ANALYZING TEMPORAL AND SPATIAL TRENDS IN MANAGEMENT PLANS OF FEDERAL PROTECTED AREAS IN BRAZIL

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Abstract: Protected areas are the most frequently used tool for the mitigation of threats to biodiversity. However, without effective management, the creation of new protected areas may be ineffective. In Brazil, protected areas must have both a governing body (consultative or deliberative council) and an official management plan. Here, we analyzed general trends and patterns in the approval of the management plans for Brazilian federal protected areas. We considered all federal protected areas, and compiled data on (i) the year the area was created, (ii) the type of protected area (integral protection *vs.* sustainable use), (iii) year its management plan was approved, (iv) year in which the management plan was revised after its approval, (v) total area (in hectares), and (vi) the biome in which the area is located. We stablished three groups of protected area: 1) Group A: protected areas created prior to 1979, 2) Group B: protected areas created between 1979 and 1999, and 3) Group C: protected areas created between 2000 to the present time. Finally, we tested whether time for the approval of the management plan suffered a simultaneous effect of the type of biome and type of categories of protected area (strictly protected vs. sustainable use areas). We found 211 (63.17% of the 334) protected areas with management plan. On average, the time taken for the creation and approval of a management plan far exceeds the deadlines (5 yrs.) defined under current Brazilian law. All Brazilian biomes are poorly covered by protected areas with effective management plans, with the highest and lowest value observed in the Pantanal (100%) and Caatinga (46.42%), respectively. Our results suggest that the effectiveness of many federal protected areas in Brazil can be reduced considerably by the lack of a management plan, with deleterious consequences for the country's principal conservation strategies.

Keywords: Brazilian biomes; conservation strategies; Brazilian environmental legislation; integral protection areas; sustainable use areas.

INTRODUCTION

In the last decades, the rapid increase in human population growth and anthropogenic activities, like deforestation, farming, and ranching, represented a serious threat to global biodiversity (e.g. Pimm *et al.* 1995, Myers *et al.* 2000, Maxwell *et al.* 2016). Protected areas are the most frequently used tool for the mitigation of these threats and have been the foundation of global conservation initiatives worldwide (Bruner *et al.* 2001, Rodrigues 2004, Rodrigues *et al.* 2004, Chape *et al.* 2005, Pimm *et al.* 2014, Watson *et al.* 2014). The target established by Convention on Biological Diversity (CBD) determines a coverage of 17% for the protection of terrestrial ecosystems and 10% for marine ecosystems (CBD 2010). At the present time, global protected area coverage is at 15,67% for terrestrial ecosystems and inland waters and 7,65% for marine ecosystems (UNEP-WCMC & IUCN 2021). The conservation agenda has been quite successful in driving the creation of protected areas worldwide (Zimmerer *et al.* 2004, Jenkins & Joppa 2009, Juffe-Bignoli *et al.* 2014); although, in many cases, the official creation of new protected areas *per se* can be ineffective as a conservation strategy, due to the lack adequate personnel, funding and/or management measures (Leverington *et al.* 2010), and exclusion of important ecosystems during the elaboration (Azevedo-Santos *et al.* 2018). Protected areas without adequate funding or management are commonly referred to as "paper parks" (Joppa *et al.* 2008).

Brazil is a key country for global conservation, since it encompasses a significant portion of the world's biodiversity (Lewinsohn & Prado 2005, Agostinho *et al.* 2005), including two biodiversity hotspots (e.g. Brazilian Cerrado and Atlantic Forest - Mittermeier *et al.* 2005). In a recent past, Brazil led the global ranking in the creation of protected areas (Jenkins & Joppa 2009), with a major expansion of its network of protected areas, even though coverage still falls short of the CBD target (Vieria *et al.* 2019). An important threshold in this process was the implementation of federal law 9985 of 2000 (Brasil 2000), which established the National System of Conservation Units, or NSCU (In Portuguese: *Sistema Nacional de Unidades de Conservação - SNUC*). The NSCU establishes

formal criteria for the creation and management of protected areas in Brazil (Silva 2005).

The NSCU defines two major groups of protected area, Integral protection (IP) and sustainable use (SU), both of which must have a governing body (consultative or deliberative council) and an official management plan (Brasil 2000). Management plans are technical-scientific documents that establish the zoning, land use, and management of natural resources, both within the reserve itself and in the surrounding area (Brasil 2000). This means that a management plan is fundamentally important for the adequate and effective allocation of the available resources for the monitoring and management of the local wildlife, and the regulation of human activities within protected areas. Federal decree 84017, published in 1979, was the first legislation to require a management plan for protected areas in Brazil, although it was superseded by federal law 9985, which was published in 2000.

Some studies found evidence that management plans improve the effectiveness of protected areas in reducing deforestation (Muñoz Benes *et al.* 2018, Powlen *et al.* 2021), in preventing biodiversity loss (Geldmann *et al.* 2018) and in safeguarding ecosystem services (Muñoz Benes *et al.* 2018). Despite this, few studies have considered the management plans of protected areas in Brazil. For example, Medeiros & Pereira (2011) analyzed the management plans of five national parks in the Brazilian state of Rio de Janeiro, and found mainly deficiencies related to the execution of the planning proposed in the management plan and also to environmental zoning of the protected areas. Posteriorly, D'Amico *et al.* (2020) considered the management plan of 126 federal protected areas to investigate the connection between environmental diagnoses and effective planning of these areas. The present study considers all federal protected areas (N = 334 PAs) in Brazil and provides an overview of the patterns and trends in the approval of management plans, as a surrogate for adequate management. In this analysis, we investigated five specific questions: (i) Are management plans more frequent in older protected areas? (ii) Does the pattern of approval of management plans vary over time (pre-1979, 1979–1999, and post-2000)? (iii) Are management

plans approved within the time frame (five years) stipulated under Brazilian environmental legislation (federal law 9985/2000)? (iv) Do differences exist among biomes in the approval of management plans? and (v) Do differences exist between strictly protected and sustainable use areas in the approval of management plans?

MATERIAL AND METHODS

In Brazil, federal protected areas are managed by the Chico Mendes Institute for the Protection of Biodiversity (*Instituto Chico Mendes de Conservação da Biodiversidade*: ICMBio), that is a public institution linked to the Brazilian Minister of Environment. The National System of Conservation Units (federal law 9985/2000) allocates these areas to two major groups – (i) Integral Protection: that is represented by National Park, Biological Reserve, Ecological Station, Natural Monument, and Wildlife Refuge; and (ii) Sustainable Use: that is represented by Extractive Reserve, Sustainable Development Reserve, Wildlife Reserve, National Forest, Environmental Protection Area, and Area of Relevant Ecological Interest. Information on these protected areas was obtained from a federal database (ICMBio 2021).

We considered 334 protected areas on this database (Table S1), for which we compiled the data on (i) the year the area was created, (ii) the type of protected area (integral protection *vs.* sustainable use), (iii) year its management plan was approved, (iv) year in which the management plan was revised after its approval, (v) total area (in hectares), and (vi) the biome in which the area is located (Amazon, Atlantic Forest, Caatinga, Cerrado, Coastal Marine, Pampa and Pantanal). We did not consider the private natural heritage reserves in our sampling, because they are private domain and, therefore, are not under influence of the conservation and management strategies implemented by the federal government. Prior to any statistical analysis, we tested the assumptions of normality and the homogeneity of variances of the data, and when these assumptions were not satisfied, after their transformation ($\log(x+1)$), we decided to use non parametric tests. We used Welch's unequal variances t-test to assess whether management plans are more frequent in older

protected areas. In this case, we tested whether the "age" of the protected area with management plan (current year - the year that it was created) differs from those without management plan.

We also established three groups to compare the interval time (in year) between the creation of the federal protected areas until the approval of their management plans: 1) Group A: protected areas created prior to 1979, 2) Group B: protected areas created between 1979 and 1999, and 3) Group C: protected areas created between 2000 to the present time. We established these groups based on following federal legislations: 1) federal decree nº 84017/1979 (Brasil 1979) and 2) federal law nº 9985/2000 (Brasil 2000). These legislations were considered because: 1) the federal decree nº 84017/1979 established that the Brazilian national parks should have management plans within five years after their creation (Brasil 1979); 2) the federal law nº 9985/2000 (current legislation) stipulates that any protected area from Brazil must have a management plan within five years of its creation (Brasil 2000). Thus, the groups established above allowed us to evaluate the influence of these legal devices on the elaboration/approval of management plans in Brazilian federal protected areas.

We used an Aligned Rank Transform (ART) ANOVA to test whether the interval time (in year) between the creation of the federal protected areas until the approval of their management plans suffered a simultaneous effect of the type of biome (Amazon, Atlantic Forest, Caatinga, Cerrado and Coastal Marine) and type of protected area (strictly protected vs. sustainable use areas; as established by NSCU). We used this statistical test because it is a non-parametric approach to factorial ANOVA that enables to analyze the interaction between two (or more) categorical variables. The analyses were run in the R software (R Core Team 2020), with a 5% significance level.

RESULTS

In Brazil, only 211 (63.17%) of the 334 protected areas present in database from ICMBio have management plans, covering 58,095,805 (33.5%) of the 173,424,193 hectares legally protected by the federal government (Table S1). We observed

that protected areas with management plan are older than areas without plan (t = 9.19; p < 0.001; Figure 1). In average, protected areas with management plan were created 31.28 ± 14.71 years ago (range = 5 – 84 years; N = 211 PAs), while protected areas without management plan were created 18.38 ± 10.78 years ago (range = 3 – 42 years; N = 123 PAs). Forty-four (20.85%) of the 211 federal protected areas had their management plan revised and, on average, these plans were revised 19 ± 9 years (range = 3 – 37 years; N = 44 PAs) after their approval.

The number of protected areas with management plan considerably increased over the decades (Figure 2). However, we observed that management plans were elaborated for only one (3.22%) of the 31 federal protected areas created until 1978 (Group A), rising to 41 (23.29%) of the 176 areas created by 1999 (Group B), and 211 (63.17%) of the 334 areas created by 2018 (Group C). The mean interval time between the creation of the protected area and the approval of the management plan varied considerably among the three groups, A, B, and C. Prior to 1979 (group A), the time for the approval of the management plan was four years (N = 1 protected area or PA)

after the creation of the area. Between 1979 – 1999 (group B), the mean time increased to 16.12 ± 11.6 years (range = 2 – 45 years; N = 41 PAs), and after 2000 (group C) the mean time was 18 ± 10.48 years (range = 1 – 59 years; N = 211 PAs).

The number and extent of the federal protected areas with management plan for each biome are described in the Figure 3. We observed that the biome with the greatest number (in percentage) of protected areas with management plans is the Pantanal (100%), falling to 72.83% for the Atlantic Forest, 67.2% for the Amazon biome, 66.67% for the Pampa biome, 51.22% for the Coastal Marine biome, for the 51.16% of Cerrado and 46.43% for the Caatinga (Table 1 and Figure 3). Of the 211 areas protected with a management plan, 107 are classified as integral protection and 104 as sustainable use. We did not observe any simultaneous effect of the type of biome and type of protected area on the time for the approval of management plans (F = 1.23; df = 4; p = 0.298). Additionally, we also didn't find any isolated effects of the type of biome (F = 2.28; df = 4; p = 0.062) and type of protected area (F = 0.784; df = 1; p = 0.377) on the time taken for the approval of management plans.

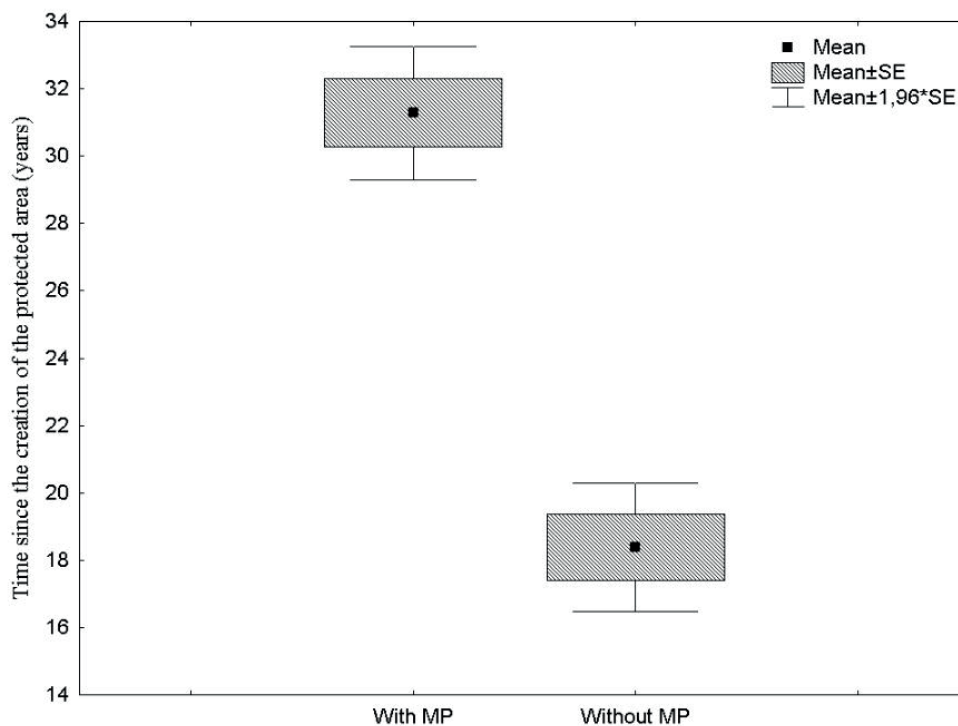**Figure 1.** Differences in the time since the creation of the protected area with and without management plan.
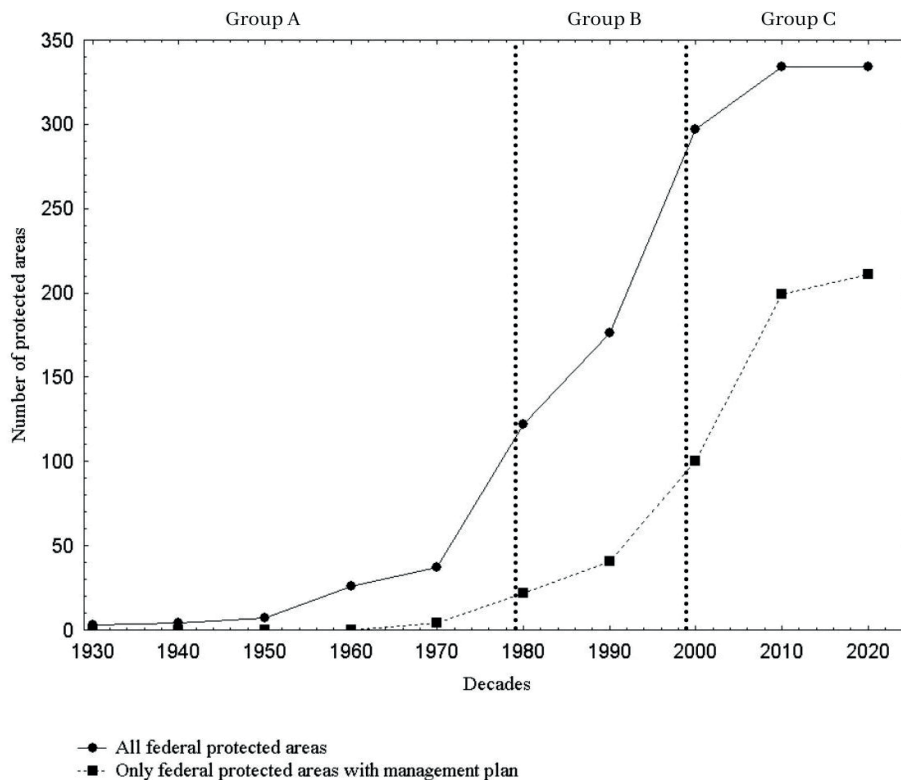
Figure 2. Time line of the approval of management plans in federal protected areas from Brazil. Grupo A): protected areas created prior to 1979, Group B: protected areas created between 1979 and 1999 and Group C: protected areas created between 2000 to the present time.

DISCUSSION

The creation of protected areas that are poorly planned, designed and/or managed may compromise the global conservation targets (Chape *et al.* 2005, CBD 2010, Watson *et al.* 2014). In this context, we have described the temporal and spatial trends in the approval of management plans for Brazilian federal protected areas, and uncovered one fundamental shortcoming, which is the fact that only 63.17% of these areas are supported by management plans. This suggests that many Brazilian protected areas may be poorly managed, due to lack adequate zoning and management of land use and natural resources, or the physical infrastructure necessary for

Table 1. Number and coverage area of federal protected areas (PAs) in Brazil by biome.

| Biome	Protected areas			Coverage (hectares)		
	N	N with a management plan	% with a management plan	All areas	Area of PAs with a management plan	% of total area covered by PAs with a management plan
Amazon	125	84	67.2	65,533,690	47,695,648	72.78
Atlantic Forest	92	67	72.8	3,849,554	1,980,925	51.46
Caatinga	28	13	46.42	5,535,751	2,883,603	52.1
Cerrado	43	22	51.16	5,310,486	3,346,306	63
Coastal Marine	41	21	51.21	92,660,914	1,688,331	1.82
Pampa	3	2	66.66	386,320	353,514	91.5
Pantanal	2	2	100	147,478	147,478	100
Total	**334**	**211**	**63.17**	**173,424,193**	**58,095,805**	**33.5**
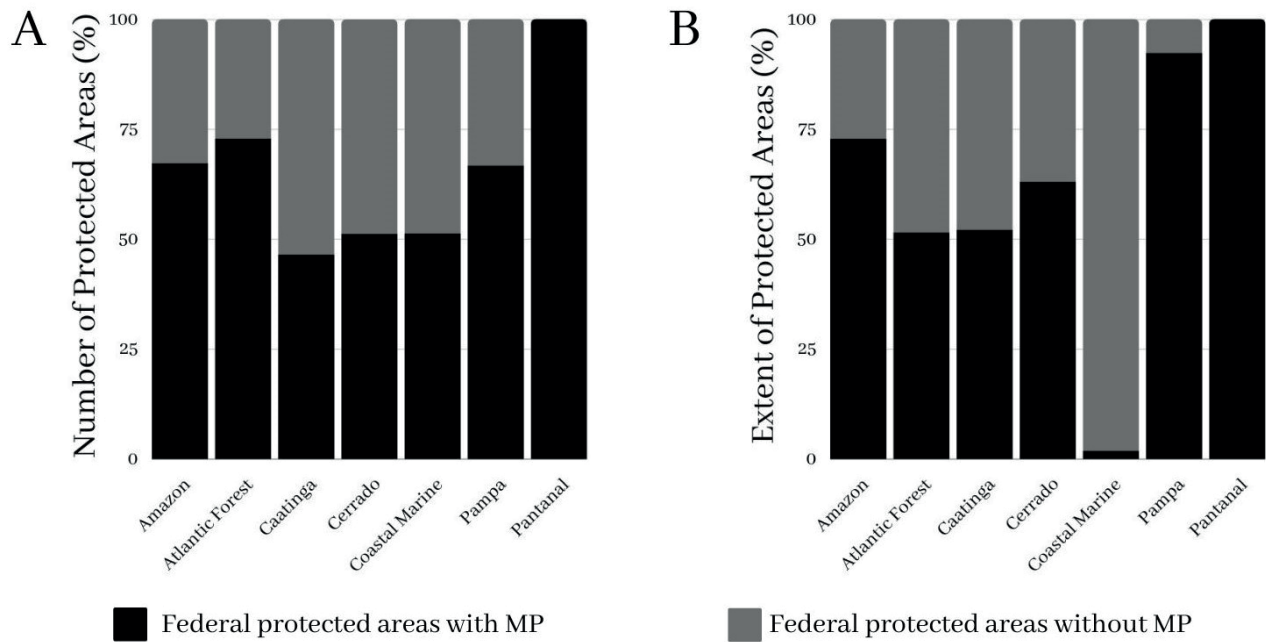
Figure 3. Number (A) and extent (B) of the Area of federal protected areas (PAs) with and without management plans in Brazil by biome.

their administration. This scenario is even more preoccupying when we consider the sustainable use protected areas, because management plans should guide the sustainable exploitation of natural resources within of these protected areas. However, for many Brazilian sustainable use protected areas, due to a lack of proper management plans, most of the natural resource exploration is not sustainable at all (e.g. Fernandez *et al.* 2012).

Worldwide, approximately 40% of protected areas have major management deficiencies (Leverington *et al.* 2010), and based on the lack of a management plan, an even larger proportion of Brazilian federal protected areas may be at least as deficient. The lack of a management plans can have a negative impact on the conservation of biodiversity, in particular by facilitate the recent, growing tendency to downgrade, downsize, degazette or reclassify protected areas both in Brazil and worldwide (Mascia & Pailler 2011, Bernard *et al.* 2014). We thus suggest that the lack of a management plan can contribute to a reduction in the effectiveness of these protected areas, with negative implications for Brazilian conservation strategies. In the future, to support our statement and direct research efforts, we suggest one have to test for possible correlations between deforestation and lack of management plans.

We also observed that management plans more frequent in older protected areas. Gonçalves *et al.* (2021) described the trends in the production of scientific knowledge within Brazilian protected areas and found that older protected areas have the greatest number and diversity of papers. It is likely that there is a relationship between scientific knowledge and the management plan in protected areas; therefore, we suggest that future studies can test whether protected areas with a management plan are those most studied over time. Even though Brazil was the global leader in the creation of protected areas (Jenkins & Joppa 2009, Cabral & Brito 2013), many of these areas exist only on paper. Our results can reinforce this issue, because many protected area do not have management plans, particularly, this a preoccupying issue, given that, we consider only federal protected areas that have management plans, the effective coverage of Brazil declines from 9% (Cabral & Brito 2013) to only 6.82% of the country's territory. This problem is further exacerbated by the delay in the approval of management plans, which also defers the effectiveness of these areas as conservation tools for long periods of time. Since 1979, Brazil has had legal mechanisms, *i.e.* federal decree 84017/1979 and federal law 9985/2000 that determine the management plans as tool for the administration

of protected areas. However, since 1979 (groups B and C), there has been a mean delay of more than 10 years between the creation of a protected area and the implementation of its management plan.

To be effective as conservation tools, protected areas must be managed both individually and in networks, which is only possible when their management plans are created and implemented within an adequate time frame, and are subject to periodical review. The delay in the approval of a management plan or its review can have serious implications for the protected area, not least because anthropogenic pressures tend to increase over time in the surrounding area, both within the conservation unit itself and in particular (e.g., Defries *et al.* 2005, Françoso *et al.* 2015). In Brazil, protected areas are distributed disproportionately among biomes, with most units being found in the Amazon (Vieira *et al.* 2019). We found a similarly imbalanced distribution of protected areas with management plans among the Brazilians biomes.

Overall, the Atlantic Forest and Pantanal had the highest proportion of protected areas with management plans, whereas the Caatinga biome had the lowest coverage. It is also important to note that the pattern observed in the Pantanal is influenced by sample size (i.e. only two protected areas). In absolute terms, the Amazon biome has the largest number of protected areas with management plans. The Atlantic Forest and Cerrado biomes have been considered priorities for conservation since 2000 (Myers *et al.* 2000), Brazilian conservation policies should prioritize these biomes; both by maximizing the creation of new protected areas and supporting the effective implementation of management plans. Despite this, we did not observe difference on the time for the approval of management plans of the protected areas among Brazilian biomes.

When a protected area lacks a management plan, it is difficult to know what it is actually under protection, due to the lack of inventories, unclear long-term patterns in the local wildlife and absence of monitoring. Effective protection is hampered by the poor definition of requirements for funding, infrastructure, and personnel (Bruner *et al.* 2001). This lack of basic data also impedes the effective planning of conservation measures for these areas. Ultimately, the lack of a management plan or a major delay in its approval

(or its review) represents a form of political misconduct, and the consequences of these failings must be considered more systematically by the Brazilian authorities.

ACKNOWLEDGMENTS

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SUPPLEMENTARY MATERIAL

Table S1. Brazilian federal protected areas (PAs) considered in the present study. For each PA, this table provides information on: (i) the year the protected area was created; (ii) the year its management plan was created; (iii) the type of protected area; (iv) its size; and (v) the biome in which it is located. AF = Atlantic Forest; AM = Amazon; CA = Caatinga; CE = Cerrado; CM = Coastal Marine; PA = Pampa; PT = Pantanal.