Essay

Downgrading, Downsizing, Degazettement, and Reclassification of Protected Areas in Brazil

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Abstract: *Protected areas (PAs) are key elements for biodiversity conservation and ecosystem services. Brazil has the largest PA system in the world, covering approximately 220 million ha. This system expanded rapidly in the mid-1990s to the mid-2000s. Recent events in Brazil, however, have led to an increase in PA downgrading, downsizing, and degazettement (PADDD). Does this reflect a shift in the country's PA policy? We analyzed the occurrence, frequency, magnitude, type, spatial distribution, and causes of changes in PA boundaries and categories in Brazil. We identified 93 PADDD events from 1981 to 2012. Such events increased in frequency since 2008 and were ascribed primarily to generation and transmission of electricity in Amazonia. In Brazilian parks and reserves, 7.3 million ha were affected by PADDD events, and of these, 5.2 million ha were affected by downsizing or degazetting. Moreover, projects being considered by the Federal Congress may degazette 2.1 million ha of PA in Amazonia alone. Relaxing the protection status of existing PAs is proving to be politically easy in Brazil, and the recent increase in frequency and extension of PADDD reflects a change in governmental policy. By taking advantage of chronic deficiencies in financial and personnel resources and surveillance, disputes over land tenure, and the slowness of the Brazilian justice, government agencies have been implementing PADDD without consultation of civil society. If parks and reserves are to maintain their integrity, there will need to be investments in Brazilian PAs and a better understanding of the benefits PAs provide.*

Keywords: Amazonia, conservation policy, in situ conservation, national parks, PADDD

Degradación, Reajuste, Eliminacióm de las Listas y Reclasificación de Áreas Protegidas en Brasil

Resumen: *Las áreas protegidas (APs) son elementos clave para la conservación de la biodiversidad y los servicios ecosistémicos. Brasil tiene el sistema más grande de APs en el mundo, cubriendo aproximadamente 220 millones de hectáreas. Este sistema se expandió rápidamente desde la mitad de los 90s hasta mediados de los 2000s. Sin embargo, los eventos recientes en Brasil han llevado a un incremento en la degradación, reajuste y eliminación de listas (PADDD, en inglés) de las áreas protegidas. ¿Esto refleja un cambio en la política de de APs del país? Analizamos la ocurrencia, la frecuencia, la magnitud, el tipo, la distribución espacial y las causas del cambio en las fronteras y categorías de las APs en Brasil. Identificamos 93 eventos de PADDD desde 1981 hasta 2012. La frecuencia de dichos eventos incrementaron desde 2008 y fueron adscritos principalmente a la generación y transmisión de electricidad en Amazonia. En las reservas y parques brasileños, 7.3 millones de hectáreas fueron afectadas por eventos de PADD, y de estos, 5.2 millones de hectáreas fueron afectadas por el reajuste o la eliminación de las listas. Además, proyectos que están siendo considerados por el Congreso Federal pueden remover 2.1 millones de hectáreas de AP tan solo en Amazonia. Relajar el estado de protección de APs existentes está probando ser políticamente fácil en Brasil, y el incremento reciente en la frecuencia y la extensión de PADDD refleja un cambio en la política gubernamental. Al tomar ventaja de las deficiencias crónicas en los recursos financieros y de personal y en la vigilancia, de las disputas por tenencia de terrenos, y de la lentitud de la justicia brasileña, las agencias de gobierno han estado implementados PADDD son consulta*

de la sociedad civil. Si los parques y las reservas quieren mantener su integridad, las inversiones en las APs brasileñas serán necesarias junto con un mejor entendimiento de los beneficios que las APs proporcionan.

Palabras Clave: conservación *in situ*, PADDD, parques nacionales, política de conservación

Introduction

Currently, nearly 158,000 protected areas (PAs) cover some 13% of Earth's surface (WDPA 2012). Despite a concern about the size, location, distribution, efficiency, regime of management, and social impacts of PAs (e.g., West et al. 2006; Joppa & Pfaff 2009; Mora & Sale 2011), they remain key elements in the maintenance of biodiversity and ecological services (e.g., Chape et al. 2005; Hannah et al. 2007; Gaston et al. 2008). The current worldwide PA system can and should be improved, but there is a consensus that PAs are environmentally important to our planet (e.g., Bruner et al. 2001; Terborgh & van Schaik 2002; Nepstad et al. 2006; Andam et al. 2008).

Brazil has the largest PA system in the world, nearly 220 million ha or 12.4% of the global total (WDPA 2012). Excluding indigenous lands, *quilombola* territories (areas owned by descendants of slaves), and military areas, other categories of parks and reserves are recognized in Brazil and are locally known as *unidades de conservação* (conservation units, hereafter CUs). Conservation units are managed administratively at federal, state, and municipal levels. Federal CUs are regulated by the *Sistema Nacional de Unidades de Conservação* (National System of Conservation Units, hereafter SNUC). Created in 2000, SNUC aims to unify and standardize administration and management of CUs (Supporting Information). In 2007, the responsibility for creation and management of federal CUs was transferred to the Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio). Although states are responsible for the management of their CUs, many have not fully implemented their own PAs systems yet.

Currently, there are 886 federal, 729 state, and 147 municipal CUs that cover nearly 150 million ha (MMA 2013). Sustainable use CUs (1214 sites, or 68.9% of all CUs), which have the goal of conserving ecosystems and habitats and cultural values and traditional natural resource management systems, are the most numerous and cover the largest area (about 100 million ha or 65.9% of all CU). Because of their area and diversity, CUs are essential to maintain biodiversity and ecological services, including carbon storage and sequestration (e.g., Nepstad et al. 2009; Ricketts et al. 2010; Soares-Filho et al. 2010). From the mid-1990s to the mid-2000s, Brazil substantially expanded its PA and created very large CUs, such as the 5.0 million ha Terra do Meio Mosaic, the 4.2 million ha Grão-Pará Ecological Station, and the 3.6 million ha Paru State Forest (Veríssimo et al. 2011). Since 2009, the creation of CUs in Brazil has stagnated.

PAs are a commitment and a legacy to future generations. However, PA downgrading, downsizing, and degazettement (hereafter PADDD) has become increasingly common in many countries and is currently a global phenomenon (Mascia & Pailler 2011; WWF 2014). Recently, the national and international media reported changes in Brazilian CUs (e.g., Bragança 2012; Mongabay.com 2012; Piovesan & Siqueira 2012). Do these trends reflect a change in Brazil's PAs policy? How extensive are such changes, and why are they happening? To answer these questions, we analyzed the occurrence, frequency, magnitude, type, spatial distribution, and causes of changes in boundaries and categories in Brazilian PAs in the last 3 decades.

Survey of Changes in Brazilian Conservation Units

We examined enacted PADDD events throughout Brazil between January 1981 and December 2012 and proposed PADDD events in Brazilian Amazonia (i.e., formal initiatives in progress or under analysis that could affect CUs in that region; see WWF 2014 for definitions). We considered only federal and state CUs, not indigenous lands, military PAs, or *quilombola* territories. Municipal CUs were not included due to the difficulty of identifying their areas. We classified CUs as sustainable use or full protection (Supporting Information).

For the analysis of enacted PADDD, we followed the definition created by Mascia and Pailler (2011). *Downsizing* is an event in which a CU has its legal boundaries officially altered by decree or similar legal act, the result of which is the reduction of its area without the alteration of type or category of use. *Degazettement* refers to events in which a CU loses completely its protection status and no longer exists as a CU. *Downgrading* refers to a decrease in legal restrictions on the number, magnitude, or extent of human activities within the CU. We also investigated *Reclassifications*; that is, the category of a CU changes, but the area and protection status of the CU is maintained. *Upgrading* is when a change in category results in an increase in legal restrictions on the number, magnitude, or extent of human activities within the CU's boundaries. Following SNUC designations, alterations of status necessarily imply a change of category, but alterations of category do not necessarily imply a change of status. For example, a biological reserve reclassified as a national park undergoes a change of category, but not a change in status of protection because they are both in the full protection category, whereas a biological reserve

reclassified as extractive reserve undergoes alteration of both status of protection and CU category.

We searched for enacted PADDD events in Google (www.google.com), Google Scholar (http://scholar. google.com.br/), Portal Periódicos CAPES (www. periodicos.capes.gov.br), Scientific Electronic Library Online (Scielo–www.scielo.org), and Web of Knowledge (www.webofknowledge.com). Portuguese equivalent keywords used (alone or combined) were *adjustment*, *alteration*, *PA*, *compensation*, *conflict*, *degazettement*, *legal exclusion*, *law*, *limits*, *area lost*, *changing limits*, *reclassification*, *downsizing*, and *reserve*. Whenever an event was identified, a new search was made, focusing specifically on the name of the PA linked to the event.

We also used the PAs database maintained by ICM-Bio (2012), the Ministry of Environment´s *Cadastro Nacional de Áreas Protegidas* (National Registry of Protected Area) (MMA 2013), the WWF Brazil´s *Observatório de Áreas Protegidas* (Observatory of Protected Areas) (WWF 2013) (as above), and the Instituto Socioambiental´s website of PAs in the Brazilian Amazonia (ISA 2013). When different sources provided conflicting information, we used the information from official sources.

For the analysis of proposed PADDD, we searched the websites of the Chamber of Deputies (http://www2. camara.gov.br/) and the Federal Senate (http://www. senado.gov.br/) for bills or legal acts and the websites of the *Tribunal Regional Federal* (Regional Federal Court of the 1st Region), Supreme Court of Justice, and Supreme Federal Court for lawsuits in progress whose object could result in changes in CU boundaries in Amazonia (see Martins et al. 2012).

Once identified, we compiled the information on the enacted or proposed change in a spreadsheet containing CU name, municipality, state, and region (north, northeast, mid-west, southeast, or south); CU biome (Amazonia, Caatinga, Cerrado, Atlantic Forest, Pantanal, Southern Grasslands, and Marine; only for enacted PADDD events); CU management level (federal or state); CU date of creation and area; CU current area; type of event (downgrading, downsizing, degazettement, reclassification, or upgrading); date of event; CU pre- and postevent category; area lost or gained; change in intention of CU; event extension of threatened area (only for proposed PADDD); event drivers and context; and supporting references about each event. We considered affected area the total area of the affected PAs subject to sum of downgrading, downsizing, degazetting, reclassifying, and upgrading and lost area the total area lost to downsizing and degazetting.

For the temporal distribution of events in federal areas, we considered the last 9 presidential terms in Brazil: João Batista Figueiredo (part of his term, 15 March 1979 to 14 March 1985), José Sarney (15 March 1985 to 14 March 1990), Fernando Collor de Melo (15 March 1990 to 29 September 1992), Itamar Franco (30 September 1992 to 31 December 1994), Fernando Henrique Cardoso (first term, 1 January 1995 to 31 December 1998, and second term, 1 January 1999 to 31 December 2002), Luís Inácio Lula da Silva (first term, 1 January 2003 to 31 December 2006, and second term, 1 January 2007 to 31 December 2010), and Dilma Rousseff´s (part of current term, 1 January 2011 to 31 December 2012).

Frequency and Extension of Changes in CUs in Brazil

Enacted PADDD

We identified 93 events that changed the boundaries or categories of Brazilian CUs in the last 31 years: 5 downgrading, 26 downsizing, 11 degazetting, 49 reclassifying, and 2 upgrading (Supporting Information). Events occurred in 16 out of the 27 Brazilian states (Supporting Information). Sixty-nine events occurred in full protection CUs and 24 occurred in sustainable use CUs (Fig. 1). Sixty-eight events occurred in state and 25 in federal CUs. The Amazonian biome had the largest number of events (39 or 42.3% of the total), and marine areas had the smallest (1 event [Fig. 1]).

In CUs 7,289,214 ha were affected by one or more events: 53.9% of the area affected was downsized, 20.8% was downgraded, 17.0% was degazetted, 7.8% was reclassified, and 0.5% was upgraded (Fig. 2). Most of the PADDD events were in sustainable use CUs (56.3% of the total): 74.9% of that area was downsized, 24.5% was degazetted, 0.5% was upgraded, and 0.1% was reclassified. Most of the CUs affected were federal (4,362,478 ha or 59.8% of the total): 78.3% of that area was downsized, 12.8% was reclassified, 8.4% was downgraded, and 0.5% was upgraded (Fig. 2). We did not detect any degazetting in federal CUs. In state CUs, 42.6% of the affected area was degazetted, 39.4% was downgraded, 17.6% was downsized, and 0.4% was reclassified.

Of the area lost to downsizing and degazetting, 78.8% occurred in sustainable use CUs (24.7% of the area was degazetted and 75.3% was downsized [Fig. 2]). Federal CUs accounted by 70.0% of the total lost area. The most substantial event affected the Roraima National Forest (2,497,416 ha, nearly 93.7% of the original area, lost in 2009). The affected area overlapped with and was reassigned to the Yanomami Indigenous Land. Among the 30.0% lost in state CUs, 70.7% of the area was degazetted.

The number of PADDD events increased in frequency over time. We detected 6 events from 1981 to 2000 (Fig. 3). In 2001, there was a peak of 11 events: 10 reclassifications and 1 downsizing. Events increased from 2008 on; events peaked at 37 in 2011. The period from 2008 to 2012 contained 74.1% of the events. Considering federal CUs only, no changes occurred during the presidential
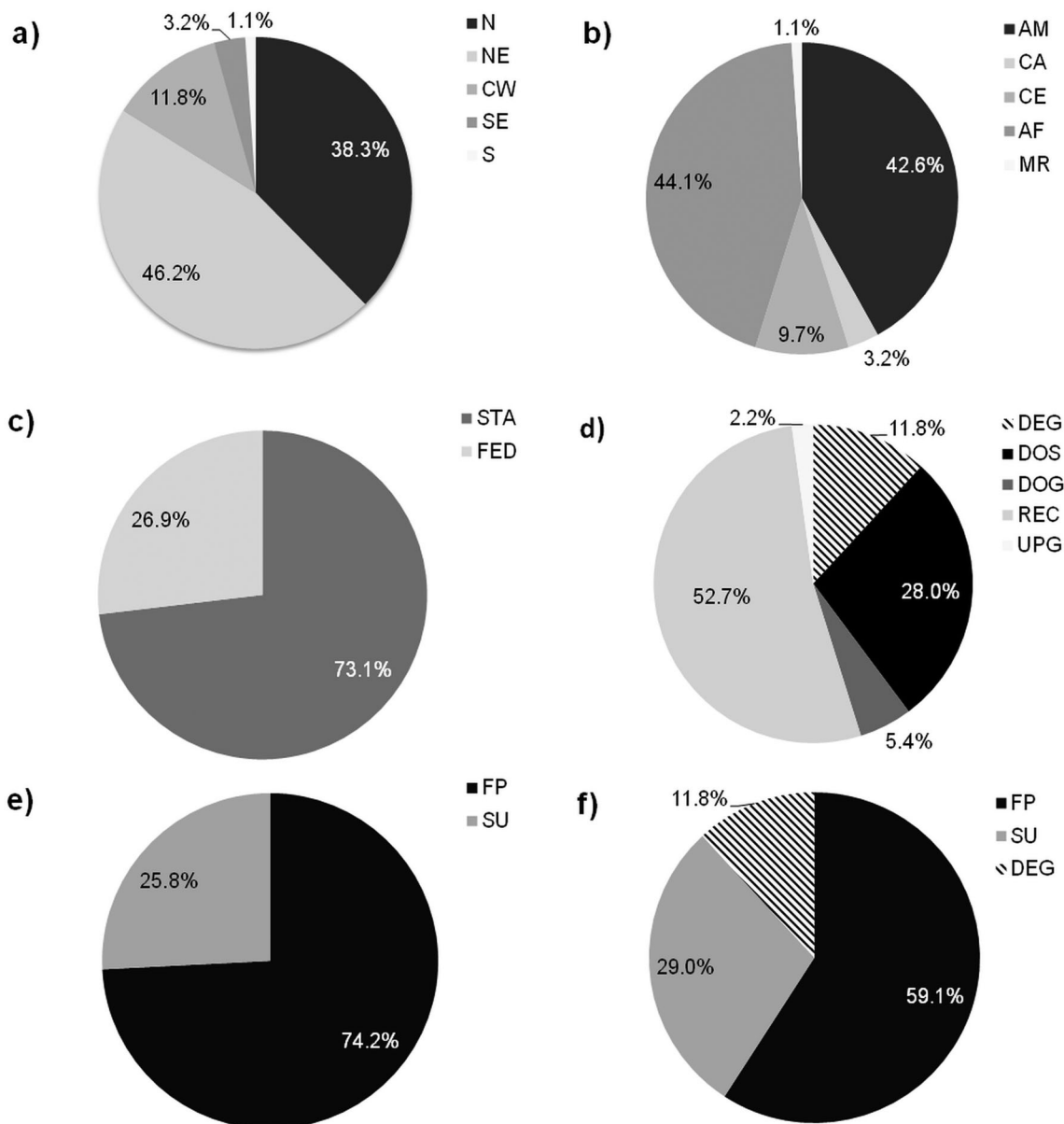
Figure 1. Percentage of protected areas in Brazil affected by downgrading, downsizing, and degazettement (PADDD) events from 1981 to 2012 by (a) region; (b) biome (AF, Atlantic Forest; AM, Amazonia; CA, Caatinga; CE, Cerrado; MR, marine); (c) administrative level (FED, federal; and STA, state); (d) type of event (DEG, degazettement; DOG, downgrading; DOS, downsizing; REC, reclassification; and UPG, upgrading); and category of protected area (e) before and (f) after events (DEG, degazettement; FP, full protection; SU, sustainable use).

terms of Sarney, Collor de Melo, Franco, or Cardoso's first term.

Changes were more frequent in CUs of <1000 ha (45 events, all reclassifications [Fig. 4]). Thirty-one events occurred in CUs >100,000 ha: 23 downsizings, 4 degazettements, 2 downgradings, and 2 reclassifications. The smallest affected area was the Mata do Passarinho Urban Forest (13.6 ha) in Pernambuco, which was reclassified in 2011, and the largest affected area was the Roraima National Forest (Supporting Information).

We categorized drivers of events into 10 categories (Fig. 5): proposal of a new category (1 event, Mamirauá Ecological Station was reclassified as a sustainable development reserve in 1996, before the promulgation of SNUC); reclassification to be in accordance with the SNUC (8 federal CUs reclassified in 2000, 31 Pernambuco CUs reclassified in 2011, 4 Mato Grosso CUs reclassified in 2001 and 2011, and 1 CU Maranhão reclassified in 2011); agribusiness (8 events in which the CU area or status were affected by pressures from the agriculture or
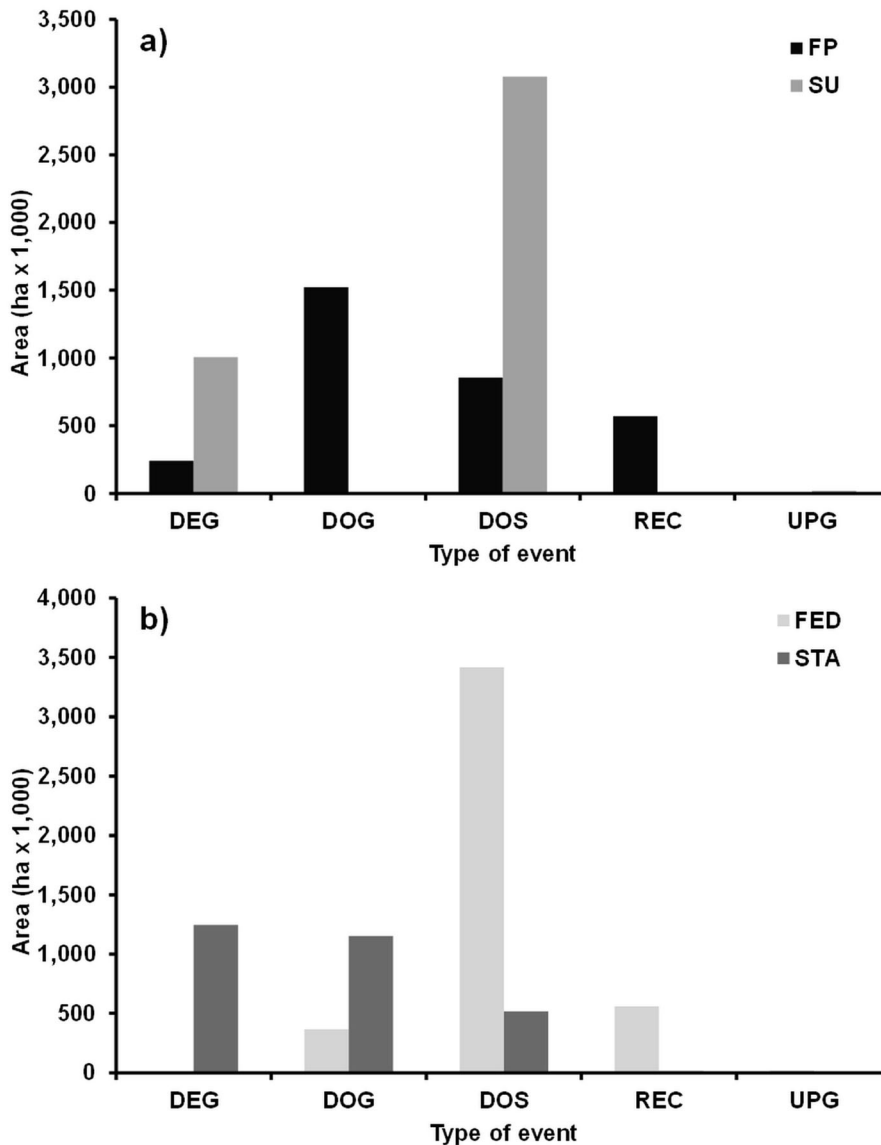
Figure 2. Amount of protected area affected by downsizing (DOS), degazettement (DEG), downgrading (DOG), reclassification (REC), and upgrading (UPG) in Brazil from 1981 to 2012 by protected area (a) category (FP, full protection; SU, sustainable use) and (b) administrative level (FED, federal; STA, state).

livestock sectors); conversion to allow rural settlement (Rio Negro Setor Sul State Park was partially degazetted as a result of agrarian reform); reclassification to allow tourism (Anavilhanas Ecological Station was reclassified as a national park to allow ecotourism.); reclassification to resolve overlapping land uses (5 cases in which CU limits were changed to resolve overlapping legally recognized land use classification, either indigenous lands, other PAs, or private lands); real estate conversion (7 cases, changes resulted from pressures by the construction sector); generation and transmission of electricity (21 cases associated with the construction of hydroelectric power plants or deployment of transmission lines); political interference (3 cases that resulted from direct political intervention for unspecified reasons); and conservation (Jericoacoara National Park, previously an environmental protection area, and Murici Ecological Station,

previously an area of ecological concern, were upgraded for conservation purposes).

Proposed PADDD

There are 4 legislative bills that propose to degazette, downsize, or downgrade 5 CUs in the Brazilian Amazonia (Table 1): Serra do Pardo National Park, Terra do Meio Ecological Station, Nascentes da Serra do Cachimbo Biological Reserve, and Jamanxim National Forest. All but one of these CUs (the Rio Ouro Preto Extractive Reserve in Rondônia) are in the state of Pará. Two bills were proposed in the Chamber of Deputies and 2 in the Federal Senate from 2006 to 2009. All have received at least one favorable commission vote and remain in the pipeline for plenary voting. If the bills are enacted, the changes would affect parks and reserves that cover 2,102,951 ha
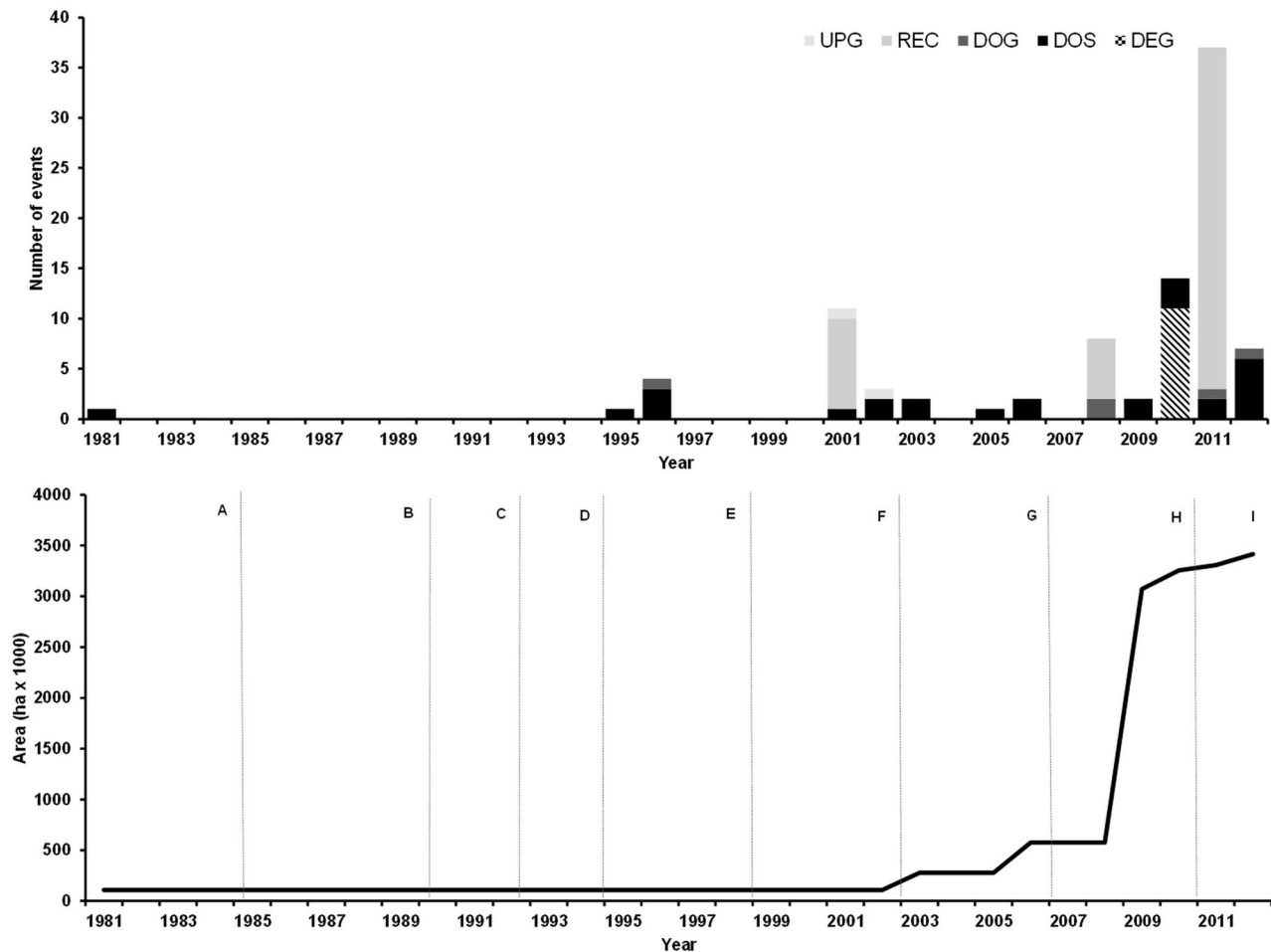
Figure 3. From 1981 to 2012, temporal distribution in Brazil of (top) downsizing (DOS), degazettement (DEG), downgrading (DOG), reclassification (REC), and upgrading events in protected areas by type of event in state and federal areas and (bottom) federal protected area downsized and degazetted (cumulative) by presidency (dashed lines, demarcate presidential terms; A, Figueiredo; B, Sarney; C, Collor; D, Franco; E, Cardoso's first term; F, Cardoso's second term; G, Lula da Silva's first term; H, Lula da Silva's second term; I, Rousseff).

(Table 1). In all the cases, the limits of the CUs have been challenged on the basis of land tenure, generally due to a claim on the land ownership previous to the creation of the area.

Changes in the Government's Attitude toward PAs in Brazil

Although Brazil has a massive PA system, accounting for the largest share of parks and reserves in the world, we found extensive changes in the boundaries and categories of CUs have occurred from 1981 to 2012. The increase in PADDD was most evident after 2007. Since 1981, Brazilian parks and reserves covering 7.3 million ha have been affected in some way, and of this 7.3 million ha, 5.2 million ha were degazetted or downsized. Furthermore, the Brazilian Federal Congress has proposed altering the limits of CUs covering 2.1 million ha in Amazonia alone.

Not all the events we detected were necessarily bad from a conservation perspective. Some reflected appropriate adjustments and refinements of protection. This is the case for CUs reclassified after the creation of the SNUC in 2000 and later for the creation of equivalent state systems. However, a recent increase in the frequency and extension of PADDD events point to a shift in the government's attitude, in particular the federal administration, relative to its national PAs system. The federal government has to date not degazetted any CU—a practice so far restricted to state governments—but it is accelerating the pace of downsizing and downgrading.

Technical studies and public consultation have not characterized the recent PADDD in Brazil (Araújo et al. 2012). On the contrary, PADDD has been occurring unilaterally by presidential (for federal CUs) or state governor decrees (for state CUs). None of the recent PADDD events in Brazil were based on technical studies that
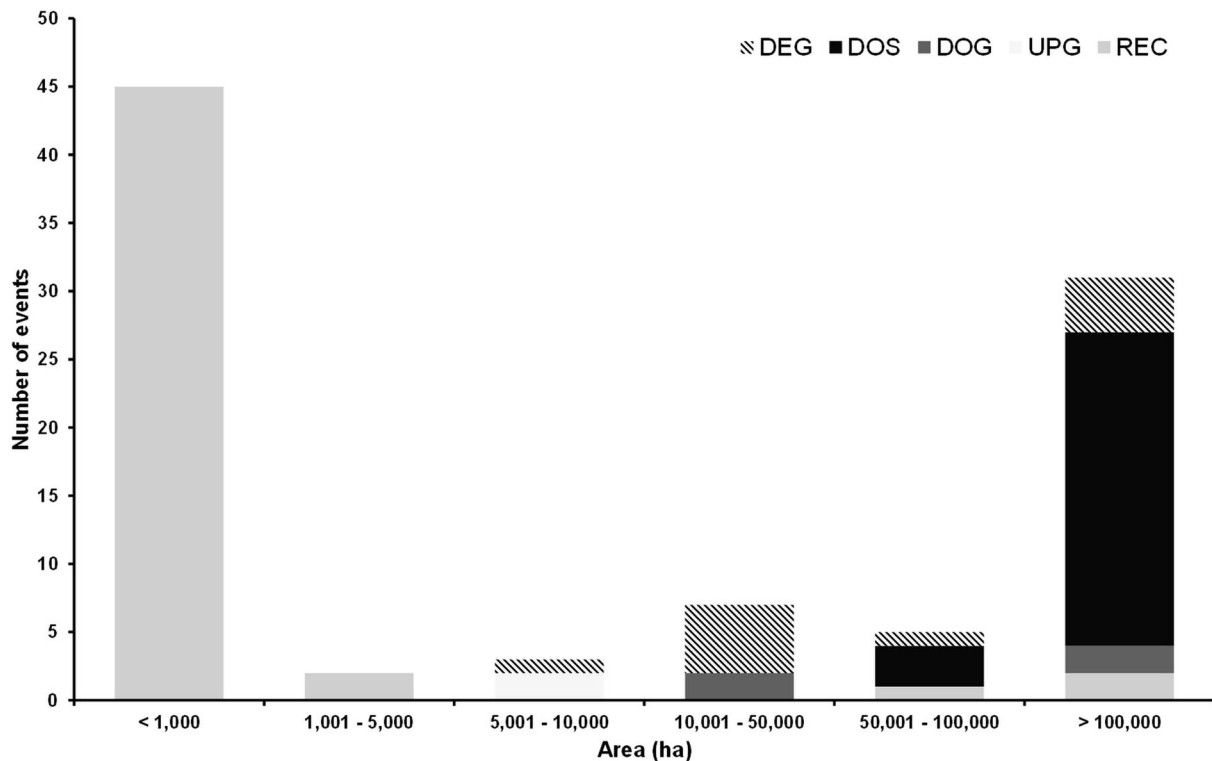
Figure 4. Distribution of events of downsizing (DOS), degazettement (DEG), downgrading (DOG), reclassification (REC), and upgrading (UPG) of protected areas in Brazil from 1981 to 2012 by size class.

considered their impact on the CU, and there was no consultation with civil society. To the contrary, legislative chambers have been sensitive to political lobbying from the agribusiness, construction, and energy sectors. Relaxing the protection status of existing CUs is proving to be politically easy in Brazil. Forty-five percent of CUs are controlled by states (MMA 2013), and they accounted for all the degazetted area (approximately 1.2 million ha). State legislative chambers are arguably more susceptible to local interests and political deals; therefore, state CUs are more vulnerable to PADDD. In Rondônia, for example, the Guajará-Mirim State Park was downsized twice (1996 and 2002), while Corumbiara State Park was downsized first in 1996 and was completely degazetted in 2010.

Temporal Patterns and Drivers

The historical distribution of changes in Brazilian CUs reveals a long period, from 1981 to 2000, during which there were few records of downsizing (5) and downgrading events (1), and most of these were in state CUs of Rondônia (5), indicating that in general PAs boundaries were being respected. In 2001, there was a peak in the number of PADD events, mainly reclassifications due to the establishment of the SNUC (Brasil 2000). Searching for standardization and legal compliance, the Ministry of Environment and some states (such as Per-

nambuco, later in 2011) reclassified several CUs that did not fit in the categories proposed. Most of these reclassifications could be considered positive because the intent was a more organized and consolidated PA system.

From 2002 to 2007, driven mainly by pressures from the agribusiness, 422,328 ha of CUs were lost to downsizing in 6 separate events (5 in state CUs). From 2008 on the scenario changed: downsizing and downgrading became frequent and were associated with the generation and transmission of electricity. This shift coincided with Lula da Silva´s second term and Dilma Rousseff´s current term, both marked by a growing economy and subsequent increase in the demand for electricity (Brasil 2007).

In Brazil, there is a projected annual growth of 4.5% in the demand for energy over the next 10 years (EPE 2012). To meet this demand, Brazil, which is strongly dependent on hydroelectricity, plans to increase the number of power plants in the country. In 2007, the Ministry of Mines and Energy published its National Energy Matrix 2030 (Brasil 2007), indicating the construction of hydroelectric plants in all large rivers of Amazonia (Brasil 2007). In 2010, the Federal Decree 7154 addressed prospecting studies on hydropower potential and distribution of electricity within CUs and their installation in sustainable use CUs. These regulatory changes in federal CUs have now started to occur in Amazonia. Between 2010 and
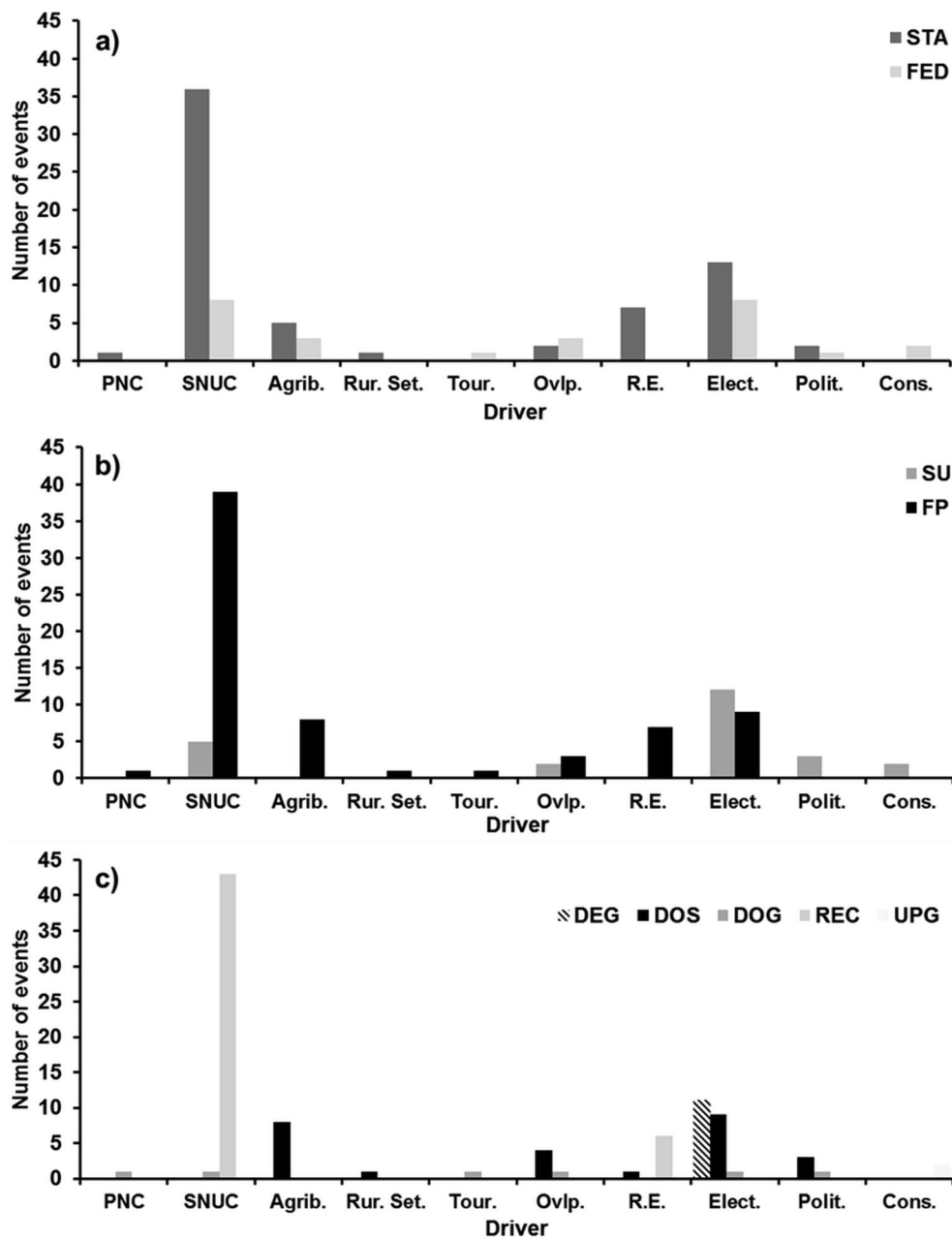
Figure 5. Drivers behind changes in protected areas in Brazil from 1981 to 2012 by (a) administrative level (FED, federal; STA, state); (b) category of protected area (FP, full protection; SU, sustainable use); and (c) type of event (DEG, degazettement; DOG, downgrading; DOS, downsizing; REC, reclassification; UPG, upgrading). Drivers: Agrib., agribusiness; Ovlp., reclassification to resolve overlapping land uses; PNC, proposal of a new category; Polit., political interference, and Cons., conservation; R.E., real estate conversion; elect., generation and transmission of electricity; Rur. Set., conversion to allow rural settlement; SNUC, reclassification to be in accordance with SNUC rules; tour., reclassification to allow tourism.

2012, 19 CUs and other PAs were downsized or downgraded for the generation and transmission of electricity (Araújo et al. 2012), indicating the government's preference for energy generation over PAs. Not surprisingly, river damming is as a major conservation issue for Amazonia in the next years (Finer & Jenkins 2012; Castello et al. 2013).

A Matter of Cost versus Opportunity

Proximate causes of PADDD events vary widely among countries and regions, but often they are related to the access and use of natural resources or competition for space for infrastructure and energy production (Mascia & Pailler 2011). If PAs were subject to the

Table 1. Bills and decrees proposing the alteration of boundaries of protected areas in the Brazilian Amazonia under evaluation by the Brazilian National Congress.

Protected area	State[a]	Identification (year of introduction)	Objective	Affected area (ha)
RESEX Rio Ouro Preto	RO	bill 206 (2007)	downsizing	31,489
FLONA Jamanxim	PA	decree 258 (2009)	degazettement	1,301,120
REBIO Nascentes da Serra do Cachimbo	PA	bill 1148 (2008)	change of category and downsizing	1785
ESEC Terra do Meio	PA	bill 6479 (2006)	area exchange	181,743
PARNA Serra do Pardo	PA	bill 6479 (2006)	downsizing and area exchange	586,813
Total area				2,102,951

[a]*Abbreviations: PA, Pará; RO, Rondônia.*

same cost-benefit analyses as any private project, they could receive broader public support. This is the case of Brazilian CUs. Their creation and maintenance sequesters at least 2.8 billion tons of carbon, conservatively estimated to have a value of US$48.3 billion (Medeiros et al. 2011). In addition, the estimated value of the carbon stock held by these areas is from US$1.46 billion to US$2.92 billion/year. Brazilian CUs have the potential to accommodate 20 million visitors/year and to have a total economic impact of approximately US$1.10 billion (Medeiros et al. 2011). Furthermore, 80% of the hydroelectricity in the country comes from rivers that have at least one tributary crossing a CU, 9% of the water for human consumption is directly collected within CUs, 26% is collected in springs directly downstream of a CU, and 4% of the water used in agriculture and irrigation is collected in springs within or downstream of a CU (Medeiros et al. 2011). If such values are properly internalized in the national economy, the benefits generated by Brazilian CUs greatly exceed the current expenditures on their management. In fact, with the correct accounting of environmental services, some PAs around the world are more economically profitable than the enterprises projected to occupy their space (Scharlemann et al. 2010; Strassburg et al. 2010; Fearnside & Pueyo 2012).

Maintaining of PA Integrity in Brazil

Currently, the Brazilian CU system covers some 150 million ha (MMA 2013). We found that nearly 3.4% of CU area has been degazetted or downsized, mostly since 2008. Will this trend continue? The increasing frequency and intensity of PADDD in Brazil means actions and mechanisms to assure the integrity of the remaining PAs need to be identified. Downsizing and degazetting can be legally challenged through federal and state prosecutor's offices, though this is not an ideal solution because the slowness of the Brazilian justice system (e.g., Barreto et al. 2011; Araújo et al. 2012) can delay definitive decisions such that irreversible damage may be done to the ecological integrity of the CU during the process. In addition, long judgment processes may encourage new threats or the

expansion of the already existing threats. Nevertheless, technically unsupported and biased PADDD initiatives can be challenged through the courts.

Brazil also should improve technical assessments of the locations dimensions, and environmental, social, and economic impacts of infrastructure projects such as dams, hydroways, roads, and power lines affecting CUs. Such projects cause habitat loss, degradation, and fragmentation (e.g., Souza Jr. et al. 2005; Laurance et al. 2009). Current plans to dam almost all large Amazonian rivers needs to be reconsidered because this will have severe environmental impacts (e.g., Fearnside 2006; Vale et al. 2008; Fearnside & Pueyo 2012; Finer & Jenkins 2012). Seventeen parks, reserves, and indigenous lands will be directly or indirectly affected by 10 hydroelectric power plants planned for the Brazilian Amazonia in the next 8 years (see Araújo et al. 2012).

More effective management of CUs would deter PADDD events. The so-called paper parks—PAs that exist only on maps and in the law but offer little real environmental protection—are more vulnerable to having their boundaries challenged (e.g., Rife et al. 2012). A rapid assessment and prioritization of PA management conducted in 2007 in 246 Brazilian federal CUs showed that only 13% of these CUs were highly effective, 36% were moderately effective, and the remaining 41% were primarily ineffective (Onaga & Drumond 2007). About 50% of CUs in Brazilian Amazonia do not have management plans, and approximately 45% do not have a management council (Veríssimo et al. 2011). Implementing these areas de facto would help reduce the political pressure for their degazettement or downsizing.

Illegal logging in Brazilian CUs, which is frequently associated with the opening of pastures and areas for agriculture, should be actively discouraged, and the government should send a clear message that such activities are not tolerated within CUs. The larger problem, however, is that Brazilian environmental agencies and prosecutors are too slow to stop and prosecute the invasion and illegal harvest of timber within CUs. In a study of environmental crimes through 2008, Barreto and Mesquita (2009) identified some 1200 instances in federal CUs and

indigenous lands in Amazonia. Of these, only 5% were prosecuted, and about 70% were still under investigation, a phase that can last from 2 to 8 years (Barreto & Mesquita 2009). Several measures are in progress to change this situation (Barreto et al. 2011), but they are recent and will have an effect in the medium and long term. With this weakness in prosecution, the prevention of environmental crimes within CUs must be the priority.

Nolte et al. (2013) found that unsettled land tenure conflicts within PAs contributes more to deforestation than other factors, such as deficiencies in park budget, staff, equipment, management plans, and stakeholder collaboration. Hence, land tenure regularization of Brazilian CUs is fundamental to accomplish their conservation objectives (Rocha et al. 2010). Data compiled by ICMBio indicates that 3 out of 10 ha of CUs in Brazil did not undergo the legal process of ownership transfer, and at least 188 of these areas still have private properties within. The estimated cost to solve these land tenure problems is US$5.1 billion (Angelo & Magalhães 2011; Bragança 2013).

Solving the problems associated with surveillance, effectiveness, and land tenure will require an increase in the budget for the Brazilian CU system. However, the Ministry of the Environment (MMA) has a low capacity to mobilize political interest and negotiate budget increases. Multilateral initiatives, such as ARPA Program (*Programa Áreas Protegidas da Amazônia*, http://programaarpa.gov.br/en/), that aim to expand, consolidate, and maintain 50 million ha of CUs in the Amazon biome are exceptions. Nevertheless, MMA has one of the 5 smallest budgets among Brazilian ministries (0.15% of the total budget in 2011), and since 2006, it has undergone consecutive budget cuts (Menezes & Chagas 2012). The average disbursement since 2000 was about US$900 million/year, and only part (approximately US$150 million/year) of these funds was designated to the management of federal CUs. Funds designated for the maintenance of federal CUs have remained relatively unchanged since 2001, but because the area of federal CUs has increased by approximately 83.5% from 2000 to 2009, the CU funds per hectare actually decreased by about 40% (Medeiros et al. 2011). Investments of approximately US$900 million would be necessary to provide state and federal CUs with sufficient funds for basic infrastructure and planning, and an additional US$455 million/year would be needed to make this system function to its full capacity (MMA 2009). Staff costs were not considered in these calculations. Brazil has some of the largest PAs in the world, but they are understaffed. An analysis of 246 CUs showed there is an average of 1 employee/187,100 ha of federal CUs (Onaga & Drummond 2007). There is a need to hire 800 employees so that 5 employees would be assigned to each area (Muanis et al. 2009).

The overall message should be clear: PAs offer environmental services and economic opportunities amidst a complex and uncertain future that involves the need for biodiversity conservation, climate change mitigation, and consideration of the welfare of human populations. An extensive global network of PAs has been developed over many years (WDPA 2012). These systems and the national level of commitment to their maintenance vary considerably among nations. But the weakening of such networks due to PADDD events, such as those happening in Brazil and other parts of the world (Mascia & Pailler 2011), compromises the capacity of these areas to deliver benefits that may be crucial in a near future.

Acknowledgments

Supporting Information

The equivalence between the International Union for Conservation of Nature categories of PAs and the SNUC (Appendix S1); a list of all 93 PADDD events detected (Appendix S2); and a map showing the spatial distribution of these events (Appendix S3) are available online. The authors are solely responsible for the content and functionality of these materials. Queries (other than absence of the material) should be directed to the corresponding author.

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