MANAGEMENT PLANS FOR PROTECTED AREAS IN BRAZIL REVEAL SIMILARITY BETWEEN SPECIFIC OBJECTIVES AND MAMMALS AS THE MAIN FOCUS OF CONSERVATION

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Protected Areas, including conservation units (UCs), are among the main strategies for maintaining biodiversity worldwide. Their management plans are an essential instrument for the suitable functioning of these areas. In this context, the present study analyses the Brazilian management plans to identify differences between their goals, and to investigate target biological groups for conservation. We identified 2544 Protected Areas in Brazil, of which only 496 (19.5%) have management plans. However, only 62% of these management plans (307) were fully available. The category with the fewest management plans is the Wildlife Refuge (only 5.95% of the Protected Areas with management plans) and the least represented biome, in terms of a number of management plans, is the Caatinga one, with 10.35% of Protected Areas with management plans. Among the categories of UCs, the Private Natural Heritage Reserve (RPPN) stands out, with 85 units with management plan. This category is among the most recently established UCs, and also presents most updated plans. There were no differences in the specific goals by category of UC and by biome between Protected Areas with management plans. Mammals and birds were the main umbrella species, sheltering the high diversity of species. Therefore, we have identified that only 20% of the UCs in Brazil have management plans. In relation to UCs without management plans, even if their main goals are ecological and have mammals as focal species, which globally present positive results as umbrella species, it is necessary to update the management plans periodically.

Key words: biodiversity, Conservation Unit, Felidae, protected areas management, umbrella species

Introduction

Biodiversity plays an important role in maintaining ecological balance and ecosystem services, and consequently has high relevance to human well-being (Pimm et al., 2014; Bennett et al., 2015; Oliver et al., 2015; Díaz et al., 2018). However, biodiversity has been declining at all scales (local, regional, and global) (Collen et al., 2009; Butchart et al., 2010; Pimm et al., 2014), and this loss is considered one of the most critical environmental problems today (Gustafsson, 2013; Karlsson-Vinkhuyzen et al., 2018). The current loss of biodiversity is a result of several human-induced factors; the main ones are changes in vegetation cover, climate change, pollution, overexploitation, and introduction of invasive species (Pereira et al., 2012; Mehring et al., 2017; Whitehorn et al., 2019).

In this scenario, the establishment of Protected Areas (PAs) is one of the most used strategies for biodiversity conservation and restoration (Chape et al., 2005; Geldmann et al., 2013; Carranza et al., 2014). It is crucial for decreasing species extinction rates (Gray et al., 2016; Fer-reira et al., 2020), in addition to reducing forest fires (Nelson & Chomitz, 2011), carbon loss (Scharlemann et al., 2010), and negative changes in vegetation cover (Geldmann et al., 2013). Thus, the PAs are fundamental tools to achieve goals of reducing the loss of biodiversity through actions that provide full protection or sustainable use, balancing the relationship between environment and society.

Brazil is worldwide one of the most biologically diverse countries, which needs to prioritise its conservation (Oliveira et al., 2017), investing in the creation of new PAs (nationally classified as Conservation Units, hereinafter – UCs), and also in the maintenance and inspections of PAs so that they are efficient (Soares-Filho et al., 2010; Oliveira et al., 2019). The UCs play a crucial role in protecting the country's resources and are divided into two groups: Integral Protection Units, which aim to preserve nature, thus allowing only the indirect use of existing resources in this area; and Sustainable Use Units, which aim to make nature conservation compatible with the sustainable use of its natural

resources (Brasil, 2000). Furthermore, the UCs can be subdivided into 12 categories, which is especially due to the multiplicity of conservation objectives that will be given priority by each one of them. The better example of these categories is the Environmental Protection Areas (APA), whose basic goal is the protection of biological diversity, ensuring sustainability with the use of natural resources and has as main characteristic the protection of large areas with private and public interest (Brasil, 2000).

The effectiveness of these areas is a key factor in promoting biodiversity conservation (Mattar et al., 2018). The management plans and environmental zonings are the main management instruments for the success of a UC (Almeida & Loch, 2012; Saleme & Costa, 2020). Management plans are dynamic and practical instruments with guidelines and overall conservation objective (Amend et al., 2002). Flexibility and adaptability of plans are important characteristics so that the measures meet the current needs of the area (Kinouchi, 2015). In Brazil, the management plan is considered a mandatory document for a UC, and the deadline for its conclusion is up to five years after their creation (Brasil, 2000).

Considering the importance of the management plan for the decision-making in the UCs, this study was based on a detailed analysis of the management plans of the UCs in Brazil, in order to understand three key questions: (i) the existence of the management plan and its updates; (ii) the specific objectives and their possible variations between categories and region (biome); (iii) the target and benefited biological groups (with a focus on fauna) by UCs.

Material and Methods
Database
The data on Brazil's Conservation Units were extracted from the website of the National Registry of Conservation Units (Cadastro Nacional de Unidades de Conservação – CNUC), in the second half of 2020. The management plans were obtained in the ICMBio platform (https://www.icmbio.gov.br/portal/unidades-de-conservacao). Some old plans are available only as a physical paper form, and they were not used in this study. The following general information was extracted from each management plan: name of the unit; year of establishment; category; total area; location (biome); year of the last update. In addition, specific objectives and focus species were also assessed.

Guidelines of the UC: mission or longing established for unity
The main objectives were classified according to themes. 1. Ecological: aiming at the protection, conservation or restoration of the environment or species present in the UC, in order to ensure the continuity of local ecological processes; 2. Social: aiming at the improvement of the quality of life of the populations living inside or near the UC, as well as environmental education activities and encouragement of scientific research or actions focused on the conservation of cultural and historical society; 3. Economic: aiming at actions to improve local income, considering the sustainable use of resources, whether extraction or tourists; 4. Mixed: when they equally address more than one of the previous themes (ecological and social; social and economic; ecological and economic; or ecological, economic and social).

The main species were separated as two categories. 1. Focal species: conservation of endangered species; these species were commonly described in the guidelines or among the first five specific objectives of the management plan; 2. Benefited species: ecologically important species in the UC, but not necessarily threatened with extinction, commonly described in the list of species present in the UC, in which it gives more emphasis to the animal part. For both cases, the order was the taxonomic level used.

Data analysis
The time for creating the UC and the time for updating the management plan were analyzed and compared by a PERMANOVA, in order to identify which UCs have more updated plans. From the specific objectives categorised by themes (ecological, social, economic, and mixed), the frequency of them per UC was determined, following the number of times that the theme appears divided by the total number of UC objectives. The frequencies by UC were grouped first by category and by biome. Thus, the PERMANOVA test, followed by pairwise test, was performed to assess differences between the categories and the biomes (Zar, 2014) for these two divisions (category and biome). Linear discriminant analysis (LDA) was performed between the objectives of the PAs grouped by category and by biome.

The focal and benefited species were grouped according to their taxonomic order, except for Carnivora. Species from this order were grouped

according to their suborder (Feliformia or Caniformia). Subsequently, it was carried out at the frequency of the target group and it is necessary to analyse the interaction with the beneficiaries, to identify which target group helps in the conservation of the greatest diversity of animals.

Based on the density values of the main focal groups, the diversity indices (Hill series) were calculated, considering the taxonomic order of the species. The Hill series defines the «q» orders of diversity, which are sensitive to the frequency of species of the community. The indices analysed were: total species richness ($q = 0$); Shannon-Wiener index ($q = 1$); Simpson dominance index (1/D) ($q = 2$); gini-Simpson index ($q = 3$); Tsallis index ($q = 4$); and Renyi index ($q = 5$) (Chao et al., 2014).

Results

A total of 2544 UCs are registered in Brazil. However, only 496 (19.5%) of these have a management plan. However, only 268 management plans are available in the ICMBio platform, representing 62% of the total management plans in Brazil. When the percentage of UCs with management plans was analysed by biome, Caatinga, Cerrado, and Atlantic Forest ones have less than 20% of the UCs with management plans, and the difference between the number of UCs with and without plans was significant ($p < 0.004$). The coastal marine biome has a higher percentage of PAs with management plans (35.75%), while the biomes Pampa and Pantanal have the lowest number of available management plans (Table).

Among the categories of UCs, the Private Natural Heritage Reserve (RPPN) stands out, with 85 units with a management plan. This category is among the most recently established units

and also presents more updated plans, with an update every 6.5 years. Also, the National Parks (PARNA) and the National Forests (FLONA) have 50 and 43 units with a management plan, respectively. However, these categories had a mean of 12 years for a plan update (Fig. 1).

Ecological objectives, regardless of category or biome, were the most frequent in the UCs (Fig. 2). Among the categories, the Extractive Reserves (RESEX) was also prominent in the mixed social and economic objectives, while the RPPN in the Social Theme (Fig. 2A). In addition, the UCs by category showed significant differences (PERMANOVA, $F = 4.061$, $p < 0.001$); FLONA and RESEX categories were the most differentiated from the other ones. The objectives grouped by biome showed a higher similarity between the UCs by biome (Fig. 2B), but also showed a significant difference (PERMANOVA, $F = 2.131$, $p = 0.021$), in which the Amazon biome differed from the Cerrado, Atlantic Forest and Marine biomes; the Atlantic Forest biome was also different compared to the marine UCs.

The themes of the specific objectives by LDA, points out low separation by categories of UCs (Fig. 3A) and by biome (Fig. 3B), showing that the objectives of the UCs tend not to present high variations. However, the accuracy by UC categories (mean: 0.45; 95% CI: 0.38–0.53) was higher than by biome (mean: 0.39; 95% CI: 0.33–0.47).

The main theme of the objectives was related to the conservation and preservation of the fauna and flora in the UCs. Among the focal species of conservation, 73 orders were identified, in which the first ten represent 48% of all the focal species (Fig. 4). Among them, Feliformia animals were mentioned in 54 management plans, followed by primates (24 management plans).

Table. Number of Brazil Conservation Units with management plans by biome in 2020

Biome	Total UCs	UCs with MP	UCs with available MP	Proportion between UCs with MP and UCs with available MP (%)
Amazon	397	109	66	60.55
Atlantic forest	1536	298	116	38.92
Caatinga	232	24	20	83.33
Cerrado	468	85	40	47.05
Marine	193	69	25	36.23
Pampa	36	9	1	11.11
Pantanal	29	6	3	50.00
Total	2544	430*	271	62.79

Note: UC – Conservation Unit, MP – management plan; * – The UC can be in more than one biome; in total, it only counts once.
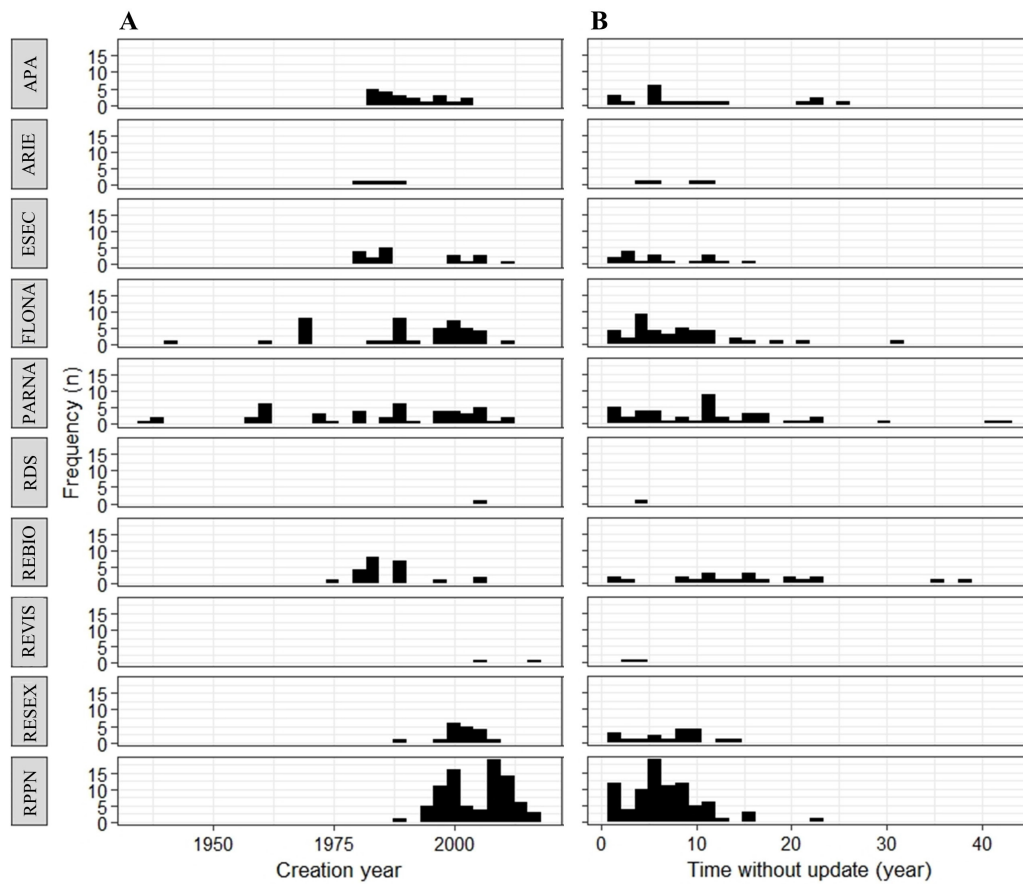
Fig. 1. Frequency of Conservation Units in Brazil, by declaring time (A) and management plan update time (B), by category. Designations: APA: Environmental protection areas; ARIE: Areas of relevant ecological interest; ESEC: Ecological stations; FLONA: National forests; PARNA: National parks; RDS: Sustainable development reserves; REBIO: Biological reserves; RESEX: Extractive reserves; REVIS: Wildlife refuges; RPPN: Private natural heritage reserves.
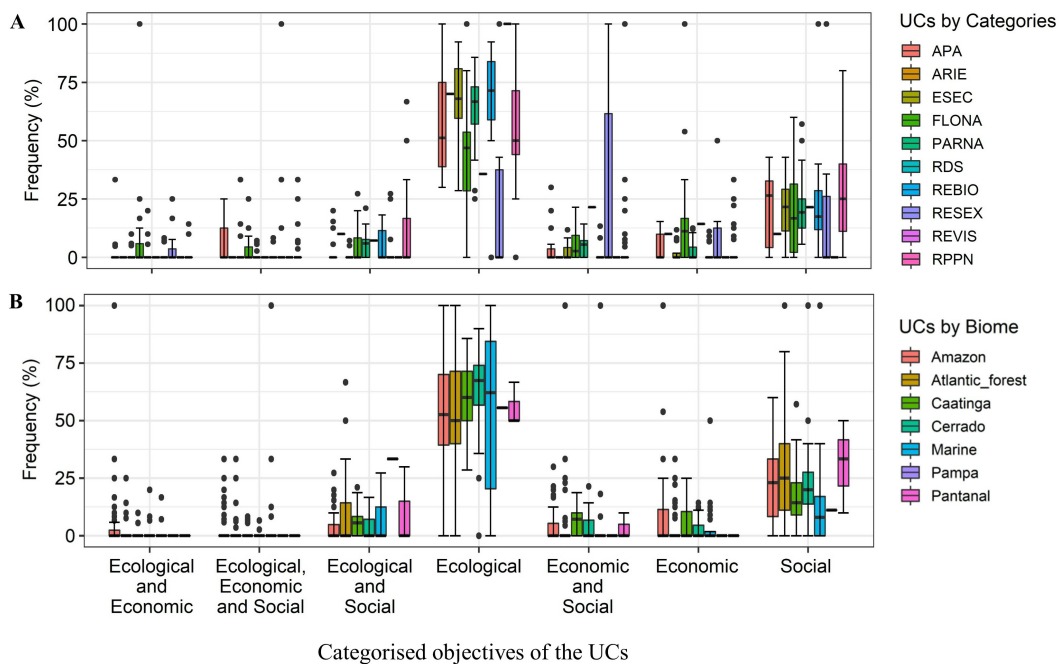

Fig. 2. Frequency of the themes of the specific objectives of the Brazilian Conservation Units by category (A) and by biome (B). Designations: APA: Environmental protection areas; ARIE: Areas of relevant ecological interest; ESEC: Ecological stations; FLONA: National forests; PARNA: National parks; RDS: Sustainable development reserves; REBIO: Biological reserves; RESEX: Extractive reserves; REVIS: Wildlife refuges; RPPN: Private natural heritage reserves.
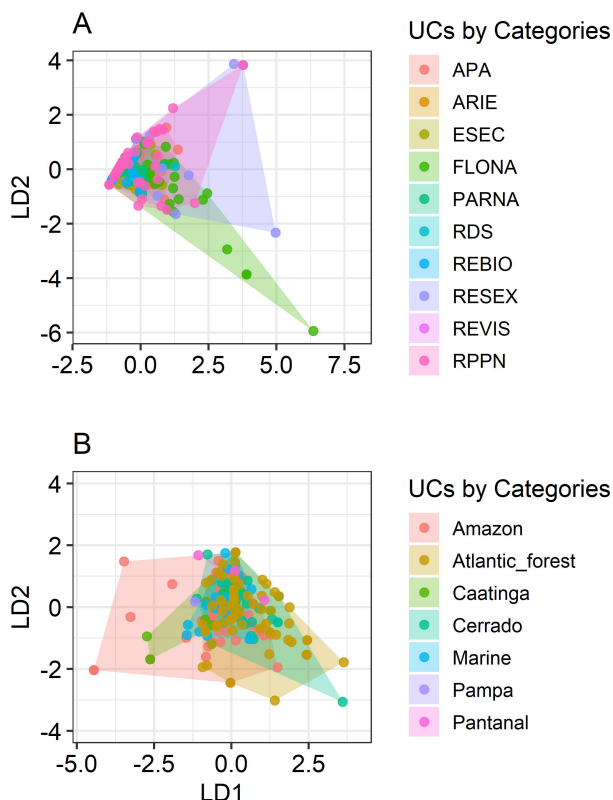
Fig. 3. Linear discriminant analysis (LDA) of the frequency of specific objectives of Brazilian Conservation Units by category (A) and by biome (B). Designations: APA: Environmental protection areas; ARIE: Areas of relevant ecological interest; ESEC: Ecological stations; FLONA: National forests; PARNA: National parks; RDS: Sustainable development reserves; REBIO: Biological reserves; RESEX: Extractive reserves; REVIS: Wildlife refuges; RPPN: Private natural heritage reserves.
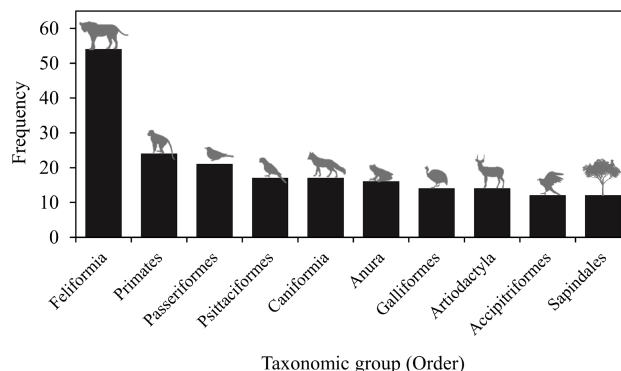

Fig. 4. Frequency of taxonomic groups in the Conservation Units of Brazil.

An analysis of the interaction of target-beneficiary species, pointed to a different pattern between the taxonomic orders. The fish and amphibians appear as only one of the main groups benefiting from the Feliformia group. The primates only appear among as the main beneficiaries in the order of their own primates. The Canniformes only appear in the Psittaciformes. Passerine birds were among the first five groups of focal species, being the most benefited of this order (Fig. 5).

The analysis of the diversity indices showed that the Feliformia group has the higher rates of richness and diversity of the orders benefited, followed by the canids (Fig. 6). These two groups tend to be more indicated as umbrella species, sheltering more groups and having less dominance. On the other hand, Primates, Passeriformes and Psittaciformes were similar, and had lower values of richness and diversity.
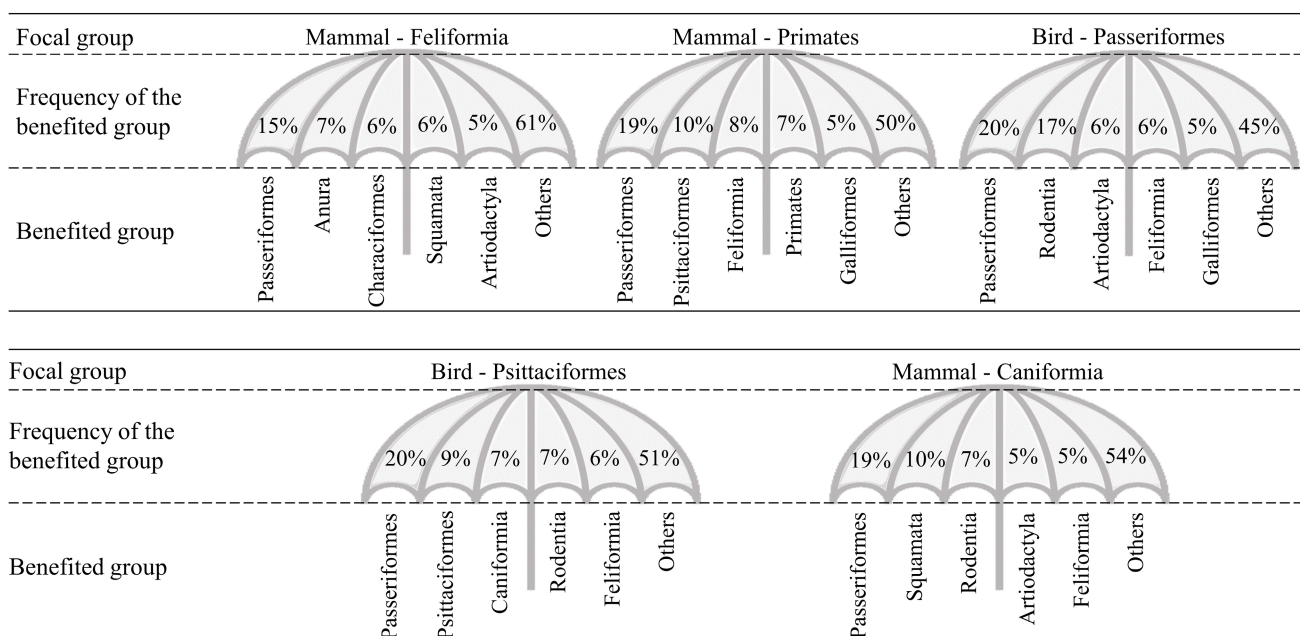

Fig. 5. Frequency of groups of benefited species by group of focal species in the Conservation Units in Brazil.
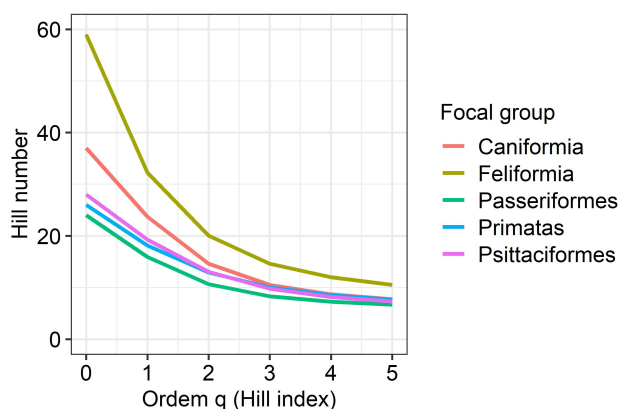
Fig. 6. Hill diversity index by conservation focal group of Conservation Units in Brazil. Designations of the Hill number: 0 – total species richness; 1 – Shannon-Wiener index; 2 – Simpson dominance index; 3 – gini-Simpson index; 4 – Tsallis index; and 5 – Renyi index.

Discussion

The increase in ecosystem degradation, exacerbated by agricultural and urban expansion, has increased the number of threatened species of fauna and flora worldwide (Foley et al., 2005). In view of this, the UCs are very important tools for the continuity of the endangered species and degraded ecosystems, besides the protection of traditional people's cultures (Lovejoy, 2006). Moreover, the management plan is a fundamental instrument in the establishment of norms for the use of these areas, as well as the actions and management to be developed (Saleme & Costa, 2020).

The lack of a management plan can lead to inefficiency of a UC, which is generally a major concern for conservation units in Brazil, as only 17% of UCs have a management plan. Another important issue is to make these management plans easily available, mainly in the case of Pampa (11% of management plans are available) and Marine (38% of management plans are available) biomes. These management plans are essential for the success of the UCs, according to Laurance et al. (2012), only a half of tropical PAs are efficient, which indicates that in Brazil this percentage may be even lower. Therefore, it is necessary to pay more attention to these UCs, and especially to the less represented biomes, so that the management plans can be implemented and made available to society in general.

Moreover, another important topic is the updating of the management plans, since some UCs do not update their management plans over the time (Mattar et al., 2018). This updating is a fundamental step, especially for the short-term objectives, modifying the goals and improving the UC effectiveness. Regarding the management plan updating, we observed that the categories of sustainable use (such as Private natural heritage reserves, PRNH) was highlighted, presenting more up-to-date, different from APAs and National Parks (PARNAs) that have non-updated management plans, as is the case of the Amazon National Park, whose available management plan dates back to 1978. This difference in updating may be related to the sizes of the UCs, since the most updated (RPPNs) tend to have smaller areas, facilitating management and consequently the dissemination of this data, but there is a lack of data supporting that.

Regarding the specific objectives, the UCs presented in most cases the ecological theme, being related to the conservation of fauna, flora, and ecosystems. In relation to the biomes, it can be observed that there is greater uniformity of objectives, with a low difference in the ecological objectives, in which the Amazon presents the second high frequency (median) among the biomes, behind the Pantanal that has only three UCs. A high number of ecological objectives of the Amazon biome may be related to its high biodiversity, in addition to the intense fires, making its conservation a priority (Bowman et al., 2012; Davidson et al., 2012; Lapola et al., 2014; Franco et al., 2019). Although the number of ecological objectives was high, the UCs located in Amazon have the lowest sampling rates, resulting in a non-realistic dataset (Oliveira et al., 2017). Therefore, biodiversity inventories and analyses should be a priority for this biome, and more financial and research investment is needed.

The specific objectives by UC categories are more divergent than those by biome. This is related to their classification between sustainable use and integral protection. Sustainable use units, such as RESEXs, have a moderate/lower frequency of ecological objectives, due to the permission of sustainable exploration of resources. On the other hand, RPPNs, APAs, and ESECs (Ecological stations) show a high frequency of social objectives since they present environmental education programs and integration of the resident communities in the management of the UCs. The economic objectives include FLONAs, which aim at the sustainable and diversified use of forest resources. The integral Protected Areas do not present food production

and are important areas for preserving more vulnerable species and biological diversity; thus, they present a high frequency of ecological objectives (Rylands & Brandon, 2005; Azpiroz et al., 2012; Lima et al., 2020). Therefore, these categories have different demands, which generate different objectives and a more restrictive management of the objectives results in greater biological diversity (Gray et al., 2016).

Globally, the PAs are 41% efficient in retaining species richness and 51% in retaining local diversity abundance (Gray et al., 2016). According to Oliveira et al. (2017), in Brazil, PAs protect a considerable part of biodiversity, covering about half of the species and phylogenetic endemism. In our study, we found 73 groups (taxonomic orders) to be the focus of conservation, being mammals (12 orders) the more common, especially Feliformia, Primates, and Caniformia. According to ICMBio (2018a), these three groups are among more threatened, while the carnivorous order has one Endangered species (EN) and 12 Vulnerable species (VU). The primates have six Critically Endangered (CR) species, 15 Endangered species, and 14 Vulnerable species. After mammals, birds are the second group of endangered animals, mainly of the orders Passeriformes and Psittaciformes (ICMBio, 2018b). In this group, 12% of the species are in some degree threatened with extinction (VU, EN or CR). Due to this high number of endangered species, it makes these groups common as focus species of the UCs, since one of the main objectives of the units is the conservation of rare, endemic, and/or threatened species (Mustin et al., 2017).

Also, the conservation of these focal species benefits the conservation of several other groups, such as Feliformia, which conservation benefits several other species (e.g. birds, amphibians, and fishes). Thus, this group can be considered an important umbrella group, supporting a high wealth and diversity of orders. The canids were the fifth most present group in the management plans, presented the second major richness and diversity of orders benefits, becoming the second most important as an umbrella, surpassing primates and birds. These two focal groups, even with different indices tend to have a similar composition of the benefited orders. The carnivores, especially top predators and mesopredators, are considered particularly vulnerable and sensitive to deforestation and forest fragmentation (Vet-

ter et al., 2011; Ripple et al., 2014), and therefore they are the most frequent focal species in management plans. Also, they harbour a greater richness and diversity because of their restricted carnivorous diet and the need for large areas to compose their life cycle, with diverse habitats such as open and closed forests and aquatic environments (Ripple et al., 2014; Wang et al., 2019). Due to this large area, carnivores are also good candidates for umbrella species (Carroll et al., 2001; Macdonald et al., 2015).

The pattern of focal species for conservation in PAs was also reported by Roberge & Angelstam (2004), who identified that the main umbrella species were mammals and birds, similar to our results. However, even though mammals are the main umbrellas, Caro (2003), when evaluating the potential of large mammals in East Africa, reported that they are not efficient for rodents and insects. Therefore, even if carnivorous mammals have been considered good candidates to be used as umbrella species, it is necessary to have a wide overview of which groups need protection and why. It is essential to have more research on and inventories of the Brazilian fauna and flora, inside and outside the UCs.

Conclusions

In conclusion, we reported that 80% of UCs in Brazil urgently need their management plans updated and easily available in large database, such as ICMBio platform. This action will facilitate both the management of the area as well as future evaluations that can improve the conservation efficiency of the unit. This also applies to conservation units that have very old management plans. The lack of update makes it difficult to assess a UC and identify which objectives have been met or not. Regarding the objectives, we observed that most of the UCs have an ecological focus, and that these objectives change according to the biomes and UC categories. This is beneficial for the environment, since each biome has its own characteristics and consequently specific problems. Regarding biological groups, the Brazilian UCs follow the global pattern, with mammals of the order Carnivora being one of the main focus groups, and they harbour the greatest diversity of species, thus being considered as umbrella species. In addition, we observed that, regardless of the UCs' focus species, the birds of the Passeriformes order are more protected. Still on the use of umbrella species, it is necessary

for future research to identify whether these umbrella species are harbouring species at higher risk of extinction. In addition, studies on efficiency of UCs need also be conducted to assess the eventual decrease/increase in biodiversity. Finally, it is worth highlighting the importance of expanding and/or creating new PAs, especially in poorly protected regions such as the Pampa and Pantanal biomes, which have less than 5% of their territory under PAs.

Acknowledgements

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ПЛАНЫ УПРАВЛЕНИЯ ОСОБО ОХРАНЯЕМЫМИ ПРИРОДНЫМИ ТЕРРИТОРИЯМИ БРАЗИЛИИ ОБНАРУЖИВАЮТ СХОДСТВО МЕЖДУ ИХ КОНКРЕТНЫМИ ЦЕЛЯМИ И МЛЕКОПИТАЮЩИМИ КАК ОСНОВНЫМ ОБЪЕКТОМ ОХРАНЫ

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Особо охраняемые природные территории (ООПТ), включая природоохранные единицы (ПЕ), являются одной из основных стратегий сохранения биоразнообразия во всем мире. Их планы управления являются важным инструментом для надлежащего функционирования этих территорий. В этом контексте настоящее исследование анализирует бразильские планы управления, чтобы выявить различия между их целями и исследовать целевые биологические группы для их сохранения. Мы определили 2544 ООПТ в Бразилии, из которых только 496 имеют планы управления. Однако только 62% этих планов управления (307) были полностью доступны для ознакомления. Категория с наименьшим количеством планов управления – это рефугиум дикой природы (Wildlife Refuge) (только 5.95% ООПТ имели доступные планы управления), а наименее представленным биомом с точки зрения количества планов управления является биом Каатинга, включающий 10.35% ООПТ с планами управления. Среди категорий ПЕ выделяется частный заповедник природного наследия (Private Natural Heritage Reserve), насчитывающий 85 ПЕ, имеющих планы управления. Эта категория входит в число недавно созданных ПЕ, а также представляет наиболее обновленные планы управления. Не было обнаружено различий в конкретных целях по категориям ПЕ и по биомам между ООПТ с планами управления. Млекопитающие и птицы были основными зонтичными видами, обеспечивающими укрытие (охрану) большого разнообразия видов. Таким образом, мы определили, что в Бразилии только 20% ПЕ имеют планы управления. Что касается ПЕ без актуальных планов управления, даже если их основные цели имеют экологическую направленность и включают млекопитающих в качестве основных охраняемых видов, которые в глобальном масштабе дают положительные результаты в качестве зонтичных видов, необходимо периодически обновлять планы управления.

Ключевые слова: Felidae, биоразнообразие, зонтичный вид, природоохранная единица, управление особо охраняемыми природными территориями