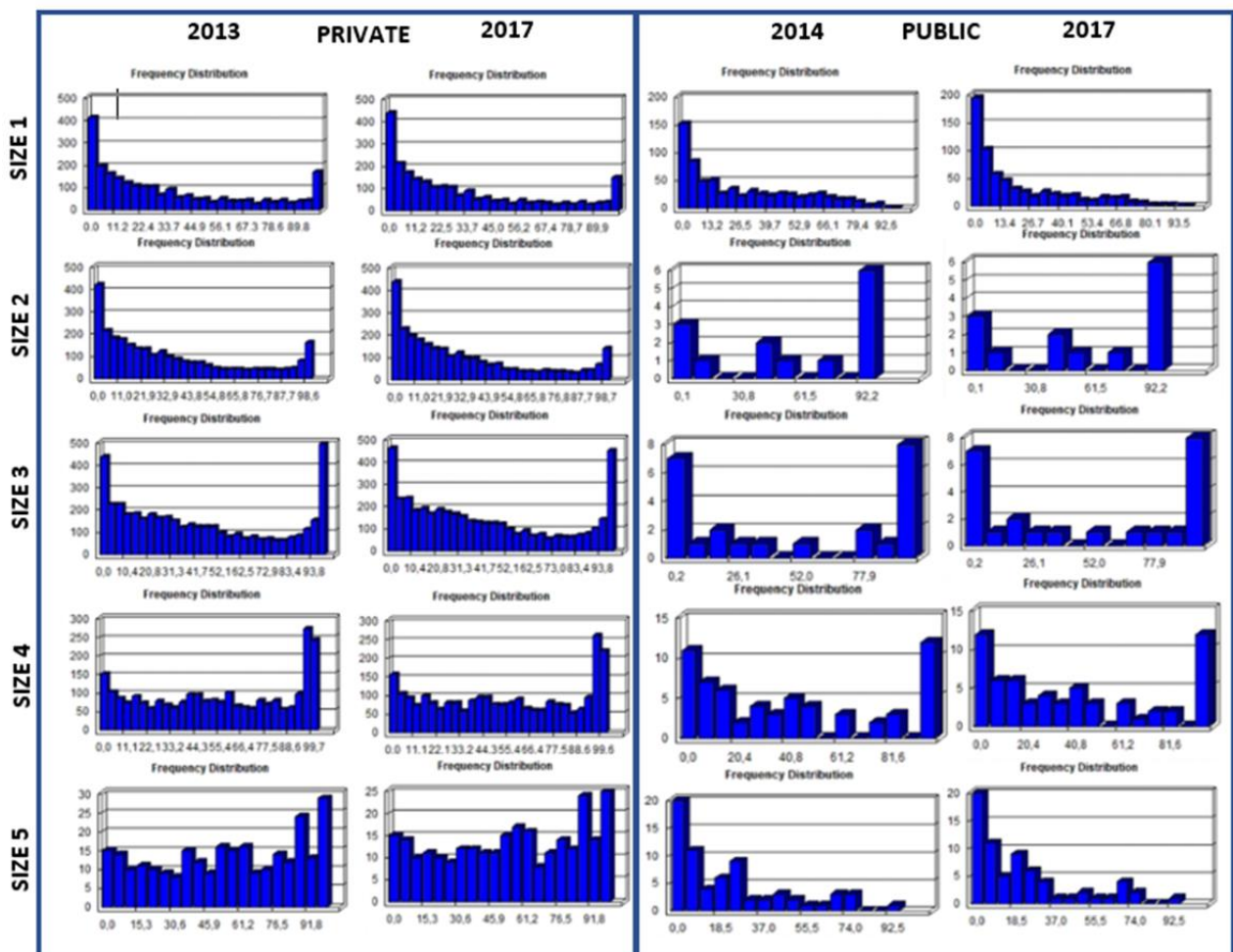


Fig. 8. Frequency distribution of Forest Cover by property size in 2013 and 2017.

Figure 8 comprises the frequency distribution of the five different properties sizes in both public and private land plots in 2013 and 2017. We observe that public land plots presented a distinctive behavior from private plots in sizes 1 and 5. Whilst private size 1 and 5 presented preservation of 80% or more since the beginning of the analysis and kept the preservation in compliance with the Forest Cover in some cases, in public plots this amount of almost zero since 2013. We did not find evidence of reforestation over the three years of the study (within the SIGEF implementation timeframe).

## 2.4. Discussion

Brazil is currently facing several interconnected challenges such as land tenure insecurity, certification through land registration and management systems, misappropriation of public lands, reduction of productive potential, agrarian conflicts, and deforestation (Alix-Garcia *et al.*, 2018; Marra *et al.*, 2015). Our results suggest that secure land tenure rights through certification in the SIGEF had an impact factor for controlling forest degradation only in specific cases – related to the size of the property, where small landowners seem to be more susceptible to these public policies. These results agree with McIndewar (2016), who considers that registration in the national land programs contributes to higher territory governance and a reduction of deforestation in Brazil. Studies in the state of Pará developed by L'roe *et al.* (2016) also confirm that land ownership may be one factor associated with forest degradation behavior. This relationship between ownership and land-use practices occurs even in developed countries. Heide (2019) describes in Austria an increase of this relationship when the rent is insecure or short term, a situation compatible with the Brazilian scenario.

The Brazilian Constitution (1988) establishes that "the Union, the states, the Federal District and the municipalities, in common, have the power: VII – to preserve the forests, fauna and flora," which indicates the importance of the forest preservation in the national legal system. Although the rules are clear, our research shows that obedience is a challenge to overcome. The current law has the potential to combat illegal deforestation but faces significant difficulties: economic viability for enforcement and international pressure for food production. Enforcement activities utilize satellite data on the land cover but need improved monitoring systems and regulations to ensure the legal security effectiveness (Nunes *et al.*, 2019; Azevedo *et al.*, 2017; Assunção *et al.*, 2015).

Deforestation is heterogeneous within the public and private rural properties upon certification.

Large public forest areas are susceptible to the failure of federal and state government policies to allocate those areas into social and environmental protection projects because of the difficulties of public supervision and governance enforcement, especially in agriculture and cattle ranching frontiers existent in Mato Grosso State (Azevedo-Ramos and Moutinho, 2018; Schielein and Börner, 2018).

Deforestation behaviors differ according to property size. In the first four years after the implementation of the SIGEF certification, smallholders showed a decrease in the deforestation pace compared to the size of larger properties. Considering that large properties have more area available for restoration than small farms, those findings strengthens the necessity for better initiatives supporting smallholder production (Thaler *et al.*, 2019; Stefanos *et al.*, 2018).

Sparovek (2019) found that 44.2% of Brazilian lands are private, 36.1% are public, and 16.6% are unregistered or with unknown tenure, and there is up to 50% of overlaps among land tenure categories, a cause for concern because SIGEF system methodology does not allow overlaps. The SIGEF timeframe is still recent, and further studies are necessary to establish the parameters for a native vegetation conservation trend.

## **2.5. Conclusion**

This study used a GIS analysis to evaluate the impact of certification of public and private properties with deforestation within the Amazonian biome in Mato Grosso State. We found that private properties certified in 2015 slowed deforestation rate in the subsequent years. Certification of public plots did not give strong signs of influence in the deforestation behavior, where we found a positive relation only in 2014.

Smaller landholders (less than 100ha) represent most of the system (SIGEF) inputs, corresponding, in 2017, to 22,4% of all properties (public and private). Still, their impact on deforestation rates is significantly lower when compared to large landowners that represent only 2,5% of all properties but concentrates 78% of the forest loss in 2017. Size 1 properties, both in public and in private land plots, were the only cases where we found a positive relationship between certification and decrease in the deforestation behavior over the years after the implementation of the SIGEF database.

Land tenure inequality and the still narrow timeframe of the SIGEF database challenged the present research. We were able to identify signs of the relation between certification and deforestation increase when we compared our analysis with the deforestation rates of non-certified/out of SIGEF properties in the Amazonian biome of Mato Grosso.

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### **CAPÍTULO III – CONCLUSÕES E CONSIDERAÇÕES FINAIS**

Conclui-se que o Sistema de Gestão Fundiária (SIGEF) é uma ferramenta eletrônica recente e por isso estudos futuros poderão estabelecer parâmetros e diretrizes de governança fundiária para subsidiar políticas de regularização fundiária e manejo de fronteiras.

Destaca-se que foram avaliados três aspectos do monitoramento do desmatamento em propriedades rurais: as propriedades públicas x privadas, a área de estudo fora do SIGEF e as propriedades divididas em cinco intervalos de tamanho: Size 1 (<100 ha); Size 2 (100–250 ha); Size 3(250–1,000 ha); Size 4 (1,000–5,000 ha) e Size 5(>5,000 ha).

No contexto do desmatamento na região do bioma Amazônia no Estado do Mato Grosso, de 2013 a 2017, sob o âmbito da política de regularização de imóveis rurais do SIGEF, o estudo verificou que: (i) Existe uma heterogeneidade entre a evolução do desmatamento em propriedades públicas e privadas, sendo as públicas mais vulneráveis à políticas de governança, controle da fronteira agrícola e apresentou maior variação nas taxas de floresta, especialmente em propriedades maiores; (ii) As propriedades fora do SIGEF apresentaram variação na área de floresta maior do que nas propriedades com certificação, porém não foi possível identificar relação direta com a gradativa implementação do SIGEF e (iii) Propriedades menores apresentaram uma relação positiva identificável entre a obtenção da certificação e a diminuição da taxa de desmatamento nos anos subsequentes, porém, o impacto da soma das suas áreas desmatadas ainda é menor que o desmatamento observado nas grandes propriedades, o que fortalece a argumentação de que boa parte da responsabilidade com o desmatamento observado na Amazônia Legal deve ser endereçada aos grandes proprietários, considerando também que, em 2013, mais de 20% das propriedades certificadas já não possuíam áreas de floresta identificadas pelo PRODES.

Espera-se que este estudo possa servir como fonte de auxílio para futuros trabalhos sobre o desmatamento na Amazônia Legal Brasileira e que os resultados aqui encontrados sirvam como fonte de motivação para a realização de outras pesquisas.