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The Extent of Reductions to Protected Areas in the Brazilian Amazon: Case Study of Amazon National Park

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The Extent of Reductions to Protected Areas in the Brazilian Amazon: Case Study of Amazon National Park

by

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Thesis

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

Master of Arts

The University of Texas at Austin

May 2014

Dedication

I dedicate this thesis to Erin and my parents

Acknowledgements

I thank my advisor, Eugenio Y. Arima, for his guidance, advice and support. I learned a great deal while under his tutelage and am very grateful to have had the opportunity to work with him. I also thank my committee members Jennifer A. Miller and Edgardo M. Latrubesse for their support, commentary, and recommendations both in the classroom and on my thesis. I would like to acknoweldge Elis Araújo and Paulo Barreto from IMAZON who provided me with material and leads for this thesis. I thank Eraldo A.T. Matricardi who enthusiastically provided me with background information and research suggestions. I am also very grateful to all of the interviewees who patiently shared their knowledge with me.

Funding for my research endeavors and fieldwork was graciously provided by: the National Science Foundation project "Territorializing Exploitation Space in the Fragmentation of the Amazon Forest", NASA Interdisciplinary Sciences Grant NNX11AB89G, the Robert E. Veselka Fellowship, and the Brazil Center Scholarship.

Last but certainly not least, I thank Erin, my parents, siblings, and grandparents for their everlasting support.

Abstract

The Extent of Reductions to Protected Areas in the Brazilian Amazon: Case Study of Amazon National Park

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Over the past several decades, the preservation of Brazil's natural landscapes and traditional cultures has received significant global attention; the focus of which has been primarily on the Amazon Basin. In order to safeguard the Amazon's unique biodiversity, natural resources, and traditional cultures, Brazil's state and federal governments have designated hundreds of thousands of square kilometers as conservation units with legally protected statuses. To effectively accomplish conservation objectives, it is necessary to maintain the permanence of protected areas. However, over the past decade, a host of circumstances has plagued Brazil's protected areas. Due to land use and economic pressures, the sizes of many protected areas throughout the Amazon are being reduced. Understanding the drivers and outcomes of reductions to protected areas is essential for the long-term preservation of ecosystem services. To that end, the objectives of this thesis were to understand why and how quickly a national park in the Legal Brazilian Amazon was being reduced in size by the Brazilian government. Interviews with key informants demonstrated that the park historically lacked legitimacy amongst newly arrived migrants

which influenced the colonization amongst its borders. Moreover, inept governance regimes facilitated settlements within the park. Satellite imagery was used to detect and quantify the substantial rise in deforestation within the park. Spontaneous settlement in the region and a governance structure that did not enforce the park's legality played a significant influence on the downsizing of Amazon National Park. In addition, domestic energy demands prompted the federal government to embark on a national energy strategy centered on hydropower construction that has directly impacted the park's conservation effectiveness of maintaining natural forest cover. Together, these two drivers have united to considerably reduce both the size and the effectiveness of Amazon National Park.

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Acronyms

ANEEL	Brazilian Electricity Regulatory Agency *Agência Nacional de Energia Elétrica*
APA	Environmental Protection Area (*Área de Proteção Ambiental*)
BNDES	National Bank for Economic and Social Development *(Banco Nacional de Desenvolvimento Econômico*)
EPE	Energy Research Agency (*Empresa de Pesquisa Energética*)
FLONA	National Forest (*floresta nacional*)
IBAMA	Brazilian Institute of the Environment and Natural Resources (*Instituto Brasileño para el Ambiente y los Recursos Naturales Renovables*)
IBDF	Brazilian Forestry Development Institute (*Instituto Brasileño de Desarrollo Forestal*)
ICMBio	Chico Mendes Institute for Biodiversity Conservation (*Instituto Chico Mendes de Conservação da Biodiversidade*)
INCRA	Institute of Colonization and Agrarian Reform (*Instituto Nacional de Colonização e Reforma Agrária*)
IUCN	International Union for Conservation Nature
PA	Settlement Projects (*Projetos de Assentamento)*
PADDD	Protected Area Downsizing Downgrading & Degazetting
PARNA	National Park (*Parque nacional)*
PDS	Sustainable Development Projects (*Projetos de Desenvolvimento Sustentáve*)
PIC	*Projetos de Integração e Colonizaca*
PNA	Amazon National Park (*Parque Nacional da Amazônia*)
SEMA	Special Secretariat for the Environment (*Secretaría Especial del*

Medio Ambiente)

SNUC National Protected Areas System

STR Rural Workers Union (*Sindicato dos Trabalhadores Rurais*)

SUDEPE Secretary of Fishery Development

Chapter 1: Introduction, research objectives and background

INTRODUCTION

Protected areas, a critical strategic component of conservation policy, safeguard the Brazilian Amazon's unique biodiversity, traditional cultures, and carbon stores. Since the 1970s, Brazil's state and federal governments have designated hundreds of thousands of square kilometers as conservation units with legally protected statuses. To effectively accomplish long-term conservation objectives, it is necessary to maintain the permanence of the Amazon's protected areas. However, protected areas are vulnerable to the whims of their governance structure. To that end, protected areas are not immutable institutions but rather dynamic structures that may undergo transformations in size, changes in management, or dismantling of their legal status.

Recently, Brazil's federal government has reduced the areal extent of a host of protected areas in the Amazon. Understanding the circumstances and drivers that led to these reductions in size is essential for the long-term preservation of the Amazon's ecosystem services.

This thesis investigates the reasons, magnitude and implications of the reductions for one of the Amazon's original protected areas, Amazon National Park (*Parque Nacional da Amazônia*, in Portuguese). Specifically, this thesis seeks to: (1) understand why and how protected areas in the Brazilian Amazon are shrinking in size; (2) determine why Amazon National Park has lost some government support for its protection; and (3) identify the social and ecological consequences of Amazon National Park's reductions at the local and national scale.

This study relies on two primary data gathering approaches that were undertaken during fieldwork in Brazil in July 2013. First, interviews were conducted with community leaders, key informants, and local experts. The purpose of these interviews was to understand the factors and the historical conditions that led to the reduction of Amazon National Park. Second, archival research of Brazilian government reports and management plans provided additional historic context and motivation behind the reductions. In addition to fieldwork, an analysis of satellite imagery elucidated the extent that land cover change has occurred within the park.

Following the introductory remarks above, this chapter addresses the emergence of national parks as a prominent conservation policy. The motivation for the creation of these parks is outlined next, together with a review of the literature demonstrating the importance of protected areas for global conservation strategies. This chapter also outlines how societal and economic pressures may lead to the modification of a protected area's legal status.

BACKGROUND

On March 1st, 1872, the United States Congress enacted legislation to set apart a tract of land lying near the headwaters of the Yellowstone River as a public park to be "reserved and withdrawn from settlement, occupancy, or sale…" (Congressional Act 1872). The creation of Yellowstone National Park was the world's first occurrence of a protected area (Chase 1987). For centuries, societies have shielded lands that were deemed valuable for their aesthetic, cultural, and/or natural resources from human development. However, the creation of Yellowstone National Park represented the birth of the modern conservation movement (Chape 2005).

Since the creation of Yellowstone, the extent of protected areas has increased exponentially (Naughton-Treves, Holland, and Brandon 2005) and today includes 13.0% of the Earth's terrestrial surface (Le Saout et al. 2013), in well over 100,000 sites (IUCN and UNEP 2010). Furthermore, protected areas represent 15% of all land in developing countries (Miteva, Pattanayak, and Ferraro 2012) and over a quarter of all tropical forest land (Nelson and Chomitz 2011).

The motivation for creating protected areas has evolved since the creation of Yellowstone National Park. The location and size of a protected area is largely an arbitrary decision based on society's value system at the time of its creation. The earliest protected areas employed a romantic vision of nature. These areas, such as Yosemite National Park, were protected primarily based on their aesthetic value. In these original parks, there was a clear division between nature and human modified environments (Fall 2002). The boundaries of these protected areas were designed for humans to enjoy visually pleasing landscapes of a supposedly pristine wilderness. At the same time, management of the parks prevented significant human development within the borders. People could travel through a park but they were not permitted to reside within it (Fall 2002). This rigid approach towards protected area design is often termed a fortress model of conservation (Anderson et al. 2000).

Over time, the motivation and design of protected areas evolved to incorporate scientific principles that integrated the conservation of flora and fauna and aesthetic values. The boundaries were still based on a fortress model of protection but protected areas were no longer limited to merely visually pleasing locations. Instead, protected areas incorporated lands with ecological functions (Fall 2002). An understanding eventually emerged in the mid twentieth century that this romanticized ideal of an unspoiled wilderness was in reality a myth. Conservationists came to recognize that humans, including native peoples, have been impacting and influencing the landscape for centuries (Denevan 1995; Mann 2005). This newfound knowledge influenced the creation of protected areas to incorporate cultural and social resources, in addition to ecological values (Chape 2005).

By the 1970s, a new paradigm of protected area design and management began to take hold. Strict boundaries were disregarded in favor of a zonal design. Managers of protected areas recognized that protected areas are sometimes created with boundaries that are arbitrary to ecological and anthropological realities—nature is not self-enclosed and does not obey political or social agreements (Fall 2002). In response, many protected areas were designed with sliding scales of protection that took into account the many economic and social realities of creating a protected area (Fall 2002). In this approach, there was an acknowledgement that the conservation of ecosystem services should occur in tandem with the land use practices of local communities in and near the protected area.

Moreover, protected areas were designed to fit within a regional, national, or global master plan of conservation. For instance, in 1976 UNESCO initiated the World Network of Biosphere Reserve (Fall 2002). Similarly, there was a growth of global institutions with the mission to monitor and expand protected areas. The most notable examples include the International Union for Conservation Nature (IUCN) and the National Parks Commission (now the World Commission on Protected Areas; WPCA).

By the end of the twentieth century, in part because of the work of these institutions, developing countries had surpassed the developed world in the quantity of protected areas, both in volume and number of sites (Fall, 2002; IUCN and UNEP 2010). This burgeoning of protected areas in the developing world was instigated largely because the international community pressured the developing world to protect their large reservoir of biodiversity and carbon stores (O'Neill 1996; Bates and Rudel 2000). Deforestation was a rampant problem in the tropical forests of the developing world and the creation of protected areas, although not a panacea, were viewed as a partial solution to curb deforestation.

The perceived effectiveness of protected areas has fluctuated significantly over the past thirty years. Historically, research on the impact of protected areas on biodiversity and deforestation has found both benefits and costs. For example, in his pivotal 1988 paper on ecological hot spots in tropical forests, Norman Myers lambasted protected areas as ineffectual (Myers 1988). He contended that all protected areas, even those of notable size such as in the Brazilian Amazon, do not have the capacity to preserve biodiversity because they are merely isolated patches in an otherwise human-dominated ecosystem, a circumstance he called islandizing (Kramer, Schaik, & Johnson, 1997). Consequently, Meyers argued that even the best-managed protected areas are not of adequate size to deter species decline. Similarly, other researchers have claimed that due to strained natural resources and constant human economic development, protected areas will not attain their stated goals (Ghimire, Ghimire, and Pimbert 1997). In addition, critics of protected areas have argued that protected areas do not prevent deforestation. Rather, they merely substitute deforestation in one location for another, in a process known as leakage (Cronon 1996; Aukland, Costa, & Brown, 2003).

However, contrary to the above described perceptions popularized in the 1980s and 90s, recent literature suggests that protected areas do successfully achieve their conservation objectives (Nelson and Chomitz 2011). The most basic measure of the effectiveness of a protected area is how well its forest cover has been and continues to be preserved (Barber et al. 2012). Multiple global and local analyses of protected areas in tropical forests have determined that protected areas do maintain forest cover, which in turn provides additional ecosystem services (Joppa, Loarie, and Pimm 2008; Nelson and Chomitz 2011; Soares-Filho et al. 2010). Local and global studies have demonstrated that protected areas successfully preserve biodiversity, maintain carbon-dioxide stores, diminish human induced forest fires, and prevent deforestation. The Convention on Biological Diversity, which counts a membership of 187 countries, considers protected areas to be at the foundation of biodiversity conservation (CBD, 1992).

PADDD

Yet, protected areas must be properly managed to successfully accomplish their conservation objectives. Contrary to popular perception, protected areas are not immutable swathes of land (or sea) but rather they are dynamic institutions, bending to the whim of their governance structure. These governance structures are not static and as such their stance towards protected areas is constantly changing. As society and governance regimes change, the expectations placed on protected areas and the reasons for their establishment continually evolve (Chape 2005). As a humanly devised construct with artificial boundaries, protected areas are only as impermeable to human encroachment as the legal and enforcement mechanisms that govern them. On occasion, due to various pressures discussed below, the legal status of a protected area changes.

Governing bodies employ several tactics to manipulate the characterization and existence of protected areas. One such tactic is to downgrade a protected area's hierarchical management category, e.g. removing its strict conservation status with one that permits so-called sustainable use practices. This tactic allows an increase in human development, such as selective logging, within an area once deemed completely insulated from land use pressure. Second, and usually only in extreme cases, governments may undertake the drastic action of degazetting (removing) the status of a conservation unit as a legally protected area (Peres and Terborgh 1995). Third and much more commonly, the government will reduce the areal extent of a protected area. In this case, a protected area loses a percentage of its size. Together, these three legal changes to a protected area's status have been coined as PADDD (Protected area downgrading, downsizing, and degazettement, Figure 1.1).

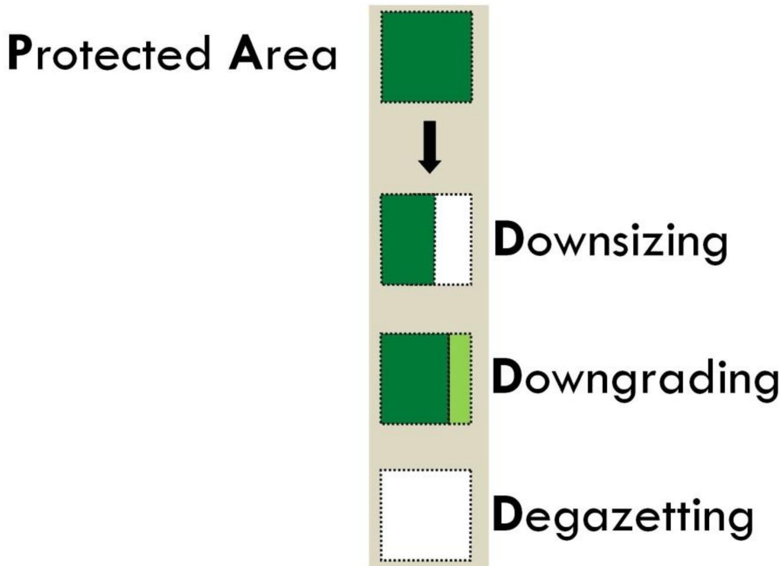

Figure 1.1. PADDD. In downsizing, a proportion of the protected area loses its protected status. Downgrading a protected area modifies its management type. Degazetting a protected area completely removes the protected status of the area.

The precise reasons for PADDD to occur are innumerable, but PADDD events can generally be traced back to one or more of three common themes: (1) industrial-scale natural resource extraction and development, (2) local land use pressure and land tenure claims, and/or (3) conservation planning modifications (Mascia et al. 2014). PADDD events are not limited to a particular geographic region or to a country's economic status (Mascia and Pailler 2011).

In an exhaustive historical search of hundreds of PADDD events in Latin America, the Caribbean, Africa, and Asia, Mascia and Pailler (2011) found instances of

PADDD in 57 countries, affecting 503,591 km of terrestrial and marine protected areas. The authors acknowledge that this figure is surely a gross underestimation as many PADDD events are not extensively documented.

Land tenure claims, where people dispute the ownership of the land, result in PADDD because many protected areas were created through a top-down policy approach that did not take into consideration the concerns of local communities (Weladji and Tchamba 2003; Naughton-Treves, Holland, and Brandon 2005). In many cases, a protected area becomes a matter of contention because local people are displaced from their settlements or deprived of the traditional use of the local resources (Coad et al. 2008; Prendergast and Adams 2003). In turn, local inhabitants display their contempt for the protected area, in the form of political pressure (Naughton-Treves, Holland, and Brandon 2005), violent outbursts (Agrawal 2005), and/or overt dismissal of the protected area's legitimacy (Carey, Dudley, and Stolton 2000). This type of local pressure on a protected area's managers is most likely to lead to a downgrade of a protected area.

A second theme, conservation planning, is a cause for PADDD when previously held conservation techniques and methods are considered to be dated or economically insolvent. For example, an endangered species that is delisted can remove the obligation of maintaining a protected area (Black 2012). Likewise protected areas are at risk of PADDD when their funding streams decrease, possibly due to lack of payment for ecosystem services (Corbera, Soberanis, and Brown 2009). These types of events are more likely to be correlated with the degazetting of protected areas.

Natural resource extraction is overwhelmingly the most common cause of PADDD events. This extraction is generally at the industrial scale and includes oil drilling, forestry, mining, industrial agriculture, and industrialization. Instances of PADDD regarding mining most commonly led to downgrading. Industrial agriculture, which requires substantial land to be effective, most often led to downsizing (Mascia et al. 2014).

To justify PADDD events, governing bodies may append land to a protected area in exchange for downsizing a portion of it. In a limited number of cases, PADDD events may be ecologically beneficial. For instance, a conservation plan may be strengthened by exchanging ecologically valuable land for land of limited conservation value within a protected area. Yet, the vast majority of PADDD cases are disassociated from conservation objectives (Mascia et al. 2014). Most commonly, PADDD events are economically motivated.

Proposals to enact PADDD often motivate extensive opposition. The Society for the Preservation of the Wild Fauna of the Empire (SPWFE) was formed in 1903 in response to threats by the British Colonial Office to degazette a Sudanese game reserve (Prendergast and Adams 2003). The efforts of the SPWFE galvanized a large contingent of highly motivated hunters who organized to successfully block the PADDD legislation. Similarly, recent proposals for PADDD in the Arctic National Wildlife Refuge have generated tremendous grassroots and international opposition (Sovacool 2008).

The remainder of this thesis is organized as follows. Chapter 2 provides a history of Brazil's protected areas network, its various management types, and its level of effectiveness. Furthermore, this chapter introduces instances of PADDD in Brazil. Chapter 3 analyzes the historical contexts that gave birth to Amazon National Park and subsequently led to the downsizing of the park. In Chapter 4, an application of remotely sensed imagery captures and quantifies the land use and land cover changes that occurred in the park leading up to the reduction. The thesis concludes in Chapter 5 with a discussion of the social and ecological impacts of reducing Amazon National Park and policy recommendations.

Chapter 2: Protected Areas in Brazil

This chapter provides a history of Brazil's network of protected areas, with an emphasis on the Amazon region. An overview of the various management types and the network's effectiveness is also detailed. In addition, an overview of historical and recent PADDD events within Brazil is discussed.

Over the past several decades, the preservation of Brazil's natural landscapes and traditional cultures has received significant global attention, the focus of which has been primarily in the Amazon Basin. In order to safeguard the Amazon's unique biodiversity, natural resources, and traditional cultures, Brazil's state and federal governments have designated hundreds of thousands of square kilometers as conservation units with legally protected statuses (Rylands and Brandon 2005). However, over the past decade, a host of political and economic circumstances has plagued Brazil's protected areas. The section below will illustrate the value of Brazil's protected area network to the local, regional, and global communities. Also, this section will outline the history of Brazil's protected area network from its earliest beginnings to its recent setbacks.

THE AMAZON

The name "Amazon" has a variety of definitions and connotations. It often refers to a rainforest, a basin, a biome, or a political unit. For purposes of this paper, the Amazon will refer to the Legal Amazon, or a political representation created in the late 1940s that gained meaningful status after 1953 with the creation of *Superintendência do Plano de Valorização Econômica da Amazônia* (SPVEA), which later became SUDAM (*Superintendência para o Desenvolvimento da Amazônia)* (Mahar 1979). These institutions were responsible for managing a series of financial benefits that included tax breaks, subsidized credit, and land acquisition on very favorable plans by industrial and agricultural enterprises willing to invest within this newly created political denomination (Mahar, 1979). This socio-geographic division is made up of nine Brazilian states, which overlap the Amazon Basin, the rainforest, and parts of cerrado (Figure 2.1). Together, the nine states encompass roughly 60% of Brazil's territory (Soares-Filho et al. 2006) and are home to 23 million people (IBGE 2010).

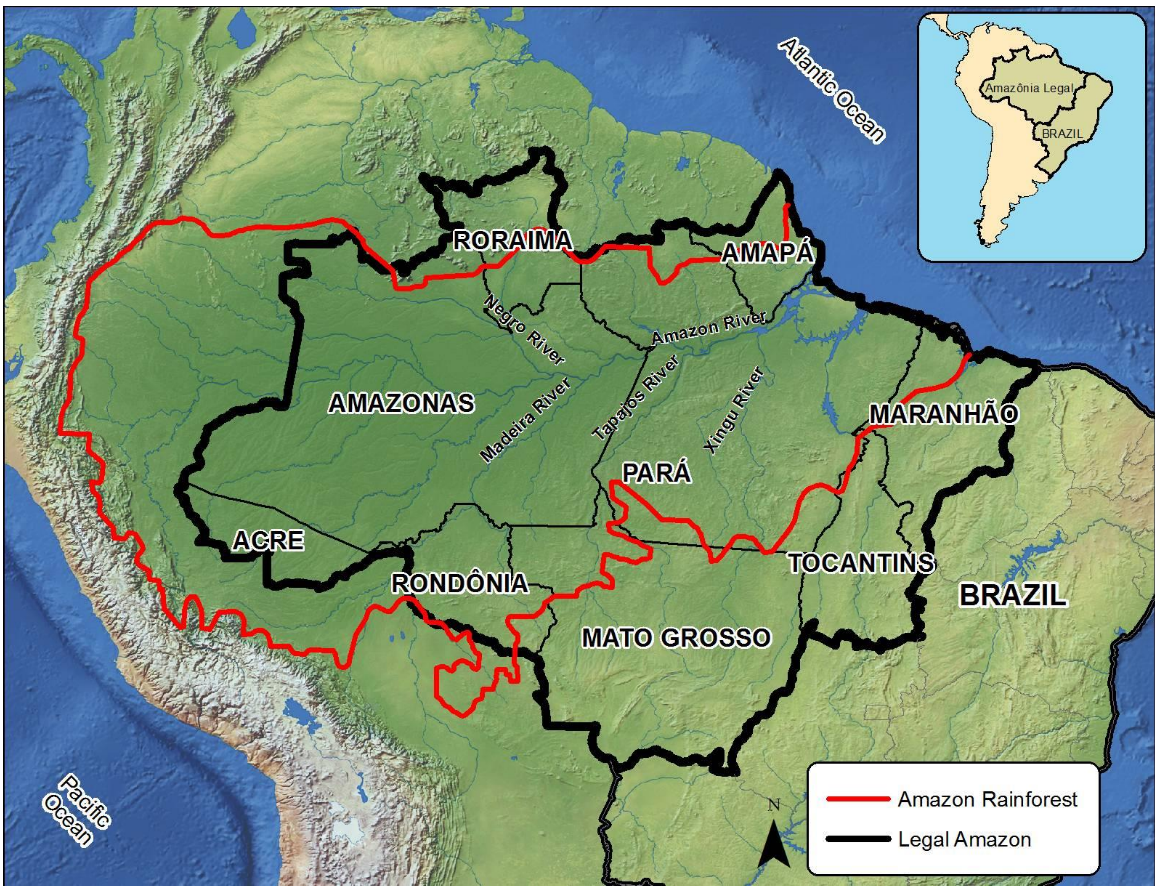

Figure 2.1. The Legal Amazon is a nine-state region of Brazil that also overlaps with the Amazon Rainforest biome, outlined in red. The Amazon River flows east from the Andes to the Atlantic Ocean. The Amazon River's largest tributaries are shown as well.

The Amazon Basin consists of a massive area of roughly 6.9 million km² characterized by areas of high local relief and significant seismic activity (Latrubesse, Stevaux, and Sinha 2005; Castello et al. 2013). The Amazon Basin has a unique geomorphology not replicated in size or extent anywhere in the world. A defining characteristic of the region is an abundance of water resources. Due largely to the Brazilian Amazon's geographic location, it contains a particularly significant amount of freshwater. Moisture and wind arrive from the Atlantic Ocean in the east, confronting the Andes, which impedes the continuation of the moisture westward (Hartley 2003). The consequences of this phenomenon result in a very wet climate. Virtually all of the Amazon Basin receives over 2000mm of precipitation per year, and much of it receives significantly more (Latrubesse, Stevaux, and Sinha 2005). In addition to substantial precipitation, the world's largest rivers cut through the Amazon. Of the world's thirty-four largest tropical rivers, eighteen of those rivers drain the Amazon Basin. Through intricate links to the terrestrial, atmospheric, and oceanic systems, the Amazon freshwater system directly and indirectly sustains countless biota and supports people's livelihoods (Castello et al. 2013).

History of Brazil's Protected Area Network

In 1876 one of Brazil's earliest conservationists, the civil engineer André Rebouças (1838–1898) proposed the creation of two national parks in two spectacular and isolated locations: one on the Araguaia River's Bananal Island and the other park around the Paraná River's Guaíra Falls (Schulman et al. 2007; Drummond, Franco, and Ninis 2009). However, the first national park was established by the Brazilian Forest Code of 1934 (Decree 23.793, 23 January 1934) in the mountains of the Atlantic Forest, followed by the first national forest in Ceará state in 1946 (Rylands and Brandon 2005).

Brazil's earliest national parks, from 1934 up until about 1970, were created primarily due to their aesthetic characteristics. The original protected areas adhered to the romanticized vision of a national park. They offered visitors unique geological formations, spectacular waterfalls, raging rivers, and mountain vistas. These parks were primarily located along Brazil's densely populated Atlantic coast (Drummond, Franco, and Ninis 2009).

By 1970, there were 14 national parks and 12 national forests in Brazil, however, there were no national parks within the Amazon. The construction of the Transamazon Highway in the early 1970s spurred a systematic conservation plan for the region called the Amazon Analysis (Wetterberg 1976; Schulman et al. 2007). The Amazon Analysis, led by biogeographer Gary Wetterberg, performed a comprehensive study of the location of many of the Amazon forest's flora and fauna. Their research was based upon the presently debunked, but at the time accepted, "refuge hypothesis". The refuge hypothesis suggested that during the Pleistocene era, the Amazonian rainforest was fragmented with patches of savanna due to periodic drying of the climate. The isolation of rainforests patches in turn creates forest repositories that impact the evolution of species, causing endemic flora and fauna to evolve (Schulman et al. 2007). The Amazon Analysis identified regions with unique species distribution patterns and rationalized that these areas were most worthy of protected status.

The work of Wetterberg and his team greatly influenced Brazil's policy makers. In the decade after the investigation, tens of thousands of square kilometers of national parks and biological reserves were created following the guidelines outlined in the Amazon Analysis (Rylands and Brandon 2005). In fact, by current estimates, roughly 30% of today's strictly protected areas were selected on the basis of the Amazon Analysis (Schulman et al. 2007).

The waning of the refuge hypothesis as a scientific theory led to a new approach for designating areas for conservation priority. In the 1990s at the behest of Brazil's Ministry of the Environment, a series of workshops took place in Brazil that were aimed at prioritizing new locations for protected areas. The attendees were scientists from around the world with a wide spectrum of specializations. They collaborated to find locations with endemic flora and fauna that overlapped with areas with unique geology, endangered species, and vulnerable soil types. Moreover, an impetus was placed on locations that were at risk of human development and land use pressures (Rylands and Brandon 2005; Mittermeier et al. 2005; Schulman et al. 2007). Workshops in 1999 and 2000 alone led to the creation of 57 new protected areas totaling roughly 5.5 million hectares, the most significant proportion of which arose out of the Amazon (Schulman et al. 2007; Rylands and Brandon 2005).

The international community has consistently played a significant role in encouraging, designing, and implementing Brazil's protected areas. In 2002, a partnership amongst the Brazilian federal government, the Brazilian Biodiversity Fund (FUNBIO), the German Development Bank (KfW), the Global Environment Facility, the World Bank, and the World Wildlife Fund created the Amazon Region Protected Area Program (ARPA). The goals of the program were to increase and protect a large quantity and quality of the Amazon's biological and ecological features (Schulman et al. 2007). Thanks to financial support from these organizations, hundreds of scientists collaborated on the project to identify regions of critical ecological importance. The international community's funding of the first five years of the program was at least partially responsible for the creation of dozens of new protected areas totaling tens of thousands of square kilometers (Soares-Filho et al. 2008). In addition to adding quantity of protected land, the program also aimed at improving the managerial efficiency of Brazil's protected areas network (Schulman et al. 2007).

Although federal protected areas were expanding rapidly in the 1970s and 1980s, up until 1989, there were no protected areas in the Amazon directly overseen by state governments (Mittermeier et al. 2005). However, since 1989, there has been a burgeoning of state managed protected areas. In fact, there are more protected areas under state control than under federal control. State protected areas are generally smaller than federal protected areas and are more commonly managed as a sustainable use area than a strictly protected area (Rylands and Brandon 2005; Peres 2011; Drummond, Franco, and Ninis 2009).

ORGANIZATION OF PROTECTED AREAS

The network of protected areas within Brazil has historically been fragmented and managed by varying and disjointed government agencies. Up until 1989 protected areas in Brazil fell under a haphazard method of classification, existing within the jurisdiction of two separate government agencies: the Brazilian Forestry Development Institute (IBDF) and the Special Secretariat for the Environment (SEMA). To streamline these agencies' often intersecting directives, the two merged in 1989 into the Brazilian Institute of the Environment and Natural Resources (IBAMA), along with the Secretary of Fishery Development (SUDEPE) and the Superintendence for Rubber (Sudhevea) (Banerjee, Macpherson, and Alavalapati 2009).

In 2007, the administrative structure of Brazil's federal conservation units was modified yet again. IBAMA was stripped of its protected area management responsibilities and tasked solely with environmental licensing, permitting, and enforcement. A newly created agency, Instituto Chico Mendes de Conservação da

Biodiversidade (ICMBio), was created to oversee direct management of the federal conservation units.

In an effort to further unify the network of protected areas, the National Protected Areas System (SNUC) was enacted in 2000 to standardize the naming and categorization of Brazil's network of protected areas and create three broad categories of protected area managed lands (Rylands and Brandon 2005). The first category is Integral Protection Units (IPUs) that aim to primarily conserve biodiversity and are not open to development. As the second category, Sustainable Use Units (SUUs) permit maintainable levels of land use and extraction with biodiversity as their secondary goal (Walker et al. 2009). Third, Indigenous reserves are recognized by the IUCN as areas under protection but are not assigned to a particular category (Nelson and Chomitz 2011). Although Indigenous reserves belong to the Brazilian federal government and are under the jurisdiction of the National Indian Foundation (Fundação Nacional do Índio, FUNAI), indigenous peoples are granted permanent occupation and usufruct privileges, excluding mineral and water rights (Schwartzman and Zimmerman 2005). Notably, Indigenous reserves have been shown to restrict large scale deforestation (Barber et al. 2012).

The SNUC decree also aligned the definitions of Brazil's protected areas with the universally accepted definitions outlined by the IUCN. Each of these categories applies to the federal, state, and municipal level. In particular, Brazil labels its strictly protected areas as: biological reserves (IUCN 1a), ecological stations (1b), national/state parks (II), natural monuments (III) and wildlife refuges (also III). The categories for protected areas of sustainable use include: areas of relevant ecological interest (IV), private natural heritage reserves (IV), environmental protection areas (V), extractive reserves (VI), fauna reserves (VI), national/state forests (VI), and sustainable development reserves (VI).

EFFECTIVENESS OF BRAZIL'S PROTECTED AREA NETWORK

Brazil's network of protected areas within the Amazon is of particular significance because of its size and effectiveness at curbing deforestation, which has historically plagued much of the Amazon. Optimistically, a 2012 study found that the less than 1.5% of the entire protected areas network within the Brazilian Amazon has been deforested, and most of that clearing occurred in sustainable use areas where some forest loss was to be expected (Barber et al. 2012). Likewise, a 2010 study (Soares-Filho et al. 2010) determined that the past decade's expansion of protected areas in the Brazilian Amazon significantly reduced the impact of deforestation. In particular, between 2004 and 2006, deforestation rates declined by 13,400km². The authors of the 2010 Soares study attributed 44% of the decline in deforestation to an agricultural slowdown and 37% of the decline to the expansion of protected areas. Essential to the integrity of their analysis was that the authors took into account the effect of leakage, the phenomenon of indirect deforestation. They concluded that protected areas do not provoke leakage. Instead, the authors hypothesized that protected areas may in fact reduce regional deforestation rates because they discourage illegal land-grabbing (Soares-Filho et al. 2010). By 2050, protected areas in the Brazilian Amazon are expected to prevent 670,000 km² of deforestation (Crawhall et al. 2012).

Similarly, protected areas have been shown to reduce the rate of fire, a proxy for deforestation. A 2007 study modeled the likelihood of fire in the Brazilian Amazon by analyzing fire's spatial connection with the market prices of beef and soy (Arima et al. 2007). The authors' results indicate that all protected areas, regardless of their categorical ranking or proximity to population centers, reduce the likelihood of fire because they inhibit deforestation and logging (Holdsworth and Uhl 1997), which are two activities usually associated with fire events.

Another significant benefit of the Amazon's protected areas is their preservation of biodiversity. The Amazon Basin contains nearly one third of the global terrestrial biodiversity (Heckenberger et al. 2007) with many of those species located within the borders of protected areas. Furthermore, there are at least 2,000 known aquatic species, and likely substantially more, in the Amazon's freshwater system (Castello et al. 2013). The largest of the Amazon's protected areas are particularly well suited for biodiversity preservation (Cantú-Salazar and Gaston 2010).

The Amazon's massive protected areas network also provides a critical climatic benefit. The protected areas effectively suppress deforestation, and thus prevent conversion of moist tropical forest into semiarid land throughout large parts of the Amazon Basin. A 2009 climatic model determined that due to the network's significant size and high moisture content, protected areas prevent the dry forests in the south and southeastern Amazon Basin from permanently converting to a semi-arid and fire prone environment, effectively preventing an irreparable climatic tipping point (Walker, Moore, et al. 2009). Similarly, another study determined that protected areas offer tremendous paybacks in the form of carbon sequestration. By reducing deforestation rates, protected areas act as a carbon sink, consequently reducing significant carbon emissions into the atmosphere (Soares-Filho et al. 2010).

PADDD IN BRAZIL

Brazil's admirable history of creating enormous tracts of protected areas is unfortunately marred by significant instances of PADDD. PADDD manifests itself as societal values, conservation ethics, and energy demands transform. Changes of heart regarding the importance of a particular protected area have historically been spurred by economic and land use pressures. For instance, in 1961, Brazil enlisted one of the world's most powerful waterfalls, Guaíra Falls, into protected status through the creation of Sete Quedas National Park (Drummond, Franco, and Ninis 2009). Since the mid nineteenth century, conservationists had called for the formal protection of the falls (Rylands and Brandon 2005). However, a mere 20 years later, the Brazilian military government degazetted Sete Quedas National Park to make way for the Itaipu Hydroelectric Power Plant. The once world famous falls were flooded by an artificial reservoir and dynamited to facilitate fluvial transportation (Pádua, 2004).

After the fall of the military dictatorship in 1985, the sanctity of Brazil's protected areas appeared secure (Mittermeier et al. 2005). Notably, since 2000, federal and state conservation units in the Amazon have increased 500% to encompass 25% of the Legal Amazon (Walker, Moore, et al. 2009). When factoring in indigenous territories, the area under protection increases to 50% of the Amazon (Scarano, Guimarães, and da Silva 2012). Figure 2.2 illustrates the extent of both protected areas and indigenous territories in the Amazon.

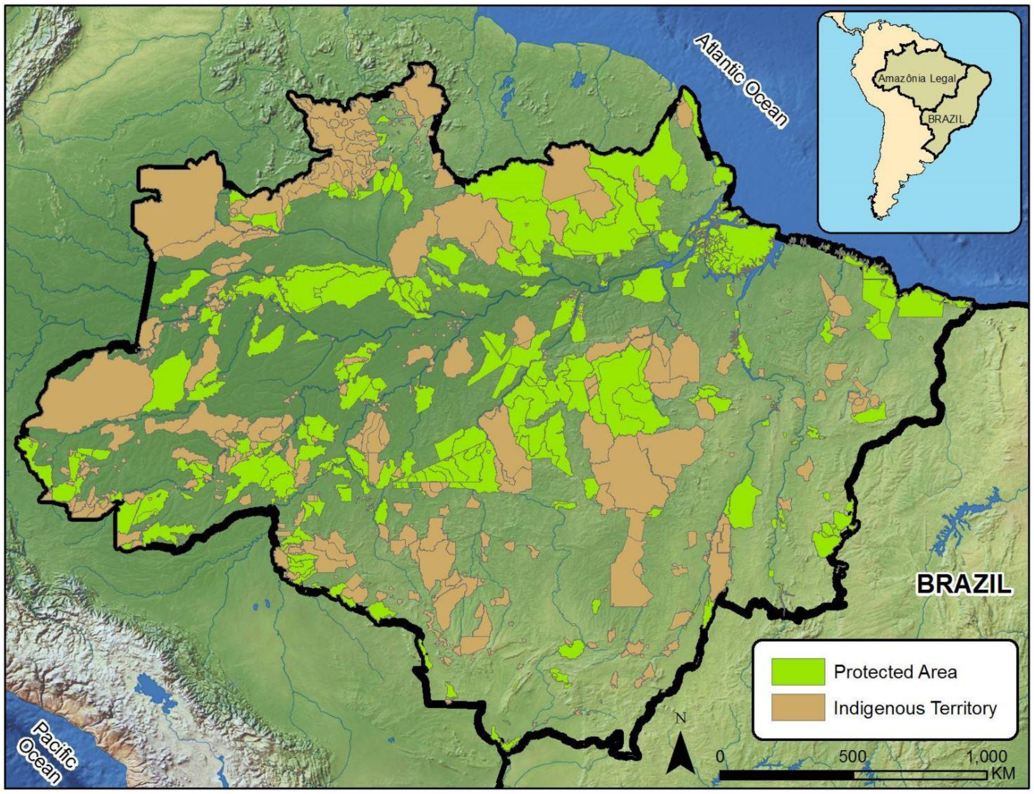

Figure 2.2. Conservation units and indigenous territories in the Legal Amazon. Combined these two forms of protected areas make up roughly 50% of the Brazilian Amazon. From IUCN and UNEP 2010.

However, in 2011 the federal government under President Rousseff, did not create any new protected areas, the first such instance in over fifteen years (Scarano, Guimarães, and da Silva 2012). Moreover, 16% of Brazil's protected areas have recently experienced unfavorable environmental restructuring (Payés, Pavão, and Santos 2013). Namely, the Brazilian government is undertaking actions that threaten to reduce the effectiveness of the entire protected areas network. The primary driver of these reductions is natural resource demand and exploitation. Given the possibility of an impending energy shortage, the Brazilian government has turned to hydroelectric power to feed its country's growing energy needs. Yet with much of the Legal Amazon designated as protected, there is limited space for massive hydroelectric projects.

Brazil's state and federal governments, as well as the state-operated energy monopolies are active participants in the reduction of Brazil's protected areas. The government's conflict of interest between managing protected areas and extracting natural resources has been exploited to the detriment of protected areas. In 2008 and 2009 alone, at least 37 proposals for PADDD were identified in the Amazon (Araújo and Barreto 2010). For instance, in May 2011 one of Brazil's original state parks, Nhamundá State Park in Amazonas state was downgraded from a state park to an environmental protection area (Área de Proteção Ambiental, APA), a less strict protection designation. The downgrade occurred in order to facilitate the construction of electrical transmission lines from Pará state to Manaus, the capital of Amazonas (Lei Estadual nº 3.602). In addition to permitting the construction of transmission lines, the downgrade of Nhamundá to an APA also opened up the former protected area to additional human settlements.

Likewise, Brazil's energy demands have motivated policy makers to embark on an ambitious plan to build hydroelectric dams in the Amazon that will impact protected areas. Since the creation of the Itaipu Hydroelectric Power Plant, the federal government has downsized multiple protected areas in order to build additional dams. The construction of dams and their associated reservoirs has the potential to flood and destroy thousands of hectares of protected lands (Fearnside 2006). The competing interests of energy conglomerates and protected areas are not unfounded. Since the 1970s, Brazil's national power authority, Eletrobras, along with northern Brazil's power monopoly, Eletronorte, have pushed for hydroelectrical power projects within the Amazon Basin (Fearnside, 1995). Figure 2.3 highlights the extensive number of dams that are proposed, many of which are aligned in or near protected areas. In fact, over the next twenty years, forty of the 151 planned Amazonian dams will be constructed immediately upstream or downstream of indigenous lands (Castello et al. 2013). For example, the potential construction of the Belo Monte Dam has garnered international attention due in part to its location near the Xingu Indigenous Reserve.

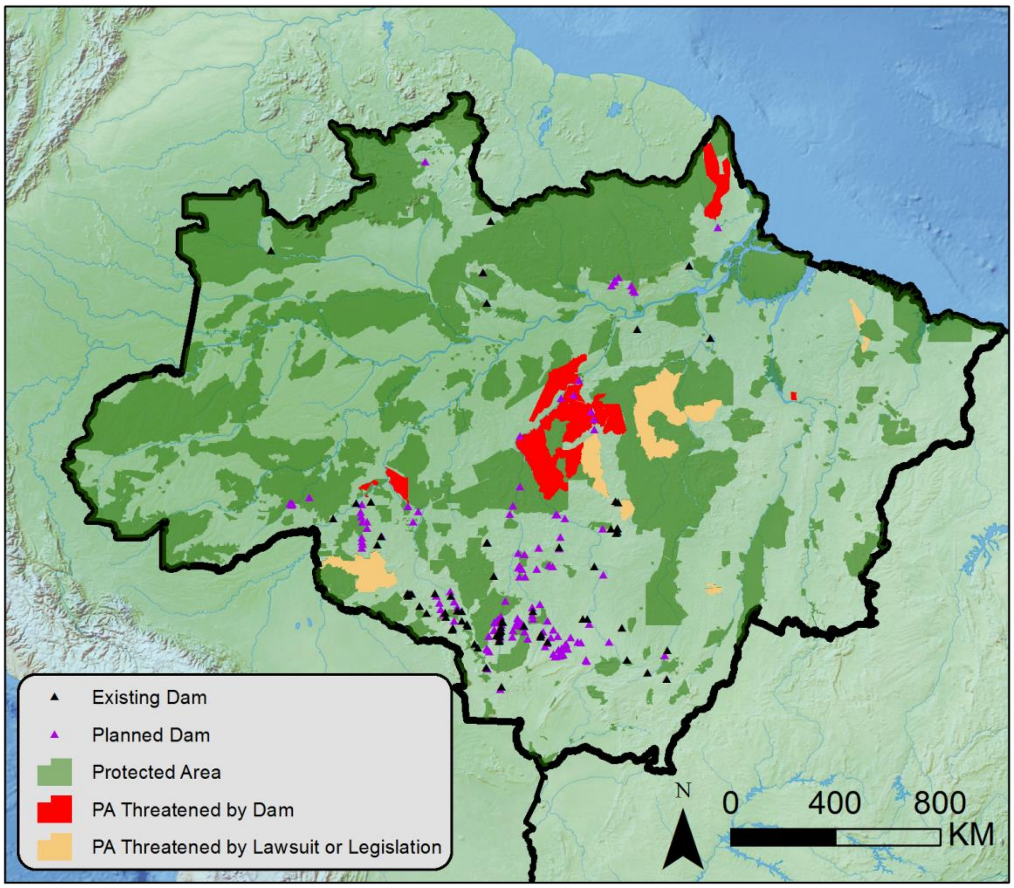

Figure 2.3. Protected Areas at risk of PADDD due to lawsuits, legislation, and planned hydroelectric projects. Adapted from Martins et al. 2012. Additional sources: ANEEL 2013, EPE 2013, ICMbio 2012, IUCN and UNEP 2010.

The impact of hydroelectric dams and reservoirs reverberates well beyond the local areas that they flood. For instance, the conversion of native forest cover into reservoirs has climatic repercussions. Flooding sections of forest has the adverse effect of emitting considerable methane, a substantial contributor to global warming, into the atmosphere. Methane gases are created when organic matter decays under anoxic conditions, such as when forest decays in sediments at the bottom of a reservoir. Similarly, any vegetation that grows on the banks of a reservoir during times of drawdown, will then decay under anoxic conditions when reservoir levels rise, releasing additional methane (Fearnside and Pueyo 2012). Although hydro-electric dams are promoted as environmentally healthy, large scale flooding of forest cover will have adverse effects on global warming. In fact, the cumulative emissions of all the proposed dams in the Brazilian Amazon exceed Brazil's projected emissions associated with the consumption of traditional fossil fuels for at least several decades (Fearnside, 2009). Furthermore, the construction of roads that carry equipment and laborers to the project site will also exacerbate the negative effect of the proposed dams. Research has shown that roads play a significant impact in causing deforestation (Pfaff et al., 2007; Arima, Richards, Walker, & Caldas, 2011).

Moreover, the impacts of dams is not limited to the flooding of terrestrial areas. The geomorphological and ecological consequences of dams can reverberate hundreds of kilometers downstream (Manyari 2007). For instance, dams retain up to 95% of the sediment for some rivers (Williams and Wolman 1984). When river water is stripped of its sediment load, the river's downstream volume and flow pattern are greatly modified, which can cause significant erosion downstream (Manyari 2007). Likewise, dams impede the natural flow of pulse floods. Pulse floods are critical in the creation and maintenance of sandbars and other alluvial features that are critical to a healthy hydrological system.

From an ecological perspective, dams have a negative impact on aquatic biodiversity. Most notably, dams hamper fish mobility, a phenomenon that has been widely documented (Agostinho et al. 2004). Dams have also been shown to affect water temperature and quality, key metrics for aquatic life (Lessard and Hayes 2003). In addition, the rationing of water discharge levels during the dry season can sever the links between the floodplain and a river's main channel. Without consistent water flows wetland lagoons and ponds are at risk of drying up, leaving the species that depend on these environments without a habitat (Manyari 2007).

Chapter 3 PADDD in Brazil: The Case of Amazon National Park

Chapter 3 analyzes the historical contexts that gave birth to Amazon National Park, including the motivation that subsequently led to the downsizing of the park is also provided in this chapter. This narrative is based on archival research and open-ended, semi structured interviews of key informants conducted during fieldwork in Brazil in July 2013.

HISTORICAL CONTEXT OF THE PARK'S CREATION

When the Spanish explorer Francisco de Orellana arrived at the confluence of the Amazon River and the Tapajós River in 1554 he described the region as "densely populated" with the Tapajós Indians who had built a great city at the present site of Santarém (Figure 3.1) (Borchard 2010). Centuries after de Orellana's expedition, the Brazilian government attempted to re-populate this region through an ambitious development project.

In the 1970s, geopolitical and sovereignty concerns motivated Brazil's military regime to integrate the Amazon and its vast trove of natural resources into the mainstay Brazilian economy. Although rubber tappers had been in the Amazon cultivating latex from the rubber tree (*Hevea brasiliensis*) since the late nineteenth century, this industry was small and continuously declining (Salisbury and Schmink 2007). To develop the Amazon, the government embarked on a vast set of projects. Dubbed "Operation Amazonia," these initial efforts concentrated on road building and colonization projects as a means to support industrial, mining, and agricultural endeavors in the region.

One of the most prominent undertakings was the creation of the National Integration Program (PIN) and the formation of the Institute of Colonization and Agrarian Reform (INCRA). PIN was initiated in 1970 as a wide-ranging federal strategy to achieve modernization in Brazil through the colonization of the Amazon. Since its inception, INCRA's ongoing mission has been to entice settlement of the Amazon by implementing agrarian reforms and encouraging agricultural development. The strategies outlined in PIN fell under the auspices of INCRA.

To accomplish this aim, the federal government empowered INCRA with significant resources and authority. Notably, INCRA held enormous control over the administration of vast swaths of land, and INCRA's earliest programs were particularly generous in appropriating land. For instance, a 1971 law granted INCRA jurisdiction over all land in the Amazon that was within 100-km of a highway or within 150-km of an international border (Banerjee, Macpherson, and Alavalapati 2009). INCRA had the authority to grant settlers land titles land for an area up to three times the size of land that they cleared, up to 270-ha. In addition to providing land, INCRA also promised settlers goods such as fertilizers and building materials.

Furthermore, INCRA was charged with administering colonization schemes such as the *Projetos de Integração e Colonizacao* (PICs). A PIC is a large, organized settlement designed to accommodate throngs of landless individuals and small farmers (Walker, Defries, et al. 2009). In 1971, INCRA expropriated a large tract of land in the state of Pará, between the Xingu and Tapajós rivers. Referred to as the Altamira Polygon, INCRA's aim for the 64,000-km^2 plot of land was to encourage occupation and industrial development by offering settlers the ability to obtain land titles.

Meanwhile, through PIN, the federal government was also financing the construction of a massive highway network that would connect Brazil's peripheral states to the core of the country. The aim of these projects was to work in tandem with ICNRA's settlement programs and to spur development major highways. Two of the more prominent projects were the creation of north-south and east-west highway corridors called, respectively, the Transamazon (BR-230) and the Cuiabá-Santarém (BR-163) highways. The preliminary construction of these highways, which linked the Altamira Polygon with northeastern and southern Brazil, opened the Itaituba region up to an influx of migrant workers (Arima et al. 2013).

Concern over the escalating development and population growth in the Amazon prompted the international community and the *Grupo de Operações da Amazônia* (GOA), an advisory council to the military president, to propose that INCRA deem a portion of the Altamira Polygon to be a national park (Torres and Figueiredo 2005; Oren and Parker 1997). In 1974, 10,000-km², or roughly 16% of the Altamira Polygon along the west bank of the Tapajós River, was established as Parque Nacional da Amazônia (PNA). Figure 3.1 illustrates the relation between PNA and the Altamira Polygon. Jurisdiction for the fledgling park fell under the responsibility of the Brazilian Forest Development Institute (IBDF) (Mittermeier et al. 2005).

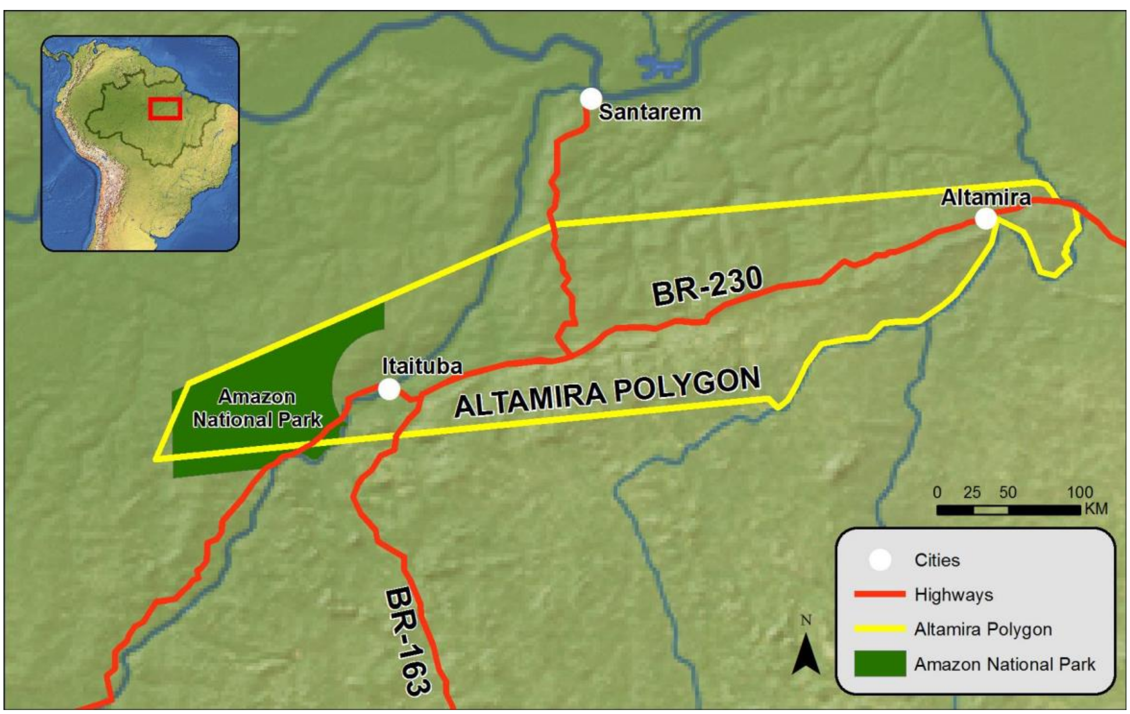

Figure 3.1. The spatial configuration of the Altamira Polygon in relation to Amazon National Park and the major towns and cities in the region. Adapted from Arima et al. 2013.

Soon after the creation of PNA, the federal government modified its Amazon development focus. The oil crisis of the late 1970s reduced demand for highway construction. In addition, expanding government debt forced the reduction of many federal projects (Sawyer 1990). As a result, the government shifted its economic emphasis to export driven goods, such as livestock, mining, and timber. (Banerjee, Macpherson, and Alavalapati 2009; Simmons et al. 2010). As such, INCRA effectively abandoned the PIC settlement model. Furthermore, the government's policy reversal reduced instances of new highway construction and diminished the impetus on small-scale colonization projects.

Nevertheless, the legacy of the partially completed highway network played a monumental role in the development of the Itaituba region and PNA. Although BR-163 was poorly maintained and often not passable, it sufficed as an adequate foundation for the movement of people and goods for the region's subsequent phase of growth. (Arima et al. 2013). A new era of economic and population growth arose in the 1980s after gold was discovered in the Tapajós basin. Itaituba became a booming Mecca for migrants who flocked to the region in search of economic wealth. Although significant growth occurred during the 1970s' colonization projects, the region underwent exponential population growth in the 1980s. By the end of that decade, 120,000 additional people had flocked to the region, a significant increase from the 12,000 who had lived there prior to 1970.

Gold mining dominated the 1980s Itaituba economy, however, ranching and logging activities concurrently intensified in the periphery. Many gold mine owners invested their handsome profits into enormous cattle ranches (Bezerra, Veríssimo, and

Uhl 1996). Likewise, timber extraction, often illegal, created non-sanctioned secondary roads west of Itaituba and into PNA (Arima et al. 2013). For small entrepreneurs, the gold rush was relatively short lived. By the late 1980s, most opportunities had dried up. As the mining operations within Itaituba diminished, many former miners migrated away from the city center in search of land and economic opportunities elsewhere. Some individuals took advantage of the clearcuts and roads that were forged by the loggers to take up residence west of the city (João, São Manoel 15 July 2013, interview[1]).

Within this context of a burgeoning population and a declining regional economy, the factors are put in place that set the stage for an attack on PNA.

ORIGINS AND PHYSICAL DESCRIPTION OF PNA

If the original IBDF managers of Amazon National Park had their way, the park's name would have been a short lived moniker. Because the Amazon basin is such a large region that encompasses multiple national boundaries, the managers argued that "Amazon" National Park was not an appropriate description to represent the diversity of the Amazon basin's geologic, biologic, and ecologic attributes. Instead, they suggested that the park be renamed Tapajós National Park as a tribute to the Tapajós River, one of the largest rivers in South America. Moreover, they argued, as Brazil expanded the number of national parks within the Amazon, there would not be a singular Amazon park unit but rather a network of Amazon parks (IBDF 1979).

Ultimately, the federal decision makers who decreed PNA decided against changing the park's name. Alas, the name of the park was not the only misguided approach in creating PNA. Local park managers also initially suggested that the park's boundaries be based on the natural flow of rivers and creeks. However, per the 1974

[1] To protect the identity of those interviewed, pseudonyms have been used.

decree that established PNA, the borders of its eastern, northern, and southern boundaries paid no heed to natural, ecological, or topographical constraints. Rather, political and economic pressures guided the demarcation with geometric precision. Straight lines cut through forests, curved lines crossed over creaks, and sharp angles sliced across hillsides. The political, social, and ecological ramifications of these artificial boundaries reverberated throughout the region for decades to come. Notably, the park's original eastern boundary was demarcated by a semi-circle originating in Itaituba with a radius extending 40-km. The western and southern park boundaries were outlined through a mixture of azimuths and angles relative to latitude and longitude coordinates. The park's original southeastern boundary which hugged the Tapajós River, was the only boundary that adhered to a physical characteristic (IBDF 1979; Brazil 1974). Over 95% of the park's area was located in Para state, with the remaining proportion located in Amazonas state.

PNA is within one of the world's most important biogeographic regions, the uplands between the Madeira and the Tapajós rivers. The park is situated atop a highly eroded dissected plateau, which has been cut by rivers and broken by deep, narrow valleys. The relief is considered slightly undulating with altitudes ranging between 20-m and 200-m. The climate remains hot and humid year-round with a mean annual high temperature of 26.7°-C. Precipitation levels range between 1700 and 2500-mm per year. The park experiences two distinct seasons: January to April being the wettest months and September through November being the warmest months (Millikan 2011; IBDF 1979).

The vast majority of PNA is enveloped by tropical rainforest. Subset forests include alluvial forest, lowland forests, open tropical forests, cocoa fields, and cipoal forests. Among the most common flora species are rubber trees (*Hevea brasiliensis*), cedar (*Cedrela fissilis*), rosewood (*Dalbergia spruceana*) and several species of Ipe

(*Tabebuia*). Twelve known species of primates occupy the park along with numerous other mammals such as jaguars and anteaters. Within the park proper there are 387 know avian species, and hundreds more can be found in the immediate vicinity. Many of these bird species are endemic to PNA. It is widely accepted by biologists that there are countless species of flora and fauna inside the park's boundaries that have yet to be discovered and inventoried (Torres and Figueiredo 2005; Branch 1983; Oren and Parker 1997).

The Tapajós River flanks the park's southeastern edge. Ephemeral sand bars, clear water, numerous rapids and many rocky outcrops characterize this border. Other significant water bodies include the Tracoá and Arixi creeks, which flow near the eastern park boundaries. The, Mariaquã, Mamuru, and Farturão, are other significant creeks that are born or cross the park.

The areal extent of PNA has fluctuated by approximately 10,000-ha from its initial 1,000,000-ha founding size (Torres and Figueiredo 2005). That said, due to demarcation issues, the size of the park is in actuality not a fixed size because the theoretical boundary and the actual boundary are often not congruent.

DEVELOPMENT AND DEMARCATION ISSUES

Since its inception, PNA has been caught in the crossfire of competing ideological groups. Governmental infighting, economic interests, colonization, and inadequate government enforcement have marred its history as a beacon for protected areas in the Amazon. Together, these factors contributed to PNA experiencing two PADDD events.

The first instance of PADDD in PNA is a clear example of economic interests trumping conservation values. In 1985, after PNA had been in existence for only eleven years, Brazil's last military president Joao Figueiredo signed legislation that downsized the park's area by approximately 6,000-ha (90,823 Decree 1985). The downsized section, midway along the "Park Arch", was an area rich in limestone deposits and thus valuable to miners (Figure 3.2). Soon thereafter, the Joao Santos Company received permission to perform mineral extraction in the downsized area. The company then proceeded to build a cement factory on the former park land. This area hereafter became known as the Tooth of CAIMA (*Dente da Companhia Agroindustrial de Monte Alegre*). The environmental impact of the mineral exploitation and the construction of the cement factory were incongruous with the conservation ethics that motivated the founding of PNA. In addition, the cement factory required a regular supply of workers, which induced population growth in the area. Due to the creation of the plant, Novo Arixi—a new community comprised of the plant's workers—was formed.

Figure 3.2. In 1985 PNA underwent its first downsizing event after a mining company successfully lobbied to obtain the limestone rich land. Due to its jagged shape, the cutout is often referred to as the Tooth of CAIMA, named after the mining company.

Unlike the relatively straightforward downsizing in 1985, PNA's second PADDD event in 2012 arose out of a set of complex factors involving the *colonization* of the surrounding region and exploitation of the Tapajos River for *hydroelectric power*. As with the Tooth of CAIMA event, this PADDD event was triggered primarily because economic interests trumped environmental considerations. In this instance a dam project motivated the federal government to downsize the park. However, unlike the Tooth of CAIMA, the 2012 event was comprised of a two-part downsizing effort that impacted separate sections of the park. In this circumstance, the park was reduced both along the water's edge, where a dam would be built, and also up in the highlands of the park where various settlement projects were located. Unlike the Tooth of CAIMA, the factors leading up to this PADDD event festered for decades before officially being recognized. The factors leading up to the 2012 downsizing of PNA can be traced back to the 1980s and 1990s when it became apparent that two of Brazils' governing agencies could not properly oversee the simultaneous implementation of settlement projects near a strictly protected national park.

Itaituba's population growth in the 1980s rapidly led to a dearth of accessible land. Although land was plentiful in the hinterlands of Itaituba, reliable accessibility proved challenging due to the rough terrain and forested land cover. Without a reliable governmental program to finance road construction, access to the land was instead reliant on grassroots construction. As a result, the spatial configuration of many of the settlements northwest of Itaituba can be traced back to a patchwork of road construction practices. Arima, et al. (2013) demonstrated that a decentralized medley of individual agents created the secondary road-network. To circumvent the lack of official roads, individual agents performed their own road construction. With BR-230 as the primary axis, agents constructed roads west out of Itaituba, often towards the direction of the park. Many of these roads began as mere footpaths but they evolved and improved as settlers, loggers, and ranchers took advantage of the accessible paths. The expanding road network consequently facilitated the movement of new settlers to the region.

During this time, the federal government's interest and funding for INCRA's small colonization programs in the Itaituba region shrank considerably (Arima et al. 2013). The surge of spontaneous settlers and ex-miners overwhelmed INCRA's existing capacity to properly function. With a burgeoning demand of settlers vying for its increasingly limited services, INCRA was unable to deliver on many of the promises that it had initially promoted. For instance, increased demand curtailed INCRA's ability to provide settlers with agricultural goods and services such seeds and fertilizers, as well community infrastructure projects such as education and healthcare (Ianni 1979; Fearnside 1986; José, Novo Horizonte 16 July 2013, interview).

Most notably, however, the colonization agency transitioned from playing an active role in land colonization schemes to a more passive role. This new model of colonization modified the way in which settlers obtained a land title. Rather than initiating the locations for new settlements through colonization projects, INCRA instead placed the burden of colonization on settlers. According to Brazilian law, a settler can obtain a formal land title after occupying an unclaimed and non-disputed plot of land (*terra devoluta*) for five years (Simmons et al. 2010). Land within a protected area is exempt from this scenario. Although this law had been active for well over a century, a 1998 presidential declaration by Fernando Henrique Cardoso emphasized and enlarged its focus.

One of the outcomes of Cardoso's "New Rural World" (*Novo Mundo Rural*) policy led to the creation of formal communities consisting of small farmers, called Settlement Projects (*Projetos de Assentamento* – PA). In this new model, the government relied on settlers to preemptively occupy land, cultivate the land, and organize themselves into settlements. After meeting these conditions, INCRA would then regularize the land by providing land titles. In addition, INCRA would establish a PA, which granted its members additional rights and services (Simmons et al. 2010). In the New Rural World policy, INCRA sanctioned land settlement rather than actively direct the settlements. This shift in policy had dramatic repercussions as settlers began to occupy land within the protected boundaries of PNA.

Consequently, as active INCRA colonization projects became increasingly rare, many colonists sought out land in locations wherever feasible. Settlers embarked on these land hunts with the interpretation that by cultivating land, the government would eventually grant them a homestead. Because much of the land immediately surrounding Itaituba was already occupied by ranchers, many of the colonists settled near and within PNA (Beiroz and Bicalho 2012). Without INCRA providing the initial formal land surveys, the colonists often did not realize they had settled within the park.

In the late 1990s, INCRA established a number of new settlements that were superimposed on PNA. For instance, in 1998, INCRA acknowledged the presence of a community located in the "Park Arch" by creating a new PA. Known as Miritituba, this PA partially overlapped with PNA. Upon becoming a PA, Miritituba attracted additional settlers to the region. With INCRA's approval, a significant number of settlers in search of land migrated to Miritituba and consequently settled within the park (IBAMA 2008).

Individual settlers were also cajoled to colonize in PNA by influential agents. In the late 1990s, the former mayor of Itaitiba, Wirland Freire, established a road leading into PNA. In December of 2000, the owner of a television station and timber company (and later the mayor of Itaituba), Walmir Climaco, used that road to access native forest, log the region, and establish a large estate within PNA. Climaco's clearing in PNA was seen as a form of legitimized colonization in the eyes of the public. Many settlers followed his lead and established settlements inside the park. (Astor, 2006; Maria, São Manoel 15 July 2013, interview; Fernando, Itaituba 16 July 2013, interview).

As more settlers flowed into the region they began to form communities and PAs. A dozen communities arose within and along the fringes of PNA: Cocalino, Nova Conquista, Novo Arixi, Nova Califórnia, Nova União, Novo Horizonte, Universo, Monte Verde, Pantanal de Areia, Nova Califórnia, Nova Integração, Nova Fronteira and São

Manuel. Figure 3.3 provides an illustration of the layout of Novo Horizonte, one of the oldest of the communities. Each of the communities was immediately adjacent and/or within the park. The outline of these communities is only a rough depiction of the actual extent of settlers on the park. Many roads and individual lots are located further within the park.

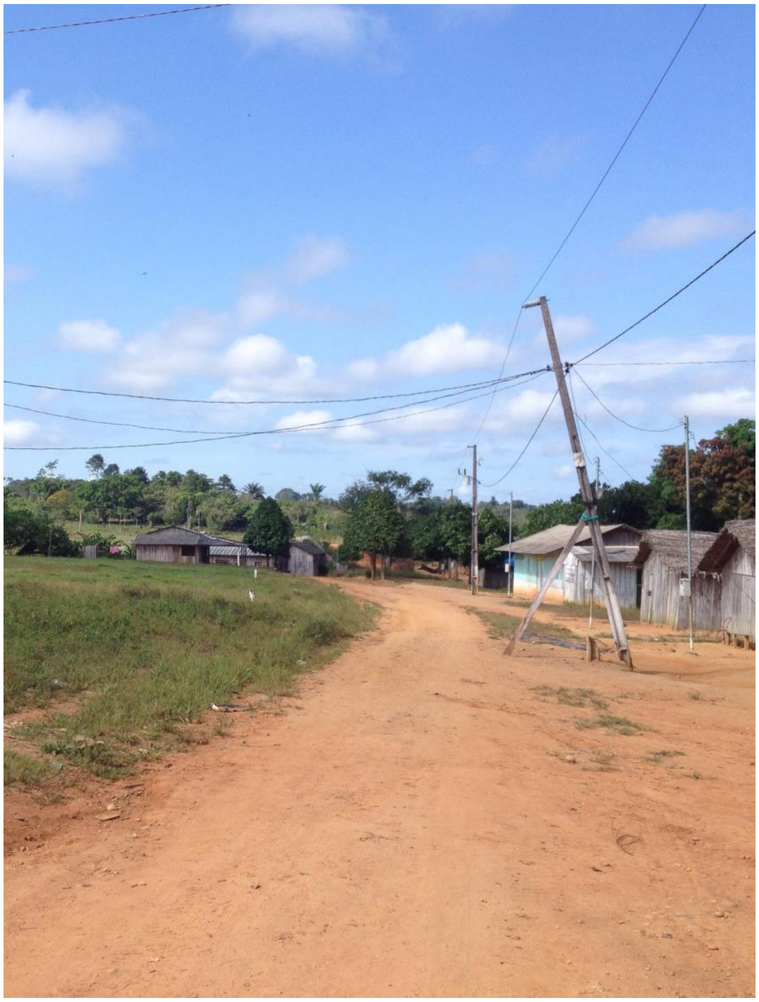

Figure 3.3. The community of Novo Horizonte. Credit J. Laue.

Disregarding Novo Arixi, which was created on account of the Tooth of CAIMA, the members of these PAs exhibited a similar sustenance livelihood focus. The farms of these communities were generally small with a focus on family sustenance through the cultivation of small fields. Each farm typically had few, if any, cattle. Additionally, some farmers produced cassava, rice and/or beans that they sold in Itaituba (Beiroz and Bicalho 2012). The home of a typical subsistence farmer is shown in Figure 3.4.

Figure 3.4. A typical home of a subsistence farmer. Credit J. Laue.

PNA Enforcement and Governmental Infighting

Settlers to the region were not able to easily distinguish between land that was inside or outside of PNA. Without a proper demarcation of PNA, many colonists did not know that they were settling inside the park. Similarly, without INCRA providing a formal land survey of the settlers' plots, the settlers were not formally notified that they were in the park (João, Novo Horizonte 16 July 2013, interview). Figure 3.5 illustrates the uncertainty of a community member pointing to PNA's original border, which crossed the middle of a lot claimed by a settler. According to him, at one time there was a benchmark at this site.

Figure 3.5. Local resident indicating where he believes the border of PNA is located.
Credit J. Laue

Even though the settlers often realized that a park existed, they did not have the knowledge of its exact boundaries (Torres and Figueiredo, 2005; Maria, São Manoel 15 July 2013, interview; João, São Manoel 15 July 2013, interview). In the absence of properly demarcated park boundaries, many incoming settlers mistakenly believed that nearby streams, such as the Arixi, were the park's official boundary line. In the forest, the

40-km arch that extended out from Itaituba was near impossible to distinguish without complex surveying tools.

Likewise, with such conjectural borders, enforcement of the strict conservation principles of PNA was handicapped from the beginning. Physical boundaries provide noticeable breaks in the landscape that facilitate air and ground patrols. With artificial boundaries, IBAMA's ability to perform air and ground patrols was severely limited.

That said, although IBAMA was tasked with environmental enforcement, it embraced its responsibility hesitatingly. For most of its history, IBAMA at the national level was slow to enforce environmental regulations, unlikely to collect any fines that it may have levied, and unlikely to pursue legal action against violators Between 2000 and 2008, IBAMA let an estimated R$ 11.8 billion worth of environmental fines go uncollected (Barreto et al. 2009). For legal cases, the results were just as ineffectual. Many infractions were dismissed due to the expiration of the statute of limitations because IBAMA failed to follow through with the administrative proceedings (Barreto et al. 2009).

With regard to PNA, instead of enforcing the park's boundaries, the agency was often complacent to illegal activities occurring within the park. For instance, Freire's road into the park went overlooked for years. The government claimed to have attempted a proper demarcation of the boundaries in 1994 and 1995 by hiring a private consulting company to survey and place boundary markers. After a few months of work, however, IBAMA announced that the company was forced to abandon their work due to a hostile work environment. Members of the community were interrupting the surveyors' work by destroying equipment and intimidating the workers. According to IBAMA, the primary antagonists were loggers and ranchers who had a vested interest in maintaining the status quo. The loggers and ranchers cajoled community residents to rise against the surveyors, claiming that the surveyors intended to force the settlers from the land (IBAMA 2008).

However, in the early 2000s, the agency began to act on its environmental enforcement responsibilities, especially for egregious behaviors. For instance, many large-scale ranchers with tracts inside PNA had their equipment and plots confiscated (João, Novo Horizonte 16 July 2013, interview).

For their efforts to suppress illegal settlement and logging, IBAMA earned media praise and support. In August of 2004, Brazil's large daily newspaper *Folha de São Paulo* published an article on IBAMA's actions against illegal deforestation activities undertaken by Itaituba's mayoral candidate Walmir Climaco. The aspiring politician had cleared an area of 746 hectares inside PNA. In a bold statement, IBAMA burned Climaco's facilities and fined him R$1,200,000, roughly US$516,000 at the time. Yet, enforcement was still spotty as Climaco's fines went unpaid. Nevertheless, IBAMA's actions had the intended effect as the clearing was recolonized by native vegetation (*Folha de S.Paulo* 2004; Maria, São Manoel 15 July 2013, interview).

Likewise, IBAMA imposed its enforcement mechanisms when Novo Horizonte residents extended electrical lines that were laid by government but ended short of their community. To the angst of the community's members, IBAMA tore down the lines. Hostilities reached a fervor pitch when the settlers kept two of IBAMA agents hostage and did not release them until they agreed to re-install the power lines (João, Novo Horizonte 16 July 2013, interview).

Family farmers were not immune from the enforcement mechanisms either. Although small cultivators were generally not evicted from their land, they did experience repercussions. For instance, IBAMA told members in Novo Horizonte that they were limited to five head of cattle, otherwise they would be labeled as a rancher instead of a family farmer. Of greater consequence, by 2008 settlers were beginning to experience land tenure complications. Although INCRA had promoted the idea that land cultivation would lead to land tenure, the agency was not delivering on its promise to those settlers who had cultivated land inside PNA. For many of these settlers who were seeking land tenure, they were given an intermediate title through INCRA but IBAMA denied their ability to receive a full title. This disparity left settlers in a disagreeable situation. Not only were they not provided with a land title, but they were also ineligible for many government programs and credit (José, Novo Horizonte 16 July 2013, interview).

IBAMA's steps towards environmental enforcement of PNA did not sit well with INCRA. A clash of ideological perspectives further developed between the agencies. In one such case, INCRA engaged in a controversial and blatant disregard for PNA's borders. In October and November of 2006, INCRA's Santarém office made the decision to develop five new Sustainable Development Projects (*Projetos de Desenvolvimento Sustentáve*-PDS) which were immediately adjacent and/or overlapped with the boundaries of PNA (Beiroz and Bicalho 2012). A PDS was an evolution of the original PA settlement idea, and was created to recognize that some Brazilians base their livelihoods on extracting natural resources from the forest (INCRA decree n.477/99). The principle difference between these two INCRA projects is that a person living in a PDS does not directly gain a land title, unlike a PA. Instead, the land title is held by the community. This lack of a title compromises a person's ability to sell their plot of land in the future. Although a PDS is a relatively sustainable method of colonization, it is inherently a settlement plan, which by definition is incongruous with PNA's strict protection mandate. Figure 3.6 highlights the extent of INCRA's five proposed projects.

The implementation of these PDS motivated additional people, with INCRA's blessing, to migrate into the region near and within PNA.

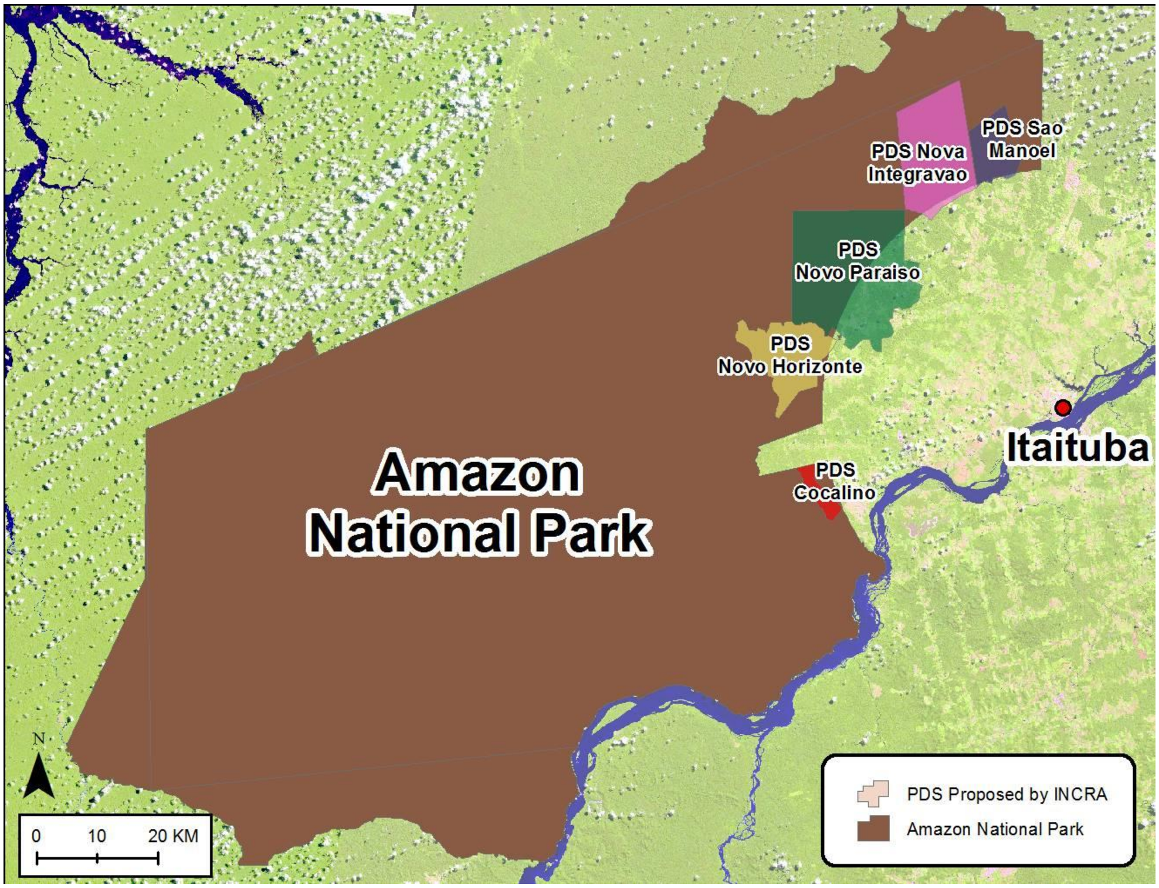

Figure 3.6. In 2005 INCRA proposed and partially carried out the development of five PDS along and within PNA. From IBAMA 2008.

The resulting PDS eventually caused institutional humiliation for both IBAMA and INCRA. Foremost, the incident demonstrated a lack of communication between the two agencies. INCRA, however, did not appear to inform IBAMA about its intentions to implement the five PDS. Also, IBAMA did not recognize when significant activity was occurring within its jurisdiction. Moreover, the event illustrated INCRA's lack of respect for IBAMA's authority. By this point in time, PNA had been a national park for over 30 years. INCRA and IBAMA had collaborated on prior projects that dealt with issues near and within the park. Yet, as this incident clearly showed, INCRA refused to acknowledge both the sanctity of the park and IBAMA's authority in the environmental domain. Key informants in Itaituba vehemently claimed that INCRA did not make a mistake in superimposing its projects on PNA. Rather, the agency was well aware that many of their projects intruded into the park's territory (Jonas, Itaituba 16 July 2013, interview). This chasm of institutional respect illustrated the period's lack of compatibility between INCRA mission to provide people with land and IBAMA's mission to protect PNA from human encroachment.

The event was not isolated to disputes between the two agencies. INCRA's initiation of the projects led the federal prosecutor in Altamira to investigate misconduct within INCRA. In his legal brief, the federal prosecutor referred to INCRA as reckless and "wasting public money" for not verifying the location of PNA's boundaries before implementing the PDS (MPF 2007). INCRA's actions were representative of inter-agency infighting and ineptness that further impeded the proper and timely demarcation of PNA. The outcome of the investigation saw INCRA backtracking on its promotion of the new PDS. However, the agency's promotion, albeit short-lived, still generated a stream of colonists who settled within the park (Fieldwork documents, São Manoel 15 July, 2013).

HINTS OF PADDD

Even though IBAMA was slowly flexing its enforcement muscle, the agency largely ignored the most pressing environmental concern—a lack of proper demarcation leading to settlement within PNA. Historically, small farmers have been vocal about the need to effectively demarcate the park boundary. Members of the communities in and around PNA live in constant apprehension about their legal status. As detailed in key informant interviews, residents would rather be explicitly and officially informed of their status instead of living in a constant state of legal limbo (Maria, São Manoel 15 July 2013, interview). Due to the lack of demarcation, in 2000, a group of residents held a public demonstration calling for IBAMA to provide additional clarification on the boundary disputes (IBAMA, 2008).

In March of 2004, government agencies hosted a trio of public meetings in Itaituba in order to discuss the challenges of the demarcation with PNA. These meetings, hosted by IBAMA, brought together representatives from governing agencies INCRA, IBAMA, the Rural Workers Union (*Sindicato dos Trabalhadores Rurais* - STR), and residents of the various communities. They came to an agreement that the boundaries should be better demarcated and they signed a pact acknowledging the need to committing to solving the challenge. The pact was published in the Brazilian gazette (Brazil 2004). In the pact, the stakeholders had various responsibilities. IBAMA was charged with demarcating the boundaries all while agreeing to work with residents to avoid relocations. INCRA was tasked with finding alternative sites and harmonizing its project sites with the park's boundaries. In addition, INCRA agreed to determine which of its settlement projects overlapped with PNA's boundaries. Should any conflict occur, INCRA would harmonize the sites with PNA's borders. The residents of the communities also committed to alleviate the problem by agreeing to monitor for new migrants and to discourage anyone from settling.

Yet, nothing concrete resulted from the pact. Owing to "technological difficulties" from the 1985 PADDD decree, the 2004 pact's attempt to facilitate communication amongst agencies failed. Moreover, the promise of demarcation was subsequently disregarded and forgotten (IBAMA 2008). This inability for governing agencies to communicate, cooperate and accomplish their duties was characteristic for this time period.

In February of 2006, the northern boundaries of the park were expanded by 167,379-ha (Figure 3.7). The motivation for this amplification was part of a region-wide effort to mitigate the impacts of an upcoming plan to pave BR-163, As part of *Plano BR-163 Sustentável*, the Ministry of the Environment (MMA) lobbied for a presidential decree to strengthen and expand protected areas within the BR-163 corridor. Funds from the European Commission and the UN FAO contributed to the expansion of a number of parks and forests in the area, including PNA (MMA 2006).

Figure 3.7. In 2006 PNA was expanded by 167,379-ha. The park's new northwest boundaries followed the watershed divides of the landscape. From ICMBio 2012.

Remarkably, the decree called for the expanded boundaries to be demarcated along physical features, namely rivers and creeks (4,340 Decree 2006). The decree called for the boundaries to incorporate the Mamuru River for long segments as well as many unnamed creeks. However, no movement was made to address the lack of demarcation on the controversial eastern boundary of PNA.

In 2007 a coalition of representatives collaborated on a study to evaluate the problematic eastern boundary of PNA. The coalition consisted of employees from ICMBio, IBAMA, INCRA along with farmer groups and residents from the communities in and around PNA. By this time IBAMA and ICMBio had split into two separate agencies. Although IBAMA took the reigns as lead agency on the study's authorship, it collaborated significantly with INCRA and ICMBio and it relied on contributions from local organizations, and community residents.

The goal of the study was to analyze the feasibility and possibility of a redefinition of the eastern boundary of the park. To accomplish this aim, the authors performed a socioeconomic survey of households in the communities surrounding and within PNA. The rationale was that by cataloging the profile of local residents, the government could better understand the characteristics of people living in the park. By understanding these demographics, they could draw conclusions about the feasibility of relocating farmers. Or, additionally, the study would provide information on the spatial extent that would be necessary to readjust the eastern limits of PNA such that social and agrarian conflict would be minimized.

IBAMA published the report in May of 2008. The report provided maps of the communities and a systematic appraisal of the demographics of the communities and the households within and near the park. Of greatest significance, the report offered recommendations on how to resolve the social conflicts in and around the park. For the first time, IBAMA publicly propose that social conflicts could be reduced if PNA was downsized along its eastern border. The report called for the boundaries to be redefined such that they aligned with the physical attributes of the terrain, namely along streams. Although this new method for delineation would add a small section of land to PNA, it overwhelmingly resulted in a reduction of the park. The report recommended that the elimination of the "Park Arch" in favor of a new demarcation that would follow a natural boundary. Namely, it would follow a length of the Arixi River, following the river's natural course until it reached the Tapajós River. The map in Figure 3.8 is a copy of the report's proposed changes.

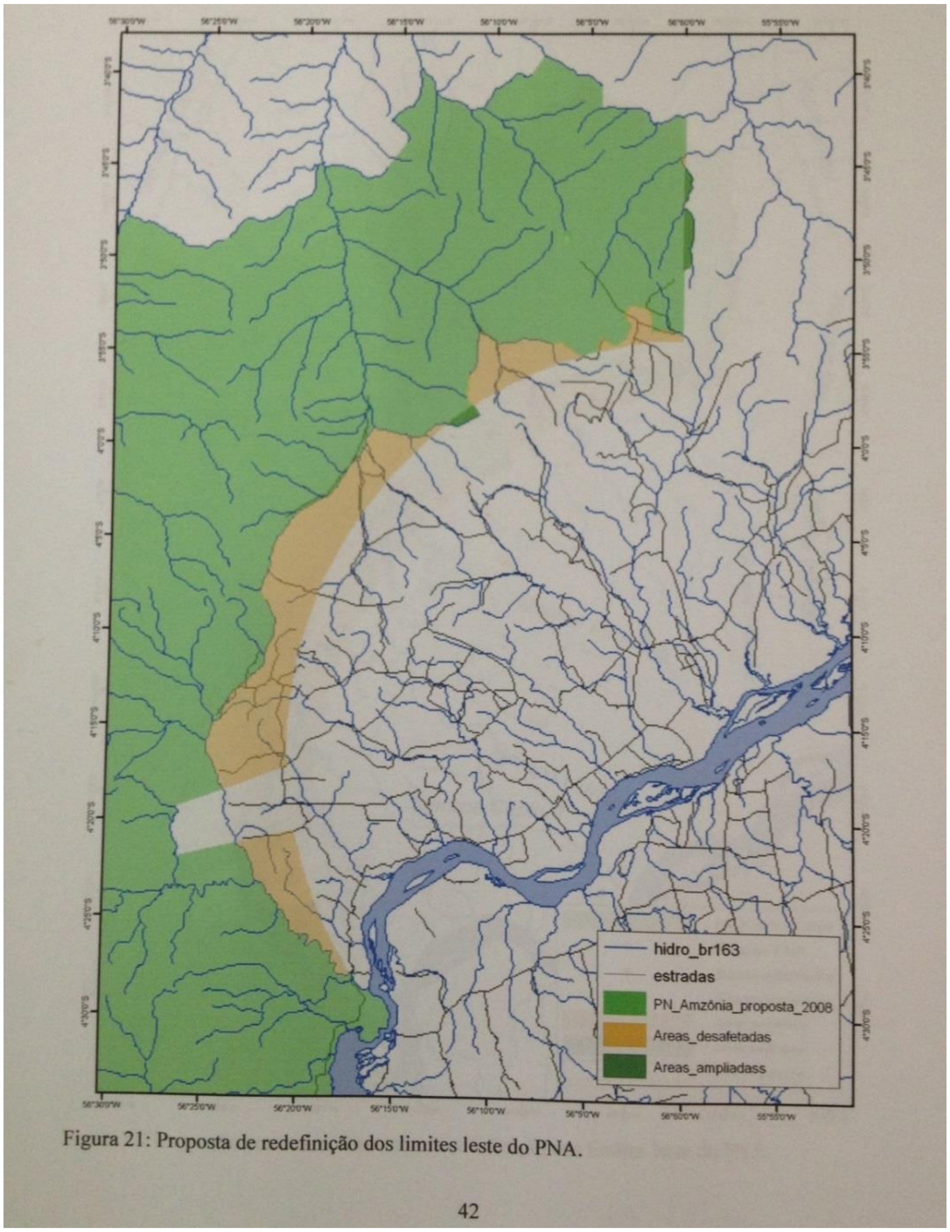

Figure 3.8 IBAMA's 2008 report on PNA proposed downsizing the "Park Arch" in order to account for settlers' demands. The new boundaries would predominately follow the physical geography of the landscape. From IBAMA 2008.

By downsizing the park, IBAMA rationalized, many of the current residents would avoid relocation. Segments of the park would be chipped away along the former "Park Arch" in order to incorporate the communities that had settled in the region. The report argued that redefining PNA's boundaries would reduce social conflicts by providing settlers with non-park land that they could eventually receive title for. Of the estimated 288 (IBAMA 2008) small landholders currently residing within the park, 75% would be outside IBAMA's proposed boundaries and thus would have their land claims recognized. The remaining 25% would still be within the new boundaries and would have to be relocated. Figure 3.9 shows the proposed boundary changes and the settlers who were located inside the park at the time of the report. The report suggested that INCRA would develop PDS for many of the relocated farmers. ICMBio would be tasked with the technical and environmental monitoring of the new boundaries.

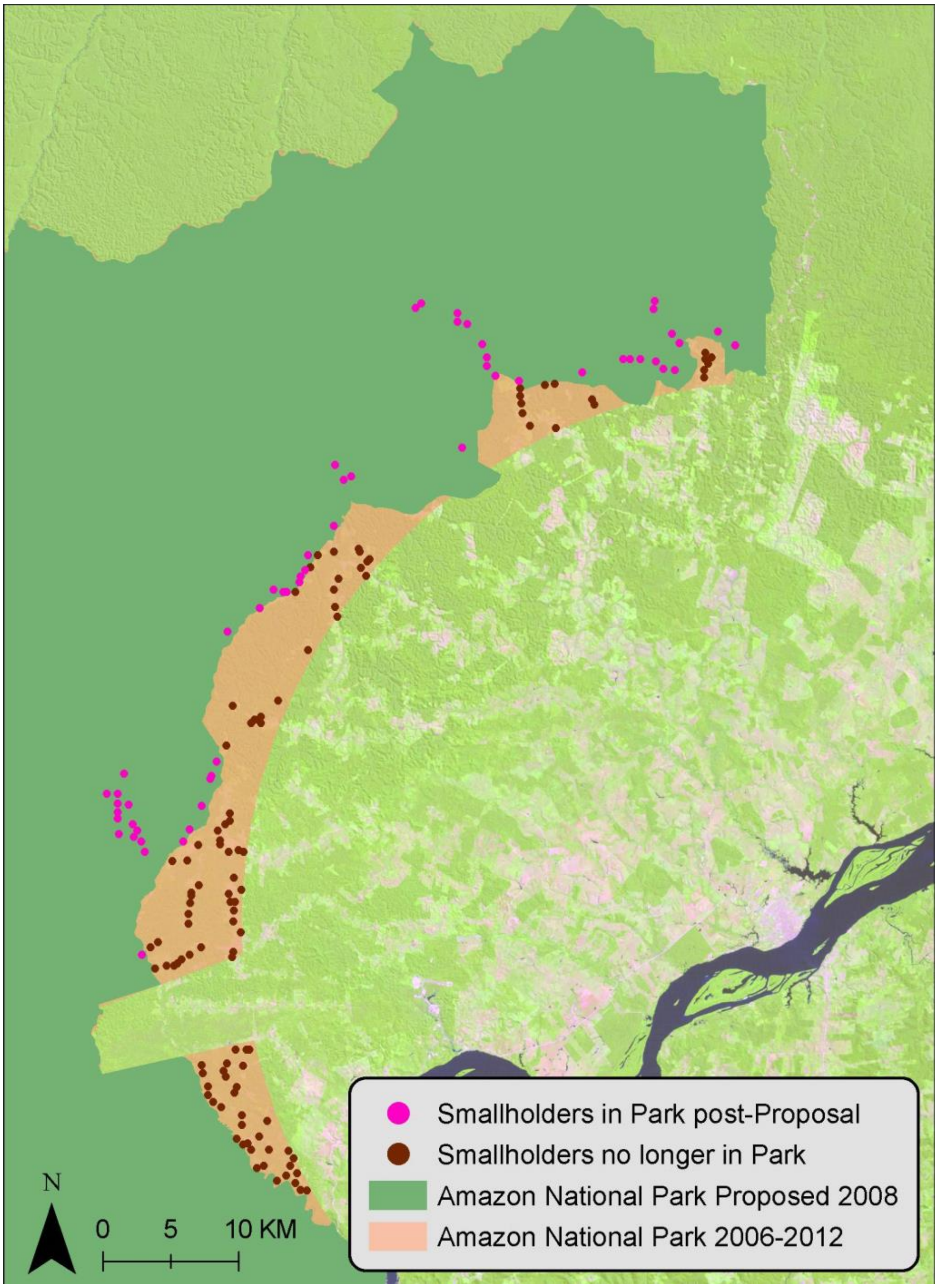

Figure 3.9. IBAMA's 2008 report proposed downsizing PNA to accommodate settlement demands and to demarcate the park boundaries with natural features (adapted from IBAMA, 2008). Background is a 2008 Landsat TM false color image (5-4-3).

In June of 2008, ICMBio organized another round of public meetings with government representatives. Unlike previous forums, which were held in Itaituba, these meetings were held in the communities themselves. The main purpose of the meetings was to show the communities the results of IBAMA's recently published report. IBAMA promoted the report as a systematic evaluation of the local communities, however, some of the local residents had their doubts. For instance, one interviewee claimed that IBAMA did not thoroughly surveyed their community. According to her account, an IBAMA agent drove his vehicle as far up a road as it could travel, then he used this location as a reference point for end of the community (Maria, São Manoel 15 July 2013, interview). However, the residents argued there are often *picadas* (footpaths) that continue beyond the road and up into many farmers' fields.

Although IBAMA's 2008 report called for the downsizing of PNA it took a national economic interest to ignite the ultimate 2012 PADDD decision.

ECONOMIC GROWTH AND ENERGY ACCESSIBILITY

While local debates over the park's status intensified, a national dialogue brewed regarding PNA and Brazil's balance of conservation ideals and economic growth.

As the world's eighth largest economy, Brazil's developing economy is thirsty for energy. In early 2001, the demand for electricity in the populous south and central regions of the country outstripped the available supply. As a result, the region was thrust into a nearly yearlong period of rolling blackouts (the *Apagão*) and power rationing measures. The shortage of energy production was primarily caused by successive years of low rainfall, which had left many of the hydroelectric reservoirs with water levels at just a third of their normal volume (Pires, Giambiagi, and Sales 2002). With such low water levels, the dams were not able to generate sufficient power to meet the needs of the country. Compounding the problem was the gross mismanagement of the electrical supply and inefficiencies in the power grid (Fearnside 2006).

The *Apagão* outraged the public, hindered the economy, and motivated decision makers to re-evaluate the nation's electrical supply. Many policy makers argued that regulatory inefficiencies had stalled planned projects from being built in a timely manner. They urged for an end to government red tape and a renewed emphasis on the construction of new hydroelectric projects that would satisfy the country's power needs.

To maintain domestic energy consumption and to stimulate economic growth, Brazil historically relied on a number of government-sponsored programs to finance major power projects. Yet federal budget cutbacks, hyperinflation, and a weakening currency in the 1980s and 1990s had curtailed the government's investment in major power projects. This was reversed in the beginning of the twenty-first century.

In 2000 Brazil signed on as a member of the Initiative for the Integration of the Regional Infrastructure of South America (IIRSA). This twelve-country pact emphasized transportation and energy projects as methods to develop and link the economies of South America. Likewise, under the administration of President Luiz Incio Lula da Silva (2003 – 2011), Brazil embarked on a particularly ambitious series of mega-infrastructure projects, principally in the Amazon. In 2007, the Growth Acceleration Program (*Programa de Aceleração do Crescimento* - PAC) was launched with the aim to utilize mega-infrastructure projects as a means to accelerate economic growth in Brazil. Examples of such projects included constructing new highways, paving existing highways, and expanding the railroad network.

However, the centerpiece of the strategic development plans outlined in PAC and IIRSA was the construction of a number of hydroelectric dams. According to PAC and IIRSA, dams were the foundation for providing reliable and "clean" energy that stimulated economic growth. Following energy availability models (Cabral, Júnior, and Reid 2010) the plans reasoned that constraints in energy accessibility hinder economic activity, while in contrast, energy availability promotes economic expansion. To accomplish these aims, the federal government has committed to investing R$ 96 billion in energy projects in the Amazon by 2020 (Martins et al. 2012). The Brazilian National Bank for Economic and Social Development (*Banco Nacional de Desenvolvimento Econômico* - BNDES) also has committed to provide long-term subsidized loans that have historically funded many large-scale development projects (Millikan 2011). The funding will be dedicated primarily to the construction of hydroelectric, renewable energy projects, which is overseen by the Ministry of Mines and Energy.

Brazil has emphasized its role as a world leader in the use of "clean" energy (Millikan 2011). Reliance on renewal energy sources, such as hydroelectric dams, fits Brazil's paradigm of clean energy production. Behind China, Brazil commands the world's second largest usage of hydroelectric power. Currently, hydroelectric power provides 81.7% of Brazil's electricity supply and that percentage continues to grow (Pao and Fu 2013).

Hydroelectric capacity has increased dramatically since the *Apagão*, due in large part to the IIRSA and PAC programs and through funding by BNDES. In 2008, Brazil began construction on two massive hydroelectric dams, the Jirau and Santo Antonio, on the Madeira River, the Amazon River's largest tributary. Meanwhile, on the Xingu River, Brazil began construction on the colossal Belo Monte Dam, albeit in fits and spurts due to legal and social conflicts with indigenous communities. When completed, the Belo Monte Complex will be the world's third largest hydroelectric dam with an anticipated installed capacity of 11,000-MW (Cabral, Júnior, and Reid 2010).

To accomplish further growth in renewable energy production, Brazil enacted Phase 2 of the PAC, commonly referred to as PAC-2, renewing the country's emphasis on hydroelectric power generation in the Amazon. PAC-2 took effect in 2010 and has continued under President Rousseff's administration.

One aspect of PAC-2 created a National Energy Plan (*Plano Nacional de Energia* - PNE). This plan has called for 80% of the country's future energy growth to come directly from large hydroelectric dams in the Amazon (PNE 2030). To accomplish these objectives, Brazil has committed to building an additional forty hydroelectric projects in the Amazon. Collectively, these dams will provide upwards of 42,000-MW of power. One notable and massive hydroelectric complex outlined in the National Energy Plan is to be built in the Tapajos River basin, home to PNA (Figure 3.10).

Figure 3.10. Proposed location of the São Luiz de Tapajós Dam.

DAMS AND PADDD OF PNA

The Tapajós Basin, a sub-basin of the Amazon Basin, encompasses an area of nearly 500,000-km². The Tapajós River's mean annual discharge of 13,500m³/s, makes it one of the world's largest rivers and the fifth largest tributary of the Amazon River. The river generally flows in a northeasterly trajectory from the confluence of the Teles Pires and Juriena rivers, 825-km up to the Amazon River near Santarém. (Latrubesse, Stevaux, and Sinha 2005).

Since the 1980s, prospectors and engineers have surveyed the potential for a hydroelectric complex on the Tapajós River (Leal 2013). The vanguard of the proceedings was Eletronorte (*Centrais Elétricas do Norte do Brasil*, S.A.), a subsidiary of Brazil's state-run energy company, Eletrobrás. Between 1986 and 1991 Eletronorte conducted a preliminary study of the feasibility of damming a section of the Tapajós River southeast of PNA. Eletronorte's 1991 outlandish plan called for a reservoir stretching from the town of Jacareacanga to the river's headwaters nearly two hundred kilometers upstream. A lack of domestic funding and no willing international partners precluded this massive project from materializing (Millikan 2011).

In 2006, Eletronorte hired an engineering firm to revisit the possibility of a hydroelectric project in the Tapajós Basin. This study, completed in 2008, recommended a series of seven hydroelectric projects for the region's two major rivers, the Tapajós and the Jamanxim. Combined, the seven proposed dams would flood an area of 302,100-ha at a cost of nearly R$ 48 billion (Millikan 2011). The largest of the projects, the São Luiz de Tapajós Dam, would generate 6,133-MW by flooding a 722-km² swath of the Tapajos basin directly adjacent to PNA. Figure 3.11 illustrates the placement of the dam from the perspective of PNA.

Figure 3.11. Photo taken from PNA looking west across the Tapajós River. If built, the expanse of the São Luiz de Tapajós Dam would extend across this stretch of the river. Credit J. Laue.

However, even with funding in place, there were still barriers preventing Eletronorte from moving towards construction. Namely, the substantial extent of flooding introduced a legal problem; the reservoirs would impact numerous protected areas. Table 3.1 highlights the generating capacity of the proposed Tapajós dams and the extent of flooding that would impact the protected areas.

Dam	River	Estimated Cost (US$ million)	Reservoir size (hectares)	Area in conservation units to be flooded (hectares)
São Luiz do Tapajós	Tapajós	9,200	72,225	Amazon NP: 9,935 FLONA Itaituba: 78 FLONA Itaituba 2: 20,238 (30,251 ha)
Jatobá	Tapajós	4,000	64,630	FLONA Itaituba 1: 2,753
Chacorão	Tapajós	4,300	61,623	PARNA Juruena: 1,004
Cachoeira do Caí	Jamanxim	1,020	42,000	PARNA Jamanxim: 15,700 FLONA Itaituba 1: 6,081 FLONA Itaituba 2: 468 (22.249 ha)_
Jamanxim	Jamanxim	984	7,445	PARNA Jamanxim: 8,516
Cachoeira dos Patos	Jamanxim	751	11.650	PARNA Jamanxim: 9,000 FLONA Jamanxim 3,600 (12.600 ha)
Jardim do Ouro	Jamanxim	500	42,606	FLONA Jamanxim: 14,700 FLONA Altamira: 1,000 (15,700)
TOTAL	--	**20,755**	**302,179 ha**	**93,073 ha**

Table 3.1. Extent that building the Tapajós hydropower complex would flood select protected areas in the Amazon. Note: PARNA – National Park, FLONA – National Forest. From Millikan 2011.

Although the preliminary study was not incredibly comprehensive, it still suggested that upwards of 93,000-ha worth of protected areas, including national parks and forests, would be flooded by the seven reservoirs.

Because of this stipulation, Eletronorte faced two legal hurdles. First of all, the Brazilian Federal constitution and environmental law (article 225, paragraph 1, item III) dictated that hydroelectric projects cannot flood a protected area (Brazil 1988). Second of all, within a protected area, energy companies could not legally conduct technical feasibility studies or authorize environmental impact assessments that investigate the possibility of constructing hydroelectric facilities (Araújo et al. 2012; Millikan 2011). These two legal stipulations were enacted by the Brazilian legislature to strengthen the effectiveness of protected areas. By prohibiting environmental assessments within protected areas, the legislation curtails speculative projects from gaining muster. The ban on hydroelectric projects that flood nearby protected areas was created in order to prevent significant disturbance of these lands.

2012 PADDD

To sidestep the legalities of building dams that would flood protected areas, Brazil's federal government eluded the issue by removing the protected area status from the dams' area of direct impact. In January 2012 President Dilma Rousseff published Provisional Measure 558 (MP 558), which proposed amending the boundaries of eight of Brazil's protected areas in order to facilitate the study and construction of hydroelectric projects (Scarano, Guimarães, and da Silva 2012). In June of the same year, the Brazilian National Congress approved MP 558 and it became Federal Law no. 12,678 (Novaes and França 2012). Through this law, one protected area had its extent expanded, however the other seven affected areas, including PNA, were downsized with an estimated loss of 164,480-ha. Table 3.2 illustrates the scope of these reductions.

Protected Area	IUCN Category	Reduction (ha)	Added (ha)	Total Change (ha)
Amazonia National Pak	II	47,080	804	-46,276
Mapinguari National Park	II	8,470	0	-8,470
National Park of the Amazonian Fields	II	34,149	184,615	150,466
Itaituba National Forest 1	VI	7,705	0	-7,705
Itaitube National Forest 2	VI	28,453	0	-28,453
Crepori National Forest	VI	856	0	-856
Tapajos Environmental Protection Area	V	19,916	0	-19,916
Tapajos National Forest	VI	17,851	0	-17,851
TOTAL	-	164,480	185,419	112,407

Table 3.2. Protected areas affected by Law 12,678. All but one protected area experienced a net downsize as a result of the decree. From ICMBio 2012.

The amount of land that Law 12,678 downsized in the seven protected areas was established without first performing a rigorous study of its impact on these formerly protected areas and without determining which areas would be subject to flooding with any certainty. As such, the protected areas were potentially downsized to a greater extent than necessary. In response, Brazil's Federal Prosecutor General (*Procurador Geral da União*) filed a lawsuit challenging the constitutionality of downsizing the protected areas without first creating an environmental assessment report. The federal prosecutor filed a Direct Action of Unconstitutionality (*Ação Direta de Inconstitucionalidade* no. 4,717) arguing that only through a formal environmental assessment could a specific location for a dam be determined with the lowest possible environmental impact. Without said report, the federal prosecutor argued, the government was merely hypothesizing the extent of the flooding. The lawsuit has stagnated in the Brazilian court system and as of this writing, an outcome has yet to be decided.

IMPACT OF THE 2012 PADDD EVENT ON PNA

For PNA, the impact of Law 12,678 went beyond modifying the borders impacted by the potential reservoir. In addition to downsizing the park along the Tapajós shoreline, the law added a small segment of land on the park's northern edge. Most notably, however, the law acquiesced to colonization demands on the park's eastern border (Figure 3.12). Law 12,678 followed the demarcation recommendations outlined in IBAMA's 2008 report and the eastern "Park Arch" was moved westward. In place of a nebulous boundary, the new boundary followed physical features such as creeks and rivers. An amendment of Law 12,678 mandated that the government convert the previously protected land along the eastern border into a number of PDS sites, to be created and managed by INCRA. This instance of PADDD on account of strife between a protected area and settlers was the first time a protected area in Brazil has been reduced in order to accommodate the demands of settlers. According to key informants in Itaituba, the federal government was willing to downsize PNA in order to gain local support for the hydroelectric project. Although the government did not necessarily require local support for the project, garnering local support reduced the chances of local strife related to the dam's construction. This decision illustrates that the federal government was enthusiastically inclined to sacrifice a protected area in its quest to expand economically.

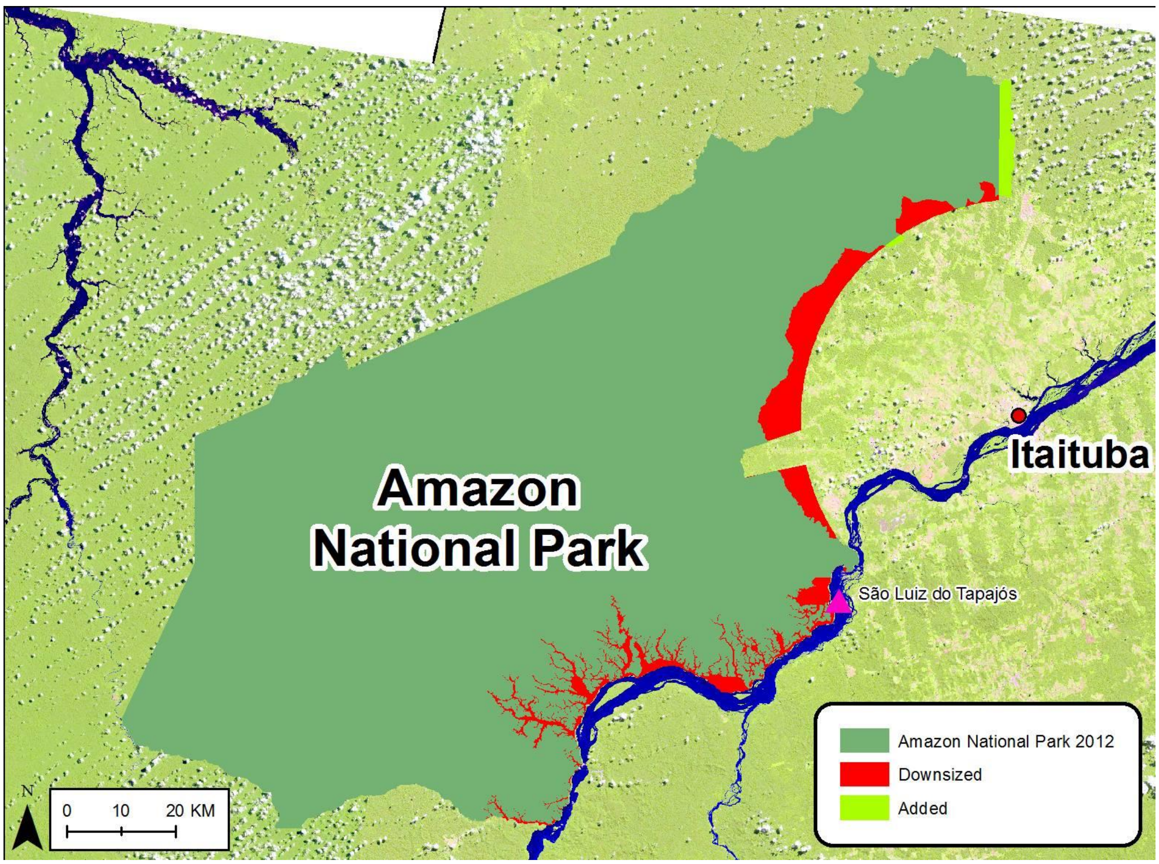

Figure 3.12. The 2012 PADDD event downsized the park along the eastern "Park Arch" to accommodate settlers' demands and alongside the Tapajós River in anticipation of the construction of the the São Luiz de Tapajós Dam. The Background image is two false color Landsat 5 TM images (5-4-3) taken in 2011. From ICMBio 2012

In all, the 2012 PADDD event resulted in a loss of 47,080-ha of land for PNA or 4.5% of the park's total area. The downsizing for the dam represented 37.3% of the total area downsized, while 62.7% was lost on account of colonization demands. The decree also amplified the park's northwest east boundary but by a much smaller area of only 804-ha or 0.08% of PNA's entire size (ICMBio 2012).

Chapter 4: Land Cover Change in Amazon National Park

Chapter 4 presents an application for using remotely sensed imagery to capture and quantify the land use and land cover changes that occurred in the park leading up to the 2012 reduction.

METHODS

Anecdotal evidence, key informants, and government reports provide a constructive narrative for explaining the burgeoning of anthropocentric land uses within PNA. Yet, to fully capture the effect of loggers and settlers on the park it is necessary to systematically quantify these impacts. Remotely sensed imagery provides a passive yet thorough method to assess the quantity and trajectory of deforestation over time. In particular, Landsat Thematic Mapper (TM) images have been used extensively to successfully detect and quantify deforestation throughout the Amazon (Souza Jr et al. 2013; Skole and Tucker 1993; Shimabukuro et al. 1998).

The objective of using remotely senses imagery of PNA is to capture the amount of deforestation that has occurred within the park and to analyze the timing of its occurrence. To perform this multi-temporal analysis of forest cover change, six Landsat TM scenes with dates between 1986 to 2011were obtained from the USGS EarthExplorer archive. Although the extent of PNA stretched across Landsat scenes, only a single Landsat scene (WRS path/row 228/63) was utilized as this scene covered the vast majority of PNA. Specifically, this scene encompassed PNA's eastern "Park Arch" where the bulk of human activity occurred. Figure 4.1 illustrates the extent of the scene in relation to PNA. The Landsat TM images chosen for this twenty-five year period were predominately cloud free, especially around the "Park Arch". To minimize seasonality differences, such as vegetation phenology all images had acquisition dates between June and September. The software packages used to perform the analysis and classification of the Landsat images was ENVI 5.1 and Esri's ArcGIS 10.2.

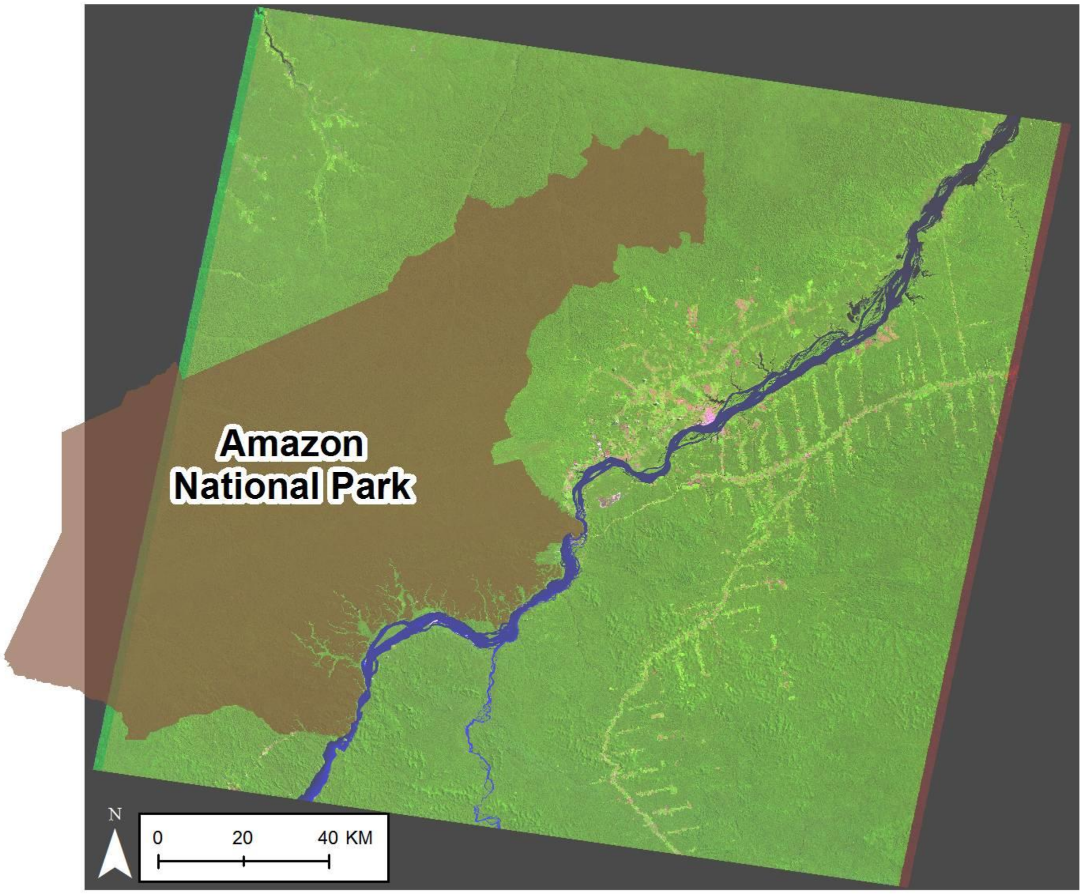

Figure 4.1. Relation of PNA to WRS path/row 228/63.

PRE-PROCESSING

Landsat TM image data from EarthExplorer comes bundled in digital number format (DN). To convert this scaled 8-bit DN format into physical units, it is first necessary to calculate at-sensor radiance (Chander, Markham, and Helder 2009; Chavez 1996). The following equation is used to convert Level 1 Landsat TM products into at sensor-spectral radiance:

$$L_\lambda = \left(\frac{LMAX_\lambda - LMIN_\lambda}{Q_{calmax} - Q_{calmin}}\right)(Q_{cal} - Q_{calmin}) + LMIN_\lambda$$

or

$$L_\lambda = G_{rescale} * Q_{cal} + B_{rescale}$$

Where

$$G_{rescale} = \frac{LMAX_\lambda - LMIN_\lambda}{Q_{calmax} - Q_{calmin}}$$

$$B_{rescale} = LMIN_\lambda - \left(\frac{LMAX_\lambda - LMIN_\lambda}{Q_{calmax} - Q_{calmin}}\right)(Q_{calmin})$$

Where

L_λ = Spectral radiance at the sensor's aperature

$\mathrm{Q}_{\mathrm{cal}}$ = Quantitized calibrated pixel value (DN)

$\mathrm{Q}_{\mathrm{calmin}}$

= Minimum quantisized calibrated pixel value corresponding to LMIN_λ(DN)

LMIN_λ = spectral at-sensor radiance that is scaled to Q_{calmin} $[W/_{m^2 sr\ \mu m}]$

$\mathrm{G}_{\mathrm{rescale}}$ = Band-specific rescaling gain factor $[W/_{m^2 sr\ \mu m}]$

$\mathrm{B}_{\mathrm{rescale}}$ = Band-specific rescaling bias factor $[W/_{m^2 sr\ \mu m}]$

Gains and offsets for this equation are provided in the respective image's metafile. At sensor-spectral radiance was then converted to exoatmospheric top of the atmosphere (TOA) reflectance. Using TOA reflectance for classification is necessary to compensate for temporal variations between images (Chander, Markham, and Helder 2009). For instance, TOA reflectance corrects for differences in the Earth-Sun distance between scenes and it also eliminates inconsistencies in the solar zenith due arising from differences in the time of data acquisition. To compute the TOA reflectance, the following equation is used:

$$\rho_\lambda = \frac{\pi \cdot L_\lambda \cdot d^2}{ESUN_\lambda \cdot \cos\theta_s}$$

Where

ρ_λ = Planetary TOA reflectance (unitless)

π = Mathematical constant equal to ~3.14159 (unitless)

L_λ = Spectral radiance at the sensor's aperature $[{}^{W}/_{m^2 sr\ \mu m}]$

d = Earth-Sun distance (astronomical units)

$ESUN_\lambda$ =Mean exoatmospheric solar irradiance

θ_s = solar zenith angle [degrees]

CLASSIFICATION

To classify the six scenes, the maximum likelihood supervised classification method was utilized. Training samples for the classification were created from reference observations taken in the field, knowledge of the region, and Google Earth's Digital Globe imagery. The resulting datasets were comprised of three classes: water, forest, and deforestation.

An accuracy assessment containing a confusion matrix for the classified images was then performed. In a confusion matrix, a collection of random points from the known classes are compared against the corresponding classes generated by the classification algorithm (Joshi, Yadav, and Sinha 2011). The accuracy assessment was conducted on the 2011 image by creating 140 points randomly distributed throughout the study area. Knowledge of the region and Google Earth imagery aided in determining the classification of these points. The resulting confusion matrix and Kappa statistic are shown in Table 4.1. The Kappa coefficient signifies the percentage of agreement between the classified data and the random point data that would occur after eliminating the proportion of agreement that would happen by pure chance (Congalton 1991). Kappa is given by the equation:

$$Kappa = \frac{N \sum_{i=1}^{r}(xii) - \sum_{i=1}^{r}(x_{i+} * x_{+i})}{N^2 - \sum_{i=1}^{r}(x_{i+} * x_{+i})}$$

Where r is the number of rows in the error matrix, xii is the number of observations in row i and column i (on the major diagonal), x_{i+} is the total observation in row i, x_{i+} is the total observation in column i.

Overall Accuracy = (138/140) 98.5714%
Kappa Coefficient = 0.9267

	Ground Truth Classes				
	Class	Deforestation (%)	Forest (%)	Water (%)	TOTAL (%)
Thematic	Deforestation	91.67	0.80	0	8.57
Map	Forest	8.33	99.20	0	89.29
Classes	Water	0.00	0.00	100	2.14
	Total	100.00	100.00	100	100

	Commission (%)	Omission (%)
Deforestation	8.33	8.33
Forest	0.90	0.80
Water	0.00	0.00

	Producer Accuracy (%)	User Accuracy (%)
Deforestation	91.67	91.67
Forest	99.20	99.20
Water	100.00	100.00

Table 4.1. Confusion matrix and kappa statistic for the maximum likelihood classification algorithm.

In other words, the obtained Kappa value of 0.92 suggests that the maximum likelihood classification method provides 92% better accuracy than if the classification results had been obtained randomly.

The accuracy assessment and classification were performed on the entire scene rather than just on the PNA subset. This was done because the section that encompasses PNA was relatively scarce of deforestation and water. Using the larger scene offered better training data to teach the maximum likelihood algorithm. After classifying the images, the PNA subset was cut from the original image. The park's boundary between 1985 and 2006 was used as this subset scene, including for the 2008 and 2011 images.

Although the park was enlarged in 2006, this enlargement occurred in the uninhabited western region of the park and away from the area of interest. The 1985-2006 boundary was preserved to maintain consistency in the display of the images.

REMOTE SENSING RESULTS

The amount of deforestation observed near the "Park Arch" over the 25-year period is shown in Figure 4.2.

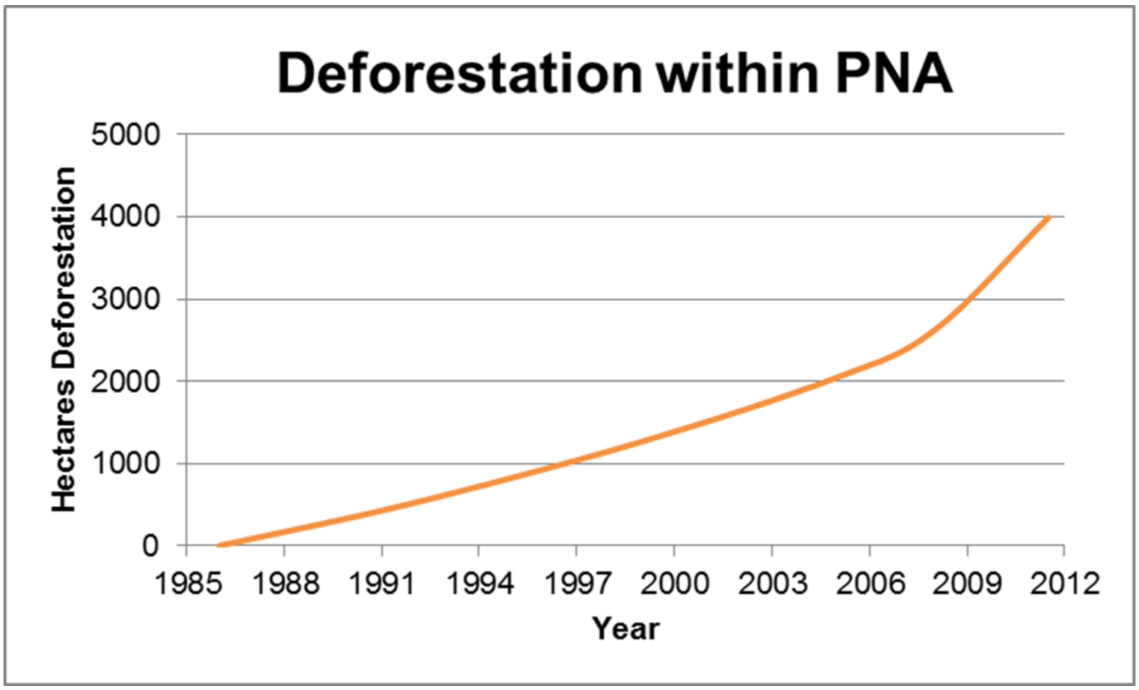

Figure 4.2. Amount of deforestation per year in PNA based on classified Landsat TM imagery.

Illustrations showing deforestation in and around PNA is shown in Figure 4.3. Unsurprisingly, deforestation was at its lowest total in 1986 with a mere 1.56-ha cleared inside the park. The amount of cleared forest steadily increased over each successive scene and by 2011 a total of 3991.5-ha had been deforested inside the park. Large scars of deforestation are visible in remote locations suggestion the presence of loggers. Of particular interest, a significant upswing of deforestation occurred after 2005.

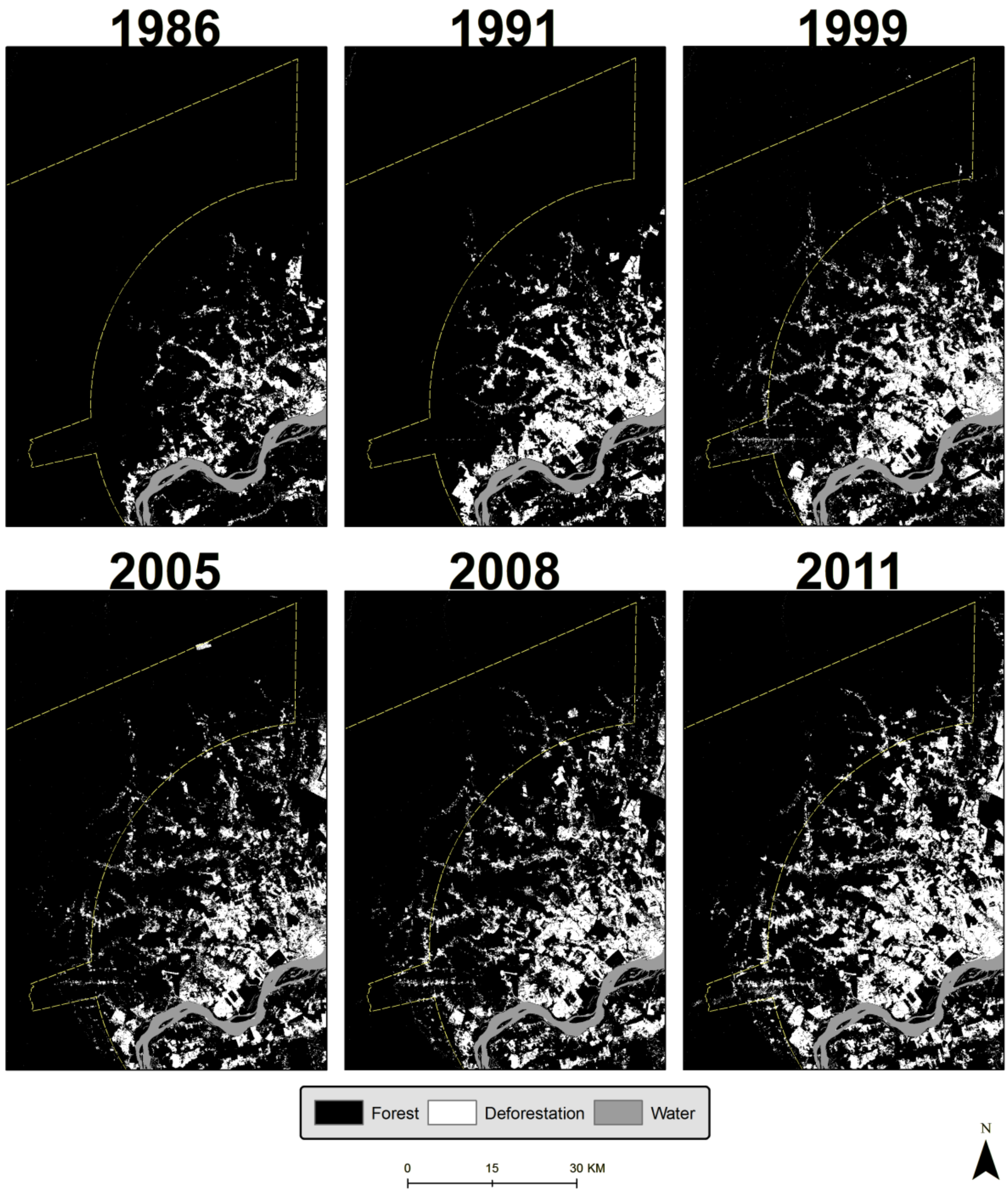

Figure 4.3. Progression of deforestation in PNA from 1986 to 2011.

Of note, in 2004 a large plot of land became deforested in the northern edge of the park only to convert back to vegetation in subsequent years. Presumably this deforested plot was caused by the activities of Walmir Climaco who, as discussed above, was fined and had his estate and equipment destroyed by IBAMA in 2005. A close-up progression of this plot is shown in Figure 4.4. A true color image is compared to a false color composite in order to highlight the differences between the native vegetation and the secondary regrowth that developed at the site after it was abandoned.

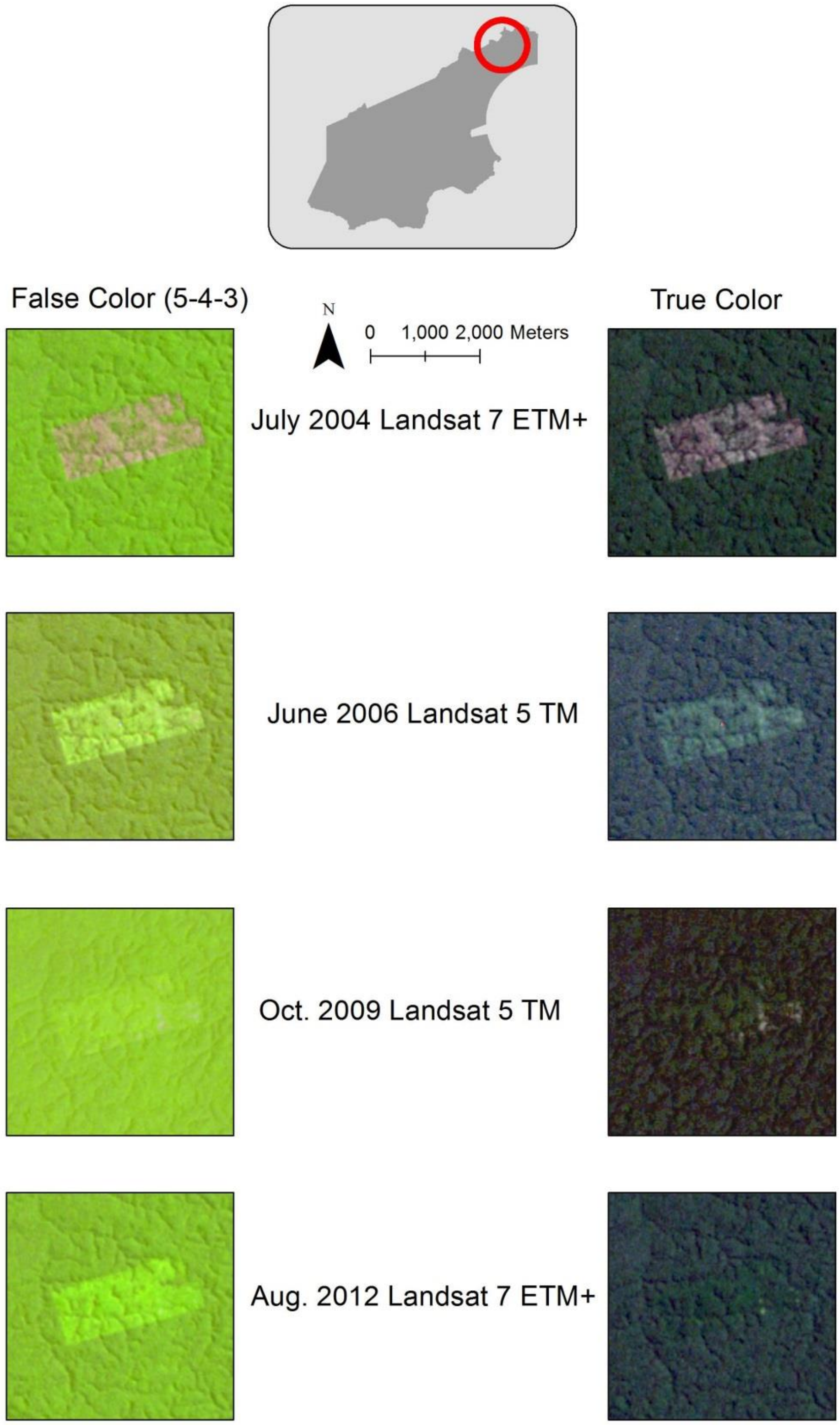

Figure 4.4. Imagery of Climaco's deforested plot inside of PNA.

Chapter 5: Discussion and Conclusion

DISCUSSION OF ECOLOGICAL IMPACTS

In addition to the direct reduction of protected land, the PADDD-2012 event has the potential to cause additional indirect impacts on PNA.

The construction of new roads in and around the park can have a deleterious impact on the surrounding forest cover. Prior to the 2012 PADDD event, BR-230 occupied a 112-km footprint within PNA. The construction of BR-230 took a toll on PNA's native forest. Trees were felled, hillsides were slashed, and the ecosystem was significantly fragmented (Torres and Figueiredo 2005). Furthermore, the construction of the highway impacted the forest surrounding the highway's right-of-way. In the peripheral forest, construction equipment was staged away from the road and workers clear-cut the native forest to make temporary camps. These actions multiplied the highway's impact on the environment more than the 112-km segment through PNA would suggest (Torres and Figueiredo 2005).

The 2012 PADDD event will re-create much of the impacts caused by the 1970s highway project. After the 2012 downsizing, roughly 18% of this segment of BR-230 was no longer within the limits of PNA. Assuming the shoreline of the new reservoir adheres to PNA's post-PADDD boundary, a 20-km stretch (author's calculation) of the highway will be flooded. Figure 5.1 highlights the predicted extent of the highway that would be flooded by the reservoir. To maintain the highway's present configuration, roughly a dozen bridges would have to be constructed in order to span the reservoir's various reaches. Many of these bridges would have to be thousands of meters in length. The cost to design and implement these structures is likely financially infeasible and impractical from an engineering standpoint. More likely, the highway's present alignment will have to be altered, which would cause habitat fragmentation within the park. The construction of the modified route would have to gravitate away from the Tapajós River to the higher elevations of the park.

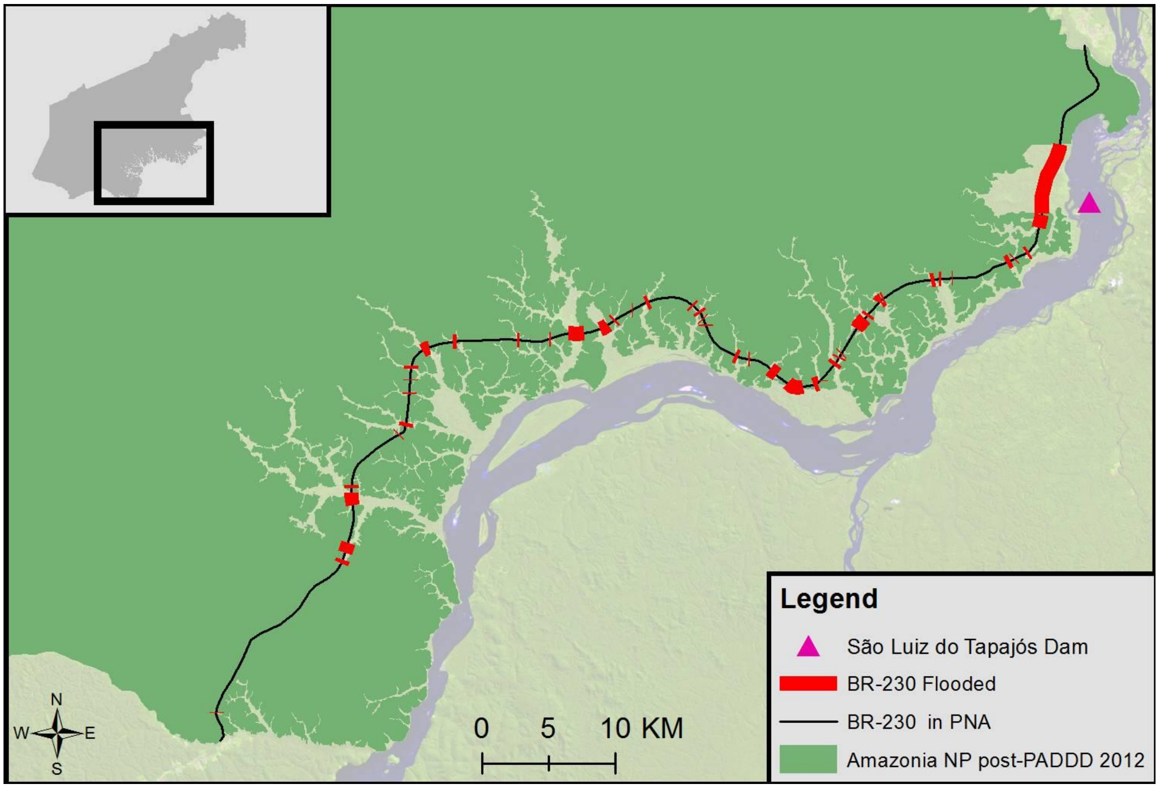

Figure 5.1. Extent of potential flooding of BR-230 due to construction of the hydroelectric dam.

Without an accurate survey, such as those mandated by an environmental impact assessment, the precise extent that the reservoir would flood BR-230 is uncertain. Nevertheless the extent of the flooding will undoubtedly impact the highway's current alignment. As of this writing, the government has not yet announced a method for mitigating the likelihood of flooding BR-230. The highway is a critical gateway for the transportation of products throughout the Amazon and it is unlikely to be reduced in any capacity. Similarly, the high local relief of the park suggests that the reservoir will not stretch into the upper reaches of the downsized area. To that end, the government likely downsized the park more than necessary. Because the downsized area will not be completely flooded, the government may lease the former park land to the dam's concessioner who could use the land as a staging ground or for the construction of facilities.

Likewise, the government has also provided scant details on the direct effects that the construction of the dam will have on PNA. Land near large dam projects is at risk of deforestation because of construction activities that disrupt native forest cover. To mitigate the potential impact of construction activities on the nearby native forest cover in PNA, the plans for the São Luiz de Tapajós Dam have proposed an untested method of construction referred to as the platform model. The platform model, borrowed from the offshore oil industry, is a scheme to build the dam without relying on the surrounding land to support the construction (Martins et al. 2012; Millikan 2011). According to the government, the platform model is more environmentally friendly than traditional dam projects because it does not require the construction of new roads. To accomplish this, all equipment and workers will be shepherded to the site by boat or helicopter.

However, the feasibility and probability of the project adhering to these lofty targets has been doubted by scholars and non-governmental organizations (Millikan 2011). Employing the platform model for dam construction is unproven and based on a different reality than utilized by the offshore oil industry. Oil platforms support at most 175 workers while the federal government has estimated that the construction of the Tapajós River complex will generate 75,000 jobs (Martins et al. 2012; Millikan 2011). The Tapajós River near PNA is inundated with rapids that would make travel difficult for large vessels so the likelihood that the project will not require new roads to transport heavy machinery is highly unlikely. Furthermore, transporting tens of thousands of construction workers via helicopter to the project site is logistically daunting compared to driving them to the project site or constructing housing in the vicinity.

In addition to the likelihood of direct deforestation, the São Luiz de Tapajós Dam project puts PNA at risk of losing significant forest cover through indirect deforestation. The influx of migrant workers to the area will be reminiscent to the thousands of workers who flocked to the Itaituba region during its gold rush heyday. It is conceivable that after the completion of the dam project, many of the dam workers will remain in the region and seek out land to cultivate for themselves and their families. Construction of the Tucuruí Hydroelectric Dam, one of the earliest major dams in the Amazon, led to the rapid growth of the town of Tucuruí, which grew from 10,000 in the 1970s to 61,000 during construction in the 1980s. After the completion of the dam, the population of Tucuruí stood at 88,000 (Manyari 2007). Construction and related activities associated with the Jirau and Santo Antonio Dams on the Madeira River have been estimated to attract roughly 50,000 laborers (Fearnside 2014). Likewise, the construction of the Belo Monte Dam on the Xingu River has attracted 25,000 laborers, the vast majority of which are not local to the region (Leite, Amora, & Kachani, 2013).

DISCUSSION OF SOCIAL IMPACTS

Contentions over the placement of protected areas are a longstanding occurrence in conservation history. Disagreements between local agents and the managers of protected area are neither novel nor are they unique to PNA. Likewise, the extraction of natural resources from within a protected area has been practiced since the creation of Yellowstone National Park. Yet, Brazil's federal government has set a number of dangerous precedents in downsizing PNA in 2012.

First, the government sanctioned the reduction of a protected area to accommodate the needs of a recently arrived group of migrants. These settlers arrived well after the establishment of the park yet they were nevertheless permitted to occupy the park. Although the migrants actually performed the action of occupying PNA, the government is largely to blame for their behavior. In particular, INCRA did little to discouraged and the occupation of land inside the park. In fact, some of the interviewees went as far as to claim that INCRA promoted the occupation of the park as discussed above. In this case, the government systematically and officially condoned the colonization of a strictly protected national park. For instance, PA Miritibua gave settlers the false impression that INCRA would regularize settlements even if they were located within the park boundary. Likewise, IBAMA was at fault too for employing a laissez-faire approach towards enforcement. The agency's lack of enforcement action escalated the problem by permitting settlers to occupy without repercussions. Also, IBAMA did not immediately notify settlers that they were within the limits of the park, which led the settlers to further establishing themselves within the park (José, Novo Horizonte 16 July 2013, interview; Maria, São Manoel 15 July 2013, interview).

Moreover, in the 1990s, IBAMA's ineffectual policies failed to adequately deter the agents who built roads and logged inside PNA (Barreto et al., 2009). It was not until IBAMA stepped up its enforcement duties in 2004 that the agents' exploitation actions decreased. As illustrated by the incident with Walmir Climaco, IBAMA had the capacity to enforce the sanctity of PNA from logging interests. Yet Climaco and his company deforested more than 300-ha before IBAMA halted their activities. The agency waited too long to perform its enforcement duties. By the mid-2000s numerous subsistence farmers had also settled inside the park, causing significant losses of forest cover.

The sharp increase in deforestation exhibited inside PNA bucks the trend of deforestation rates decreasing nationwide during this same time period. Between 2005 and 2011 as IBAMA enforced PNA's boundaries against loggers and ranchers, concurrently the amount of deforestation inside the park increased. At first glance this swell of deforestation appears contradictory to IBAMA's simultaneous enforcement actions. However, because IBAMA's enforcement was not aimed at settlers or subsistence farmers, IBAMA did not directly prevent them from continuing their subsistence practices. The cause of this increase in deforestation is likely due to settlers anticipating the end of their occupancy of PNA and maximizing their remaining time by cultivating additional land. For the time being, the government permitted the settlers to reside inside the park, however, many settlers rationalized that IBAMA would soon curb their occupancy within PNA's borders.

IBAMA's presence in PNA became much more pronounced in the mid-2000s, causing anxiety and worry amongst the settlers (José, Novo Horizonte 16 July 2013, interview). In addition to enforcement, the agency was also performing a demographic survey for their 2008 report. Upon seeing that the government was performing a census and enforcing the park's boundaries, many settlers rationalized that IBAMA was planning changes that would drastically affect their livelihoods. According to the settlers, these potential changes could take one of two outcomes.

One scenario that the settlers predicted was that the government would compensate them for the land that they occupied inside the park. As a result, these farmers deforested additional PNA land as a means to maximize their potential remuneration. With a larger amount of land under their cultivation, the settlers rationalized, the government would be obligated to increase the amount of compensation that they received as a payment to cease their occupation of PNA.

Alternatively, the settlers may have believed that IBAMA was considering evicting them without compensation. These settlers rationalized that they were confronted with the choice of abandoning their homes or reaffirming their claim to the land. To remain static, the settlers believed that they needed to demonstrate that they had a strong motive to stay. Consequently, they increased their plot size to emphasize their commitment to stay.

Regardless of the settlers' motivation, both scenarios resulted in additional deforestation inside PNA. In the end, both scenarios came to fruition as some settlers who lived inside the park were relocated to settlements outside of the park, while other settlers were pardoned by the government for their occupancy.

The federal government's willingness to grant amnesty to settlers who occupied a national park and IBAMA's lack of enforcement represents a moral hazard problem. A moral hazard occurs when a party takes a risk without being burdened by the costs that could result. The party is more willing to take a substantial risk knowing that the potential costs will not affect them. For PNA, settlers occupied land that was not legally open to settlement yet they felt no negative consequences as a result. This precedent could lead to negative outcomes for other protected areas. For instance, settlers could be tempted to invade another national park with the mindset that by occupying the park for a number of years, the government will eventually grant them land rights.

The federal government also disregarded the precautionary principle, which guides policy makers to make decisions that preemptively avoid environmental harm. The precautionary principle counters the notion that activities should only be halted if they are shown to cause environmental harm. Instead, the precautionary principle calls for decision makers to act only after first creating a plan that anticipates, monitors, prevents, and mitigates potential threats. It is prudent for policy makers to adopt precautionary principles in order to protect an environmental resource rather mitigate an action's aftereffects. That is, policy makers should ensure that the methods that they are using to achieve sustainability should in themselves be sustainable. Yet for the case of PADDD in PNA, policy makers have moved forward with the construction of the hydroelectric dam, a renewable energy source, despite the fact that there will be detrimental environmental costs to the surrounding terrestrial and aquatic environments.

Theoretically, an environmental impact assessment would evaluate and inventory the environmental costs of building the dam and downsizing PNA. However, as noted above, Brazilian law prohibits the creation of an environmental impact assessment for protected areas. Environmental impact assessments are grounded in the need to adhere to rigorous scientific analysis by following the precautionary principle. However, biased stakeholders can taint the assessment's scientific rigor and manipulate the results. It is for this reason that Brazilian law restricts these assessments from being created in the first place in a protected area. Protected areas in Brazil were created out of an obligation to maintain native land cover and to avoid widespread environmental harm. To accomplish these objectives, often the best course of action is no action. Instead, the government acted hastily and downsized PNA without understanding and concerning itself with the environmental ramifications of its decision. By doing so, the government has expressed its willingness to disregard the very purpose of a protected area.

The relocation of individuals within PNA also encumbers the government with a social and financial cost. As discussed above, the new park boundaries still harbor roughly 25% of the smallholders who had settled within the park's limits prior to 2012. The government has expressed its commitment to compensate and relocate these people to PDS outside of the park. In general, the government provides compensation to relocated individuals for expropriated land based on the buildings they constructed, the crops they harvested, and other land improvements (*benfeitorias*) that they may have undertaken (Mitigation 2010). Yet, in the case of relocation of settlers out of PNA, the amount of compensation that these people receive should not be distributed solely based on these qualifications. Ideally, the government should provide compensation based on the initial motivation and subsequent actions that these people took to occupy the park. These people can be classified into three groups. How the government distributes compensation amongst these three groups is a moral dilemma. The first group consists of settlers who were honestly unaware that they had settled within the park's boundary. This group of settlers was genuinely looking for available land to acquire and cultivate. These colonists settled within PNA because charismatic public misled them or INCRA encouraged them to settle. Due to the government's mistakes and deception, this group of settlers arguably has a right to compensation for the land that they settled.

The second group of actors includes settlers who took advantage of the fuzzy demarcation of PNA. This group of settlers understood that there was a park in the hinterlands of Itaituba but they also understood that the government was not enforcing the park's conservation mandate. As a result, this group took great liberty with how far into the park they settled. Many new settlers commonly referred to the Arixi and the Tracoa Rivers as possible park boundaries. Yet, this second group of colonists settled dozens of kilometers beyond the threshold of these rivers. They used the lack of boundary clarity as a scapegoat excuse for their actions to deforest. Because this group of settlers knowingly encroached considerable distance into the park, they do not deserve land titles or compensation for the land that they are occupying. The feasibility of the government to accurately categorize settlers into these first two groups is unlikely except for the most egregious of instances.

The third group of actors who caused deforestation in PNA was loggers and ranchers. It is inconceivable that this group did not know that their activities were occurring within the confines of the park's boundaries. Logging and ranching operations are sophisticated undertakings that require substantial capital and labor costs. This group knowingly built roads well beyond PNA's boundaries, logged the park, and used the park for grazing purposes. IBAMA's eventual enforcement of this group's actions was warranted and necessary, albeit slow. Based on IBAMA's actions, the government has already expressed its unwillingness to compensate these individuals.

Unlike the world's original national parks areas, which were protected primarily on the basis of their scenic qualities, PNA was gazetted primarily to protect biodiversity and to impede deforestation. Nevertheless, the park still contains significant aesthetic characteristics that draw hundreds of tourists to PNA every year (IBAMA 2008). The Tapajós Rapids are the primary draw for many of these tourists who bask in its views and marvel at its beauty. As shown in Figure 5.2, the rapids are a breathtaking illustration of an unimpeded wild river running through native forest. The construction of the São Luiz de Tapajós Dam will flood the rapids and forever mar these aesthetic qualities.

Figure 5.2. Tapajós River adjacent to PNA. The creation of a reservoir to power the hydroelectric dam would flood this stretch of rapids. Credit J. Laue.

CONCLUSION AND POLICY RECOMMENDATIONS

The lack of demarcation clarity for PNA illustrates the importance that park design plays in determining the long-term efficiency of a protected area. Arbitrary park boundaries, although politically orderly and precise, are realistically injudicious. In order to effectively delineate a protected area along political boundaries, park managers must establish ample artificial boundaries.

However, artificial boundaries are expensive to demarcate. Demarcation strategies such as building fences, signing stretches of forest, or placing large stone markers require substantial initial capital outlays. In addition, these delineation approaches necessitate periodic upkeep and management. The founders of PNA did not take these necessary steps, which hindered the park's effectiveness. Nebulous boundaries empowered loggers and some settlers to knowingly encroach into PNA and deforest the native forest. These ineffective boundaries also facilitated other settlers to inadvertently deforest within PNA. This encroachment was exacerbated by the difficulty in enforcing fabricated boundaries. IBAMA's enforcement agents were handicapped in the field by an inability to know with certainty where the protected area boundaries began.

In contrast, utilizing a region's physical characteristics is a passive yet effective method for maximizing the distinction between protected and non-protected land (Peres and Terborgh 1995). Demarcating a protected area by using the geographic characteristics of the land is a more prudent financial decision, a more effective protection strategy, and a less challenging enforcement tactic. Watershed divides constitute the ideal barrier for partitioning the landscape. These divides obstruct movement and consequently they represent the least desirable cost-path of travel. Streams and rivers in the Amazon have been shown to be difficult for settlers to cross and expensive for them to bridge (Arima et al. 2013). In addition, watersheds are generally visibly distinct from the rest of the landscape, which avoids agents from misjudging a protected area's precise boundary. Passive demarcation through topographical divides is another strategy for creating a protected area's boundary. Using the top of a hillside to delineate a protected area, while not as visibly distinct as a watershed barrier, does have the added benefit of protecting hydrological resources from encroachment and contamination of settlers who may otherwise colonize adjacent to the non-protected side of the watershed.

As shown by this case study of PNA, Brazil's federal government has exhibited a number of biases by enacting PADDD legislation. First of all, the government has permitted economic interests such as mineral extraction to override conservation ideals. Similarly, the government has shown its readiness to downsize a protected area in order to build hydroelectric dams that fuel the Brazilian economy. In addition, the government has permitted the presence of late-coming colonists inside the park, a situation that is directly incompatible with the ideals of a strictly protected national park. This dichotomy showcased how conservation ideals are subservient to large scale economic interests.

Protected areas are not permanent nor are they immutable. Although protected areas are supposed to be guarded against extensive anthropocentric influences, as shown through the history of PNA, protected areas are vulnerable to government whims and economic influences. Within a mere decade of its founding, Brazil's government had already begun to chip away at PNA's borders. Even though Brazil has greatly expanded its network of protected areas since PNA's gazetting in 1974, the two instances of PADDD within the park's first 40 years of existence set a dangerous precedent for the long-term survival of protected areas in the Amazon. As one of the first parks in the Amazon Basin, PNA set the precedent for safeguarding the Amazon's treasure trove of biological and geophysical attributes. It should not set the precedent for the erosion of conservation values.

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