Actor Network Theory and Deforestation in the Brazilian-Amazon

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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INTRODUCTION

Beginning in the 1960s, deforestation in the Brazilian-Amazon increased due to national policy that supported road building and colonization projects through the Amazon, as well as tax credits and incentives to large corporations and ranches (promoting intensive-land-use agricultural sectors) (Fujisaka et al., 1996). In the 2000s, Brazil received negative attention for its deforestation practices (slash-and-burn agriculture, etc.) (The Earth Observatory, 2009). This is partially because trees are a natural Carbon Capture and Sequestration (CCS) source: a technology which removes carbon from the atmosphere and stores it in an alternate form and/or place, for example in underground caverns (Gonzales, 2020). Additionally, deforestation is estimated to have a direct causal link to 8-10% CO_2 emissions by humans each year, which may have provoked criticism (Dean, 2019). In response to this backlash, Brazil began to roll back it's road building and colonization projects and decrease incentives to large corporations and ranches (Fujisaka et al., 1996). These events coincided with a large economic downturn beginning in 2013, which saw the devaluation of the Brazilian real and decreased commodity prices (Pravettoni, 2016). Since then, Brazil has seen an increase in illegal deforestation; especially recently, with an over 34% increase observed since August 2019 alone (*Brazil and the Amazon Forrest*, n.d.; Fujisaka et al., 1996).

In the initial rollback plan, onus and blame were placed in farmers (as they were on the front lines clearing trees), with the government sweeping in to lead the charge toward an environmentally-sustainable future for Brazil (Fujisaka et al., 1996). However, illegal deforestation rates are on the rise again, even after the needs of farmers were addressed in the rollbacks (*Brazil and the Amazon Forrest*, n.d.; Fujisaka et al., 1996). By interpreting the failure of the Brazilian government's rollbacks as caused purely by the same actors that they initially addressed (farmers), lawmakers and engineers may never fully address the underlying issues that drive deforestation in Brazil. Consequentially, deforestation and global temperature rise would continue.

Full understanding of the scientific, technological, and societal (STS) aspects of this problem are crucial to an engineer's understanding and solution to the issue of why the rollbacks in Brazil failed to provide a long-term solution to deforestation in the area, because this issue cannot be solved with a simple technological "fix" alone. In the context of Actor Network Theory, I will define a complex network of various rogue actors, to include Brazilian President Bolsonaro, the United States, China, and the United Nations, working to undermine Brazil's plans to rollback incentives for deforestation, rather than placing the blame for this developing country's inability to reduce deforestation on domestic farmers alone. I will begin by briefly developing an understanding of the current network, centered around the Brazilian government, and then defining key human and non-human actors within the network. Within the context of the network, I will show that rogue actors, not Brazilian farmers, are more dominant as they drive short-term political, social, and economic factors and feed preserved desires for independence and economic prosperity. To support my argument, I will analyze evidence from various Brazilian, and U.S. news outlets, such as *Brazilia* and *The New York Times*, which provide direct quotes and statements from President Bolsonaro, President Xi, and President Trump on the U.S.-China Trade War, the Brazilian economy, and deforestation in Brazil.

LITERATURE REVIEW

Several scholarly sources have addressed the general issue of deforestation in the Brazilian-Amazon. Most literature either provides mathematical analysis of trends in deforestation or rainfall, an analysis of sustainable energy planning in the region, accounts from farmers in the frontier regions, or a combination of these evaluations. A clear consensus has emerged that deforestation does harm the Earth's climate, with farming practices and drought exacerbating the situation. However, scholars have yet to adequately consider the effect of political, social, and economic entities, internal and external, that have led to increased deforestation. In the following evaluation, I will review the approach of two scholarly articles that represent a vast majority of the material available, as of this writing, with regard to deforestation in Brazil.

Staal et al. explores the possibility of a feedback loop between deforestation and drought in the Amazon (2020). The study first quantified fluctuations in deforestation rates with respect to dry season intensity, then used this data to find the effect of deforestation on evapotranspiration (Staal et al., 2020). Staal et al. then built a model based on the data compiled, and simulated changes in rainfall based on decreased atmospheric water input (2020). The study ultimately concluded that deforestation and drought are directly correlated in a feedback loop that gradually worsens the effects of each as time goes on and deforestation increases (Staal et al., 2020). This was based on the observation that increases in deforestation can be causally linked to intense dry-seasons (for every mm of water shortage, there was an average 0.13% increase in deforestation) (Staal et al., 2020). This allowed Stall et al. to conclude that deforestation has contributed to approximately 4% of observed water deficit averaged over the entire Amazon (2020). The study adds that this feedback loop is not the main cause of drought in the Amazon, and that global warming is the biggest contributor to water scarcity in the region; but that the gradually intensifying effects of the feedback loop cannot be ignored (Staal et al., 2020).

Arias et al. builds upon Staal et al.'s concept that climate change and a feedback loop initiated and exacerbated by deforestation are to blame for major changes in the Amazonian water cycle (Arias et al., 2020; Staal et al., 2020). However, this analysis goes one step further, and quantifies the effect these deviations have on sustainable energy planning, specifically hydropower (Arias et al., 2020). The study focuses on development in the Tapajos River basin, where approximately 50% of Brazil's potential hydropower capacity rests in 37 dams that are either already operational, or planning to be built in the coming years (Arias et al., 2020). Arias et al. used this information as well as daily river flows to build a mathematical model that takes into account the Tapajos River's ecosystem and the effect it will have on water flow, energy dynamics, and infrastructure (2020). The study concludes that dry seasons result in lower net energy production than rainier seasons, and that minimum annual power generation may decrease by 9-18% if current rates of deforestation are not curbed (Arias et al., 2020).

Both Staal et al. and Arias et al.'s studies conclude that global warming and, more regionally in the Brazilian-Amazon, deforestation, are having a catastrophic effect on the water cycle in Brazil, which is inhibiting sustainable energy planning (Arias et al., 2020; Staal et al., 2020). However, both studies also reference "socioeconomic complexity," and stressed the importance of "[learning] from past mistakes" and taking into account "broader social and environmental impacts" when hydropower planning (Arias et al., 2020; Staal et al., 2020). The studies reference the importance of political, social, and economic actors in the rollback network; however, they mention them as footnotes in the conclusion, diminishing their significance. In my analysis, I will set out to define and emphasize the political, social, and economic factors that both cause and affect deforestation in the Brazilian-Amazon by using the STS framework of Actor Network Theory, to provide a thorough and holistic view of the rollback network.

ACTOR NETWORK THEORY

My analysis of deforestation in the Brazilian Amazon draws on the STS conceptual framework of Actor Network Theory (ANT), which allows me to assess the various and numerous connections between actors in the network.

ANT is the combination of social and technical actors within an environment to create a network (Law, 235). Actors are human or non-human entities that interact with each other to form a network; a network being a collection of actors working toward a common goal (Callon, 1986). Not all actors work together, however. Rogue actors are actors that threaten the stability of the network by refusing to fulfill their role (Callon, 1986). In contrast, a network builder is the actor responsible for forming the actor-network (around which the network is built) (Callon, 1986). The concept of an actor-network combines "social and technical engineering in an environment filled with indifferent or overtly hostile physical and social actors" (Law, 235).

The bonds between actors determine their place within the network, and are defined by French scholar Michel Callon in his concept of "Translation" (1986). Translation is the process by which an actor forms and maintains an actor network (Callon, 1986). This concept involves four phases: problematization, interessement, enrolment, and mobilization (Callon, 1986). Problematization is when a network builder identifies a problem or goal, as well as the human and non-human actors needed to solve that issue (Callon, 1986). In problematization, network builders also identify how actors will interact and use this information to devise a strategy for building the network (and, in doing so, make themselves "indispensable") (Callon, 1986). Interessement is the network builder's pitch to actors in other networks. The network builder persuades actors from competing networks to unite under the network builder's approach to the issue at hand (Callon, 1986). If interessement is successful, network builders engage in enrolment: incorporating actors gained from competing networks into the network builder's actor-network (Callon, 1986). As the new actors begin to perform their roles within the network, they transition into the final phase of Callon's "Translation" concept: mobilization. In the mobilization phase, the network builder tries to secure their niche in the network by representing and speaking for the newly-incorporated actors in the network and mobilizing them to act (1986). If all is successful, and the network builder is able to incorporate all actors and form a stable actor-network, the network is referred to as a "black box" (Callon, 1986). If unsuccessful in incorporating all actors into the network, the network cannot function as required, and may fail (Callon, 1986).

Standardization and operating within a designated role dictates stability in terms of ANT (Latour, 1986). Network strength itself is determined by this stability: the more intrenched and consistent the bonds between actors, the more powerful the network (Latour, 1986). Power struggles within the Actor-Network occur when actors begin to operate outside of their intended role (Latour, 1986). In my analysis that follows, I will begin by defining actors that have been meticulously outlined by researchers and scholarly literature pertaining to the rollback network; then, I will define what I believe to be rogue actors that have sabotaged the network.

ANALYSIS

Following Michel Callon's concept of "Translation", I will identify the network builder, and how the rollback network came to be. I will then define actors that have already been explored in scholarly material published as of this writing. Finally, I will define actors that I believe are both overlooked and rogue actors that threaten to sabotage the network.

Network Formation

The first phase of Callon's concept is "problematization" (Callon, 1986). The network builder, according to ANT, is the actor around which the network is built (Callon, 1986). In this case, we will analyze the rollback network, which was built by a conglomeration of human actors, combining to form one intelligent, human network builder: the Brazilian government. This network was crafted to address the problem of deforestation in the Brazilian Amazon (which has been shown to lead to global warming by removing trees, natural methods of CCS, from the renewable equation) (Gonzales, 2020). This issue brings with it a multitude of human and non-human actors that belong in the network: trees, water, farmers, and crops and livestock (Arias et al., 2020; Fujisaka et al., 1996; Staal et al., 2020). These actors are already defined in the literature available today regarding this topic.

The interessement phase is difficult to define in this sense, since the majority of actors in the network are non-human. Even so, the rollback network tried to address the threat that deforestation and CO_2 pose to global stability, and, as the network builder, the Brazilian government attempted to recruit farmers, crops, and livestock from the existing network that promoted deforestation through road building and colonization (Fujisaka et al., 1996). The network builder recruited these actors in order to alter their role from harmful to other actors in the network (namely trees and water), to helpful and harmonious.

As, initially, farmers and their crops and livestock joined the network, the third phase of Callon's concept was achieved: enrolment (Callon, 1986). In order for the network builder to then mobilize the actors, to achieve a stable actor-network, the government and farmers had to reach an agreement as to how farmers would transition their crop-planting and livestock-raising practices away from deforestation; the rate of deforestation had to slow, stop, and eventually more trees had to grow; and the water cycle in the Brazilian-Amazon had to reach a new equilibrium and observed water scarcity during dry seasons had to diminish (Callon, 1986; Fujisaka et al., 1996; OECD, 2015).

However, this version of the rollback network ultimately failed - in recent years, illegal deforestation rates have increased by approximately 34% (*Brazil and the Amazon Forrest*, n.d.; Fujisaka et al., 1996). To analyze why this happened, and to emphasize that it is important to include political, social, and economic factors in engineering analysis, I will first outline the literature-defined actors in the network and how they tie together, and follow by addressing the forgotten rogue actors of the network and how they fit into the system.

Actors Defined in Literature

In this section, I will define various actors already detailed in literature concerning Brazilian-Amazon deforestation, to include the network builder, the Brazilian government, as well as, Greenhouse Gases, Amazonian trees, water, farmers, and crops and livestock. This network is shown in Figure 1.

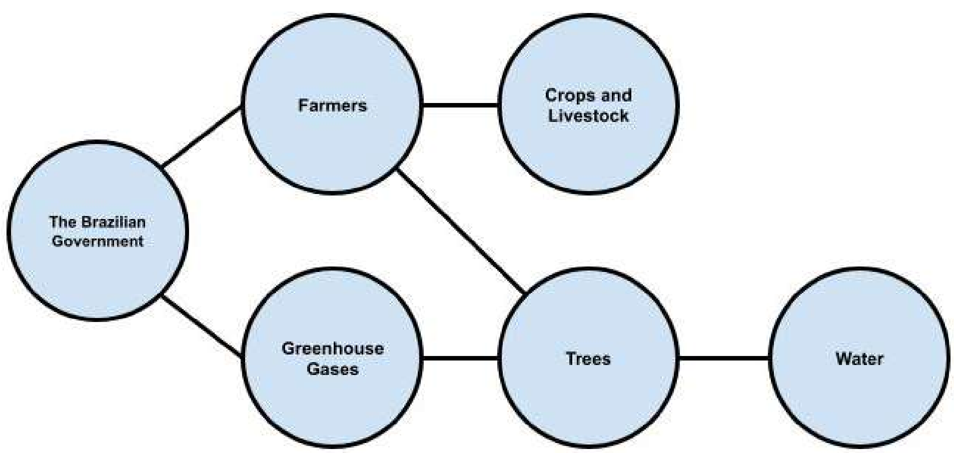

Figure 1 - The Rollback Network According to Available Literature.

The Brazilian government as a whole is a conglomeration of human actors, combining to form one intelligent body as the network builder. After identifying that deforestation in Brazil was resulting in severe environmental impacts, the government implemented a rollback program, with the intent of reducing funding and incentives to projects that resulted in deforestation

(Fujisaka et al., 1996). This funding instead went toward social policies that contributed to significant socio-economic development and decreased reliance on the deforestation of the Amazon (OECD, 2015). The Organization for Economic Co-operation and Development, OECD, has defined this period (in the 2000s) as one of "vibrant growth" (OECD, 2015). However, the environmental policies of this time, for example, extensive protection of lands, have been described as in need of stricter "implementation and enforcement" (OECD, 2015). This crack in the foundation of the rollbacks ultimately allowed for actors to capitalize on this weakness. This will be explored further in later sections with regard to rogue actors, however in the context of Figure 1, the Brazilian government implements environmental policies on farmers to address the increased presence of Greenhouse Gases.

CO_2 is a colorless, odorless gas that enters the atmosphere as both a product of respiration and a product of many industrial and corporate ventures (Praxair, 2016). Other greenhouse gases such as NH_3 are more potent/have a higher effect on the atmosphere than CO_2, however CO_2 is still the most abundant and impactful greenhouse gas in the atmosphere (Rafferty, n.d.). In the context of the network, and as shown in Figure 1, CO_2 is taken in by trees for photosynthesis; farming practices, such as slash-and-burn agriculture, destroy trees (and thereby contribute to increased CO_2 production and release); and governing institutions (such as the Brazilian government) set goals for reduced emissions and halting average global temperature rise (Fujisaka et al., 1996).

Trees are a natural form of CCS, in that they use the cellular process of photosynthesis to convert CO_2, H_2O, and sunlight into O_2 and glucose (Lambers, n.d.). The Brazilian-Amazon currently contains approximately 1.56 million square miles of established trees, all capable of this process (*Brazil and the Amazon Forrest*, n.d.). At a small scale, even a large tree that is thousands of years old only makes a minimal difference; however, with millions of acres of trees, the Brazilian-Amazon represents a large tropical rainforest ecosystem that is a key force in overcoming global climate change (*Brazil and the Amazon Forrest*, n.d.). Trees consume CO_2, are consumed by farmers (in order to use the land they grow on), and interact with the water cycle of the Brazilian-Amazon through intake of water for photosynthesis and evapotranspiration as shown in Figure 1 (Arias et al., 2020; Staal et al., 2020).

Water in the Amazon comes mainly from rivers and rainfall and follows the water cycle: evaporation, condensation, and precipitation (Arias et al., 2020; Staal et al., 2020). In the evaporation phase, transpiration also occurs, which is the evaporation of water from within a plant through elements of the plant exposed to the air (leaves, stems, flowers, etc.) (Staal et al., 2020). Transpiration accounts for approximately 10% of all water in the atmosphere (United States Geological Survey, n.d.). Therefore, with increases in deforestation, this supply of water to the cycle is interrupted, causing drought (Staal et al., 2020). This lack of water also increases the risk of fire to the ecosystem and general human population (Arias et al., 2020; Staal et al., 2020).

Brazilian farmers, according to a study by Fujisaka et al., utilize two primary farming practices that contribute to deforestation: slash-and-burn agriculture, and pasturing (1996). Slash-and-burn agriculture, as opposed to crop shifting or rotation, involves the destruction of trees and forest by cutting the trees with axes, machetes, and other sharp instruments, and clearing the fallen foliage; followed by burning the slashed trees in order to clear land for crops, increase soil fertility, and kill off weeds and pests (Fujisaka et al., 1996). Clearing land for pasture accounts for the majority of deforestation, especially in frontier states with untouched land and where an overwhelming majority, from Fujisaka et al.'s population, about 86%, of farmers own cattle

(1996). This land is cleared using the slash-and-burn method in most cases (Fujisaka et al., 1996). Farming practices interact with the network by destroying trees to provide suitable conditions for crops and livestock, while the legality of these practices is dictated by the Brazilian government.

Crops and livestock are the fruits of Brazilian farmers' labor and practices. Typical crops grown in Brazil include oranges, bananas, soybeans, coffee, cassava, corn, cacao, and rice (Britannica Academic, 2019). Cattle are the main form of livestock put to pasture in Brazil, with the country currently producing over 23% of the world's beef and buffalo meat and 21% of the world's poultry (Khan, 2019). Crops and livestock are produced by farmers in the network and consumed by the Brazilian people and countries around the world, such as China (Khan, 2019).

Rogue Actors

While the actors above are all valid and active members of the network, other actors have been overlooked in the assessment of the network in published literature. I will define current, established (in the network for over one year), actors that I believe to be worthy of note in publications going forward for their extensive impact on the rollback network. These actors are: the Brazilian President, China, the United States, and the United Nations. Their roles in the network are represented pictorially in Figure 2. Some connections are depicted as arrows in an attempt to emphasize which actors are exerting power over others, and disrupting the balance of power within the network. Areas of note include: the power the Brazilian government exerts on Greenhouse Gases and Farmers, the power China holds over Brazilian Crops and Livestock, and the power the United Nations exerts over Greenhouse Gases.

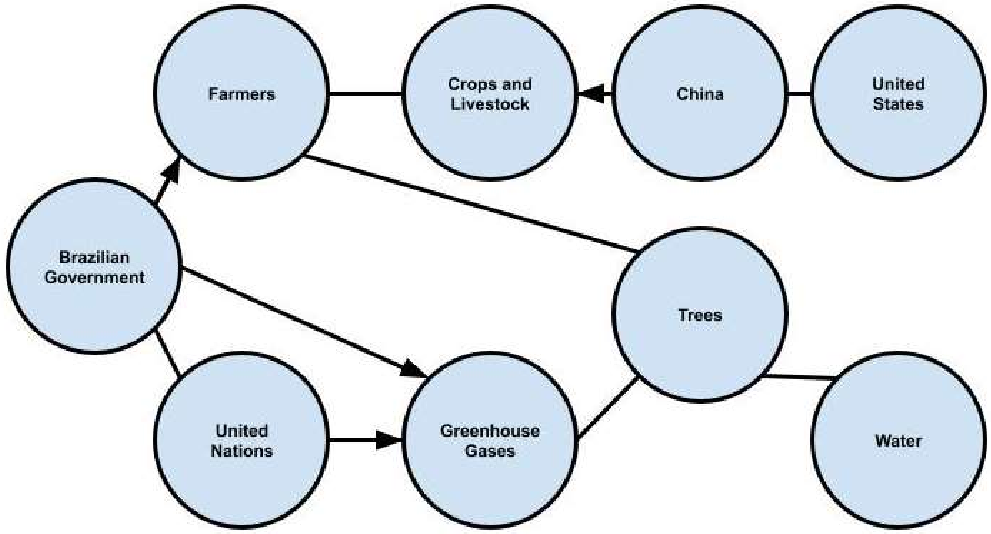

Figure 2 – The Rollback Network with Rogue Actors Accounted for.

The Office of the President

One organization within the Brazilian government will specifically be discussed here as a rogue actor: The Office of the President (Phillips, 2019). President Bolsonaro, who took office in 2019, has made statements rejecting European countries' assessment of deforestation in the Amazon (Phillips, 2019). Bolsonaro sees the situation like so: "the Amazon is not [Europe's]", and European countries should be focusing on their own environmental projects (Phillips, 2019). The outsider's view is that he is failing in his responsibility to protect this global resource (Phillips, 2019). He is aiming to open Brazil to partnerships that exploit its biodiversity and mining operations, while throwing into doubt data from his own government regarding dramatic increases in deforestation (Phillips, 2019). The President has further accosted the nation's environmental agencies and plans to undermine their authority by opening indigenous reserves (Khan, 2019). The President's rejection of European influence from European nations and governing bodies, like the United Nations, as well as dominion over public opinion and farmers (vested in his ability to undermine other government agencies), allow him to compromise the cohesive nature of the network builder, which makes him an important, rogue, actor in the rollback network.

The China-U.S. Trade War

China and the United States are two actors with a direct relationship to each other in this network. Beginning in 2018, tensions between the countries intensified when U.S. President Donald Trump imposed tariffs on Chinese goods; this eventually sparking reciprocal action and fledging into a trade war (Swanson, 2019). This led the two countries to seek commodities from other countries, which is where the countries' connection to the rollback network is formed. China is now buying soybeans from Brazil instead of the U.S. (Khan, 2019). Soybeans are Brazil's largest commodity export, and Brazil is now exporting more than $25 billion USD worth a year (Khan, 2019). The increased demand for Brazilian agricultural products has increased the necessary supply. This means that Brazilian farmers must increase their crop and livestock production values, which requires more land and deforestation. The extensive revenue that China provides to Brazil in terms of crop and livestock purchases shows that a new actor can enter the network and exert a large amount of power, even in a relatively short period of time (Khan, 2019).

The United Nations

The United Nations (UN) is the final actor I will explore in this analysis. The Paris Climate Agreement was crafted by the United Nations Framework Convention on Climate Change (UNFCCC) and outlines guidance for signatories to meet the goals set out in the Intergovernmental Panel on Climate Change's (IPCC) latest Special Report on "Global Warming at 1.5 Degrees Celsius" (Denchak, 2018). The Agreement outlines clear methods for major emitters of greenhouse gases to gradually lean toward more sustainable technology over time, as well as record and report climate data (Denchak, 2018). Within the rollback network, the UN is tied to the Brazilian President, as he resents European intervention in internal affairs, and European members in the UN have been some of the quickest countries to condemn Brazil's continued deforestation (Phillips, 2019). Most obviously, however, the UN's creation of the Paris Climate Agreement, and commitment to ending climate change, ties it to Greenhouse Gases (Denchak, 2018).

An Alternate View of the United Nations Involvement

Overall, the United Nations has established itself as a member of this network through the creation of the Paris Climate Agreement; to which Brazil must comply as they are a member of the United Nations (Denchak, 2018). One competing opinion of the United Nations, and Brazil's involvement in UN initiatives, however, is that the UN demands too much of developing nations like Brazil, and that environmental protections are a "obstacle to economic growth" (Casado & Londoño, 2019). This is the prevailing opinion of President Bolsonaro (Casado & Londoño, 2019). However, the Agreement does call on developed nations to assist developing nations in their sustainable transition (Denchak, 2018). This assistance can be in the form of loans or other monetary investments (Denchak, 2018). As a developing nation, Brazil is in a position where outside interference would allow them to both uphold their commitments to the United Nations while maintaining a period of economic growth (Denchak, 2018). President Bolsonaro paints the situation as a choice between two extremes: either environmental policies remain in effect but the economy and people suffer, or the economy and people flourish while a natural resource is mined (Casado & Londoño, 2019). However, it is clear that a third option exists where environmental and economic initiatives can both be explored (Denchak, 2018).

Actors Excluded from Definition

For simplicity, actors such as the Brazilian people, and large corporations with investments in farming operations in Brazil are not explicitly defined in this analysis, as they perform roles similar to those of actors already included in the network (the people acting as consumers, and corporations acting as producers, niches already filled by China and farmers, respectively). This does not mean that these actors are entirely the same, however. For example, the motivations of the Brazilian people are not the same as those of the Chinese people and government, which may cause the two actors to act differently in the future. As was my goal, to expand the network, I would encourage future research to do the same as time goes on and actors come and go from the process.

CONCLUSION

In this thesis, I have used the STS concept of ANT to build and enhance the rollback network of the Brazilian-Amazon by addressing rogue actors that have sabotaged the network. By analyzing the identities of rogue actors that have destabilized the network and inhibited progress in deforestation and sustainable energy planning efforts, researchers and engineers can develop practical solutions that allow for more feasible analyses and proposals with regard to deforestation in the Brazilian-Amazon and, ultimately, decreased deforestation in general. By developing an understanding of ANT and deforestation, the reader should become more aware of the political, social, and economic actors that play into a failure to meet an outlined goal (in this case, the roll backs of the late 2000s-early 2010s), and how they can contribute to the eventual success of the goal.

Word Count: 3,993

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