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Uneven conservation efforts compromise Brazil to meet the Target 11 of Convention on Biological Diversity

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Brazil is the most biodiverse country in the world. It performed an expansion of its Protected Areas system in order to better preserve nature and to accomplish international agreements, such as the Target 11 of the Convention on Biological Diversity, which establishes a minimum percentage of territorial coverage and adequate management of Protected Areas (PAs). We evaluated the achievement of those objectives by analyzing the distribution of Conservation Units (CUs), Indigenous Territories and other classes of PAs on Brazilian biomes, as well as their current management situation. The country is unlikely to meet the target due to the lack of PAs outside the Amazon biome and to poor CUs management conditions, whose main causes are the fragile financial situation of environmental agencies and the high costs of land tenure regularization. In addition to other environmental policies setbacks, the Brazilian environmental leadership is seriously threatened.

Introduction

Protected Areas (PAs) are one of the main pillars of species conservation and ecosystem functions safeguard (Rodrigues et al., 2004). According to the Convention on Biological Diversity (CBD), a Protected Area is "a geographically defined area, which is designated or regulated and managed to achieve specific conservation objectives". In order to foster the effective protection of global natural heritage, the CBD has set 20 targets (Aichi Targets) in its Strategic Plan for Biodiversity 2011–2020. Aichi's Target 11 establishes that Protected Areas should cover 17% of terrestrial and inland water, and 10% of coastal and marine areas in all countries, while being ecologically representative, satisfactorily integrated into the wider land and seascapes, and managed in an effective and equitable way (CBD, 2017).

Brazil is a signatory of CBD and has set its own goals to meet Aichi Targets in one of the National Biodiversity Commission resolution (BRAZIL 2013). Such goals are even more ambitious than CBD's as they establish that 30% of the Amazon should be protected and each biome should individually meet 17%, while keeping the management statement. In order to accomplish it, Brazil considers the following PAs classes: Conservation Units (CUs), the main land use designation for environmental conservation in the country, corresponding to the classification of IUCN Protected Areas (classes I to VI); Permanent Preservation Areas (PPA), including riverside forest buffers, hilltops, high elevations and steep slopes; Legal Reserves (LR) which are part of rural properties whose native vegetation has to be maintained by the landowner, representing 80% of forested and 35% of savanna areas located in the Legal Amazon, and 20% of other ecosystems in Legal Amazon and regions of Brazil; and Indigenous Territories (ITs) containing native vegetation.

In the present study, we evaluated the Aichi's Target 11 achievement, in attendance of Brazil (2013), by: (1) analyzing the proportion of the Brazilian territory and its biomes covered by PAs – CUs, PPAs, LRs and ITs; (2) discussing the PAs effectiveness and main challenges for environmental protection; and (3) monitoring the CUs financial situation based on the available literature and data synthesis, including the liability of implementation and expansion of the entire CU system given the current political context.

Material and methods

In order to estimate the extent of Brazilian territory covered by CUs, we consulted the National Registry of Conservation Units (CNUC, 2017). We collected information on the area covered by federal, state, and municipal CUs in each of the six Brazilian biomes, in addition to coastal and marine areas, and recorded the kind of land and natural resources uses allowed (i.e., Sustainable Use CUs = IUCN categories IV, V and VI; Strict Protection CUs = IUCN categories I, II and III). Conservation Unit categories are detailed in Table 2. Coastal

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Fig. 1. Brazilian biomes and its coverage by current CUs and ITs.
Source: Brazilian Ministry of Environment database (http://mapas.mma.gov.br/i3geo/datadownload.htm). Elaboration: Alexandre Ferrazoli.

and marine ecosystems were evaluated as a single biome according to data arrangement in literature and to the methodology defined by the National Biodiversity Commission Resolution (Brazil, 2013). No information was found about the extension of PPAs and LRs coverage by biomes, and the most recent estimates were obtained from Sparovek et al. (2010) and Soares-Filho et al. (2014). Indigenous Territories coverage follows ISA (2017) and includes identified, delimited, demarcated and homologated ones, not counting areas under identification studies.

We analyzed five groups of indicators concerning management effectiveness of terrestrial CUs: (i) the existence of a Management Plan – a document that determines the management objectives, planned procedures and actions in the focal CU; (ii) existence of an Advisory Board – a group of representatives from the government and the society that deliberates and issues opinions on the CU, ensuring balanced decision making; (iii) human resources of CUs, including local workers and senior planning officials; (iv) land tenure regularization, i.e., a process that guarantees the land ownership by the national or local governments in some CUs categories and strongly influences the relationship with the surrounding populations and the execution of the management plan; and (v) the existence of adequate infrastructures and operational resources, related to the existence of equipment and financial assets enabling the daily activities running. Data were obtained from Onaga and Drumond (2007), Brazil (2009), Muanis et al. (2009), Fonseca (2012), Rocha et al. (2010), Medeiros and Young (2011), Veríssimo et al. (2011) and TCU (2012).

The CUs financial situation has been analyzed based on the references previously mentioned, aside from the government expenditures and investment database (Portal da Transparência, 2015) and official data published in reports (Angelo and Magalhães, 2011; Bragança, 2013). All monetary values were calculated in Brazilian currency (Real), adjusted for inflation according to the IGP-M index (FGV), and then converted to US$ using the exchange rate of 1US$ = R$ 2.692 (January 2015).

Results

Territory coverage by Protected Areas

The distribution of ITs and CUs in each biome is presented in Fig. 1.

Altogether, the 2251 Brazilian CUs cover a total area of 1.54 million km^2 (Table 1).

The Amazon biome almost reaches the goal, with 27.7% of coverage (Table 1). The marine biome falls far short with the 10%

Table 1
Area Protected by Conservation Units (CUs) in each Brazilian biome in relation to its total area and kind of land and natural resources uses allowed. Situation of 2251 CUs in Jul. 2017.

Biome	Area (*10^3 km^2)		Coverage by CUs	Types (% of the total CU area)	
	Total	CUs		Strict protection	Sustainable use
Amazon	4199	1166.2	27.7%	37%	63%
Caatinga	828	64.7	7.8%	17%	83%
Cerrado	2040	177.2	8.7%	37%	63%
Atlantic Forest	1118	115.1	10.3%	25%	75%
Pampa	179	5.1	2.8%	17%	83%
Pantanal	151	6.9	4.6%	64%	36%
Terrestrial area and inland water	8514	1535.1	18.0%	35%	65%
Coastal and marine	3556	55.2	1.6%	10.0%	90.0%

Source: CNUC (2017).

Table 2
Relative contribution of different categories of Conservation Unities (CUs) in the Brazilian system. ESEC – Ecological Station, REBIO – Biological reserve, PARNA/PES – National/State Park, MN – Natural Monument, REVIS – Wildlife Refuge, ARIE – Area of Relevant Ecological Interest, RPPN – Private Reserve of Natural Heritage, APA – Environmental Protection Area, FLONA/FES – National/State Forest, RDS – Sustainable Development Reserve, REFAU – Fauna Refuge, RESEX – Extractive Reserve. Situation of 2251 CUs in July 2017.

CU types	IUCN category	CU category	Participation in CU system (%)							
			Amazon	Caatinga	Cerrado	Atlantic Forest	Pampa	Pantanal	Terrestrial area and inland water	Coastal and marine area
Strictly protection	Ia	ESEC	9.2%	2.15%	6.45%	1.29%	6.34%	1.7%	8.0%	0.3%
	Ia	REBIO	4.5%	0.11%	0.05%	2.17%	2.07%	0%	3.6%	1.0%
	II	PARNA/PES	23.1%	11.77%	28.49%	20.22%	7.74%	62.2%	23.2%	71%
	III	MN	0%	0.92%	0.21%	0.44%	0%	0%	0.1%	0%
	III	REVIS	0%	2.31%	1.39%	0.73%	0.51%	0%	0.3%	1.6%
		Subtotal	36.9%	17.3%	36.6%	24.9%	16.7%	63.9%	35.2%	10.0%
Sustainable use	IV	ARIE	0%	0.19%	0.05%	0.24%	0%	0%	0.1%	0%
	IV	RPPN	0%	0.74%	0.60%	0.95%	0.08%	36.1%	0.4%	0%
	V	APA	14.9%	80.80%	61.56%	72.57%	83.23%	0%	27.5%	80.4%
	VI	FLONA/FES	26.8%	0.84%	0.31%	0.31%	0%	0%	20.5%	0%
	VI	RDS	9.5%	0.15%	0.39%	0.45%	0%	0%	7.3%	0.1%
	VI	REFAU	0%	0%	0%	0%	0%	0%	0%	0%
	VI	RESEX	11.8%	0.03%	0.50%	0.62%	0%	0%	9.1%	9.5%
		Subtotal	63.1%	82.7%	63.4%	75.1%	83.3%	36.1%	64.8%	90.0%

Source: CNUC (2017).

target, while the other biomes vary from 2.8% to 10.3%. Sustainable Use CUs predominate in the system, which is remarkable because the efficiency of biodiversity protection and the permissiveness allowed for economic activities vary according to the CU class. A more detailed analysis shows that Areas of Environmental Protection (hereafter APAs) represent a majority of CUs in four biomes (Table 2).

The estimated coverage for ITs is 1.176 million km^2, or about 13.81% of the Brazilian territory. Its total deforestation is estimated at 2% (ISA, 2016), meaning they are very well-protected. The Amazon biome holds the highest percentage of ITs, as it concentrates 90.4% of the total area, followed by Cerrado (8%; Table 3). Other biomes together hold only 1.6% of the country's total ITs.

Soares-Filho et al. (2014) estimates the area protected by PPAs and LRs to be 1,930,000 ± 50,000 km^2, or about 22.6% of the country terrestrial area. However, no information was found regarding their distribution among biomes. Its overall percentage is summarized in Table 3, demonstrating that the total protected area, including all types of PAs, can reach 55.1% of the national territory:

CUs management indicators

The data demonstrate a negative picture regarding all management indicators. The majority of CUs (up to 92%) do not have a Management Plan (Fonseca, 2012), and most of those that have one are not managed in accordance to it (TCU, 2012). The amount required to develop the Plans is estimated to tens of millions of dollars (Brazil, 2009; Muanis et al., 2009). Furthermore, Advisory Boards are lacking 61.5% of federal CUs (Muanis et al., 2009).

The situation of land tenure is chaotic and requires deep investigation (Rocha et al., 2010). In the Amazon, for example, many CUs ownership is not even known. Diverse sources estimate that private lands occupy 54–200 thousand of km^2 of CUs throughout Brazil (Brazil, 2009; Angelo and Magalhães, 2011; TCU, 2012; Bragança, 2013). Besides, the necessary purchase of those areas would cost US$ 2.63–7.43 billion (Brazil, 2009; Angelo and Magalhães, 2011; Bragança, 2013). In 2009, infrastructure was estimated to be nonexistent or insufficient in 82% of the CUs in the Amazon, and in initial implementation stage in 13.5% (Muanis et al., 2009). The required investment in infrastructure is evaluated at U$ 383.6 million for the entire Brazilian CU system, besides US$ 47.7 million/year required for operation (Brazil, 2009). No study was found providing insight into coastal and marine CUs managerial situation. However, it is unlikely that it differs greatly from terrestrial CUs (Brazil, 2010; Conservation International, 2012).

A limited budget is a major impediment to the efficient management of Brazilian CUs, as US$ 3.3 to 8.1 billion are needed to consolidate all existing CUs, including land tenure regularization, equipment, infrastructure, advisory board and management plan implementation. The operational cost of the entire CU system, for human, administrative and operational resources, would require circa US$ 464.2 million per year (Brazil, 2009). These values disregard the CUs that still need to be created. The budget needed to manage the whole CU system, in order to meet the qualitative aspect of the Aichi's Target 11, represents US$ 942.3 million

Table 3
Territorial coverage of Brazilian biomes by Conservation Units (CUs), Indigenous Territories (ITs), Legal Reserves (LRs) and Permanent Preservation Areas (PPAs). For Caatinga, Cerrado, Pampa and Pantanal the only information available are CUs.

Biome	PA class						Total	
	Conservation Units		Indigenous Territories		Legal Reserves + Permanent Preservation Areas		Area (10^3 km^2)	Coverage of biome
	Area (10^3 km^2)	Coverage of biome	Area (10^3 km^2)	Coverage of biome	Area (10^3 km^2)	Coverage of biome		
Amazon	1166.2	27.7%	1063.4	25.33%	–	–	2229.6 + PPAs + LRs	53.03% + PPAs + LRs
Caatinga	64.7	7.8%	3.86	0.47%	–	–	68.56 + PPAs + LRs	8.27 + PPAs + LRs
Cerrado	177.2	8.7%	94.4	4.63%	–	–	271.6 + PPAs + LRs	13.33% + PPAs + LRs
Atlantic Forest	115.1	10.3%	8.05	0.72%	–	–	123.15 + PPAs + LRs	11.02% + PPAs + LRs
Pampa	5.1	2.8%	0.04	0.02%	–	–	5.14 + PPAs + LRs	2.82% + PPAs + LRs
Pantanal	6.9	4.6%	6.48	4.29%	–	–	13.38 + PPAs + LRs	8.89% + PPAs + LRs
Terrestrial area and inland water	1535.1	18.0%	1175.83	13.81%	1880–1980	22.1–23.2%	4590.9–4690.9	53.9–55.1%

to US$ 2.14 billion per year from 2017 to 2020. After this period, this amount would need to stabilize at US$ 464.2 million per year. However, the average annual budget for the managing body of the federal CUs was approximately US$ 137.1 million per year between 2010 and 2014, while the sum expended for land regularization did not reach US$ 400,000 per year from 2012 to 2014 (Portal da Transparência, 2015) – an amount increasing only during situations of serious conflicts inside CUs.

Discussion

Coverage of Brazilian territory by Protected Areas

The CUs and ITs large area in Amazon and the estimated extent of PPAs and LRs contribute to the broad coverage of the Brazilian territory by PAs. However, this hides serious management and infrastructure problems regarding CUs, PPAs and LRs – regardless of biome, region or administrative level (State or Federal) – as well as a huge PAs deficit in terrestrial biomes outside the Amazon, and in marine biomes. This severely hampers the achievement of the objectives for which PAs have been established. The available data also converge with a bigger picture where all CU management indicators, regardless of the biome, region or administrative level, are far from ideal.

The large coverage of the CUs and ITs network significantly contributes to protect the Amazon, the largest forest in the world, by preventing deforestation and other types of degrading land use (Soares-Filho et al., 2014; Brazil, 2016a). However, this disproportionate concentration of PAs in a single biome is worrying for Brazil, since the most threatened biomes (Cerrado, Atlantic Forest) are unprotected (Overbeck et al., 2015; Fernandes, 2016). Conservation Unities should be better distributed throughout the territory in order to attain Aichis Target 11 goal of ecological representativeness and to maximize biodiversity protection, which is, in principle, perfectly feasible since there is a countrywide myriad of unprotected areas pointed as priority when it comes to conservation (Brazil, 2016b).

Despite the great importance of ITs for environmental protection in the Amazon, major gaps are observed regarding to their contribution. Unlikely CUs, there is no prospect of significant expansion of ITs in other biomes, since they aim to protect indigenous populations displaced during the first centuries. Just like in any other PAs categories, it is important to make a general environmental diagnosis of ITs, primarily their contribution to native vegetation conservation in order to evaluate their eligibility as PAs, as stated by Brazil (2013). A good news is the creation of public policies meant to assist the environmental management of ITs and to train their inhabitants (Brazil, 2016a), which may improve the protection of the immense biological heritage they hold. While ITs may not contribute much to other biomes, these policies will be vital to enhance the strategic role they play in the protection of the Amazonian biome.

Regarding the contribution of PPAs and LRs to the PAs network, a lot of uncertainties remain. First, because they are small and scattered, making it difficult to settle their distribution and cover area. Some recent estimates have been made using remote sensing techniques (Sparovek et al., 2010; Soares-Filho et al., 2014), but the assessment of the whole picture would require much more detailed information, such as fine scale maps of drainage networks, river widths and estimates of forest remnants (Soares-Filho et al., 2014). Hopefully this will be better achieved in the coming years with the advancement of Rural Environmental Cadastre, a georeferenced system in which rural landowners provide social, economic and environmental property information (Brazil, 2016a). However, such cadastre is auto declaratory, and ideally, PPA and LR should not simply be included in the system – it would be necessary to check the information declared. Anyway, it is interesting to note its complementary role with CUs (except APAs) and ITs because they are to be within private properties, thus, they will have a relatively larger share of biomes outside the Amazon, where some types of public lands (including CUs and ITs) are not subject to this legislation. The estimates of Soares-Filho et al. (2014) show that a great effort will also be needed to restore PPAs and LRs throughout the country so that they can effectively contribute to the conservation of threatened biomes, especially throughout the Atlantic Forest, which has large deficits regarding to these PA modalities, in the Central-West region (Cerrado and Amazon of Mato Grosso and Goiás states) and in the eastern border of Amazon biome, on the frontier with the Cerrado (Tocantins and Maranhão states). Unfortunately, in a current debate, the restoration of such areas is being considered to be made with exotic species.

Due to problems in the PPAs and LRs implementation throughout the country, the contribution of these areas to biodiversity conservation has been debated. For example, from 2002 to 2010, Brazilian Government accounted PPAs and LRs as mere elements of landscape integration, not considering them in the meeting of Aichi's Target 11 (Brazil, 2016a), because of widespread illegal activities within private properties, as well as non-compliance with their very creation by landowners (Sparovek et al., 2010). Their preservation is missing an overall approach as there is no

management guideline, and the presence of vegetation on rural properties itself, is the sole available indicator. There is also uncertainty regarding the possible expansion of the PPAs and LRs network, as the legislation related to this issue was amended in 2012 and is currently being judicially challenged. If reversed, millions of hectares will benefit official protection in all biomes again (Soares-Filho et al., 2014).

Actually, of all Brazilian PAs types, only CUs are specifically created to preserve biodiversity. Furthermore, they are the sole class that directly converges with the classification of Protected Areas of the International Union for Conservation of Nature (IUCN), since they are to be managed and evaluated according to environmental metrics. Other land designations are primarily meant to stabilize sensitive environmental areas (PPAs), prevent total deforestation within rural properties (LRs) or guarantee the possession of original areas by traditional populations (ITs), while biological conservation is a secondary consideration. There is a high risk that poorly preserved areas – or not very relevant for conservation –, such as PPA and LR will be accounted as PAs, hiding the risk of biodiversity loss at long term.

Another serious problem, especially in forest ecosystems, is the predominance of APAs among CUs. This category is permissive of many economic activities, including some with high environmental impact, such as mining, forestry and industrial agriculture. Many times, they do not contain forest remnants and purely function as a territorial planning tool (Dourojeanni and Pádua, 2001; Padua, 2012). For these reasons, they even were excluded of the Brazilian Government workshop when defining priority areas for conservation (Brazil, 2010). APAs can be important buffers and ecological corridors between CUs with more restrictive use in well designed and managed territorial plans, besides contributing to the management of biodiversity in ecosystems where this aim is important, such as in the Pampa and Cerrado biomes. However, it is unacceptable that they represent 61.2–83.2% of the area covered by CUs in biomes outside the Amazon and Pantanal. In this way, it seems pretty likely that most of the area covered by CUs in many biomes is not providing the required native ecosystems protection. The predominance of APAs can be explained by the facility to create them compared to CUs of other categories, resulting from a simplified process and a reduced rate of conflicts (since it does not require expropriations or extreme restrictions to economic activities), making it easy to reach conservation goals and to access funds given by programs that benefit municipalities retaining larger CU coverage (e.g., "Ecological ICMS" – Taxes On the Circulation of Goods and Services; Dourojeanni and Pádua, 2001; Padua, 2012).

Coverage by biome

Among the Brazilian biomes, the most critical case is the Atlantic Forest one. A biodiversity hotspot that is more than half the target (10.3%) is protected, but of which 72.6% of the CUs are APAs. It is estimated that all of its (highly fragmented) remnants account for only 11.73% of the biome's original area (Ribeiro et al., 2009). A major effort is urgently needed to stop deforestation and restore this biome and to create a larger network of CUs protecting its biodiversity and astonishing level of endemism (Rodrigues et al., 2004; Ribeiro et al., 2009).

Other biomes with serious problems are the Pampa, the Cerrado and the Caatinga. The Pampa and Cerrado have been mainly exploited for livestock, crops, such as soybeans, and eucalyptus forests, respectively retaining 36% and 51% only of their native vegetation in 2009 (Fernandes, 2016; PMDBBS, 2016). Indeed, ecosystems where native grasslands predominate, such as some Pampa and Atlantic Forest ecosystems, need periodic management to maintain their biodiversity and prevent species losses, which is often impossible in CUs subject to very restrictive use (Overbeck et al., 2013). Specifically for the Pampa, the presence of APAs (83.2% of PAs area) does not seem to be an actual problem because it allows both the necessary intensity of management to maintain biodiversity and the mechanisms that can prevent activities with greater environmental impact, such as mining. A big challenge is to find how to expand PAs to other regions, especially in the less protected phytophysiognomies of plateaus and mountains.

The Cerrado – the most biodiverse savanna on the planet and a biodiversity hotspot – loses more than 1% of its native vegetation every year (Overbeck et al., 2015; Fernandes, 2016). Only 8.7% of the area is covered by CUs, 61.6% of which are APAs. In the Caatinga, APAs represent 80.8% of the entire CU system. Only 1.5% of the biome area is effectively protected under other CU categories, out of the ~50% of the original biome remaining in 2009 (PMDBBS, 2016). Marine CUs occupy only 1.6% of the total biome area, 80.4% of which is in APAs, thus seriously threatening mangroves, coral reefs and fish stocks. The percentage of coverage has remained stagnant for years (Brazil, 2016a) despite proposals completed and finalized by environmental agencies that are not approved by the Federal Government (Conservation International, 2012).

Management in Conservation Units

The verified situation for the management indicators, as well as the estimated values for implementation and operation of the Brazilian PAs system in relation to the current budget, indicates that the country will hardly meet its management quality objectives. The data also indicate that a significant budget increase is necessary in order to achieve the minimum level of efficiency for all indicators, while the reality of environmental policy in the country is characterized by setbacks in environmental agenda (e.g., Tollefson, 2011; Bernard et al., 2014; Loyola, 2014; Soares-Filho et al., 2014), political crises and, mainly, the reductions of the budget for research and management of PAs (Angelo, 2016; Arsenault, 2017; Fernandes et al., 2017). Brazil urgently needs to reformulate its model of management and financing of CUs by studying alternatives such as the payment for ecosystem services, a reality in CUs of several countries, like Mexico and Costa Rica (e.g., Muñoz-Piña et al., 2008; Pagiola, 2008).

Conclusion

It is not certain that Brazil will achieve the conservation goals adopted after CBD's meeting due to its insufficient territorial coverage of PAs in non-Amazonian biomes, particularly in coastal/marine ecosystems, and to the poor management of PAs. The appropriate quantification of LRs and PPAs will be decisive in ascertaining the fulfillment of this objective, although their low degree of preservation may reduce their contribution. The main cause behind the precarious management is the fragile financial situation of environmental agencies. The National Target should prioritize CUs out of other land designations that are not established and managed to ensure environmental protection, and because ITs have few possibilities to expand over threatened biomes. The predominance of APAs should be urgently reviewed. Considering them as important as other CU categories compromises the safeguard of Brazil's environmental heritage, especially in forest ecosystems.

Brazil needs to reformulate its CUs management and financing model by looking for alternatives, although the current political context is causing extensive setbacks to the environmental agenda, threatening the country compliance with international environmental agreements and its position as a global environmental leader.

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