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FORESTRY SCIENCE

Twenty Years of the National Protected Areas System: are Brazilian National Parks achieving their legal objectives?

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Abstract: Among the policies for the creation of protected areas, the "Park" category is the best known worldwide. In Brazil, the national parks are important areas for the conservation of biodiversity and for ecotourism, but twenty years after the enactment of the law that regulates the National System of Protected Areas, there is no clear scenario of the National Parks' current situation regarding the fulfillment of their legal objectives. Aiming to understand this scenario in the six main Brazilian biomes, we evaluated variables related to: level of land regularization, existence and updating of management plans, number of authorized scientific research studies, variation in the number of visitors, development of recreation activities, ecotourism, and existence of an Advisory Council. For all biomes, the results regarding the legal objectives' attainment are negative, mostly in terms of land regularization, with the worst results being found in the *Caatinga* biome < 2% of the area within parks regularized. We concluded that only in specific cases the legal objectives of these protected areas are being accomplished and, therefore, if we keep the pace and the implementation and management policies of the last 20 years, the outlook is pessimistic for the conservation of Brazilian biodiversity.

Key words: Conservation, public use, environmental policy, ecological tourism.

INTRODUCTION

Since the dawn of human civilization, natural protected areas have served many different purposes. In ancient Constantinople, now Istanbul – Turkey, as early as 330 BC, there was a complex network of aqueducts connecting water supplies to this city, which functioned as protected areas (Crow et al. 2008). Another example is from Mongolia: in 1778, in order to preserve archaeological sites, protection areas were created for the ruins of *Manzushir Monastery, Buddha Park*, and *Zaisan Memorial*, which would become *Bogd Khan Uul* National Park (NP) in 1995. In 1997 its ecological importance was recognized by UNESCO (Dudley & Stolton 2010). Today, NPs are internationally recognized natural protected areas, that stand out mainly to ecosystem protection and recreation (Eagles et al. 2002, Ferraro et al. 2013, Leung et al. 2019), and are classified in Category II of protected areas by IUCN (Leung et al. 2019).

The modern concept of NPs aimed at safeguarding scenic beauty and wildlife originated with the US National Parks with the creation of Yellowstone NP on March 1, 1872, whose establishment is considered to be the birth of the modern concept of parks (Nasch 1970, Eagles et al. 2002). The initial purpose of these areas was to be an open space for physical activities and nature contemplation, thus improving the urban population's life quality (Eagles et al. 2002), linking the protection

of natural, historical, and/or cultural heritage with tourism.

Within the Brazilian context, about 171.4 million hectares are protected in Federal level protected areas. This equals the combined total of the territorial areas of countries such as Germany, France, Finland, Bosnia and Herzegovina, Croatia, Hungary, and Romania. These protected areas comprise approximately 78.7 million hectares of land areas and 92.6 million hectares of marine areas, and NPs represent 15.6% of the total federal level protected areas (ICMBio 2020).

In the year 2000 a federal law established a National System of Protected Areas (*Sistema Nacional de Unidades de Conservação*, SNUC, literally translated as National Conservation Units System) (Brasil 2000), following a model similar to the one adopted in 1995 in Costa Rica with the creation of a protected area system with different management categories (Guzman & Heiner 2015). From then on, specifically in Brazil, the protected areas are known as Conservation Units (*Unidades de Conservação* - UC), a term used to distinguish them from other natural protected areas, such as indigenous or *quilombola* lands, or from legal reserves and permanent preservation areas, such as riparian forests and river springs (Omena et al. 2020). This National System defined 12 categories of protection, and parks are the most well-known among them.

The first NP created in Brazil was *Itatiaia* NP, on June 14, 1937 (Milano 1985), therefore, prior to the SNUC law, which standardized the types of protected areas in Brazil. Thus, SNUC law standardized the types of protected areas in Brazil, in all administrative spheres (federal, state, and municipal). Regardless of the administrative sphere, the parks must aim (Article 11 of the SNUC): *"the preservation of natural ecosystems of great ecological relevance and scenic beauty, enabling scientific research and the development of environmental education and interpretation activities, recreation in contact with nature, and ecological tourism"* (Brasil 2000). Three fundamental lines of action stand out in these objectives: the preservation of nature, the development of scientific research and environmental education, and recreation and ecotourism.

The preservation of nature is dependent of the level of land tenure regularization in the Park (Rocha et al. 2010, Santos & Krawiec 2011, Bernard et al. 2014), that is, since a given national park is created, what percentage of the Park's area did the government acquire from private individuals to be dedicated exclusively to nature conservation. We know that regularized protected areas where domestic cattle were removed, had a significant increase in species of small mammals and amphibians (Neilly et al. 2021).

The fulfillment of the objectives of the parks depends on research efforts towards the understanding of its biodiversity, and researchers depend on well protected areas to answer several scientific questions regarding conservation (Machlis & McNutt 2015). Thus, a higher or lower number of researches in a Park in comparison to other similar parks (e.g. within the same biome and with similar access and distance from urban and research centers) can indicate if this Park is fulfilling its legal objective of development of scientific research.

As a third important component in the legal objectives of creation of NPs according to the SNUC, it is necessary to assess the visitation that is taking place in each park. Before the pandemic, eight billion people/year visited protected areas worldwide and they spent billions of dollars (Balmford et al. 2015). But, more than the amount of tourists, it is important to evaluate the variation in the number of visitors from

year to year, a big variation is a problem when it comes to managing tourism in protected areas, bringing more losses than benefits to parks (Kim et al. 2018). And, although 80% of visitation in protected areas worldwide is concentrated in Europe and North America (Balmford et al. 2015), the visitation growth in Brazilian Parks has been steady in recent years (ICMBio 2021). Another point related to visitation is if there are different impact activities for visitors and these also do not degrade the attractions, otherwise the financial benefits for the parks may not be sustainable, also compromising the conservation objectives of the area (Hadwen et al. 2007).

To order visitation and other activities in the parks, the SNUC law established the need for the elaboration of a document called Management Plan for each area. Thus, to define a management plan is a legal objective to be achieved. As important as having this document ready, is the need to keep this document up to date, based on periodic revisions. A document made before the enactment of the SNUC law itself in 2000 may not reflect the legal advances that the legal standardization has brought, for example, the obligation to have an advisory council.

The last legal objective is the existence of an Advisory Council (Brasil 2000), a collegiate which contributes to the management of the protected area. The implementation of this management body was one of the novelties of the SNUC law, ensuring the civil society participation in the management of the protected areas (Magno 2020). Strengthening environmental management with the participation of local stakeholders and communities is essential for the conservation of biodiversity (Ellis et al. 2021). Usually, representatives from civil society, such as non-governmental organizations and residents, and public entities, such as city governments, environmental agencies, and City Councils, are part of the Advisory Councils.

Even though environment education is clearly specified in the SNUC Law and it is associated to positive factors such as the decrease of illegal hunting and the improvement in interactions with society (Maciel & Alves 2018), there is no data about the quantity of environmental education projects being effectively executed in Brazilian parks beyond those registered in SISBIO, making its use as a variable infeasible.

Unfortunately, due to the increasing amount of deforested areas, mining, cattle ranchs and other negative impacts on nature conservation, which also endanger human health, exposing it to new epidemics (Val 2020), the importance of NPs is increasing, turning them into "conservation islands". Therefore, 20 years after the creation of the SNUC, the question that guides our study is how are the Brazilian NPs doing regarding their legal objectives? To this end, we intend to systematize the legal objectives evaluated through measurable variables and test whether and how much the NPs are achieving their legal objectives. Since the Brazilian territory covers different biomes, it is necessary to consider this effectiveness of the parks also per biome, therefore their effectiveness regarding the fulfillment of their legal objectives may not be homogeneous. By comparing the national parks' situation in the different Brazilian biomes we intend to systematically demonstrate the panorama of Brazilian NPs regarding the achievement of their objectives and legal obligations, in order to contribute with subsidies for broad management policies and for the civil society which can monitor the management of these protected areas.

MATERIALS AND METHODS

Study areas and data collection

National Parks is the most representative category of protected area within the 334 federal protected areas, which also include categories such as Biological Reserve, Wildlife Refuge, Extractive Reserves, among others. We analyzed data from all 74 Brazilian NPs managed by the federal government (Figure 1), grouped into six biomes: Atlantic Forest (total parks = 25), Amazon (22), *Cerrado* (12), *Caatinga* (8), *Pantanal* (1), and Marine/Coastal (6) (ICMBio 2013).

The distribution of NPs by biome is not uniform in terms of number of parks or total area protected (Table I).

We obtained data for the indicators, that we call variables, that characterize the compliance with the legal objectives from official sources (ICMBio, each Park, and the Ministry of Environment websites) (Table II). For each legal objective, a corresponding variable (or set of variables) was established to check if that objective is being met. The caput of article 11 of the SNUC Law (Brasil 2000) highlights as the basic objective of national parks "the preservation of natural ecosystems of great ecological relevance and scenic beauty, enabling scientific research and the development of educational activities and environmental interpretation, recreation in contact with nature and ecological tourism". To assess the development of recreation activities in contact with nature and ecological tourism, we used two variables: "Activities", corresponding to the number of recreational activities available to visitors in 2019, and "Visitors", given by the average value of the percentual variation in the number of visitors. Since the total number of visitors changes from one year to another, we calculated the percentual variation per year between 2012 and 2019. The SNUC Law also states that NPs must have a regularized area,

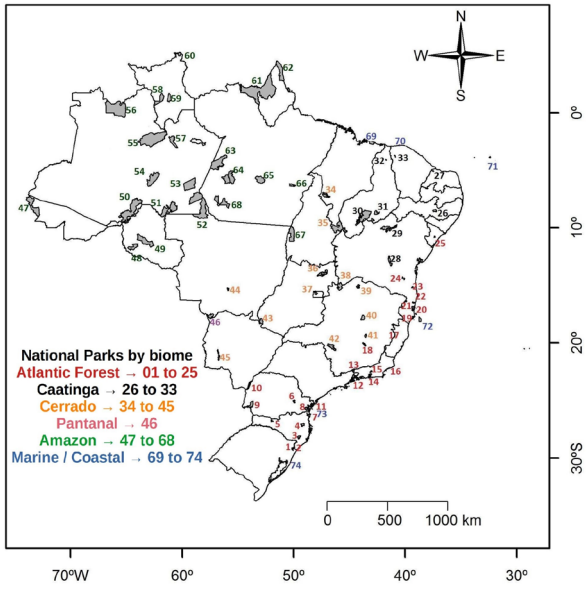

Figure 1. Location of the National Parks in Brazil: Atlantic Forest (Numbers in red: *Serra Geral*[1], *Aparados da Serra*[2], *São Joaquim*[3], *Serra do Itajaí*[4], *Araucárias*[5], *Campos Gerais*[6], *Saint-Hilaire Lange*[7], *Guaricana*[8], *Iguaçu*[9], *Ilha Grande*[10], *Superagui*[1], *Serra da Bocaína*[12], *Itatiaia*[13], *Tijuca*[14], *Serra dos Órgãos*[15], *Restinga do Jurubatiba*[16], *Caparaó*[17], *Serra da Gandarela*[18], *Descobrimento*[19], *Monte Pascoal*[20], *Pau-Brasil*[21], *Alto Cariri*[22], *Serra das Lontras*[23], *Boa Nova*[24], and *Serra de Itabaiana*[25]), *Caatinga* (Numbers in black: *Catimbau*[26], *Furna Feia*[27], *Chapada Diamantina*[28], *Boqueirão do Onça*[29], *Serra das Confusões*[30], *Serra da Capivara*[31], *Sete Cidades*[32], and *Ubajara*[33]), *Cerrado* (Numbers in orange: *Chapada da Mesas*[34], *Nascentes do Rio Parnaíba*[35], *Chapada dos Veadeiros*[36], *Brasília*[37], *Grande Sertão Veredas*[38], *Cavernas do Peruaçu*[39], *Sempre-vivas*[40], *Serra do Cipó*[41], *Serra da Canastra*[42], *Emas*[43], *Chapada Guimarães*[44], and *Serra da Bodoquena*[45]), *Pantanal* (Number in purple: *Pantanal Mato-Grossense*[46]), Amazon (Numbers in green: *Serra do Divisor*[47], *Serra da Cutia*[48], *Pacaas Novos*[49], *Mapinguari*[50], *Campos Amazônicos*[51], *Juruena*[52], *Acari*[53], *Nascentes do Lago Jari*[54], *Anavilhanas*[55], *Pico da Neblina*[56], *Jaú*[57], *Serra da Mocidade*[58], *Viruá*[59], *Monte Roraima*[60], *Montanhas do Tumucumaque*[61], *Cabo Orange*[62], *Amazônia*[63], *Jamanxim*[64], *Serra do Pardo*[65], *Campos Ferruginosos*[66], *Araguaia*[67], and *Rio Novo*[68]), and Marine/Coastal (Numbers in blue: *Lençóis Maranhenses*[69], *Jericoacoara*[70], *Marinho de Fernando de Noronha*[71], *Marinho de Abrolhos*[72], *Marinho das Ilhas dos Currais*[73], and *Lagoa do Peixe*[74]).

compensating the private properties within its area. Thus, we used the percentage of land regularization as a variable, given by the total area owned by the government within each NP. Another requirement for NPs, according to SNUC, is the management plan. In this case we used two variables: the existence of the plan and its age. Although having a management plan is an important step for park management, if it is very out of date, its efficiency will be compromised. We used the age of the management plan as a variable to measure the effect of time since the last revision of each management plan. We included the variable "scientific research" given by the number of research studies registered in the governmental system used for this purpose (SISBIO, the National System of Authorization and Information on Biodiversity), for each NP. We are aware that many researchers and institutions overlook this requirement, however this variable was chosen supported by the SNUC which cites "Scientific research depends on the prior authorization of the institution responsible for managing the unit and is subject to the conditions and restrictions established by it". Finally, since the need for an Advisory Council is foreseen in the SNUC law, we used the existence of an Advisory Council as a variable (Table II).

We used 2019 as the reference year for the variables research studies, visitors, and activities, considering that the most recent data, later than 2019, may have effects of the COVID-19 pandemic. As for the other legal objectives, the variables are not explicitly influenced by the pandemic, such as the existence or not of a management plan and Advisory Council, and the percentage of land regularization. These variables were chosen prioritizing the accessibility and reliability of the data so that the study could be checked and replicated in the future, for example, the number of scientific 190 studies considered only those authorized in the official system, which can be checked with relative ease, to the detriment of other sources that could provide more data, but are not standardized, such 192 as the number of scientific articles published per park. All the detailed data per park are in Supplementary Material - Table SII (Brazilian National Parks Data).

Data analysis

From the raw data provided by ICMBio (2020) and SISBIO (2020) we calculated the percentages for the variables land regularization in relation to the size of the total park, and visitors and research 198 in relation to the total number of visitors and studies in the year. As we are analyzing the

Table I. Number of Brazilian National Parks by biome and total area protected (based on ICMBio 2013, 2021).

Biome	Number of Parks	Total Protected Area (Hectares)	% in relation to the total in Parks
Atlantic Forest	25	875.611	3,26
Amazon	22	21.411.309	79,70
Cerrado	12	3.612.138	13,45
Caatinga	8	692.065	2,58
Marine/Coastal	6	136.957	0,51
Pantanal	1	135.924	0,50
Total National Parks	74	26.864.004	*[1]15,67
Total national protected areas	334	171.424.192	*1 % Parks in relation protected areas

achievement of the parks' objectives according to the legislation, we opted to only consider the 200 studies registered in SISBIO. The SNUC Law cites specifically in its eleventh article §3º that studies must be authorized by the managing institution. Then, we calculated the number of research studies per year and identified the existence of Advisory Council and Management Plan and their age in years. With the standardized variables in a scale from 0 (unfavorable results) to 1 (favorable 204 results), that simultaneously adjusts the magnitude and variability of the data (Legendre & Legendre 2012), we produced a ranking graphic to analyze the dispersion and concentration of the transformed (range) values, thus assessing achievement of the legal goals in the total set of parks using the ggplot function (geom violin) (Wickham 2016). Subsequently, we evaluated the sets of parks by biomes.

We used a Principal Coordinate Analysis (PCoA) (Legendre & Legendre 2012) to evaluate 210 the differences between the parks in relation to the variables (land regularization, plan, age, research, visitors, activities, and council). Estimating the Euclidean distance for the similarity 212 matrix, and we produced a plot graphic with the first two axes of PCoA, parks are represented with different symbols and colors according to the biome. We performed the analyses and plots in the R 214 program (R Core Team 2019) along with the vegan (Oksanen

Table II. Variables that characterize the fulfillment of the legal objectives provided for by National Conservation Units System – SNUC law (Brasil 2000) to Brazilian National Parks.

Variable	Description
Objective: Nature Protection	
Land regularization	Percentage of area acquired (regularized) by the federal government from private individuals for the exclusive purpose of nature conservation. Referring to § 1 of article 11 of the SNUC law. Source: Attached in Supplementary Materials – Table SI (% Land regularization in Brazilian National Parks).
Plan (Management plan)	Existence (1) or not (0) of a Management Plan (ICMBio 2020). Referring to § 2 of article 11 of the SNUC law.
Age (Management plan age)	Difference in years between 2020 and the MP's publication or its last update (ICMBio 2020). Referring to § 2 of article 11 of the SNUC law.
Objective: Development of Scientific Research	
Research	Sum of the number of research studies registered in Biodiversity Information Authorization System (SISBIO 2020) between the years 2009 to 2019 divided by the number of years in the period (11 years), except for parks created after 2009, in which case it was divided by the number of years of the park existence. Referring to *Caput* and §3º of article 11 of the SNUC law.
Objective: Recreation and ecotourism	
Visitors	Average value of the percentage variation in the amount of visitors year by year between the years 2012 and 2019 (ICMBio 2020). Average value of the percentage variation in the amount of visitors year.
Activities	Total number of recorded recreational activities, such as hiking, contemplation, diving, among others, available to visitors in 2019 (ICMBio 2020). Referring to *Caput* of article 11 of the SNUC law.
Objective: Existence of an Advisory Council	
Council	Existence (1) or not (0) of an Advisory Council in the Protected Area (ICMBio 2020). Referring to *Caput* of article 29 of the SNUC law.

et al. 2019), HH (Heiberger 2020), and ggplot2 (Wickham 2016) packages.

RESULTS

The concentration and dispersion of the variables´ values regarding the legal objectives (Figure 2) show that for some objectives the values are more concentrated around lower values, reflecting poor results for the legal objectives achievement: age (management plan age), research (number of research studies), visitors (variation in the number of visitors), and land regularization. As for the existence of management plans (plan) and Advisory Council (council), the general scenario is positive. The variable number of recreational activities (activities) is the only variable with a more homogeneous distribution between good and bad situations regarding the achievement of the legal objectives determined by SNUC law.

When assessing the sets of parks in the biomes, we point out that the *Pantanal* biome will always be a distinct case, since only the *Pantanal Mato-Grossense* NP represents this biome. With regard to land regularization, the average percentage of regularized area in the set of parks is 35.2% (σ = 37.23), removing from this account 36 parks that have zero regularized area. The best situation by biome is in the *Pantanal* biome, whose only Park is 100% regularized. On the other hand, the other biomes show a great variation in percentages of regularized areas: in the Amazon biome there're 16 out of 22 parks with practically zero regularized area, in the Atlantic Forest there're 9 out of 25 parks, in the *Cerrado* and Marine/Coastal biomes there're 3 out of 12 and 4 out of 6 parks respectively, also with zero regularization. Particularly, the Marine/Coastal biome involves terrestrial and marine areas, the latter not requiring regularization because sea surfaces are already federal areas. However, what draws attention is the *Caatinga* biome, where the 8 parks together do not add up to 2% of the regularized area foreseen for the biome. And even though in quantity and total area the

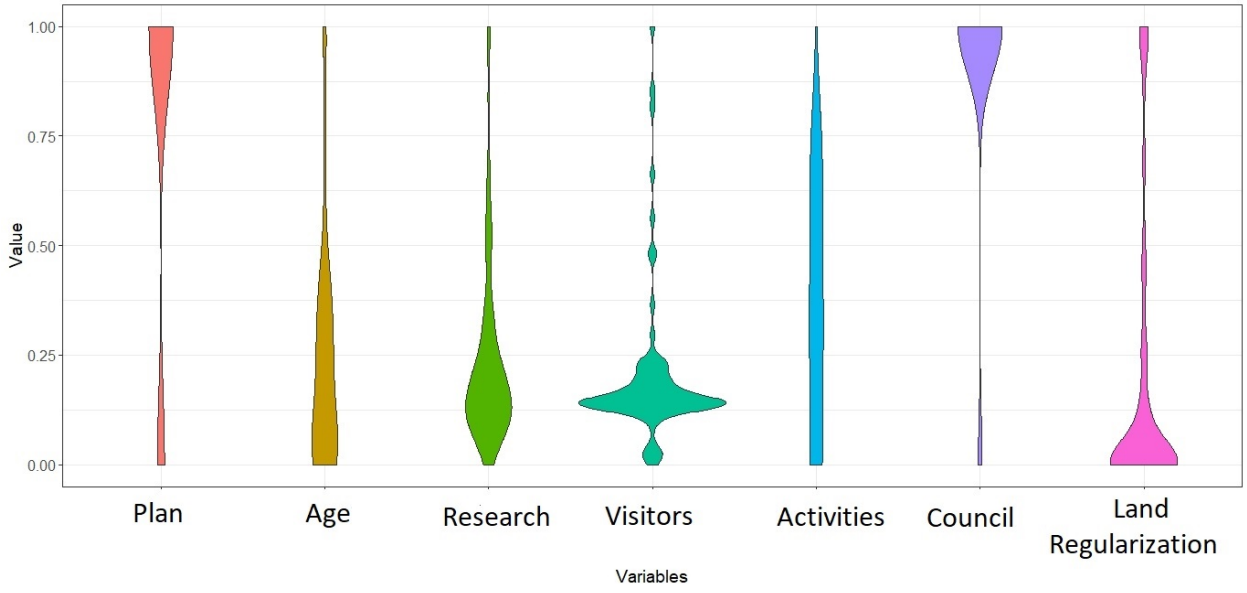

Figure 2. Dispersion of the Brazilian National Parks' results by legal objective transformed into variables: land regularization, plan (existence of management plan), age (age of the management plan), visitors (variation of the number of visitors), activities (recreational activities), research (number of researches registered), and council (existence of Advisory Council).

Amazon biome presents the largest number of non-regularized hectares, proportionally the *Caatinga* biome is the one in the worst situation in terms of regularized protected hectares.

Currently 57 parks have management plans, however, 8 of them have a document older than 20 years and another 12 have management plans older than 12 years, which is the set's average (σ=10.4). There're only 19 parks with updated and revised plans. The best situation occurs in the parks of the Marine/Coastal and *Cerrado* biomes, where only one park in each biome has no management plan, *Ilhas dos Currais* and *Nascentes do Rio Parnaíba*, respectively. On the other hand, plans are missing for 7 parks in the Atlantic Forest biome, 5 in the Amazon, and 3 in the *Caatinga*.

For the parks with management plans, the worst situation is for the Amazon National Park, whose document is 42 years old. The Amazon biome is home to the NPs with the most outdated documents (5), but proportionally, the situation of the parks in the Marine/Coastal biome is also worrying in relation to the management plans' updating: 4 of the 5 parks have plans that are more than 12 years old.

The average number of research authorizations registered in the period from 2009 to 2019 is 209 research studies per park (σ=179.1), with an emphasis on the Atlantic Forest biome's parks, where 6 parks (*Serra da Bocaína, Serra dos Órgãos, Tijuca, Caparaó, Itatiaia*, and *Iguaçu*) concentrate 24.2% of the total number of research authorizations requested between 2009 and 2019. These figures may be influenced due to the higher number of research centers in the Atlantic Forest region. The negative highlight is the Amazon biome, where only *Viruá* National Park has a number of research studies above the general average. Most parks in the Marine/Coastal biomes (5 of 6) and *Caatinga* (5 of 8) are below the overall average for the number of research registered.

Reflecting its proximity to large urban centers, the largest volume of visitors is concentrated in the parks of the Atlantic Forest biome (70% of the total in 2019), with an emphasis on the *Tijuca* National Park that has concentrated most of the visitors in parks and in all types of protected areas in the country in recent years (in 2019 *Tijuca* received more than 2.9 million visitors, or 30.2% of the total visitors in Brazilian parks). On the other hand, the Amazon biome, which has the larger protected area within parks, has a low number of visitors (only 0.56% of the total in 2019) probably due to the remoteness of these protected areas. Furthermore, of the 19 parks that did not register any visitors in the period, 11 of them are in the Amazon biome. The average variation in the number of visitors over the period 2012 to 2019 was 11.9% (σ=10.86). A big fluctuation in the number of tourists can show us that the park is having an uncontrolled visitation, which is dangerous to nature conservation. For the parks that recorded visitors, we defined a variation above 25% as an indicator of an abnormal variation, therefore harmful, because the flow of visitors would be varying more than twice the average for the whole set of parks, and potentially challenging visitation management actions. Thus, 8 parks in the Amazon biome have variation values above 25% for the period from 2012 to 2019. Twelve out of 21 parks in the Atlantic Forest biome as well (total of the biome is 25, but 4 have zero visitation), *Caatinga* 3 out of 7, *Cerrado* 6 out of 10, Marine/Coastal 3 out of 5, and also the *Pantanal Mato-Grossense* National Park.

Regarding the recreational activities available to visitors, such as hiking, contemplation, diving, among others, the average for the parks that have activities (n=60) is 5 activities (σ=2.5), and the biome whose parks receive more visitors

is also the one that concentrates the largest number of parks with an amount of activities for visitors above average, the Atlantic Forest (n=22). However, the Marine/Coastal biome parks stood out for the greatest total availability of activities, with 5 of the 6 parks in the top five positions in quantity of activities available to visitors.

The existence of an Advisory Council is a legal premise, and most of the parks (68) have Advisory Councils. Advisory Councils are missing in only 3 parks in the Amazon biome (*Pacaás Novos, Acari*, and *Campos Ferruginosos*), one in the Atlantic Forest (*Serra das Lontras*), one in the *Caatinga* (*Catimbau*), and one Marine/Coastal (*Ilhas dos Currais*).

There's no clear differentiation between the set of parks by biomes for all variables (Figure 3). The first two axis of the PCoA account for 62.2% of the variation, separating parks with older management plans, which have more recreational activities, scientific research, and less variation in visitation (in the upper right quadrant, figure 3). These parks have management plans and Advisory Councils. In opposition, in the upper left (figure 3) are the parks without a management plan and without an Advisory Board, and that present fewer recreational and research activities. Almost half of these parks are located in the Atlantic Forest biome. The vertical axis (figure 3) separates the parks with the highest percentage of area with land regularization (upper quadrants) from the others. This is justified by the lack or low percentage of land regularization in most of the parks. Most of the parks are in an intermediate position with negative results for research and land regularization and positive for the other variables (lower right quadrant, figure 3). The worst results are found in the lower left quadrant, where all parks have poor results for all variables (*Serra do Pardo, Pacaás Novos, Nascentes do Lago Jari,* and *Chapada das Mesas*).

Thus, the variables that weigh most negatively on the achievement of the parks' legal objectives are land regularization, age

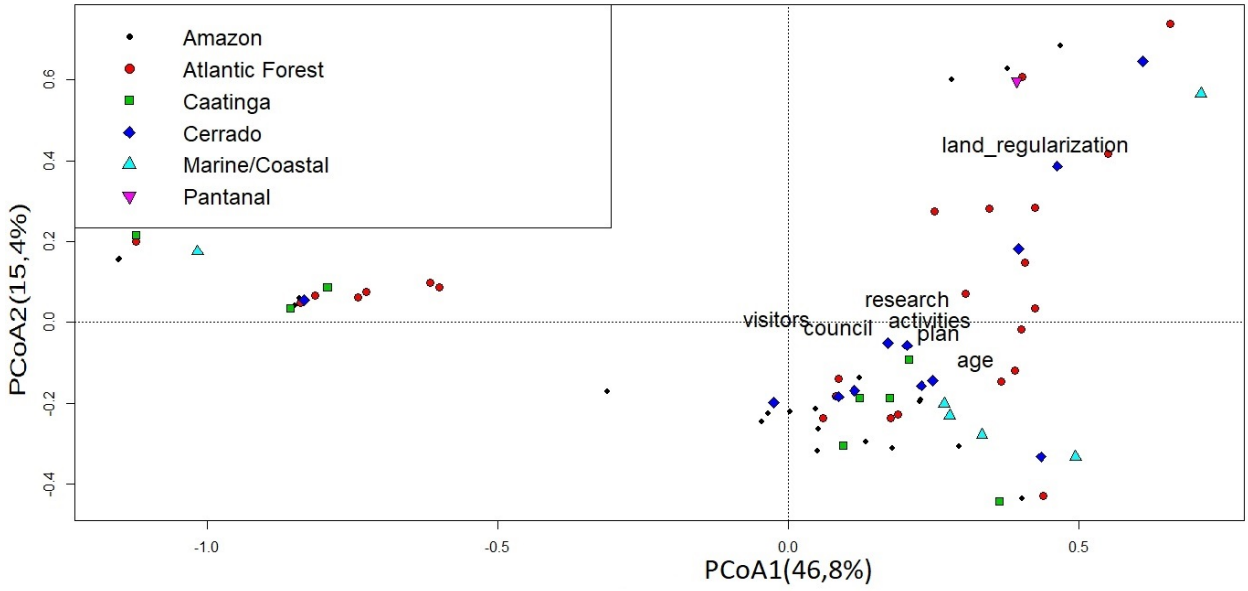

Figure 3. Principal Coordinate Analysis for the 74 Brazilian NPs, per biome, regarding the variables: land regularization, plan (management plan), age (age of the management plan), activities, visitors, research, and council.

of the management plan, visitors, research studies, and activities. On the other hand, for the management plan and council variables, the situation of the parks is better. There's no clear trend as to the achievement of the legal objectives per biome for the NPs (Figure 3).

DISCUSSION

The results obtained regarding the achievement of the legal objectives of the Brazilian NPs are worrisome, since most of the parks presented negative results for the criteria established for the assessment in this study, based on the premises of the SNUC law. Other indicators or variables could bring more detail to this study, for example, regarding environmental education projects, however there is no homogeneity in the data of the parks and no easy access to information. Therefore, the specific use of this list of variables, accessible and reliable, enabling the review and 316 replication of the study in the future.

Parks and other protected areas are crucial for biodiversity, which is higher inside protected areas than in areas outside them (Busch & Grantham 2013, Gray et al. 2016). These areas are also relevant in providing benefits to human health (Maller et al. 2009, Amato-Lourenço et al. 2016) and providing the conditions necessary for diverse contributions by nature to humans, such as drinking water and climate regulation (Pascual et al. 2017). But the threats to which protected areas are subject and the lack of management effectiveness endangers biodiversity protection (Laurance et al. 2012, Ribeiro et al. 2018). It is estimated that by protecting 30% of land areas and not increasing the Earth's average temperature by more than 2°C, we could mitigate the risk of tropical species extinction due to climate change by 50% (Hannah et al. 2020). In this scenario, the results that show a higher concentration of parks with negative results for the achievement of their legal objectives - especially regarding the percentage of land regularization – reveals the impairment of the protected areas as effective mechanisms to protect biodiversity and to assure human wellbeing. The NPs that stand out most negatively in terms of achieving their legal objectives (in the lower left quadrant of figure 3) have in common few research studies per year, absence of visitation records, and zero land regularization.

The lack of infrastructure, especially land regularization, weakens the protected areas (Pack et al. 2016), affecting not only the parks' environmental conservation but also the development of ecotourism activities. This problem is highlighted daily in reports and articles (Rocha et al. 2010, Pringle 2017) and is among the main concerns of Brazilian environmental managers (Semeia 2019). In Brazil, the SNUC law is specific regarding the need to expropriate private areas within parks to guarantee its land regularization, a rather conflicting theme in the country (Zeneratti 2021) and among some of its continental counterparts such as Mexico and Costa Rica (Vasquez-Villa et al. 2020). Other countries, like Guatemala, allow human presence in parks (Carr & Barbieri 2006). After 20 years of the SNUC law, which instituted the land regularization as one of the Park category's premises, unfortunately, the land regularization situation is very bad in the parks of all biomes (with the exception of the only national parks in the *Pantanal* biome): more than 70% of the parks' area still lacks land regularization, revealing a fragile situation of the nature conservation which is associated with the level of land tenure regularization (Rocha et al. 2010, Santos & Krawiec 2011, Bernard et al. 2014, Pack et al. 2016, Hannah et al. 2020).

The situation in the *Caatinga* biome is the most compromised, especially when we consider that 76% of the population residing in areas with dry forest – in which the national parks of the *Caatinga* biome are included – live below the poverty line, and depend on natural resources for their survival, such as firewood extraction and hunting (Specht et al. 2019), which pressures the population against the natural resources within protected areas.

With this scenario regarding land regularization, the existence of updated management plans become more essential, because besides being a legal obligation (Brasil 2000), they are the document that guides the park management. These documents need to be updated so that they promote the decrease of negative impacts and the increase of positive ones, such as the improvement of the socioeconomic situation of the surrounding society (Santos 2011). However exactly 50% of the parks have no management plan or the document is too old and is probably no longer fulfilling its guiding function, a situation like the protected areas in Chile without a management plan (Sierralta et al. 2011). In the Marine/Coastal biome, of the 6 parks, only one has an updated plan (less than 12 years old). To deal with this scenario, a broad policy to update the management plan and the application of more agile methods for their elaboration of would facilitate their preparation and revision, such as the adaptation of the Foundation Document, a document used by the National parks Service in the United States (Omena et al. 2020).

Parks depend on researchers and researchers depend on parks (Machlis & McNutt 2015). However, when analyzing the NPs of the largest Brazilian biome, the Amazon, there're few authorized or registered research studies, similar to what occurs in the Peruvian and Ecuadorian Amazon (Correia et al. 2016). Other than that, the political crisis in the country, worsened since 2018, has been used to weaken scientific research, environmental legislation, and environmental law enforcement (Magnusson et al. 2018).

There seems to be a link between research studies and parks with more visitation or visibility (such as for *Serra da Bocaina, Serra dos Órgãos, Tijuca, Caparaó, Itatiaia,* and *Iguaçu* Parks), because these same parks concentrated in 2019 the majority of national parks visitors. This can be influenced by the relationship between biodiversity and ecotourism (Chung et al. 2018), which would attract more visitors and researchers. However, it could be due to the proximity of these conservation areas to large urban areas and research centers, especially in the southeastern and southern regions of the country.

Visitation is also concentrated in the Atlantic Forest biome parks. However, more than the total number of visitors, we are interested in assessing the variation in the number of visitors in recent years, since disorderly visitation brings more harm than good to the protected areas and society (Wolf et al. 2019). The parks in the Amazon biome stand out for the small number of visitors and the high variation in the number of visitors from one year to the next, which is a problem for the protected areas' management, which may have difficulties in planning the flow of visitors they should receive.

As for the number of activities available to visitors, there are more parks in the Atlantic Forest biome offering activities to visitors. Visitation in these parks may reflect the greater number of facilities and attractions in the region itself (Castro et al. 2015). However, what we know is that tourism in areas near a park reflects positively on the economy of the surrounding populations and the entire production chain (Souza et al. 2018). For example, a study

conducted on an endurance (adventure racing) event on the Collon-Trek trail in the mountains between Switzerland and Italy revealed that for every Euro invested in the area there is a return of 5.64 to 6.9 Euros to the local economy (Duglio & Beltramo 2017). And further, that this human-nature interaction provided by tourism in parks and recreational trails contributes to human health (Amato-Lourenço et al. 2016, Buckley et al. 2019). If Brazilian users of parks follow what research studies in Germany have shown, the number of visitors should double with the end of COVID-19 pandemic (Derks et al. 2020).

The importance that parks have for tourism and ecosystem services (Joly et al. 2019) turns out to be one of the main attractions for society's participation in the management of protected areas. The alliance between managers and society helps in promoting sustainable uses and solutions and protecting the protected area from external threats (Omena & Bregolin 2020). Despite this, there're many challenges to overcome to ensure effective participation of society in management (Zafra-Calvo et al. 2019), which is still excluded by some governments (Wang 2019). The main device that allows greater participation of society in the management of NPs are the Advisory Councils. However, even if the general situation of the Brazilian parks is positive regarding the existence of Advisory Councils, there're challenges to overcome, for example, the lack of transparency and equity in decision making, like it occurs in China (Zhang et al. 2020). Moreover, as we see on the African continent, in the protected areas where collaborative management has been effectively implemented the results have been positive (Baghai et al. 2018), such as in *Mole* NP in Ghana (Soliku & Schraml 2020), showing that it is possible to integrate social participation into the parks' management.

In the 68 parks that already have a constituted Advisory Council, it is necessary to think about mechanisms or instruments for maturing and strengthening social participation (Bezerra et al. 2018). In addition, Advisory Councils as an environmental governance tool need to demonstrate that they are effective, equitable, dynamic, and strong to play a good role as a governance body (Bennet & Satterfield 2018). It is also necessary to prevent the environmental conflicts inherent to the creation of a protected area from being transferred to the Council, as observed in the *Serra do Brigadeiro* State Park (Magno 2020). Even so, as we see in the Advisory Councils of US NPs, the collaborative actions that take place in these Councils make an important connection between society and the management of protected areas for the benefit of the latter (Foster 2020).

In a global analysis of the effectiveness of management of 8,000 protected areas, despite the lack of funding for these areas, there're indicators of their contribution to biodiversity conservation and society's welfare (Leverington et al. 2010). Geldmann et al. (2015) further point out that when these areas receive adequate resources there's a direct effect against biodiversity loss. On the other hand, a study by the International Forestry Resources and Institutions (IFRI) showed that among 163 legally protected areas there was no effective gain in protection compared to other forest areas under different types of management, casting doubt on the creation of protected forests (Hayes 2006).

In Brazil, we can perceive a similar context to what was observed in 2012 on the 20th anniversary of the Habitats Directive – regulatory act for the protected areas of the 27 member States of the Eurozone – when managers detected the growth of the pressures and threats to these protected areas (Jones-Walters & Civic 2013). In the future, a statistical

analysis with systematized variables will allow advancing from an exploratory analysis of these to a deeper statistical evaluation. However, our results and discussion with the data available today allow us to state that, twenty years after the SNUC law enactment, the set of assessed NPs are not meeting their legal objectives, especially in regard to land regularization. This situation is aggravated by the threat of downsizing, downgrading, and degazettement processes that are affecting some protected areas in the Amazon (Pack et al. 2016) and in other biomes, added to the worrying scenario for protected areas as a whole, with current processes of commercial exploitation of protected areas and indigenous lands (Diele-Viegas et al. 2020). These threats, together with the fragilities of the parks that are not fulfilling their legal objectives, compromise the conservation of biodiversity associated with protected areas in general and the protected areas system in particular. It is important to point out that our criticism is not against the SNUC law, but against the conditions for the fulfillment of its objectives through policies that provide opportunities for the responsible bodies to put into practice actions to effectively promote the achievement of the legal objectives of each category of protected areas, which, as a rule, should ensure the conservation of nature.

CONCLUSION

Although 26 million hectares are protected as National Parks, the reality behind this number is worrisome. Considering the main legal objectives of creation of Brazilian parks, defined by the SNUC law 20 years ago, only with regard to the existence of Advisory Councils most of the Brazilian National Parks are fulfilling their legal objectives. However, it is necessary to assess the effectiveness of social participation in these governance bodies. The existence of management plans could show a positive situation at a first glance, but when we analyze the age of these management plans, half of the parks have no plan or have outdated documents. As for the other legal objectives: land regularization, visitation, activities, and research studies, it is with concern that we conclude that 20 years after the SNUC law enactment, most NPs are not fulfilling them. The worst situation is for the land regularization, a basic premise when an area is declared a park of federal administration. Without effective land regularization, nature conservation management in the parks is compromised. In this sense, the other legal objectives gain more relevance because they can help park managers to have the support of society, through the development of ecotourism and the provision of ecosystem services, and the support of the scientific community, through the scientific dissemination of their ecological relevance. However, even in these aspects the situation is far from ideal. This evaluation of the group of 74 Brazilian NPs is an excellent marker for the general situation of Brazilian protected areas, but that, unfortunately, shows that important public policies to protect the environment are not being properly implemented.

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SUPPLEMENTARY MATERIAL

Tables SI, SII.

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