Indigenous Peoples of Brazil: Guardians of the Amazon Rainforest

Evaluating the effectiveness of indigenous territories in curtailing deforestation within the Brazilian Amazon

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I hope this thesis sheds light on the institutionalized injustices indigenous peoples face around the world. It is now up to us to mobilize to not only defend their rights but ensure a prosperous future for our world's greatest resources.

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Chapter 1: Introduction

On January 1, 2019, Brazilian President Jair Bolsonaro issued a decree that could grossly undermine the territorial rights of the country's indigenous peoples[1]. Moments after being sworn-in, he transferred the responsibility of recognizing and protecting indigenous territories to the Ministry of Agriculture known for promoting extractive activities within protected areas. This major decision validated the fears of indigenous peoples instilled during his presidential campaign when he vowed to open the Amazon to deforestation and promised "there won't be a square centimeter demarcated as an indigenous reserve" (Sengupta 2018).

The demarcation[2] of indigenous territories was initially under the responsibility of FUNAI, the National Indian Foundation. Changing this responsibility from a governmental agency that protects the interests of indigenous peoples to one linked to the agribusiness lobby suggests that the demarcation of indigenous territories under FUNAI helped deter illegal extractive activities such as deforestation. This thesis aims to uncover whether this statement is true. Thus, the main questions that I address are the following: do indigenous territories experience less deforestation than non-indigenous territories? If so, what factors explain variation in rates of deforestation on indigenous territories?

While the role of indigenous territories as strong agents against deforestation remains quite uncontested, much of the existing literature examined this role prior to 2014. Deforestation rates have greatly changed since then alongside a radicalization of the Brazilian stance against indigenous territorial rights. Therefore, this thesis seeks to provide a present-day analysis while also uncovering the various factors that explain why some indigenous territories experience

[1] 'Indigenous peoples' is plural because their rights regard the collective rather than the individual. Indigenous peoples are entitled to claim their rights, such as the right to self-determination, based on this collectivity.
[2] Gaining the title of demarcated results in the official recognition by the government of a territory as being indigenous and protects it from illegal extractions of the land's resources.

much more deforestation than others. Regarding these factors, a few scholars have examined the effect of indigenous land tenure on deforestation. Gebara (2018) explains that indigenous land tenure, across the globe, has no effect on deforestation because of its insecurity, which is mainly due to the absence of supporting institutions. These findings do not seem to be applicable to indigenous territories in Brazil as the full demarcation of a territory entails its full protection by supporting institutions. In contrast, other scholars have focused on the effect of the size and population density of a territory on deforestation in Brazil. By focusing on protected areas[3] in the Brazilian Amazon, Vitel et al. (2009) found that large protected areas tend to be more protected from deforestation than smaller ones. Furthermore, Nepstad et al. (2006) found no correlation between the population density of indigenous territories and deforestation. However, there remains some misunderstanding around these findings as it is merely logical that an indigenous peoples' ability to actively protect their land is dependent upon the number of people that inhabit this land.

I argue that the boundaries of indigenous territories serve as great barriers against deforestation. Nonetheless, this barrier is not always strong enough as I argue that its effectiveness is dependent upon the territory's legal status, size and population density. Thus, I seek to analyze the various factors that affect the efficiency of this barrier in curtailing deforestation. To determine these effects, I compare rates of deforestation inside indigenous territories to rates occurring right outside these territories. Specifically, I analyze rates of deforestation that are within four kilometers of an indigenous border, on either side of it. I follow a geographic regression discontinuity design that aims to create treated and control groups split by a boundary. In this empirical study, the boundary is the border of each indigenous territory.

[3] Indigenous territories, parks and Conservation Units

Consequently, deforestation on indigenous territories comprises the treated group while outside deforestation comprises the control group. This design is well suited for this analysis in that both groups are good counterfactuals for each other.

By following the previously mentioned design, I find that, between 2015 and 2017, indigenous territories experience less deforestation than their neighboring lands, proving the instrumental role of indigenous territorial borders. This barrier increases in effectiveness where deforestation is a bigger threat. My results further highlight the crucial role of demarcation and the size of a territory in curtailing deforestation. Indeed, variation in deforestation avoidance is attributed to both a territory's legal status and a territory's size. Contrary to my expectations, densely populated territories did not avoid the most deforestation, but neither did the least densely populated territories.

This thesis proceeds as follows. In Chapter 2, I summarize the current state of the art at the basis of my theories and hypotheses. I then present my hypotheses in Chapter 3. Chapter 4 provides the necessary historical background around demarcation and deforestation with a focus on the past 40 years and the present-day situation. Next, I explain my research design more explicitly and present my variables followed by an analysis of my results in Chapter 6. Finally, I conclude this thesis with a summary of my findings and their global implications.

Chapter 2: Indigenous Territories and Deforestation

2.1. A '*Glocal*' Challenge

The complexity of the relationship between deforestation and indigenous territories is best characterized as an issue with 'glocal' dimensions. The term 'glocal' has been used to describe climate change as an issue that is caused locally, accumulates into a global problem whose global impacts are then experienced on a local level (Gupta 2008, 146). First, deforestation violates the rights of indigenous territories. Second, forest loss in the Amazon forest heightens climate change issues plaguing our world. Finally, indigenous peoples' way of life is altered resulting in a loss of biodiversity on their land. The consequence of this 'glocalization' has two dimensions. On one hand, our world is facing the global challenge of preserving the Amazon rainforest crucial to reducing climate change and ensuring a prosperous future for our planet. On the other hand, indigenous peoples face the local challenge of obtaining the official recognition of their ancestral land and protecting it from deforestation. These 'glocal' dimensions contribute to the increasing importance of my thesis in world politics, human rights and environmental policy.

At the current rate of deforestation occurring in the Brazilian Amazon, it is predicted that the Amazon rainforest will be reduced by 60% by 2030 (Benjamin 2007). The Amazon rainforest accounts for half of the remaining tropical forest on our planet, stocks large amounts of CO2 and holds a major influence on the world's climate and hydrological cycles (Le Tourneau 2015, 213). Two thirds of this forest are in Brazil and 444 out of 721 Brazilian indigenous territories are situated in this forest representing over 23% of the Brazilian Amazon. It is important to note that forestry is one of two common-pool resources "that are of great concern in this era of major ecological challenges" (Ostrom 2008, 11). Interestingly, indigenous peoples

have been identified as fulfilling all the requisites needed for a "successful common-property resource management regime" (Schwartzman, Zimmerman 2005, 724). Facing this, indigenous peoples fulfill a crucial position in promoting sustainability within the region in that they help curtail deforestation. This position further holds major global implications as indigenous territories "are considered as key areas for carbon sequestration and climate change mitigation" (Le Tourneau 2015, 213).

While Brazil was acclaimed for reaching record low rates of deforestation in 2014, deforestation in 2018 symbolized the highest rates of forest loss in a decade (Rosane 2019). The main causes of this increase are rising international beef and soy prices, higher demand for gold, improved road network and greater drought which all favor the clearing of forestry (Instituto Socioambiental 2018b). However, this does not completely explain why there has been a rise in environmental crimes, namely on indigenous territories. The election of President Bolsonaro and his strong stance against indigenous peoples reflect a radicalization, over the past few years, of discourse against indigenous territories and environmental policies in Brazil (Instituto Socioambiental 2018b). Consequently, the Environment Ministry's budget was cut in half in 2017, FUNAI experienced a great number of "draconian staff cuts" (Fearnside, Schiffmman 2018) and the process of demarcation has considerably slowed down leading to an increased sense of impunity towards environmental crimes (Instituto Socioambiental 2018b). This increase in environmental crimes has not been felt in all indigenous territories meaning that some territories might be better at avoiding illegal deforestation than others.

Past and current administrations in Brazil have always held a restrictive view on indigenous land rights. This restrictive view is largely based on the idea that recognizing indigenous territories will impede on national economic and development projects such as the

creation of roads and dams (Le Tourneau 2015, 215). This position is further emphasized by the Brazilian Congress' enduring request to obtain a veto right over the process of demarcation and the Ministry of Agriculture's continuous demand to be consulted in the process – which has finally been drastically granted to them (215). While the recognition of indigenous peoples' ancestral lands is highly contested, the actual protection of these lands once recognized remains even more critical. A 2009 study examining the major pressures and threats to indigenous territories in Brazil determined that over 93% of deforestation on these territories is of external origin (Carneiro Filho, Braga de Souza 2009, 26). Because indigenous territories are rich in so many resources, they recurrently experience invasions by ranchers, loggers, farmers and miners. All these actors reveal to be the greatest threats to deforestation as ranchers and farmers clear forests for agriculture and livestock purposes, loggers are interested in wood supply and miners need to clear forests to access mines. The consequence of these invasions is twofold. First, the presence of external actors propagates diseases fatal to indigenous peoples (Le Tourneau 2015, 216). Second, deforestation affects indigenous lands greatly by a loss of diversity. Hutchison et al. (2006) even points out that deforestation has been "the principal element changing tribal life over the past 40 years" (24). Indeed, soil conditions change once forest is cleared resulting in a degradation of indigenous lands which in turn affects indigenous peoples' hunting patterns.

2.2. Indigenous Territorial Borders: Strong Barriers against Deforestation?

A great deal of research exists on the effectiveness of indigenous territories in preventing deforestation (Jusys 2018; Neptsad et al. 2006; Nolte et al. 2013; Watson et al. 2018; Busch, Ferretti-Gallon 2017; Soares-Filho et al. 2008). During the past Climate Action Summit in San Francisco (September 2018), a recently conducted study was released by the Wildlife

Conservation Society and 15 partner organizations demonstrating that "supporting indigenous peoples who manage intact forests is crucial to achieving climate goals" (Watson et al. 2018, 1). According to this policy brief, 35% of 'intact forest landscapes' in the world are owned or managed by indigenous peoples. While these lands face strong external pressures, rates of deforestation are much lower than in lands owned by non-indigenous parties.

Further studies focusing on Brazil and the Brazilian Amazon have proven that indigenous territories are the most effective among different types of protected areas in curtailing deforestation. Soares-Filho et al. (2008) found that indigenous lands among three other types of protected areas showed 'inhibitory effects' on deforestation between 1997 and 2008. This study specifically showed that indigenous lands were the most effective category in that they curtail deforestation within very active agricultural frontiers. Nolte et al. (2013) found that indigenous areas were extremely effective in curtailing deforestation in locations with high deforestation pressures between 2000 and 2005. Both studies examined rates of deforestation during a period where Brazil faced extremely high rates (almost triple compared to today), the situation has greatly changed since necessitating a more recent analysis. In a study comparing how much deforestation was avoided between 2001-2014 in different types of protected areas in the Legal Amazon, it was found that indigenous territories avoided the most deforestation between 2001-2004 and 2005-2008 (Jusys 2018). Thus, indigenous territories were able to curtail the most deforestation between 2001 and 2008, a period in which Brazil was facing heightened rates of deforestation. Between 2008 and 2015, Jusys (2018) found that indigenous territories were not the most productive in avoiding deforestation. This period experienced an important decrease in deforestation rates in Brazil which could insinuate that the role of indigenous territories in protecting forestry changes when forest loss is not a great threat. This thesis will help answer this

question as deforestation rates between 2015 and 2017 are examined, a period where deforestation greatly varied from year to year.

Overall, the findings of these three studies cannot be applied to this thesis as deforestation rates have greatly changed as well as the overall sentiment towards indigenous peoples in Brazil. Additionally, the legal status of over 70 indigenous territories has advanced in the process of demarcation since 2010. As these studies compared all types of protected areas within the Brazilian Amazon, they do not distinguish the different types of indigenous land tenures and it is quite vague whether they are simply looking at fully demarcated territories or indigenous territories as a whole.

More specifically, this thesis examines the role of indigenous territorial borders. Few studies have done this but most salient for this topic, is a study conducted by Nepstad et al. (2006). Neptstad et al. (2006) established that indigenous lands completely curtailed deforestation despite having high rates of deforestation along their borders between 1997 and 2000. This study compared the inhibitory effect of indigenous territories and parks against deforestation and fires. While this thesis has a similar argument to this article, it will offer a much-needed up-to-date account of the current situation in the Brazilian Amazon. Indeed, over 150 indigenous territories have started, advanced or finalized the process of demarcation since 2000, alongside rates and patterns of deforestation that have changed in the past twenty years. Following Nepstad et al. (2006), I seek to compare rates of deforestation on either side of an indigenous territory's border. This comparison will shed light onto the effective or ineffective role of these borders as strong deforestation deterrents. However, this study (Nepstad et al. 2006) compared deforestation rates inside and outside parks and indigenous territories within a 10km and 20km buffer on either side of a territorial boundary. This buffer is quite large compared to

the 4km buffer I use in this thesis. Thus, this thesis will examine a narrower scope of deforestation rates along indigenous territories.

2.3. Indigenous Land Tenure: Crucial in Curtailing Deforestation?

A few studies have been conducted regarding indigenous land tenure and its relationship to deforestation (Gebara 2018; Araujo et al. 2009; BenYishay et al. 2017). Gebara (2018) found that tenure reforms have not lead to tenure security on indigenous lands. She further attributes tenure security as a crucial element for indigenous territories to curtail deforestation. In line with this study but focusing on the Brazilian Amazon, Araujo et al. (2009) find that tenure reform is not sufficient in itself to affect deforestation but improvements in tenure security can explain lower rates of deforestation (in non-indigenous communities). Their study suggests that tenure insecurity may itself motivate land invasion and deforestation by squatters as a strategy to eventually gain a formal land title to said land. This has proven to be true in the case of indigenous territories. Contrary to my hypothesis, BenYishay et al. (2017) find that the formalization of indigenous territorial rights in the Brazilian Amazon has no effect on deforestation. They further find that indigenous communities receiving support for surveillance and enforcement of their forests had no significant improvement on deforestation. However, this study evaluated the effects of a specific program, the Brazil Indigenous Lands Project (PPTAL), which I believe cannot be generalized and applied to territories that were not part of this project.

These studies help us understand that the legal status of an indigenous territory might not be sufficient to protect it from deforestation; instead, tenure security is necessary for this protection. For the purposes of this thesis and my hypotheses, I associate land tenure insecurity with indigenous territories that are still in the process of being officially recognized.

Consequently, land tenure security is associated with territories that have finalized the process of demarcation. I believe this best illustrates a secure/insecure approach to indigenous land titles as the right to demarcation aims to provide protection from land encroachment and illegal resource extraction. Evaluating the security and insecurity of various indigenous land titles on deforestation comes down to comparing an indigenous territories' ability to avoid deforestation. I will determine deforestation avoidance by calculating how much deforestation a territory experiences near its border compared to deforestation rates right outside. Put simply, avoided deforestation signifies how much more deforestation would have occurred on an indigenous territory if the territory itself was not indigenous and a continuation of the outside land.

2.4. Size and Population Density of Indigenous Territories: Drivers of Deforestation?

Scholars have repeatedly proven that the presence of nearby roads leads to greater deforestation on a territory as it facilitates accessibility to said land (Jusys 2018; Barber et al. 2014; Busch, Ferretti-Gallon 2017; Fearnside 2017). Jusys (2018) determined that protected areas that avoided deforestation the least was due to the presence of nearby roads while isolated territories avoided deforestation the most. Barber et al. (2014) further proved that vicinity to roads and rivers determines much higher rates of deforestation. They further found that protected areas near roads experienced much less deforestation than unprotected areas near roads. However, roads will not be taken into account in this thesis because forestry that is 4km on either side of an indigenous border has the same proximity to roads making roads quite insignificant in my analysis.

Interestingly, very little research has been done on the effect of the size of a territory (indigenous or non-indigenous) on deforestation. Vitel et al. (2009) studied protected areas in the

southwestern portion of the arc of deforestation and found that large areas were more protected from deforestation than small ones. I believe larger indigenous territories will curtail deforestation more efficiently than smaller ones because small territories are much easier to access and surround but also because history has shown that small territories will be demarcated as a tactic to allow for more deforestation (see Chapter 3, the Calha Norte project).

Population density and its relationship with deforestation has been more commonly analyzed by scholars (Busch, Ferretti-Gallon 2017; Netpstad et al. 2006; Fearnside 2017; Laurance et al. 2002). Laurance et al. (2002) studied the predictors of deforestation in the Brazilian Amazon. This study shows that deforestation in the Brazilian Amazon is largely due to three factors: human population density, highways and season severity all contributing to higher rates of deforestation. However, this does not take into account indigenous territories and by human population the authors mean that increased immigration in the region leads to the expansion of highways and infrastructures impacting deforestation. Busch and Ferretti-Gallon (2017) further support this as they found that population is consistently associated with greater deforestation. However, both these studies were analyzing the predictors of deforestation in Brazil in non-indigenous areas which can, therefore, not be applied to this thesis. Fearnside (2017) explains that increasing population does have a significant effect on deforestation in the Brazilian Amazon. However, most research says there is no correlation because these studies look at large scale units such as political units or municipalities when a correlation can only be seen at a detailed level in specific locations. This might explain why Neptsad et al. (2006) found no correlation between indigenous population density and deforestation. I believe my results will differ from this last study because twenty years ago, support towards indigenous communities was far less common nor did strategies exist for indigenous peoples to prevent deforestation.

More densely populated territories will curtail deforestation more than less populated territories because they have more resources to mobilize and organize themselves to protect their territories.

Chapter 3: Hypotheses

Based on the state of the art explored in Chapter 2, I seek to examine the following hypotheses.

Hypothesis 1 (H1): indigenous territories will experience less deforestation near their border than their adjacent non-indigenous territories.

This hypothesis aims to evaluate the strength of an indigenous territorial boundary. I expect indigenous territories to experience less deforestation than their neighboring lands along indigenous borders. I theorize that it is an indigenous territory's border that prevents deforestation as it serves as a strong barrier against illegal activities.

Hypothesis 2 (H2): indigenous territories that have finalized the demarcation process will avoid more deforestation than indigenous territories that are still in the process of demarcation.

I theorize that the finalized process of demarcation is linked to tenure security while associating indigenous territories awaiting to be fully demarcated with tenure insecurity. Because of this, I expect secure land titles to avoid deforestation much more efficiently than insecure land titles.

Hypothesis 3 (H3): indigenous territories that are large in size will be more productive in curtailing deforestation than small territories.

I conjecture that there is a correlation between deforestation avoidance and the size of an indigenous territory. Small territories will avoid the least deforestation because they are easier to surround compared to larger territories that are more imposing.

Hypothesis 4 (H4): densely populated indigenous territories will curtail more deforestation than territories with small population counts.

I expect there to be a correlation between curtailing deforestation and the population density of an indigenous territory. Territories with small populations do not have the resources needed to mobilize around their borders and defend their land. Instead, densely populated territories are able to organize themselves more productively leading to higher deforestation avoidance.

Chapter 4: The Right to Demarcation and Deforestation

This chapter provides an overview of the constitutional right to demarcation – the right that grants indigenous peoples the official delimitation of their territory – and its relationship with deforestation. This chapter will describe the historical evolution of demarcation, a detailed analysis of the past 40 years, a description of the process of demarcation today and the current forestry legal framework of Brazil.

4.1. Main Actors in the Demarcation Process and in Deforestation

The main governmental agency responsible for the protection and management of indigenous territories – prior to President Bolsonaro's decree – is the Fundação Nacional do Indio, the National Indian Foundation (FUNAI). FUNAI was founded in 1967 under the jurisdiction of the Ministry of Justice. It replaced the Indian Protection Service (SPI) charged for genocide, rape, torture and enslavement of indigenous tribes (Watts, Rocha 2013). Indigenous peoples were placed under the 'tutorship' of FUNAI by the Indian Statute, promulgated in 1973. This statute is still in force today but receives much concern and skepticism as it is in clear contradiction with the progressive and non-assimilative provisions of the 1988 Constitution (Ortiga 2004). Assimilation was the official policy towards indigenous peoples in all Latin American states till the 1980's. Assimilation policies posed a huge challenge to indigenous peoples as they aimed to assimilate them with the nation, forcing them to abandon their collective identity by "dismantling their social institutions and cultural values in order to incorporate them into an acceptable subordinate position in the dominant society" (Stavenhagen 2013, 49). The Indian Statute embodies this approach as Article 1 states, "this law rules on the legal situation of Indians and indigenous communities, with the purpose of preserving (their)

culture and of integrating them, progressively and smoothly, to the national communion" (Valenta 2003, 647).

After the foundation of FUNAI in 1967 and the promulgation of the Indian Statute in 1973, the demarcation process was set forth in 1976 by Decree 76999 (Instituto Socioambiental 2018a). The demarcation process was then altered by Decree 88118 (1983), Decree 94945 (1987), Decree 22 (1991) and Decree 1775 (1996) (Instituto Socioambiental 2018a). For the purpose of this thesis, Decrees before the 1988 Constitution will not be examined as they are not at the basis of the demarcation process today.

As mentioned in the introduction, the main actors involved in illegal deforestation within indigenous territories are loggers, farmers, ranchers and miners. Regarding the agents that provide support in countering these actors' actions, there exist a number of monitoring programs lead by FUNAI and other Brazilian governmental agencies such as IBAMA (Brazilian Institute of Environment and Natural Renewable Resources). Many NGOs from around the world also offer support for monitoring and surveillance of indigenous territories. Monitoring and surveillance support typically takes the form of GIS platforms that monitor daily or weekly forest loss, training indigenous communities in monitoring their land through GIS technology and supplying these communities with the necessary technologies for surveillance (FUNAI "Programa").

4.2. An *'Illegalism of Rights'*

The process of demarcation dates back to 1976 and has a conflicting role. One on side, it exists as one of the only instruments indigenous peoples can use to fight for self-determination and their territorial rights. On the other hand, it has been used and manipulated by several

administrations in favor of economic development and national security**.** Maria Fernanda Gebara (2018) coined the term 'illegalism of rights' illustrating this duality through which the right to demarcation allows for "different kinds of mutually advantageous interplay between governments, transnational corporations and financial organizations" (60). President Sarney's administration (1985-89) embodied this 'illegalism of rights' as it prioritized drafting a new constitution favorable to indigenous land rights all the while utilizing demarcation in their favor to further deforest the Brazilian Amazon through the Calha Norte military project.

The Calha Norte project, made public in 1986, was born out of "military concerns about the vulnerability of the northern frontier" (Barbosa 2000, 57). The national security aspect of this project was concerned with rising drug trafficking and guerrilla activities along the border. By establishing military colonies in the region, not only would the government counter illicit activities but would also be able to gain economic benefits related to natural resource extractions. However, the government expressively failed to mention that one of the main drivers of this project was the government's rising concern that indigenous communities in the region were to form their own independent state. More specifically, the Yanomami people had the potential to form their own nation as their vast territory straddled the border between Venezuela and Brazil (Hutchison et al. 2006, 38). Bruce Albert, among many other authors, describes this project as "an attempt to redefine Indian policy in Brazil in favor of economic interests" (Barbosa 2000, 58).

Prior to the creation of military colonies alongside the borders, the Government began demarcating indigenous territories quite systematically, placing 63 000 indigenous peoples in 83 different territories "along the 150km, 6 500km northern border of Brazil" (Hutchison et al. 2006, 32). The Yanomami case exemplifies the government strategy prior to the commencement

of the project. At the time, the Yanomami traditional territory reached almost 9.5 million hectares. Facing this large parcel of land, the Government demarcated 19 discontinuous territories dividing the original territory the Yanomami lived on (32). The demarcated and discontinuous territories were strategically placed to have large areas of 'national forest' between them that had the function of resource extraction zones (32). Not only were these areas heavily deforested and mined but this facilitated land invaders and squatters to enter Yanomami territories and continue their illegal extractions of the lands' resources. The Calha Norte project was made public in 1986, the Brazil Constitution was promulgated in 1988 and the Yanomami territory was demarcated into smaller territories in 1989 further exemplifying this 'illegalism of rights'.

4.3. The 1988 Brazilian Constitution

The 1988 Brazilian Constitution is acclaimed for codifying progressive indigenous policies as it sets out the formalization and protection of indigenous rights and their territorial rights**.** Roque Roldán Ortiga (2004) classifies Brazil as having a superior legal framework regarding indigenous territorial rights as the 1988 Constitution demonstrates "a high-level commitment (...) to indigenous rights" with a strong framework, supporting institutions and "concrete actions" (2). It promotes the principles of self-determination crucial for indigenous peoples to enjoy their rights and is innovative in that it embodies a non-assimilative approach towards the indigenous (contrary to the assimilative provisions of the Indian Statue). Interestingly, constitutional provisions regarding the rights of the indigenous were not drafted in response to large grassroots indigenous movements in Brazil but resulted from international pressures, namely from the Inter-American Commission of Human Rights (Valenta 2003, 647). This distinction is important to make because rights enumerated in the Constitution do not reflect

what indigenous communities in Brazil wanted or fought for but simply what Brazil was 'forced' to put into writing facing human rights allegations from the international community.

First and foremost, the Constitution acknowledges indigenous peoples' "original rights to the lands they traditionally occupy" (Rosenn 2017, 157) and defined these lands as "those on which they live on a permanent basis, those used for their productive activities, those indispensable for the preservation of environmental resources necessary for their well-being and those necessary for their physical and cultural reproduction, according to their uses, customs and traditions" (157). Article 231 holds that indigenous peoples have the pre-existing and natural rights to own their territories and that their property rights have precedence over any other kind of property rights (Stocks 2005). Article 231 further poses that indigenous peoples have "the exclusive usufruct of the riches of the soil, rivers and lakes existing thereon" (Rosenn 2017, 158), meaning that indigenous land titles give indigenous peoples the right to use everything above ground while exploitation rights of the subsoil remain vested in the State. More specifically, the Federal Union remains the proprietor of the land itself while indigenous peoples have the "collective usufruct of all the soil and vegetation resources" (Le Tourneau 2015, 213). However, regulations on resource use for indigenous people on their territory remains vague and the legal status of resource extractions by external actors is very ambiguous (Nepstad et al. 2006; Schwartzman, Zimmerman 2005). It is quite obvious that deforestation by non-indigenous parties is flagrantly illegal on indigenous lands but there seems to be no official ramifications for such actions in the Constitution. Of specific interest here is that "the Union has the responsibility to delineate these lands and to protect and ensure respect for all their property" meaning that the Government is now responsible for officially demarcating these territories (Rosenn 2017, 157). Once demarcated these lands are supposed to be protected from encroachment, invasion and

external use of their resources. However, there is no restrictions implemented in the Constitution about the entry of third parties or the illegality of resource extractions by these parties. By focusing on the rights indigenous peoples have, the Constitution creates some sort of loophole regarding what third parties can and cannot do and seems to have absolutely no legal accountability in place to penalize third parties. This is further emphasized by paragraph 3 in Article 231 stating that resource extraction by third parties can only happen with the authorization of the National Congress after they consult the affected indigenous communities, which is rarely the case (Rosenn 2017, 158).

Two distinctions need to be made for clarification. First, indigenous land titles are collective rights rather than individual rights meaning that the indigenous community as a whole owns the right to live on their land. Second, 'indigenous territories' cannot be used simultaneously with 'indigenous peoples'. The same indigenous tribe can live on different demarcated territories while multiple indigenous tribes can live on one same territory.

Article 67 found in the Temporary Provisions of the 1988 Constitution requires that "the Union shall conclude the demarcation of indigenous lands within five years after promulgation of the Constitution" (Rosenn 2017, 186), requiring 532 indigenous territories to be demarcated by 1993 (BenYishay et al. 2017). However, five years after this requirement was stipulated, less than 50% of these lands had started the demarcation process (BenYishay et al. 2017). Since then, numerous governments have halted the process of demarcation and have rendered it more complex. Today, 486 indigenous territories have been fully demarcated. This number is still lower than the 532 territories promised to be demarcated by 1993. The President can halt the process of demarcation by refusing to sign off on the homologation of an indigenous territory. However, the missed deadline of 1993 alongside a very slow demarcation process is mainly due

to FUNAI's inadequate resources (BenYishay et al. 2017). This does not show the inefficiency of FUNAI or of the demarcation process but is directly due to Brazil's utter disinterest in and negligence of its indigenous peoples and their territorial rights.

4.4. Decree 1775/96

Presidential Decree 1775, implemented in 1996 by President Fernando Cardoso, sets out the current framework for the process of demarcation, or at least did until President Bolsonaro's decree in January 2019. Decree 1775 was put forth to repeal Decree 22 passed in 1991 under President Fernando Collor de Mello (Instituto Socioambiental 2018a). This change reevaluated the ability of third parties to contest the demarcation of an indigenous land. Decree 22 was meant to implement the constitutional policies set out in Articles 67 and 231 of the 1988 Constitution. This decree stated that after the Ministry of Justice approved the physical demarcation of an indigenous land, INCRA (Instituto Nacional de Colonização e Reforma Agrária, National Institute for Colonization and Agrarian Reform) should, when necessary, proceed with the resettlement of the non-indigenous occupants of the land (Instituto Socioambiental 2018a). These non-indigenous parties would then be financially compensated for their relocation but were not allowed to contest the demarcation decisions in court. Decree 1775 changed the latter policy and was enacted after a 1995 Supreme Court case through which a large cattle owner claimed that he should, alongside other land owners, be entitled to his own property rights during the demarcation process (Valenta 2003; Hutchison et al. 2006). The Cardoso government ruled that the process of demarcation set out in Decree 22 was unconstitutional on the basis that the rights of these third non-indigenous parties were ignored as they could not contest their rights (Hutchison et al. 2006). A year later, Decree 1775 was signed giving "states, municipalities and

individuals" (Stocks 2005, 92) the right to contest the demarcation of any indigenous territory prior to it being approved by the President of the Republic.

The process of demarcation was therefore altered by adding a 90-day period, after FUNAI approves of the demarcated land, allowing any third party to present their contestation to FUNAI "along with all pertinent proofs" (Instituto Socioambiental 2018a). After this 90-day period, FUNAI has 60 days to look at all contestations and develop their own argument against them which is then handed over to the Minister of Justice (Instituto Socioambiental 2018a). As expected, this decree was not well received by indigenous peoples, NGOs and the international community as not only would any third party be allowed to contest the process, regardless of whether they lived on the territory, but it was argued that the main driver of this decree was to enable for more natural resource exploitation on indigenous territories.

4.5. The Demarcation Process

The demarcation process starts with the realization of an "anthropological study of identification" of the indigenous territory (Instituto Socioambiental 2018a). Once completed, this first step confers the legal status of 'in study' to an indigenous territory. FUNAI appoints an anthropologist who investigates the length of time the land has been occupied by the indigenous group and makes a series of ethno-historical, juridical, sociological, cartographic and environmental analyses (Correa Neves, Machado). The indigenous community must also be a part of this study by sharing their "oral tradition and land memory" (Correa Neves, Machado 2017, 167). The anthropologist and his or her team must then submit a report to FUNAI. However, it is important to note that indigenous oral tradition is not incorporated into this report. Correa Neves and Machado (2017) heavily critique this report as an indigenous land can

only be demarcated after a scientific study requiring a juridical approach that they describe as “contributing to a (neo)colonization of the territory” (163).

The second step within this process, which confers the legal status of ‘identified’ to indigenous territories, requires the anthropological report to be approved by the President of FUNAI. Once approved, a summary of the report must be published, within 15 days, in the Diário Oficial da União (official publication of the Federal Government), the official publication of the State in which the indigenous territory is located and must be displayed in the local town hall (Instituto Socioambiental 2018a). The 90-day period set out by Decree 1775, mentioned previously, starts after the publication of this report. This report is in no way representative of the land that should actually belong to different indigenous communities as illustrated by the case of the Xucurus people. In 1992, Itamar Franco, the FUNAI President approved the anthropological study, "acknowledging the FUNAI study which found the Xucurus entitled to 26,980 hectares as ancestral land"' (Valenta 2003, 654). It was further acknowledged in the same report that this approved area is "equivalent to one-fifth of what they had before the conquest” (Valenta 2003, 654). This was then contested by third parties and resulted in the Xucurus being able to “occupy only 12% of those 26,980 [hectares], the rest is now owned by ranchers and lumbermen" (Valenta 2003, 654).

After the 60-day period in which FUNAI can issue their own argument (if the demarcation of a territory has been contested), the demarcation process is handed over to the Minister of Justice. The Minister of Justice then has 30 days to: (i) issue a directive declaring the limits of the demarcated territory (thus rejecting any contestation); or (ii) order a reevaluation that must be carried out within 90 days, or (iii) disapprove the demarcation of said territory (Instituto Socioambiental 2018a). If the Minister approves the delimitation, then the said

indigenous territory gains the legal status of ‘declared’ once FUNAI “promotes its physical demarcation” (Instituto Socioambiental 2018a) meaning that the limits need to be materialized and georeferenced. Once declared, INCRA should resettle any non-indigenous parties occupying the territory and provide them with monetary compensation.

The demarcation process is submitted to the President of the Republic for homologation by decree (Instituto Socioambiental 2018a). Following this, the indigenous territory gains the legal status of ‘homologated’. Once homologated, the territory must be registered, within 30 days of its homologation “in the notary of the correspondent judicial district and in the Secretaria de Patrimônio da União - Office of Patrimony of the Union - (SPU)” (Instituto Socioambiental 2018a). This registration is the final step in the process of demarcation, indigenous territories then gain the title of ‘registered’. Some lands still remain homologated pending registration and others remain homologated and registered without being registered in the SPU. This final step between being ‘homologated’ and ‘registered’ has also been used by several administrations to perpetuate an ‘illegalism of rights’. The Cardoso administration (1994-2002) withheld the registration of many homologated territories waiting to be formally registered at the titles office (Hutchison et al. 34). This revealed to be part of a greater strategy as these lands were then open to contestation under Decree 1775.

There exist three other types of land tenure an indigenous territory can hold, although much less common than demarcation. The difference lies in that territories undergoing the process of demarcation are considered as ‘traditionally occupied indigenous lands’ while the others are not (FUNAI “Terras Indìgenas”). First, an indigenous land can hold the title of ‘reserve’. An indigenous territory is a reserve if the land was donated by a third party, purchased or expropriated by the Union (FUNAI “Terras Indìgenas”). Once recognized as a reserve, the

indigenous territory undergoes the same final step as demarcation: registration. Second, indigenous territories can also be 'domains'. Domains are fully owned by indigenous communities "under the terms of civil law" (FUNAI "Terras Indìgenas"). Similarly to reserves and the demarcation process, domains must be officially registered in the Union to be recognized as such. Finally, some indigenous territories hold the title of 'with restrictions on usage' meaning that they are restricted areas. This title is typically gained through the process of demarcation. Here, FUNAI designates these areas as restricted because they are comprised of isolated indigenous peoples who have yet to enter in contact with society. These territories aim to protect isolated indigenous peoples by establishing restrictions on the entry and transit of third parties (FUNAI "Terras Indìgenas"). This last land tenure sheds light on the weaknesses of the demarcation process. It is quite odd that traditionally occupied territories do not have restrictions regarding the entries of third parties as this is the main cause of land encroachment leading to illegal deforestation.

4.6. The Forest Code of 2012

The Forest Code of 2012 does not provide further protections for indigenous territories against deforestation. Instead, it perpetuates this 'illegalism or rights' that uses demarcation as a tool for economic development and as a tactic to allow for more deforestation. The Forest Code of 2012 requires private landowners in the Legal Amazon to set aside 80% of their land as a 'Legal Reserve' meaning that it cannot be deforested (Freitas et al. 2018, 1). The other 20% can be deforested and the Code establishes further rules about regenerating forestry once this 20% is deforested. Interestingly, this 80% requirement can be reduced (again only in the Legal Amazon) to 50% if (i) 65% or more of a state's territory is protected public land – Conservation Units and indigenous territories – or (ii) more than half of a municipality's area is occupied by

Conservation Units or indigenous territories (Machado 2015, 45). Thus, states and the national government can be motivated to demarcate more indigenous territories to allow for more deforestation on private lands. While this does not specifically allow for more illegal deforestation on indigenous territories it may lead to an increase as exemplified by the Yanomami case in the Calha Norte project. Interestingly, private landowners surpassing the 20% limit of deforestation will be fined but ramifications for those who illegally deforest indigenous lands are not addressed. While the Forest Code of 2012 focuses more on deforestation on private lands there exist other legal frameworks aimed to curb deforestation on indigenous lands. For example, a law passed in 2007 prohibits the cultivation of genetically modified organisms on indigenous lands (Ambiente Brazil 2019). This is aimed towards prohibiting farmers from clearing forests on indigenous lands and contaminating the soil with pesticides detrimental to the biodiversity of the territory (Ambiente Brazil 2019).

4.7. Demarcation and Deforestation today

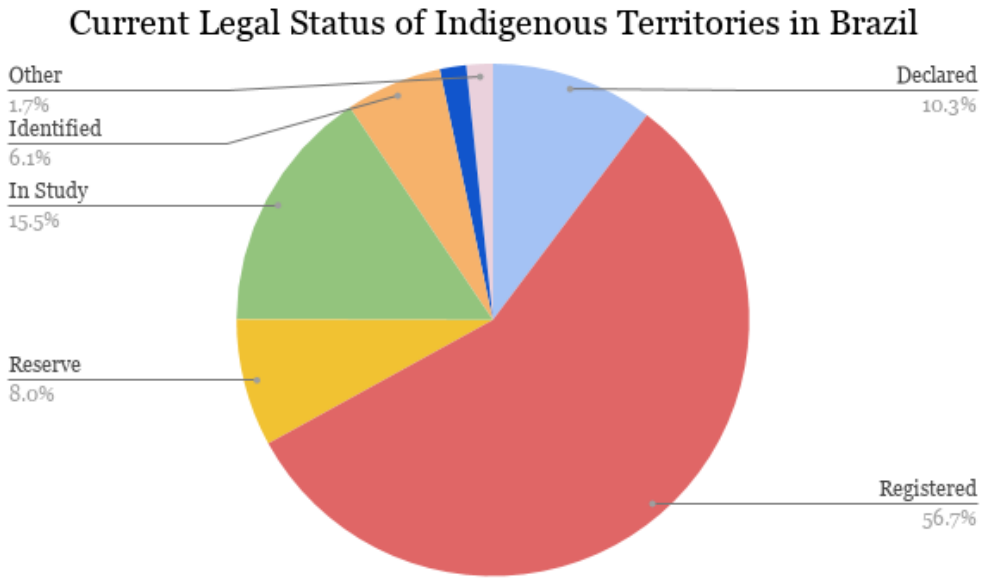


Figure 1: Current Legal Status of Indigenous Territories in Brazil. Total of 720 indigenous territories. Other signifies: Dominions (0.85%) and Restrictions on Usage (0.85%).

This chapter has provided an overall background on the government's strategic position with demarcation and how it can be utilized to allow for more deforestation. Figure 1 offers a promising picture of the current status of indigenous territories in Brazil as the majority has been registered (56.7%). However, the protection of these lands lies in the hands of their supporting agencies that are currently at risk. While the government has truly failed to implement more efficient protections and punishments, it is not the only actor involved. IBAMA and FUNAI accompanied by other ministries and police forces have attempted to put forth various mechanisms to protect these lands and punish the perpetrators.

The main restrictions and punishment existing today to help curtail illegal deforestation on indigenous lands are fines, embargoed areas and seizing timber and equipment mainly carried out by IBAMA and its partner organizations (Instituto Socioambiental 2018b). One must note that in some cases external actors strike deals with indigenous peoples to clear their forests for various reasons. These deals have monetary compensation but, most often than not, indigenous peoples are misinformed on the consequences of these deals. Additionally, indigenous peoples can be motivated by monetary compensation because their way of life has been greatly affected by globalization and funds are needed to access various necessities outside their territories. However, even in cases where deals are made, IBAMA will intervene, conduct operations and fine the deforesters.

In January 2018, IBAMA identified the deforestation of 90 hectares on the Taunay-Ipégue indigenous territory. Their operation was carried out with the Federal Public Prosecutor's Office (MPF), imposed a total fine of 450 thousand R$ (Brazilian real) – 5 thousand R$ per hectare – and issued an embargo on the area based on special preservation (IBAMA 2018a). In another operation conducted in June 2018, IBAMA joined by the Environmental Military Police

of Parà seized the equivalent of 150 loaded trucks of wood and 1.2 thousand liters of pesticides on the indigenous territory of Tembé (IBAMA 2018b). Consequently, six sawmills were deactivated, vehicles, tractors and a truck were seized and a fine of 3 million R$ was imposed (IBAMA 2018b). However, there seems to be no actual solution implemented in response to long-term land invasions by outsiders. There are many cases where external actors have actually invaded indigenous lands and the government has and is still failing to remove them resulting in very high rates of deforestation. Cachoeira Seca and Apyterewa are amongst the most deforested indigenous territories in Parà and are currently still suffering from the presence of non-indigenous parties on their land **(**Instituto Socioambiental 2018b). No solution has been implemented to remove these invaders giving them and others more incentives for land invasions.

These operations must be acclaimed in that they effectively punish the perpetrators of illegal deforestation, but it seems that they do not deter future actions as deforestation keeps increasing. This is most probably due to the clear contradiction between these penalties and the overall stance of the national government on deforestation and indigenous territories. Unsurprisingly, these mechanisms and operations are widely contested. In December 2018, employees of IBAMA sent a letter to President-elect Bolsonaro stating that IBAMA's actions and operations were biased and influenced by socialist and democratic parties (Zuker 2018). Additionally, in January 2019, the Minister of the Environment, Ricardo Salles, criticized the mechanisms put forth by IBAMA and FUNAI as an "excess of voluntarism" (Ambiente Brazil 2019). This is simply absurd as from a human rights and political point of view, IBAMA and FUNAI's operations constitute a system of checks and balances on the national government. Furthermore, these contestations reflect the radicalization of Brazilian discourse on sustainable

development and indigenous peoples. Ending illegal deforestation on indigenous territories now lies within indigenous peoples' and their advocates' ability to protect their land.

Chapter 5: Research Design

5.1. Scope

The geographic scope of this study is the Brazilian Legal Amazon. The Legal Amazon was created as an administrative region in 1948 to promote regional planning and economic development of states that share the Amazon Forest (Freitas 2018, 668). The Legal Amazon encompasses 59% of Brazil and is comprised of nine states: Acre, Amapà, Amazonas, Parà, Rondônia, Roraima, Tocantins, Mato Grosso and part of Maranhao west of the 44° W meridian (Freitas 2018, 668) (Map 1).

Map 1: Legal Amazon, Brazil

This region is of specific importance due to the 'arc of deforestation'. The highest rates of deforestation comprise this arc shaped area situated in the southeast part of the Legal Amazon (Durieux, Machado, Laurent 2003). This analysis is limited to the Legal Amazon as it is home to 61.7% of Brazil's indigenous territories and because of the dense and tropical rain forests – representing 30% of the world's tropical rainforests – that characterize its forest cover (Food and Agriculture Organization of the United Nations).

5.2. Method and Data

The research design of this study is largely based on a geographic regression discontinuity (GRD) design put forth by Keele and Titiunik (2004). A GRD design is a type of regression discontinuity design applied to spatial data through which one can draw causal inferences. This quasi-experimental design is fitting for this thesis as it splits the units of a geographic boundary into treated and control areas. This cutoff creates two groups along a boundary that are good counterfactuals for each other because the placement of treated and control areas are thought to occur in an 'as if random' fashion (Keele, Titiunik 2004, 2). The overarching goal of this design is to estimate the treatment effects in both treated and control groups. I compare units in a treated area and units in a control area denoted by A^t and A^c respectively. The adopted potential outcomes framework assumes that unit i has two potential outcomes Y_{i1} and Y_{i0} corresponding to the two levels of treatment with $T_i = 1$ and $T_i = 0$. $T_i = 1$, being the treatment condition, denotes that unit i is within A^t and $T_i = 0$, being the control condition, denotes that unit i is within A^c. In my empirical application, the boundary of each indigenous territory represents the cut-off with A^t corresponding to indigenous territories and A^c to non-indigenous territories. Thus, $T_i = 1$ when unit i is within an indigenous territory, and $T_i =$

0 when unit i is within a non-indigenous territory. I am interested in the effect of treatment for unit i, $\tau_i = Y_{i1} - Y_{i0}$, where the potential outcomes represent high deforestation or low deforestation. The observed outcome is $Y_i = T_i Y_{i1} + (1 - T_i) Y_{i0}$.

It must be noted that, as Keele and Titiunik (2004) point out, the main problem of causal inference is that one cannot observe, for any given unit, Y_{i1} and Y_{i0} simultaneously, meaning that the individual effect of τ_i will not be recovered. However, the goal of this thesis is not to uncover the individual effect of τ_i but to compare the average deforestation occurring in treated and control groups overall.

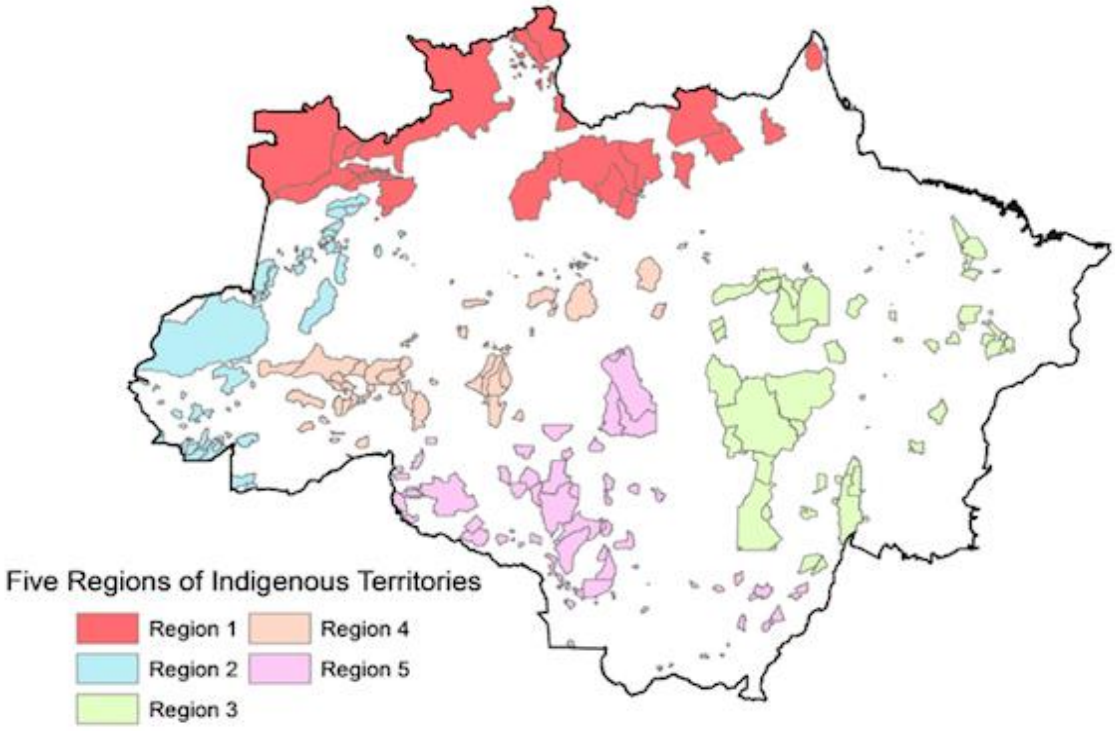
I use Geographic Information Systems (GIS) software to process all the data (specifically through ArcGIS and Google Earth Engine) before the final statistical analysis conducted in R. ArcGIS allows me to create my independent variable and consequently divide it into treated and control areas. This helps solve the problem of counterfactual observations by comparing rates of deforestation of these two groups within a fixed equal distance from the border. Thus, units that are in equal distance on opposite sides of the cutoff are taken as valid counterfactuals for each other. I also measure for other confounders that could influence units in treated and control groups causing a spurious association. This will contribute to solving the problem of counterfactual observations as units in both groups are valid counterfactuals for each other if the confounders prove to be similarly balanced on either side of the cutoff.

5.2.1. Treatment Data

FUNAI provides data on indigenous territories since the inception of the right to demarcation. The dataset provides the following information: indigenous territory name, indigenous communities living in the territory, population count, area (hectares), municipality,

state and legal status. The geographic location of these indigenous territories was already geo-coded in the file, facilitating geographical analysis. This dataset was reduced to only have the indigenous territories within the Legal Amazon, however only 383 out of the 444 territories in the Legal Amazon were geo-coded reducing the number of territories that will be analyzed. Territories that were not geo-coded revealed to be the ones 'in study'. Thus, my analysis is restricted in that I analyze deforestation on territories that have already been identified.

I divide this dataset into five regions after encountering several processing and computer system issues. These regions do not follow specific administrative boundaries. Region 1 has 51 territories, region 2 (80), region 3 (79), region 4 (89) and region 5 (78) (Map 2). The total count



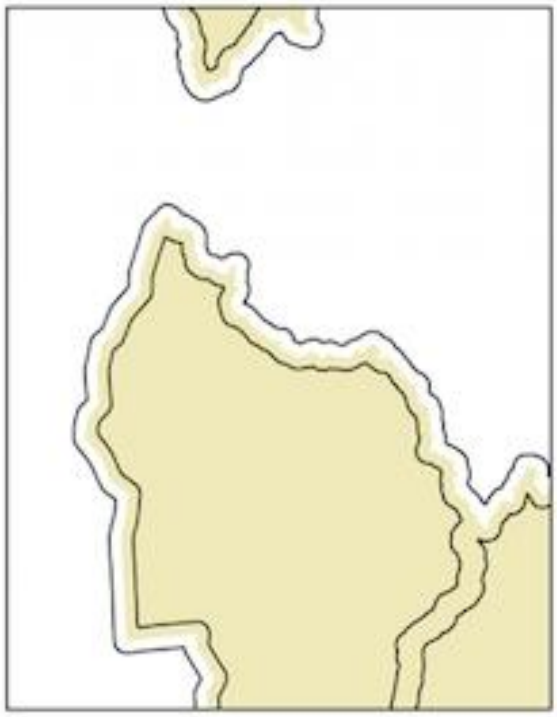
Map 2: Indigenous Territories separated into five regions (Legal Amazon, Brazil)

for indigenous territories is now 377 which is different from the 383 mentioned (the reason for deleting the six territories will be explained in the following paragraphs).

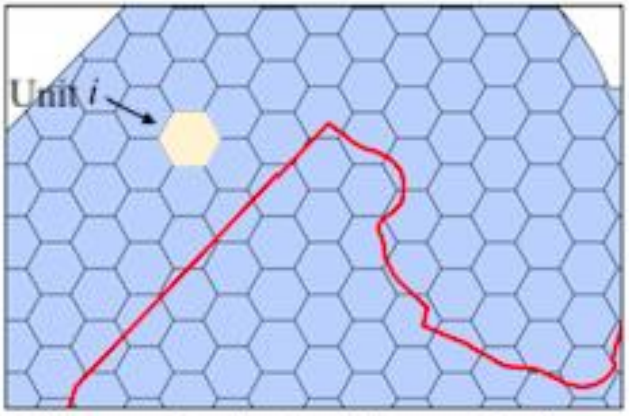
For each region, I use the FUNAI dataset to map the indigenous territories of the Legal Amazon. I first use GIS to obtain a grid of hexagons over the Legal Amazon to calculate

treatment effects. Hexagons are the unit *i* in my analysis. I generate tessellations, a tessellated shaped grid of polygons that cover a given extent. This extent is determined by a rectangle that I set, covering the entire Legal Amazon. The polygons within this grid can take on three different shapes (equilateral triangles, squares or hexagons) as they are the only polygons that can tessellate, meaning that can repeat the same shape over and over again creating an equally spaced grid without any overlap or gaps. Here, I choose hexagons as they are better suited for my analysis for two main reasons, (i) the circularity of a hexagons allows the grid to represent patterns in my data, mainly deforestation, more naturally than square or triangular grids and (ii) hexagonal grids experience less distortion over large areas. Thus, a tessellation grid is generated, comprised of hexagons with an area of 65 hectares. Six of the 383 territories have an area below 200 hectares and were consequently deleted from the indigenous territories dataset.

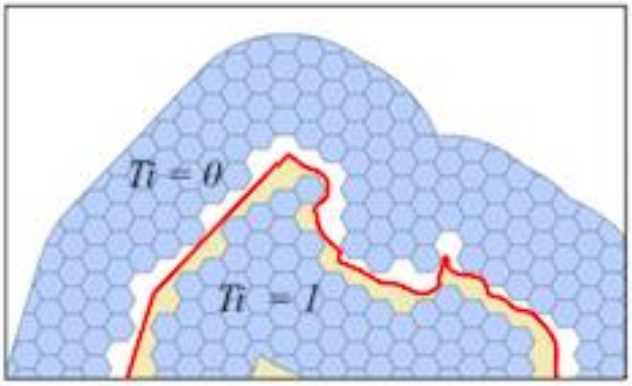
Second, I create what is called a buffer around the boundaries of all indigenous territories (Map 3.A). Prior to doing this, the boundaries have to be converted from polygons to polylines in order to allow the buffer to be created on either side of the cut-off. If this conversion had not been done, a buffer could not have been generated inside the territory. A buffer is a spatial object that records with units *i* fall within a specific distance of a geographic boundary. I use a buffer of 4km that consequently identifies which hexagons (units *i*) fall within 4km from the border on either side. Once the hexagonal grid completed, I clip the hexagons to the buffers in my five regions, deleting all hexagons that were not found within the 4km buffer (Map 3.B). I realize that many hexagons overlapped the boundary of indigenous lands (Map 3.C). All these hexagons, no matter how much they overlap, are identified as being inside the territory. I then select all the hexagons that overlap the boundary lines and delete them (Map 3.D).



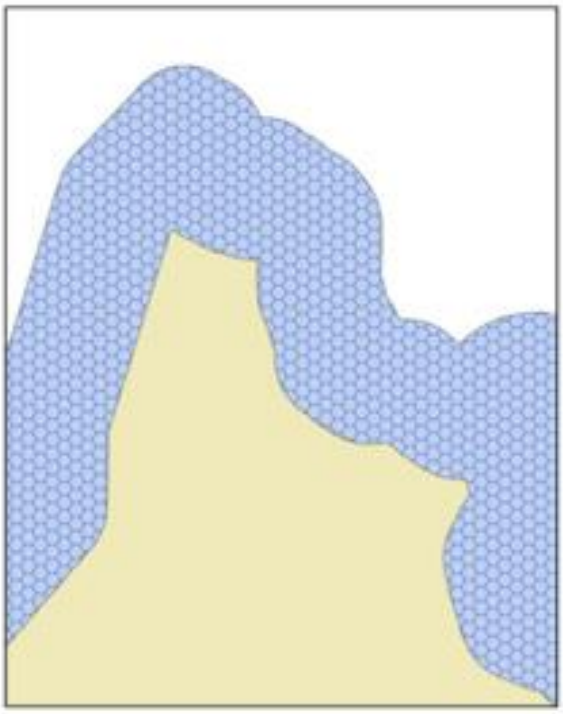
A. 4km Buffer



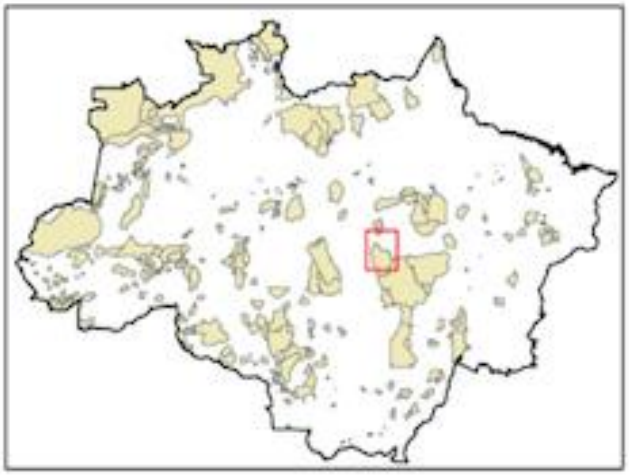
C. Hexagons Overlapping Indigenous Border



D. Overlapping Hexagons Removed



B. Hexagons Clipped to Buffer



Indigenous Territory: Baú, Pará (region 3)

Map 3: Treatment Data

I obtain a table for each region with all hexagons (units i), the buffer to which they belong, whether they are T_i= 1 or T_i= 0, and the name of the territory they belong to (with all the other information the indigenous territories dataset provided). Due to the small size of my hexagons, the sample size is very large with 2,000,868 hexagons.

I use now Google Earth Engine (GEE) to compute the rates of my dependent variable (deforestation) and my covariates for each hexagon in all regions. GEE reveals to be better suited for this computation as it has the geospatial datasets needed for my analysis.

5.2.2. Dependent Variable: Deforestation

Hansen et al. provides deforestation data between 2000 and 2017. The Hansen Global Forest Change (version 1.5) is used for annual forest cover-loss data. This dataset, developed by Hansen et al. produces several products centered around tree cover dynamics between 2000 and 2017. Of specific interest are two of these products, tree cover and loss. The former quantifies tree canopy cover for year 2000 and is measured in percentage. The latter quantifies forest loss defined as any disturbance that transforms forestry into a non-forest state. Forest loss is measured in square meters per pixel, meaning that deforestation represents how much area in square meters was deforested within each pixel. Computing deforestation per hexagon means that the rates of deforestation per hexagon represent the sum of forest loss for all pixels within each hexagon. These rates are obtained yearly for 2015, 2016 and 2017 respectively.

5.2.3 Covariates

For this study, I assess covariate balance, a common type of falsification test, with elevation, Normalized Difference Vegetation Index (NDVI) and precipitation (all were obtained

via Google Earth Engine). I seek to prove that the average of these covariates is statistically indistinguishable between treated and control areas.

The Global Multi-resolution Terrain Elevation Data 2010 (GMTED2010) dataset provided by the U.S. Geological Survey (USGS) contains elevation data for the globe. Elevation is measured in meters. As elevation does not vary yearly, mean elevation is computed for each hexagon in meters from this 2010 dataset.

NDVI data is provided by the NOAA (National Oceanic and Atmospheric Administration) Climate Data Record and measures surface vegetation coverage activity, gridded at a resolution of 0.05°. Mean NDVI is computed for each hexagon for 2015, 2016 and 2017.

The precipitation dataset (CHIRPS Pentad: Climate Hazards Group Infrared Precipitation with Station DATA 2.0) is provided by UCSB/CHG. This dataset created a gridded rainfall time series for trend analysis and seasonal drought monitoring. Precipitation is measured in mm/pentad and the mean precipitation is computed for each hexagon for 2015, 2016 and 2017.

5.3. Balance Test Results

Covariate	All mean (st. dev.)	Control Group mean (st. dev.)	Treated Group mean (st. dev.)	Difference	p-value
NDVI	3,146.63 (550.75)	3,098.02 (536.55)	3,188.62 (559.34)	-90.60	< 0.01
Precipitation (mm)	29.67 (7.11)	29.41 (7.05)	29.90 (7.15)	-4.91	< 0.01
Elevation (m)	222.59 (178.34)	222.32 (187.23)	222.82 (170.29)	-0.501	> 0.05

Table 1: Balance Table of Covariates for All, Treated and Control Groups from 2015 to 2017

Table 1 offers a summary of my covariates and shows the results of Welch t-tests. NDVI t-test results look like treated and control groups are statistically different. However, recall the very large sample of hexagons (over 2,000,000). This sample is so large that even a minor difference will be picked up as statistically significant. Thus, the t-test results and difference are merely artifacts of the sample size. Treated and control areas are in fact quite similar as the difference (90.60) is very minimal compared to the average NDVI in both regions. T-test results for precipitation are also a product of the large sample of hexagons. The difference remains quite small and looking at both means shows that precipitation is as likely on either side of an indigenous border. Elevation is balanced as the difference between the treated and control means are not statistically different (p-value > 0.05).

Chapter 6: Analysis of Results

This chapter provides an analysis of my results. This analysis focuses on comparing mean deforestation rates in treated and control groups. Mean deforestation for treated and control groups represents the average deforestation occurring in all hexagons in each group respectively. P-values were obtained when conducting Welch t-tests and prove whether my results are statistically significant. The standard deviation and difference between the means provide insight on an indigenous territory's ability to curtail deforestation and further demonstrate whether deforestation is substantially different in treated and control groups.

6.1. Hypothesis 1

Statistic	Control Group mean (st. dev.)	Treated Group mean (st. dev.)	Difference	p-value
Deforestation (%)	7.1 (18.53)	1.84 (8.84)	5.27	< 0.01

Table 2: Deforestation (%) for Treated and Control Groups from 2015 to 2017

Table 2 offers a summary of deforestation for treated and control areas between 2015 and 2017. Deforestation rates are a result of the factor of deforestation divided by the size of the hexagon multiplied by 100. T-test results from Table 2 allow us to confidently reject the possibility that the difference between the means of both groups is 0 (p-value < 0.01). Reinforcing my hypothesis that indigenous territories experience less deforestation than non-indigenous: on average, deforestation from 2015 to 2017 was 5.27% higher in control areas than in treated areas. Thus, consistent with current literature, indigenous territories experience less deforestation than lands right outside the boundary. Additionally, deforestation rates vary much

more in control areas as on mean average, deforestation in treated areas varies from the mean by 8.84% while deforestation in control areas varies from the mean by 18.53%. The standard deviation for treated areas shows that 1/10th of their land near the boundary is deforested facing 1/4th of forest loss right outside their land.

6.1.1. Yearly Variation

Yearly Deforestation (%)	Control Group mean (st. dev.)	Treated Group mean (st. dev.)	Difference	p-value
2015	6.33 (17.42)	1.35 (7.41)	4.98	< 0.01
2016	7.16 (18.57)	1.83 (8.87)	5.33	< 0.01
2017	7.83 (19.51)	2.33 (10.27)	5.5	< 0.01

Table 3: Deforestation (%) by Year for Treated and Control Groups

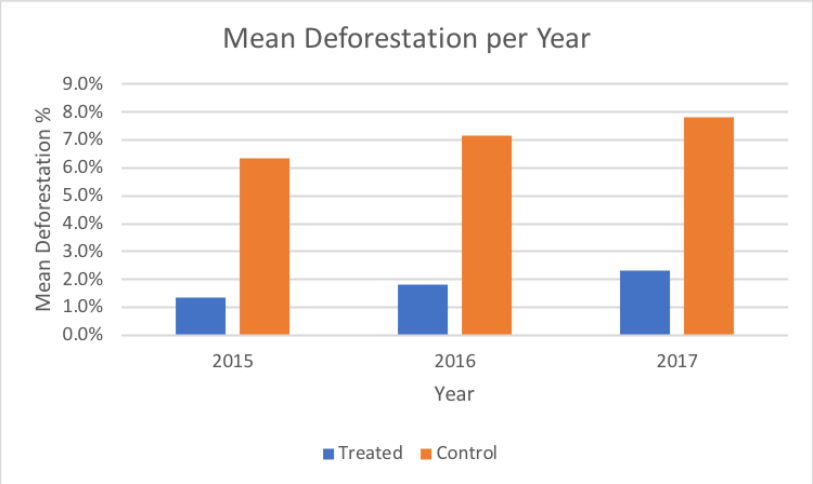


Chart 1: Mean deforestation (%) by Year in Treated and Control Groups

Between 2015 and 2017, deforestation in control and treated areas increased (Table 3 and Chart 1). T-test results allow us to confidently reject the possibility that the difference between the means of both groups, in each year, is 0 (all p-values < 0.01). Consistent with my hypothesis

(H1), treated areas still experience less deforestation than control areas even when deforestation rates are increasing.

Of specific interests are the difference results that highlight how much deforestation indigenous territories curtail. Indeed, while deforestation increases so does the difference between treated and control rates; treated areas experienced 4.98% less deforestation than their neighbors in 2015, 5.33% in 2016 and 5.50% in 2017. Deforestation increased the most from 2015 to 2016 in control (11.6%) and treated (26.1%) areas compared to 8.6% in control and 21.5% in treated areas from 2016 to 2017. Difference in difference estimation shows that while deforestation increases so does an indigenous territory's ability to avoid deforestation by 0.35% from 2015 to 2016 and 0.18% from 2016 to 2017. This exemplifies that indigenous productivity in deterring deforestation increases when deforestation is higher or, in other words, is a bigger threat. Deforestation increased the most in 2016 and indigenous territories curtailed deforestation nearly twice as much between 2015 to 2016 compared to 2016-2017. These results prove that the bigger threat deforestation poses, the more productive indigenous territories are at curtailing it.

6.1.2. Geographic Variation

Table 4 provides a summary of deforestation rates, differences and t-test results for treated and control areas in the nine states of the Legal Amazon. Chart 2 illustrates these differences. The four states experiencing the most deforestation in control areas are Parà, Rondônia, Maranhao and Mato Grosso, showing that the arc of deforestation is alive and well. Indigenous territories experience the most deforestation in Maranhao, control areas experience the most deforestation in Rondônia and indigenous territories in Rondônia curtail deforestation the most (17.5% difference). This further emphasizes the past findings of mean deforestation per year. Indeed, where deforestation is the biggest threat, indigenous territories are able to avoid the

State	Control Group mean (st. dev.)	Treated Group mean (st. dev.)	Difference	p-value
Acre	2.29 (8.52)	0.53 (3.39)	1.76	< 0.01
Amapà	1.14 (5.38)	0.42 (2.98)	0.72	< 0.01
Amazonas	2.85 (11.07)	0.68 (4.49)	2.17	< 0.01
Parà	12.79 (23.92)	1.99 (9.25)	10.8	< 0.01
Rondônia	19.11 (28.63)	1.61 (7.54)	17.5	< 0.01
Roraima	2.77 (9.64)	1.33 (5.69)	1.44	< 0.01
Maranhao	18.04 (21.82)	6.81 (14.72)	11.23	< 0.01
Mato Grosso	9.44 (22.05)	3.41 (13.62)	6.03	< 0.01
Tocantis	4.09 (9.92)	1.46 (5.48)	2.63	< 0.01

Table 4: Deforestation (%) by State of the Legal Amazon for Treated and Control Groups

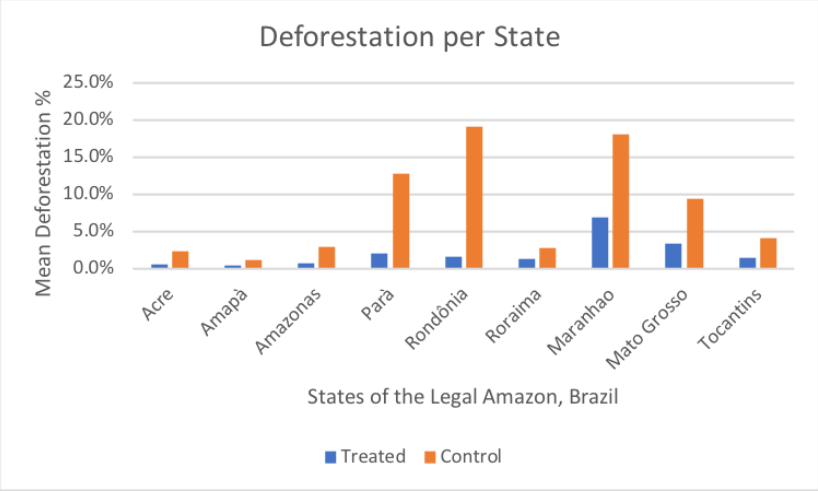


Chart 2: Mean deforestation (%) by State of the Legal Amazon for Treated and Control Groups

most deforestation with territories in Rondonia avoiding 17.5% forest loss, Maranhao (11.23%) and Parà (10.8%) compared to territories in Amapà that experience the least deforestation (0.42%), face the smallest threat (1.14%) yet curtail it the least (0.72%). Agencies in charge of providing monitoring and surveillance support as well as implementing a system of fines are more active in states that face greater threats from deforestation while disregarding indigenous territories in other states that still face an important threat of deforestation. Deforestation rates in Roraima exemplify this as deforestation is very low in the state (2.77% in control areas) while treated areas experience almost half of this (48.02%) which is the most deforestation indigenous territories experience compared to their counterparts in any other state. Indigenous territories in Acre, Amazonas, Parà, and Rondonia all experience less than 24% of deforestation outside their land while those in Amapà, Roraima, Maranhao, Mato Grosso and Tocantins experience over 35% of the outside rates. These observations show that the biggest deforestation threats to indigenous territories are not all centered around the arc of deforestation and should be taken into consideration by governmental agencies. A deeper analysis on state policies regarding deforestation and their abilities to protect indigenous territories would be necessary to further understand these differences.

6.2. Hypothesis 2

Table 5 provides a summary of mean deforestation rates, differences and t-test results for the different types of indigenous land tenures and their counterfactuals (control areas). Chart 3 illustrates these findings and regroups all the various legal status' an indigenous territory can have except for 'in study'. Focusing on the process of demarcation (identified to registered in the SPU), indigenous territories experience the most deforestation when they have been identified (3.96%) and the least once registered in the corresponding judicial district (0.85%). Looking at

Legal Status	Control Group mean (st. dev.)	Treated Group mean (st. dev.)	Difference	p-value
Identified	7.79 (20.16)	3.96 (14.32)	3.83	< 0.01
Declared	4.61 (15.53)	1.67 (9.28)	2.94	< 0.01
Homologated	7.23 (21.46)	3.58 (14.32)	3.65	< 0.01
Registered in Judicial District	3.70 (19.00)	0.85 (8.01)	2.85	< 0.01
Registered in SPU	7.59 (12.62)	1.62 (5.52)	5.97	< 0.01
Restrictions on Usage	7.20 (18.82)	1.43 (8.60)	5.77	< 0.01
Reserve	9.54 (19.56)	2.06 (9.06)	7.48	< 0.01
Dominion	10.69 (17.05)	2.16 (6.55)	8.53	< 0.01

Table 5: Deforestation (%) by Legal Status of Indigenous Territories for Treated and Control Groups

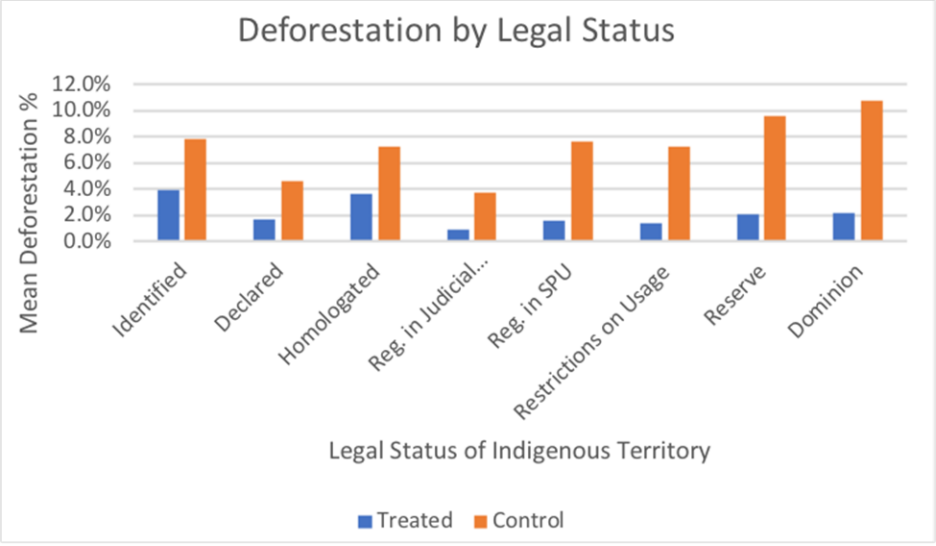


Chart 3: Mean deforestation (%) by Legal Status of Indigenous Territories

how much deforestation these territories were able to avoid offers a more insightful analysis. Territories that have completely finalized the process of demarcation (registered in the SPU) avoid deforestation the most by 5.97% compared to all other titles in the process that avoid deforestation below 4%. Standard deviation further proves how completing the process of demarcation is crucial for a land's protection as deforestation in homologated (14.32%) and identified (14.32%) territories varies from the mean nearly three times as much than deforestation on territories registered in the SPU (5.52%). Deforestation in territories registered in their judicial district varies from the mean considerably less than inferior titles. There is also a notable difference between being fully registered and only being registered in the corresponding district with a difference in difference of 3.13%. Thus, when an indigenous territory becomes fully registered, it is able to avoid deforestation the most by 3.13% compared to when it was only registered in its district.

Taking into account the three other legal titles a territory can have, territories with restrictions experience the least deforestation overall (1.43%) but are not as productive as territories registered in the SPU in avoiding deforestation with a difference in difference of 0.21%. This is further emphasized by the standard deviation which varies much more in territories with restrictions (8.60%) than territories registered in the SPU (5.52%). Reserves and dominions are the best overall at avoiding deforestation. While reserves experience less deforestation than dominions, dominions are still able to avoid deforestation much more productively with a difference in difference of 1.05%. However, the standard deviation indicates that deforestation within territories registered in the SPU (5.52%) varies less than for dominions (6.55%). Thus, deforestation varies the least in fully registered territories; reserves and

dominions avoid the most deforestation and territories still in the process of demarcation curtail deforestation the least productively.

Further comparing the rates of deforestation inside a territory to those right outside creates two distinct groups. On one hand, identified, declared and homologated territories experience over 35% of deforestation occurring outside their boundaries. On the other hand, registered territories, those with restrictions, reserves and dominions experience less than 23% of the deforestation outside. These results show how crucial it is for territories to complete the process of demarcation to protect their forestry and support my hypothesis (H2) as fully demarcated indigenous territories avoid deforestation more efficiently than indigenous territories still in the process of demarcation. But most importantly, this proves that halting the process of demarcation by several administrations was a strategy to allow for more deforestation on indigenous territories. While fully demarcated territories are not close to experiencing 0% deforestation, gaining the full title of demarcated (or the three exceptional titles) does lead to tenure security on indigenous lands. Furthermore, the differences between being fully registered and only being registered in the territory's district emphasizes that one of the main weaknesses of the process of demarcation lies in the registration of an indigenous territory.

6.3. Size and Population Density

In order to determine the effect of the size of an indigenous territory on deforestation, indigenous territories are divided into four groups that follow the four quartiles of the size of a territory in the sample (Table 6). The same was done for population density (Table 6).

Statistic	First Quartile	Second Quartile	Third Quartile	Fourth Quartile
Size (ha)	12,697.04	49,772.96	224,447.30	9,664,975
Population Density	148	342	735	26,046

Table 6: Size and Population Density Quartiles

6.3.1. Hypothesis 3

Size	Control Group mean (st. dev.)	Treated Group mean (st. dev.)	Difference	p-value
First Quartile	8.38 (16.91)	4.36 (12.00)	4.02	< 0.01
Second Quartile	7.76 (17.84)	3.43 (11.72)	4.33	< 0.01
Third Quartile	8.43 (20.56)	2.28 (10.01)	6.15	< 0.01
Fourth Quartile	6.20 (17.71)	1.26 (7.38)	4.94	< 0.01

Table 7: Deforestation (%) by Size of Indigenous Territories for Treated and Control Groups

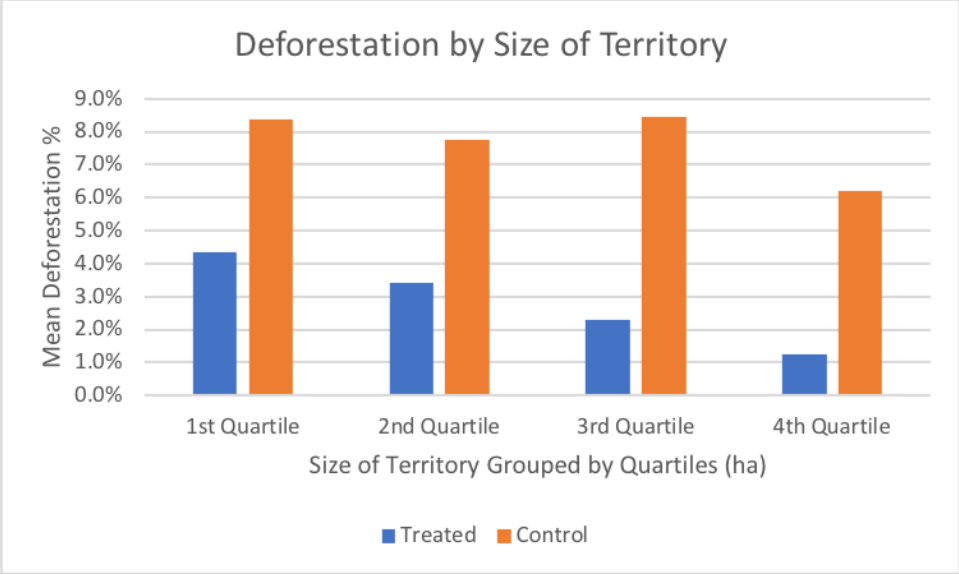


Chart 4: Mean deforestation (%) by Size of an Indigenous Territory for Treated and Control Groups

Table 7 provides a summary of mean deforestation rates, differences and t-test results for the four quartiles of the size of an indigenous territory. Chart 4 illustrates these findings and the differences between treated and control areas. Regarding the effect of the size of a territory on deforestation, deforestation varies in a linear fashion in treated areas with the most deforestation

in the smallest territories and the least deforestation in larger territories. T-test results allow us to confidently reject the possibility that the difference between control and treated groups in all quartiles is equal to 0. First quartile territories experience 52.07% of the deforestation occurring outside, 2nd quartile (44.23%), 3rd quartile (27.03%) and 4th quartile (20.34%). There is an important difference between the smallest territories and largest territories as small territories experience half of the deforestation outside while the largest territories experience a quarter of outside deforestation.

When analyzing the differences in deforestation within each quartile, treated areas in the 1st, 2nd and 4th quartile have similar abilities in deterring deforestation (4.02%, 4.33% and 4.94% respectively). The largest indigenous territories are able to curtail deforestation more productively than the smallest by 0.92%. Contrastingly, 3rd quartile territories avoid deforestation the most with a difference of 6.15%. The difference and difference in difference results show that 3rd quartile territories are the most efficient in avoiding deforestation. However, looking at these numbers proportionately to deforestation outside paints a different picture in support of my hypothesis. Fourth quartile territories avoid 76.66% of outside deforestation while 3rd quartile territories avoid 72.97%. These numbers become more significant when comparing them to the other quartiles as territories in the 1st quartile avoid 47.93% of outside deforestation and 2nd quartile 55.77%. Thus, consistent with my hypothesis (H3), larger indigenous territories are more productive in curtailing deforestation than smaller territories.

6.3.2. Hypothesis 4

Population Density	Control Group mean (st. dev.)	Treated Group mean (st. dev.)	Difference	p-value
First Quartile	9.50 (22.04)	2.61 (11.49)	6.89	< 0.01
Second Quartile	7.78 (20.09)	1.27 (7.79)	6.51	< 0.01
Third Quartile	7.85 (19.04)	1.42 (7.65)	6.43	< 0.01
Fourth Quartile	5.87 (16.28)	1.83 (8.50)	4.04	< 0.01

Table 8: Deforestation (%) by Population Density of Indigenous Territories for Treated and Control Groups

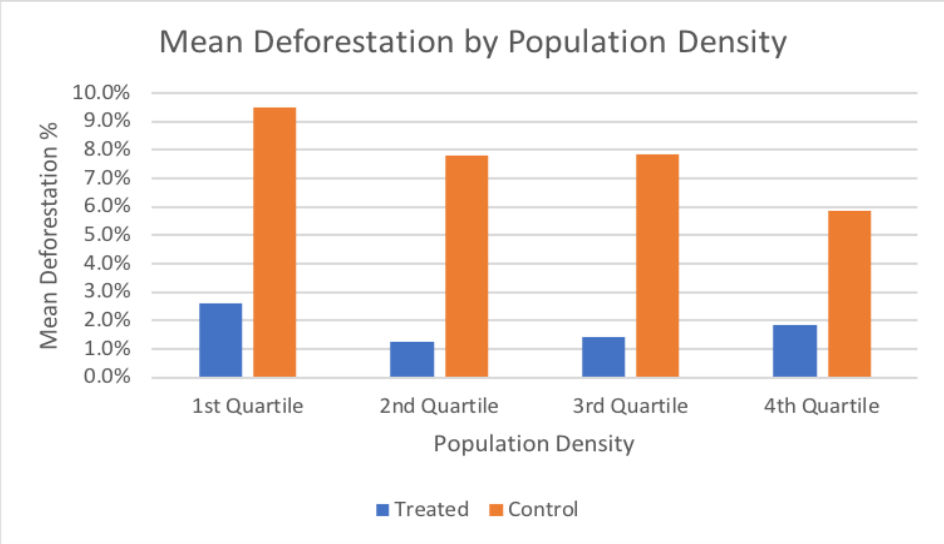


Chart 5: Mean deforestation (%) by Population Density of Indigenous Territories Territory for Treated and Control Groups

Table 8 provides a summary of mean deforestation rates, differences and t-test results for the population density of indigenous territories. Chart 3 illustrates these findings and highlights the differences between indigenous territories and their neighboring lands. Territories that are the least densely populated experience the most amount of deforestation. Interestingly, the most

populated territories do not experience the least amount of deforestation. Instead, territories within the 2nd quartile experience the least amount of deforestation. When looking at the ability of these various territories to avoid deforestation, least populated territories avoid the most deforestation (6.89%) while the most populated avoid the least (4.04%). The difference in difference resulting in 2.85% signifies that when population density decreases, the ability of a territory to avoid deforestation increases by 2.85%.

Least and most populated experience 27.4% and 31% of deforestation occurring outside their territories respectively. In these territories, deforestation varies the most from the mean with a standard deviation of 11.48% (1st quartile) and 8.50% (4th quartile). Contrastingly, the 2nd quartile and 3rd quartile territories experience 16.3% and 18.1% of deforestation occurring outside respectively. Contrary to my hypothesis, densely populated territories do not experience the least deforestation but neither do the least densely populated territories. If a territory is overpopulated, then it must be harder to mobilize all its inhabitants. Recall that some territories are home to several indigenous tribes. Over 20% of 4th quartile territories are home to two or more indigenous tribes compared to less than 10% of territories in all other quartiles. Because of this, mobilizing or organizing thousands of people from different tribes in one same territory must pose difficulties alongside the fact that these tribes have different ways of life and resource usage. In a similar manner, 1st quartile territories do not have the ability to protect their land as there is, at most, 148 inhabitants. Territories with a population count between 150 and 735 experience the least deforestation and avoid it the most.

Chapter 7: Conclusion

The primary goal of this thesis was to establish the extent to which indigenous territories are able to curtail deforestation in the Brazilian Legal Amazon. This was necessary to examine due to the increase in deforestation rates over the past few years, the radicalization of the country's stance against indigenous peoples and the worrisome intensification of environmental crimes on indigenous territories. These trends, alongside President Bolsonaro's election and the first action he undertook in changing the responsibility of demarcating indigenous territories to the Ministry of Agriculture implored for a much-needed up-to-date account of the relationship between indigenous territories and deforestation. Specifically, the fact that deforestation on some indigenous territories remains unaffected by current events while others face alarming threats of deforestation begged to wonder what factors could explain this variation.

First and foremost, this thesis proved that indigenous territories continue to experience less deforestation than their neighboring lands further confirming the crucial role of indigenous peoples in preserving forestry. This validated the first hypothesis I posed highlighting the strong barrier that indigenous territorial borders represent against deforestation. A more detailed analysis of year to year differences between 2015 and 2017 demonstrated that this barrier intensifies and becomes a stronger obstacle to external deforestation where deforestation is a major threat. This was further supported by high deforestation avoidance rates on indigenous territories in the states of the Legal Amazon where deforestation poses the biggest threat.

Second, finalizing the process of demarcation proved to be a crucial component in the protection of forestry on indigenous territories confirming my second hypothesis. This is true for indigenous territories that were demarcated under FUNAI and consequently protected by FUNAI, its various monitoring programs and its partnerships. The future of indigenous territories

still in the process of demarcation remains vague as the Ministry of Agriculture could completely end the process to allow for more deforestation. The status of territories with restrictions is even more at risk as lifting these restrictions would not only entail more deforestation but could drastically change the way of life and health of isolated indigenous peoples. Reserves and dominions also remain very well protected from deforestation. Their future is less uncertain as they are not owned by the Union and could, therefore, retain their important role in curtailing deforestation.

Finally, I hypothesized that large and densely populated territories would be more productive in curtailing deforestation than their counterparts. This revealed to be true for large territories proving not only that large territories are much-needed to prevent deforestation but also that reducing the original[4] size of and indigenous territory during the process of demarcation is a tactic to allow for more deforestation. Contrary to my hypothesis, densely populated territories were not more productive than territories with small populations in curtailing deforestation; neither were these least densely populated territories. The most densely populated territories further revealed to have the most tribes on one same territory which could be a major obstacle in effectively protecting a territory. Instead, territories with a population count between 150 and 735 were the most effective.

These findings show the crucial role of the demarcation process, the importance of delimiting large territories rather than ridiculously small ones (ie. 41 hectares, Agua Preta territory), and the negative impact of regrouping different indigenous peoples in one territory in protecting the Amazon rainforest. While these findings might provide a rather optimistic account on the relationship of indigenous territories and deforestation, they simply reflect the status of

[4] Meaning the traditional territory, prior to colonization.

this relationship under FUNAI. The dismantlement of FUNAI directly affects the protection of indigenous territories not only because the Ministry of Agriculture is now in charge of demarcation but also because this blocked any dialogue and operations FUNAI used to have with the Federal Police (Poirier 2019). These operations were crucial to the preservation of indigenous forestry. In addition to this, President Bolsonaro's change in responsibility complicated the way in which FUNAI employees can bring environmental crimes to justice creating immense bureaucratic obstacles (Poirier 2019). These consequences alongside current facts on the ground are quite disastrous and indicate that the account provided in this thesis is bound to deteriorate. Not only has there has been a spike in illegal logging and other land invasions on indigenous territories, but deathly violence and acts of torture have been carried out against indigenous peoples since President Bolsonaro took office (Poirier 2019). Indigenous leaders have been killed, others have been tortured and a plot to murder an indigenous leader and his family was exposed (Poirier 2019). Indigenous peoples, FUNAI, its partner organizations, NGOs, and the international community need to increase their monitoring and surveillance efforts to mirror the heightened invasions and increased rates of deforestation on indigenous territories. It will not be an easy fight but if these findings have proven anything is that indigenous territories have the necessary capacity to protect one of our planet's most valuable resources: the Amazon rainforest.

"*When the president says he will end human rights, what will happen to us? We cannot be held hostage by fear. We indigenous peoples in the movement need to think of everyone because our struggle is for everyone. We cannot retreat from this challenge but only advance. We must walk together to defend the Amazon, and Mother Earth who is calling for help*."
Alessandra Munduruku[5]

[5] Coordinator of the Munduruku Peoples' Pariri Association (Rosa-Aquino 2018)

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