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ORIGINAL ARTICLE

CONSIDERATIONS ABOUT HABITAT LOSS IN CHAPADA DIAMANTINA, BAHIA, BRAZIL

Considerações sobre perda de habitat na Chapada Diamantina, Bahia, Brasil

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Abstract
Habitat fragmentation is characterised by reducing a continuous vegetation area in isolated patches. The objective was to evaluate if there is a process of fragmentation or habitat loss in the Chapada Diamantina and to report the first impressions on how local biodiversity is affected. We used Geoprocessing techniques and elaborated a map of vegetation cover and land use with Sentinel satellite images. We also used QGIS 3.10, visual analysis, photo interpretation, and classification techniques supervised by the Dzetsaka algorithm. The results indicate that the Morro do Chapéu State Park (MCSP) is not yet fragmented, and there is an intermediate level of habitat loss; if it persists, it could lead to the fragmentation of the protected area and further impact biodiversity. For this problem to be repaired or mitigated, it is necessary to think of priority areas for land regularisation and increased supervision, an attempt to repress illegal activities in this conservation area.

Keywords: Land Use; Anthropic Activities; Protected Areas.

Resumo
A fragmentação de habitat é caracterizada pela redução de uma área de vegetação contínua em manchas isoladas. O objetivo foi avaliar se há um processo de fragmentação ou perda de habitat na Chapada Diamantina e relatar as primeiras impressões sobre como a biodiversidade local é afetada. Utilizamos técnicas de Geoprocessamento e elaboramos um mapa de cobertura vegetal e uso do solo com imagens de satélite Sentinel. Também usamos QGIS 3.10, análise visual, interpretação de fotos e técnicas de classificação supervisionadas pelo algoritmo **Dzetsaka**. Os resultados indicam que o Parque Estadual Morro do Chapéu (MCSP) ainda não está fragmentado, havendo um nível intermediário de perda de habitat; se persistir, pode levar à fragmentação da área

protegida e causar ainda mais impacto na biodiversidade. Para que esse problema seja reparado ou mitigado, é preciso pensar em áreas prioritárias para regularização fundiária e aumento da fiscalização, na tentativa de reprimir atividades ilegais nesta área de conservação.

Palavras–chave: Uso da Terra; Atividades Antrópicas; Áreas Protegidas.

1. INTRODUCTION

Fragmentation can be understood as dividing a continuous environment into smaller parts, the patches. They come to have different environmental conditions from their surroundings (RAMBALDI; OLIVEIRA, 2003), dominated by an anthropic matrix that tends to change ecological dynamics over time (WILCOVE *et al.*, 1986). This process may have a natural or anthropic origin. The second is the most recurrent and impactful, especially considering that biodiversity in fragmented environments is modulated by the landscape structure (ANTONGIOVANNI *et al.*, 2018), i.e., environments now altered by any anthropic activity tend to change the habitat amount and quality.

Deforestation, urban expansion, intensive agriculture, and grazing stand out among the human actions that negatively affect the environment (SPIRLANDELLI, 2019). The consequences of human activities and climate change can also collaborate with the aggravation of fragmentation effects (HADDAD *et al.*, 2015). According to Saunders *et al.* (1991), landscape fragmentation causes division into a series of vegetation patches, increasing habitat isolation and increasing edge effects since the remnants are exposed to a higher level of radiation, wind, and changes in the water. The lack of connectivity between habitat patches or areas can facilitate or hinder the movement of organisms between patches, i.e., the effects of fragmentation may have different impacts on biodiversity (TAYLOR *et al.*, 1993; VILLARD; MATZGER, 2014; LARREY-LASSALE *et al.*, 2018; BETTS *et al.*, 2019). The edge effect reflects the modification of the ecological patterns of surrounding areas (ANTONGIOVANNI *et al.*, 2018).

When the fragmentation process starts, considering an area with original vegetation cover, it is possible to observe a reduction in the number of habitats, an increase in the number of habitat patches, a decrease in the patches' size, and later the increase in the isolation of patches, affecting ecological processes such as dispersion, recruitment, and species composition in biological communities (FAHRIG, 2003; GARCIA, 2011). For fragmentation works, there is first habitat loss, which according to Fahrig (2003), is a much more impactful process than fragmentation itself.

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Generally, the expected sequence of events would be transforming continuous forest patches into many fragmented environments. Identifying and understanding the levels of fragmentation, especially the initial ones, such as habitat loss, allows for decision-making in establishing macro-scale conservation plans to avoid the process's aggravation (OLSOY *et al.*, 2016).

Habitat can be the "address" of an organism or specie where the individuals live and can be found (ODUM; BARRETT, 2020). Therefore, one environment may have more or fewer habitats than the other, presenting specific impacts on disturbance processes. Regarding habitat loss, it is essential to address the reduction in the total area of habitats in a landscape. However, it does not necessarily refer to fragmentation since the removal does not always lead to the isolation of patches (BOSCOLO, 2007; GIAM *et al.*, 2010; FRANCOSO *et al.*, 2015; RUFFELL *et al.*, 2016; MORANTE-FILHO *et al.*, 2018; FAHRIG, 2019). In contrast, some authors consider that habitat loss and fragmentation co-occur and are inseparable (DIDHAM *et al*., 2012; FLETCHER *et al.*, 2018; PUTTKER *et al*., 2020).

Some evidence indicates that the initial process of habitat loss in continuous landscape areas may lead to fragmentation if it persists, as commonly observed in altered landscapes. However, the effect of habitat loss is clear, and most species respond negatively to the phenomenon that is considered the leading cause of biodiversity decline globally (FAHRIG, 2003; HADDAD *et al.*, 2015; WATLING *et al.*, 2020; ARASA-GISBERT *et al.*, 2021). In this scenario, if habitat loss increases, some species may disappear.

Regarding habitat loss, it is necessary to consider anthropic activities such as agriculture, where small areas are deforested. Habitat loss affects the richness, abundance, and species distribution that coexist with human activities. This interaction may negatively affect several biological attributes, such as genetic diversity, population growth, trophic chain length, ecological interactions, reproduction, and dispersion (FAHRIG, 2003).

The Seasonally Dry Tropical Forest - Brazilian Caatinga, where our study area is located, is distributed over 10 Brazilian states, the main biome of Northeast Brazil. Caatinga covers about 844,453 km^2, occupies 11% of the country's area, and undergoes the influence of a semi-arid climate (MMA, [2021?][1]). The vegetation is deciduous during the dry season, remaining only white and shiny trunks of trees and shrubs. This characteristic gave rise to the name "caatinga" from the Tupi-Guarani language, which

[1] https://antigo.mma.gov.br/biomas/caatinga.html. Access: October 06, 2021.

means "white forest" (PRADO, 2005). According to Teixeira *et al*. (2021), only 8% of its territory is in protected areas, disproportionately distributed over the region.

According to the Brazilian Ministry of Environment (MMA, [2021?]), 27 million people live in the region, and about 80% of the original ecosystems have already been modified to some level. This biome has 178 species of mammals, 591 birds, 177 reptiles, 79 amphibians, 241 fish, and 221 bees (MMA, [2021?]).

Since the European occupation, this region has been continuously degraded, which increases the extinction risk of several endemic species of fauna and flora (FREIRE *et al.*, 2018). According to some authors, deforestation is the most impacting factor in the degradation of the Caatinga. Still, other threats exist, such as fires, predatory hunting, illegal and selective logging, mining, and disordered urban growth.

For Miles *et al.* (2006), the major conservation efforts of the twentieth century focus on tropical forests, giving dry environments a secondary role. Data from the Annual Report of Deforestation in Brazil by MAPBIOMAS (2021) indicate that in 2020, 61.4 thousand hectares were deforested in Caatinga. By Antogiovanni *et al.* (2018), Caatinga has already lost half of its original cover, and the other half needs to be more cohesive.

These problems of human occupation and habitat loss also occur in protected areas such as Morro do Chapéu State Park (MCSP). Human communities are inside the territory due to the lack of land regularisation since the government created the protected area in 1998. Therefore, it is essential to preserve and conserve the natural areas of the Caatinga biome to assess the state of biodiversity and expand knowledge about the region.

Our goal was to evaluate if there is a process of fragmentation or habitat loss in the MCSP and to report the first impressions on how local biodiversity is affected. Our work is resourceful information for managing the protected area, which still needs a management plan. Knowledge about the main points of fragmentation or habitat loss can help managers plan tasks of more effective supervision actions, choosing priority areas for compensation and land regularisation.

2. MATERIALS AND METHODS

2.1. Study area

The study area is Morro do Chapéu, Bahia State, Identity Territory of Chapada Diamantina, and covers 5,920 km², with altitudes between 480 and 1293 m above sea level (ROCHA; COSTA, 1995). The area has a considerable geological, physiographic,

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and climatic diversity and economic activities related to extensive agriculture, irrigated agriculture, livestock, goat farming, trade, mining, and ecological tourism. However, it is a region with an economy based on commerce and the provision of services. Therefore, there are products with little added value in agricultural production, such as Sisal and Quince (ROCHA; COSTA, 1995).

The Identity Territory of Chapada Diamantina is in the ecoregion of the same name, located in the south-central part of the Caatinga biome. The territory occupies a central position in the Bahia State, with three protected areas in this region; the MCSP is among them (FREIRE *et al.*, 2018).

The MCSP (Figure 1) was created by State Decree 7413 of August 17, 1998, with 51,955 hectares. In 2013, Ordinary Law 12924 of December 13 reduced the size of the MCSP to 46 thousand hectares and a buffer zone of 96 thousand hectares. The Institute for the Environment and Water Resources (INEMA) manages the protected area as an agency linked to the Bahia government.

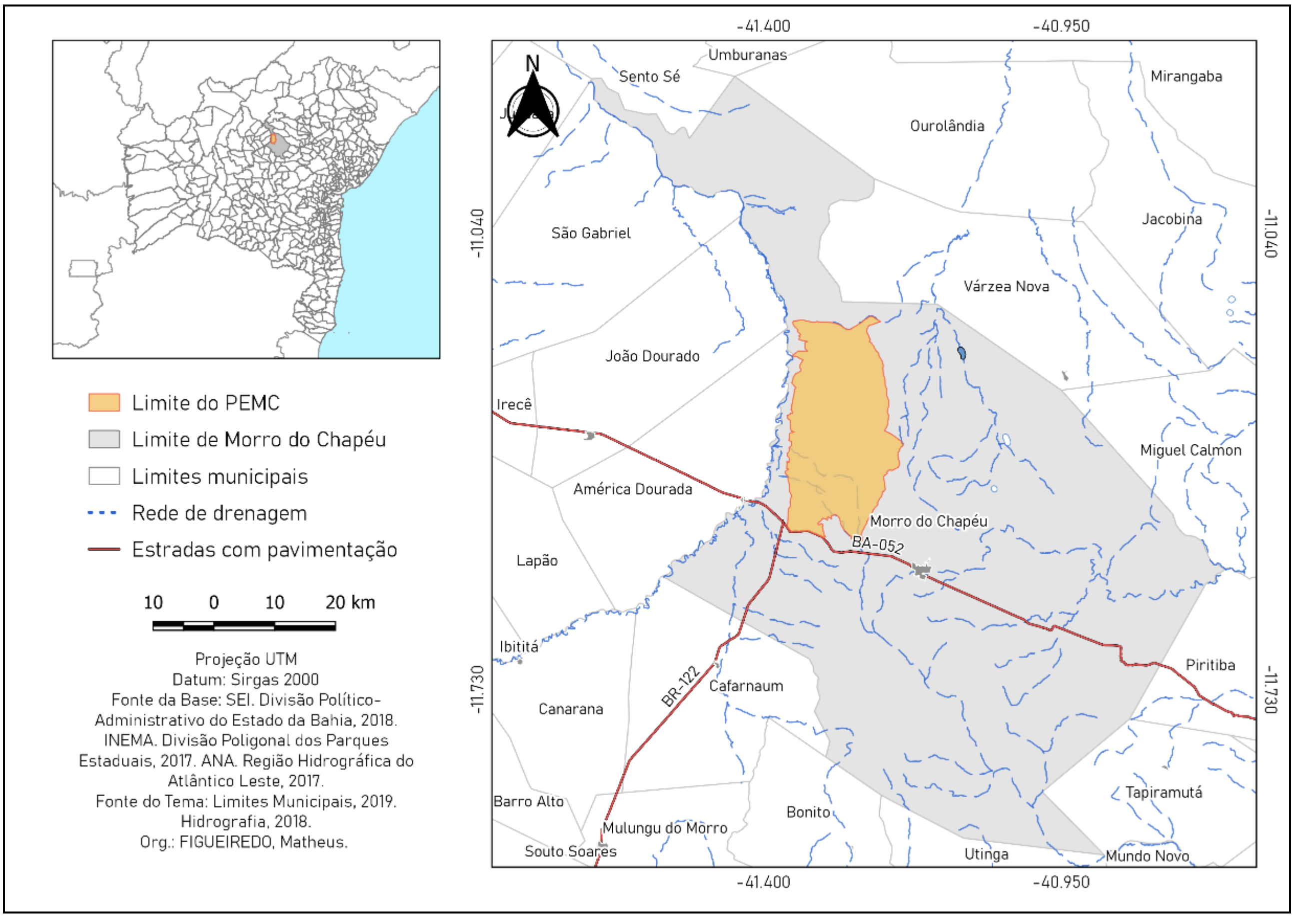

Figure 1 - Location of Morro do Chapéu State Park.
Prepared by: Matheus Santos Silva Figueiredo - UFBA (2021)

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The adjustment in the MCSP size occurred when the pressure for the settling of wind farms was intense. Today, in areas that were previously MCSP, wind power plants are settled. The human populations within the MCSP settled there when the region was not a protected area yet. Therefore, they are entitled to compensation from the government of Bahia. With the delimitation of the MCSP, the government began to monitor the area and forbid new occupations, but it is possible to observe land sales within the MCSP.

The region of Morro do Chapéu develops over the São Francisco Cratón. The Cratón is composed of four blocks resulting from collisions of crustal segments. Of these blocks, the PEMC is part of the Gavião block, more precisely to the west of the Mesoproterozoic and Neoproterozoic basement (BARBOSA *et al*., 2003).

In this block, the Chapada Diamantina Group stands out for the studied area, subdivided into Tombador, Caboclo and Morro do Chapéu formations, associated with siliciclastic, silicified and carbonate lithofacies, respectively, all of terrigenous and marine nature (LEAL; NEVES, 1968).

These formations mainly recognise meta sandstone, quartzites and mudstones in the studied area, in addition to a very varied relief with plateau areas and extensive zones of more dissected relief.

For Silva (1995), three soil classes are recognised in the PEM: the Oxisol, the Neosol and the Cambisol, the latter having a smaller spatial distribution. According to Koppen, the climate is tropical of Cwb and Cwa types, significantly different from its surroundings, because this area has the highest altitudes in the region. Both are high-altitude tropical, with mild summer, differing in the average annual variation of maximum and minimum temperatures (higher than 22 ºC for Cwb and lower for Cwa) and annual rainfall between 800 and 1,200 mm (BARBOSA, 1995).

The park is an ecotone area, where there are formations of arboreal and shrubby caatinga in contact with *campo rupestre*, other physiognomies from the Brazilian savanna (few areas), semideciduous seasonal forest and seasonal evergreen forest (SILVA, 1995), that respond to more significant rainfall indices than caatinga areas. These phytophysiognomies show a floristic composition that primarily justifies the creation and maintenance of the protected area.

We used a national and international database for literature reviews on fragmentation and habitat loss. The bases were the CAPES Journals (http://www.periodicos.capes.gov.br/), Scielo (http://www.scielo.org/php/index.php), Scholar Google (https://scholar.google.com.br), among others. In the research, we used the terms 'Landscape

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ecology', 'Landscape metrics', and 'Ecosystem fragmentation' (also their correspondents in Portuguese) in the plural and singular forms. Furthermore, only publications directly related to the topic were accounted for, considering articles, book chapters, books, dissertations, and theses. Studies that did not fit the issue were disregarded.

2.2. Classification of vegetation cover and land use

We developed a map of vegetation cover and land use to analyse the processes occurring in the MCSP. This mapping type corresponds to the spatial expression of the influence of human activities on the landscape, considering areas of overlap and integration of natural and socioeconomic systems (MESSERLI; MESSERLI, 1979 *apud* LANG; BLASCHKE, 2009). Furthermore, satellite images allow a synoptic and multitemporal (dynamic) view in studies of natural or altered environments, making it possible to evaluate ecosystems and the impacts of human activities (FLORENZANO, 2009).

According to the Brazilian Institute of Geography and Statistics - IBGE, the plant cover and land use survey indicate how the use typologies are distributed and identified through homogeneous land cover patterns. Therefore, surveys are essential for planning and decision-making, evaluating environmental impacts and causes (IBGE, 2013).

To prepare the map, we used Sentinel-2A/MSI satellite image, level L1C (correction level at the top of the atmosphere), with a spatial resolution of 10 meters, from July 02, 2020. First, the image was downloaded through the Earth Explorer (USGS) website (https://earthexplorer.usgs.gov/), selected by the criterion of recent date and lack of cloud cover. Then, we proceeded with the post-processing steps in the SIG from the QGIS 3.10 program.

First, the image composition was performed to elaborate an actual colour synthetic image from the composition of the bands R4G3B2. Then the study area was cut out and delimited by the vector file of the MCSP. The vector file was personally provided by the Bahia Institute of Environment and Water Resources (INEMA) to the authors.

For the mapping, we opted for visual analysis and photo interpretation. For the definition of visual patterns of land cover and land use classes, these patterns were systematised as interpretive keys (Table 1) in the following initial types: arboreal vegetation, shrub vegetation, sand soil, sand soil and vegetation, soil and vegetation, outcrop, and anthropised area.

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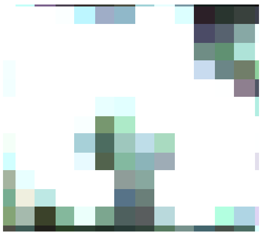
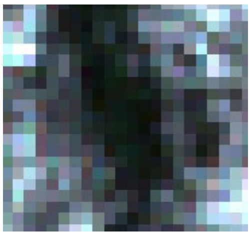
Table 1: Visual patterns of land use in the satellite image.

Classes	Images	Observations
Arboreal vegetation		Areas with forest formation are dense, natural, or little altered by anthropic use. They are usually located in the lower area of steep slopes, moist environments, and seasonal forests.
Shrub vegetation		Areas with less dense vegetation (more sparse/ less dense stratum) with arboreal and shrub species, natural or little altered by anthropic use; caatinga and savanna/ *campo rupestre*.
Sand soil		Areas with large expanses of sand originate from the region's sandy and quartzitic outcrops.
Sand soil and vegetation		Interspersed areas of sand with some cover by shrub or sparse herbaceous vegetation.
Soil and vegetation		Interspersed areas with sparse vegetation and exposed soil commonly relate to anthropised areas.
Outcrops		Exposed bedrocks.
Anthropised area		Areas of anthropic use with crops, cattle farming, and residences present typical forms and roads.

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The classes were selected because they presented areas with visual characteristics that distinguished themselves in terms of photo interpretation properties, such as texture, colour, shape, and roughness, associated with geographical contexts, such as forest vegetations and/or more dense vegetation in steep relief, and close to drainage areas (ANDERSON *et al*., 1976). In addition, these classes were grouped because they are fundamental to understanding the study area's land occupation and responding to the research interests.

Training samples were collected from the classes, delimited by polygons that best represented each land cover and use type. Between 20 and 30 polygons were collected per class to minimise errors/confusion between targets during the mapping process. The mapping classification was supervised by the Dzetsaka algorithm, available in QGIS 3.10. It is a classifier based on a Gaussian Mixture Model, a probability distribution method for grouping pixels from the attributes of their respective classes. After the supervised classification, the majority filter was applied to reclassify isolated pixels into types of larger areas of immediate surroundings. Finally, we converted the file from the matrix format to vector using the *dissolve* tool for grouping features of the same class, i.e., we joined elements of the same type in the attribute table to facilitate the handling of the results and organise the classes according to the research interest.

With the first version of the map, a field expedition was performed. It lasted 3 (three) days, and we aimed to check and adapt the classification. After the field expedition, there was a need to adjust the map through manual editions. We readjusted some polygons that presented inaccuracy and vectorised the main roads visible in the satellite image.

Considering that some areas are more difficult for human occupation because of natural characteristics, we decided to regroup the classes of sand soil, sand soil and vegetation, and outcrop into a single class entitled "areas with natural impediment for human occupation (sand soil, outcrops)". These spaces have no signs of anthropic use, given their natural limitations.

Taking into account that the classes shrub vegetation and soil and vegetation represented similar areas, and to better represent them, they were joined and called shrub vegetation, keeping separate the arboreal vegetation class since this type of vegetation is relictual in the region and the occurrence is conditioned to spaces with water flow.

The areas of soil and vegetation are zones with sparse vegetation when not for anthropogenic use. This confused the targets, and some classes needed to be more agglutinated. Because of the confusion, the class required a more detailed analysis of the

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images and field expedition to classify better if they were areas of vegetation or anthropogenic use.

The difference between arboreal and shrub vegetation is important for map analysis since the arboreal vegetation presents forest phytophysiognomies in restricted zones in the MCSP because of the rare occurrence in the region.

The anthropised area was kept separate because it represented areas effectively modified by human activities, even considering this was the main class in the data evaluation. In the end, the classes were regrouped into four categories: Areas with natural impediments for human occupation (sand soil, outcrop), Arboreal vegetation, Shrub vegetation (includes shrub vegetation, herbaceous vegetation, and exposed soil with sparse vegetation), and Areas with anthropic influence.

3. RESULTS

The mapping (Figure 2) showed that the anthropised areas occupy approximately 2,000 hectares, corresponding to 4% of the study area. Areas with some natural impediment to occupation have about 8,330 hectares (4%), and the areas with shrub and arboreal vegetation, respectively, occupy 39,640 (76%) and 2,190 hectares (16%), highlighting the relictual character of the arboreal vegetation. It should be noted that the combined areas exceed the 46 thousand hectares of the MCSP, reaching 52 thousand hectares. This area is presented in some public documents, demonstrating the need for correction by the public authorities.

Figure 3 shows the percentage of areas mapped by each type of land use. Our data showed that only 4% of the MCSP has undergone direct anthropogenic use. It is a positive result demonstrating the importance of the data that will be presented and prioritising land regularisation. This percentage mapped are the spaces with more intense use and deforestation of native vegetation. They are not counted here but are present in most of the MCSP. Areas for cattle commonly raised extensively in the caatinga and feed on shoots of native species.

Figure 4 shows some images that represent the types of vegetation cover described in Figure 3 and the types of land use considered in the classification.

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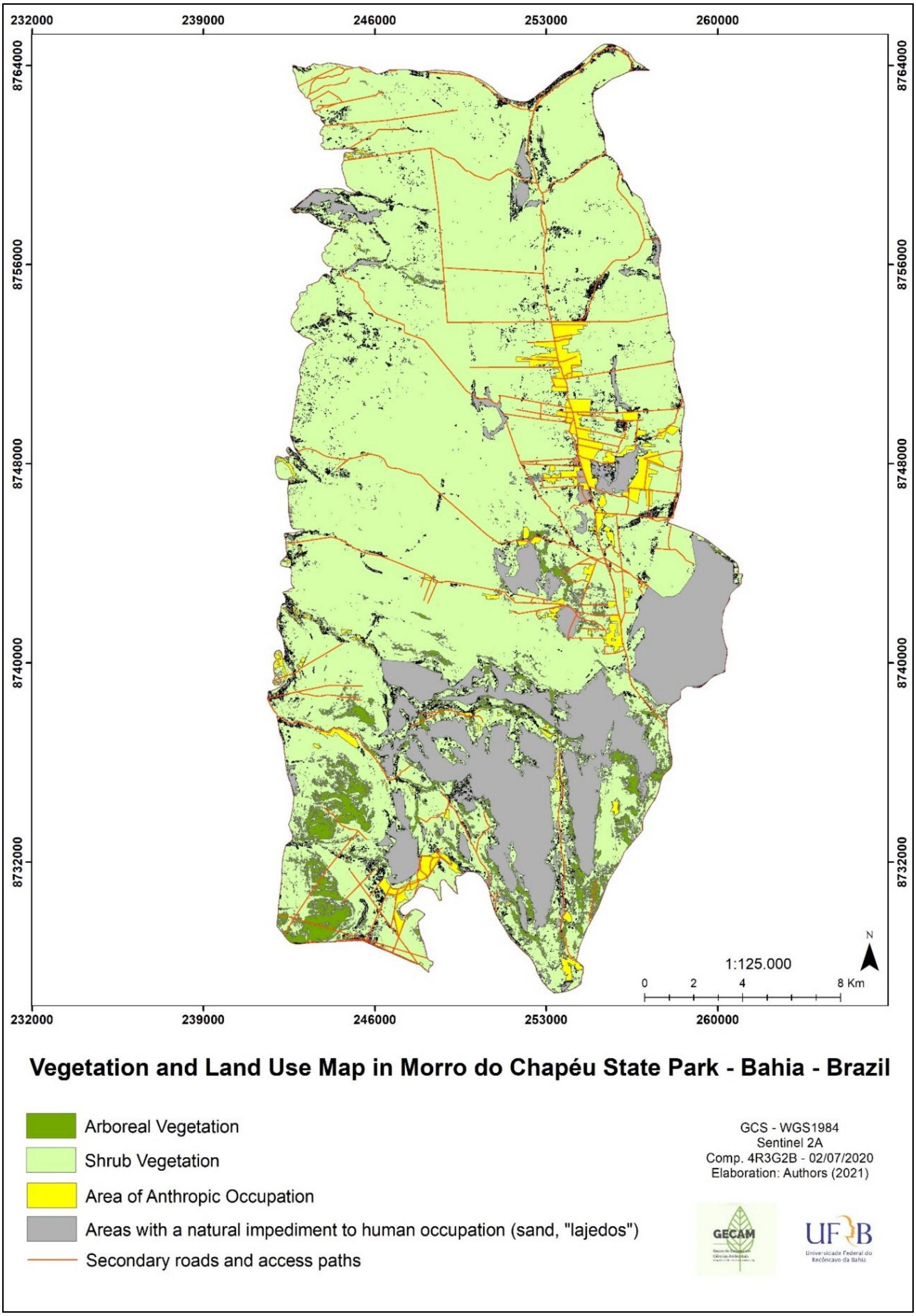

Figure 2- Map of vegetation cover and land use of Morro do Chapéu State Park.
Source: Research data

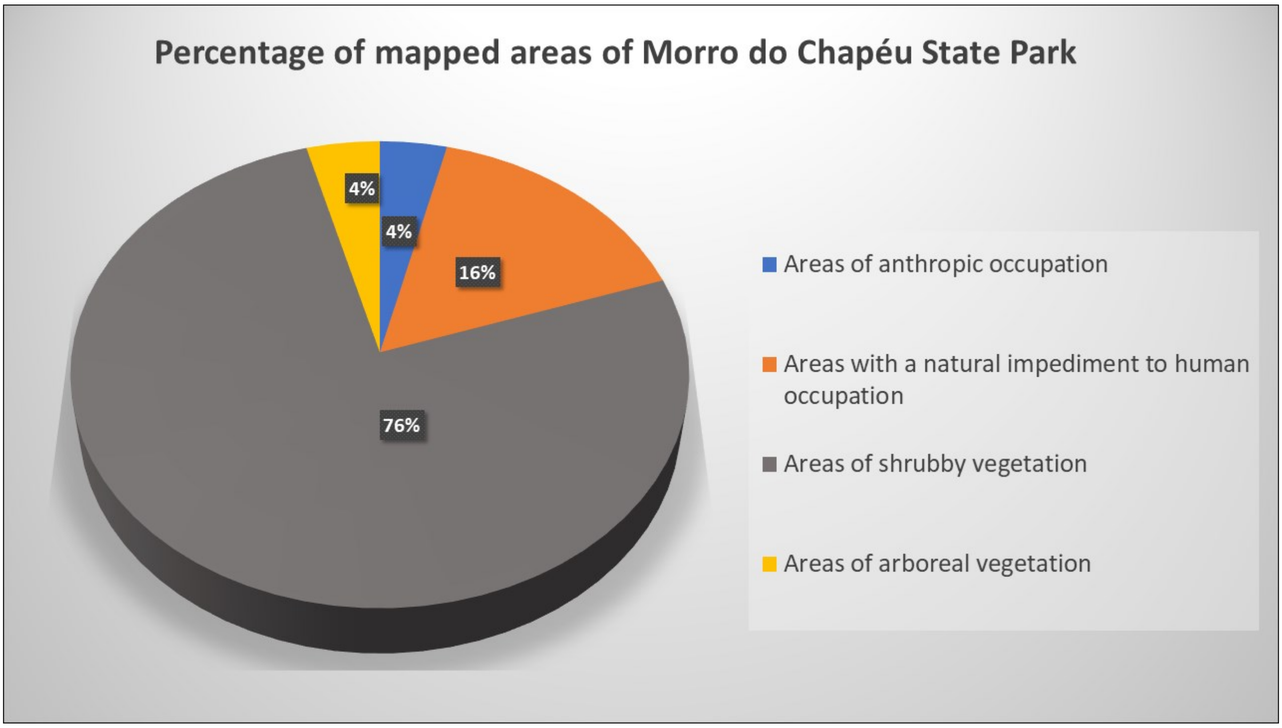

Figure 3- Percentage of vegetation cover and Morro do Chapéu State Park land use areas. Anthropised areas have approximately 2,000 hectares, areas with some natural impediment for occupation add up to 8,330 hectares, and shrub and arboreal vegetation, respectively, have 39,640 and 2,190 hectares.
Source: Research data

The internal roads and paths result in 350 km, with 138 trails mapped, and the longest is the main road along the park from southeast to north with 22 km (Figure 2). In this case, there is a clear coincidence between the largest groupings of areas occupied by residents with the longest road, which is the primary access along the MCSP (Figure 2). We observed that areas with better vehicle access are the most occupied by dwellings, with about 25 families, according to the MCSP administration. The main points of habitat loss are located surrounding these roads, which the non-complete fragmentation of the protected area can also conclude.

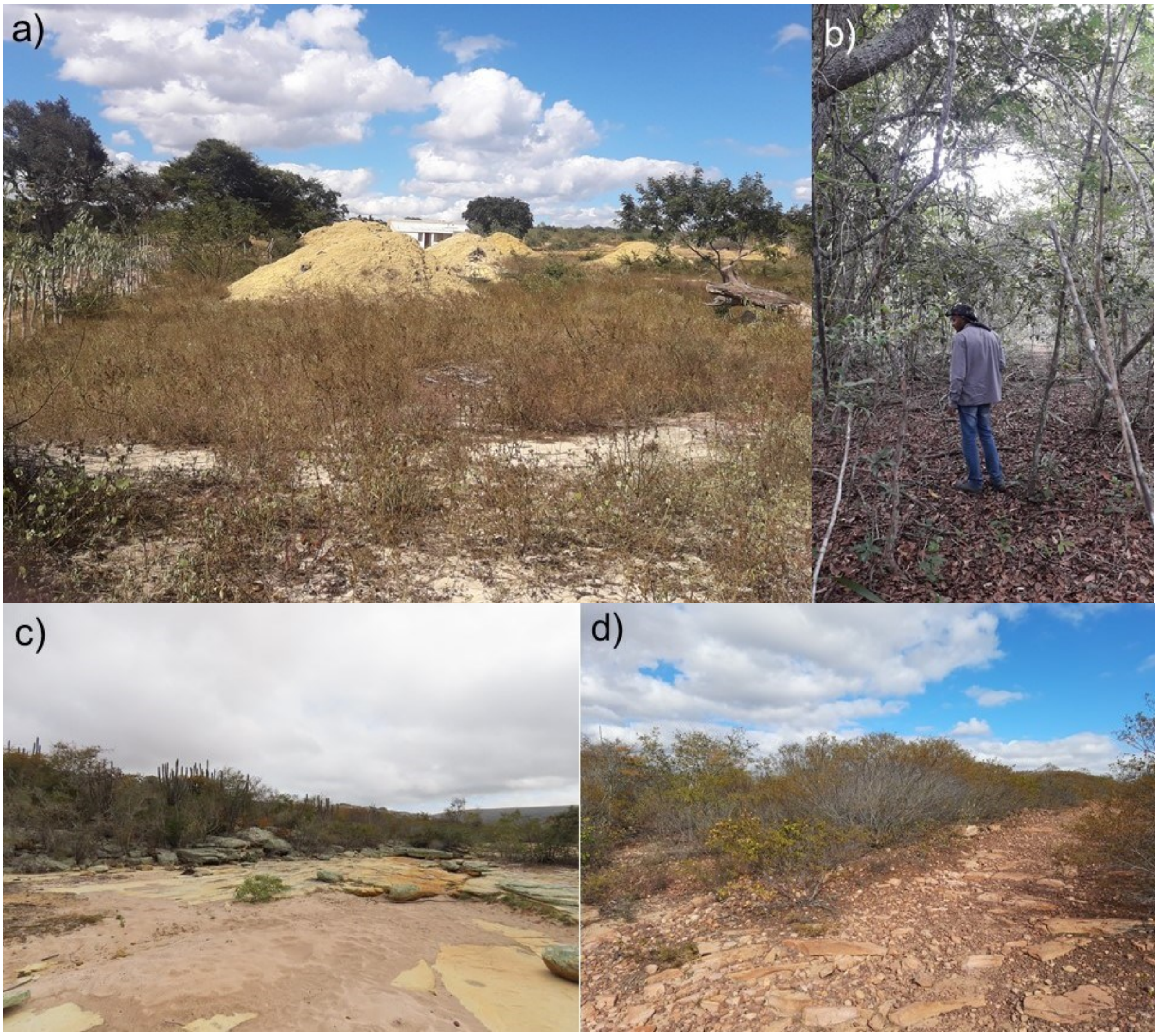

Figure 4 - Types of areas mapped and observed in the fieldwork: a) Areas of anthropic occupation; b) Areas of arboreal vegetation; c) Areas with a natural impediment to the human occupation ("lajedos"); d) Areas of shrubby vegetation. **Photos:** a, b, d: Gustavo Luis Schacht; c: Grace Bungenstab Alves

4. DISCUSSION

Considering the analysis of Figure 2 and the concept of fragmentation, the MCSP is not fragmented. However, the park is at an intermediate level of habitat loss, which may fragment the protected area if it persists.

It is necessary to isolate areas with natural cover to occur fragmentation (WILCOVE *et al.*, 1986; RAMBALDI; OLIVEIRA, 2003), but this is different with the MCSP. In figure 2, despite many areas impacted by anthropic activities (4% of the MCSP), the vegetation areas are connected, showing that may be a limitation for some species, but not the total isolation of the patch. We can notice in the map that areas dominated by anthropic

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occupation are mainly in the north centre of the park, especially where the Barracão community is located, in the centre of the MCSP. This area is considerably altered, with many dwellings (Figure 4 a).

Other clusters of residents with a large deforested area are represented in the southern, on the banks of BA-055 highway, and in a western stretch close to paved roads with several small villages with few residents.

Building and improving roads contribute to increasing deforestation as it facilitates locomotion, enabling the emergence of newly deforested areas along the routes (FEARNSIDE, 2017; DIAS *et al.,* 2020). The easy access can also attract new landowners and favour the expansion of agricultural activities.

Building roads and increased land use negatively affect biodiversity. They cause habitat loss, edge effect, increase compaction, reduce soil infiltration, affect the growth of surrounding vegetation, propagate exotic species, interfere with animal behaviour, and favour runovers (WANG *et al.,* 2015; BAGER *et al*., 2016).

In the MCSP, the roads often access areas without human occupation (residences and agricultural activities). Those areas deserve attention because increasing access to remote areas can increase human pressure in uninhabited places. Furthermore, the occupation in protected areas is harmful, considering that the most sensitive species avoid the edge areas in slightly disturbed environments, fleeing from altered spaces (BETTS *et al*., 2019).

We emphasise that there are teams, still in small numbers, that carry out more effective supervision actions activities to repress illegal practices or occupation of new residents. These professionals, linked to INEMA, are the main presence of the state government within the park. Subsistence activities with human occupation and cattle grazing in natural vegetation dominate land use.

It is possible to notice that the land uses are mostly linked to agriculture in the anthropic areas. Rudimentary agriculture focused on cassava, castor bean, or fig opuntia crops, with few recently deforested areas. It should be noted that this is not extensive agriculture, even due to the climatic and legal limitations of cultivating in a protected area. As mentioned, the farmers raise cattle extensively, which can affect the flora and lead to habitat loss, even if they are barely noticeable in remote mappings. These cattle released in extensive parts of the protected area is an action that should be better studied.

According to Ricklefs (2015), deforestation, habitat loss, and fragmentation are the primary threat to biological diversity. Specialist species undergo the highest impacts

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(ARASA-GISBERT *et al*., 2021). Püttker *et al.* (2020) reinforce that the most significant effect of fragmentation is for forest-dependent species, agreeing with Fahrig (2003; 2013).

Regarding forest ecosystems, human activities such as agriculture, roads, and housing have also turned suitable habitats for many species into small patches. In addition to reducing the forest area, it reduces the movement and distribution of species (RICKLEFS, 2015) and compromises the ecosystems' structure and functioning (JONES; SAFI, 2011; BENCHIMOL, 2016). Antongiovanni *et al.* (2018) report that areas with more isolated and smaller patches favour generalist species, which tolerate habitat disturbances. Although the study area is cohesive, it has already suffered from many activities. These activities may impact the distribution of the local fauna, in part unknown and need to be studied.

The vegetation classes presented on the map were divided into arboreal and shrub (Figures 4 b and d). The arboreal vegetation represents seasonal forests, with forest size, denser forests, and individuals up to 10 meters high. The shrub vegetation class represents less dense and smaller vegetation, up to 3 meters high. They are vegetations of arboreal caatinga, shrubby caatinga, campo rupestre, and other phytophysiognomies related to the savanna.

The arboreal vegetation is in the southern MCSP, where the altitudes are high and possibly, present more rainfall or accumulation of water from precipitation. The shrub vegetation varies the distribution according to the phytophysiognomy. The different caatingas are in the centre-north of the MCSP, especially after the large area of outcrops occupying much of the southern region. On the other hand, the phytophysiognomies related to the savanna or campo rupestre are intermingled close to the arboreal vegetation, especially in shallow soil and outcrops.

There is a lower occupancy density in the southern MCSP, even with denser arboreal and shrub vegetation in this region. However, the area most occupied by humans is covered by shrubby caatinga. It presents water scarcity in several zones, which does not confirm a direct relationship between occupation and water availability.

Other natural areas in the MCSP prevent occupation, such as sandy soil and outcrops. They were grouped and named "Areas with natural impediment for human occupation (sandy soil, outcrops)" (Figure 4 c). The locations have physical characteristics that make human occupation inappropriate because of the difficulty of access and lack of favourable agronomic or housing conditions. So, as the mapping confirmed, we believe those areas are not affected. They form continuous spaces visible on the map of Figure 2,

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and they can be considered a divider between moister plant phytophysiognomies and those drier in the north.

The sum of all forms of anthropogenic land use results in the loss of natural habitat that may lead to the emergence of a fragmented protected area. Thus, the area would no longer fulfil its role of protecting the species and ecosystems. We emphasise that this is not a criminal offence to the residents living inside the MCSP and many other protected areas in Brazil. The park was built with the families inside. However, it is worth calling attention to the need for land use regularisation that allows the MCSP management to develop more effective supervision to prevent illegal activities in the protected area, ensuring its preservation.

Therefore, establishing measures to prevent the advance of habitat loss and avoid fragmentation of protected areas means fulfilling the main objective of their creation, i.e., protecting and conserving nature and species. When the habitat of a certain species is reduced, the species will have a less living area and fewer resources for survival. Therefore, the population decreases, increasing the risk of extinction because stochastic events may be more impactful (RICKLEFS, 2015). Consequently, it is necessary to understand that impacts on species cause has implications on the entire natural system of the region, defining biologically viable or non-viable groups.

Habitat loss and fragmentation cause adverse effects on biodiversity, but habitat loss is much easier to measure than fragmentation (FAHRIG, 2003). Habitat loss can also be the most effective and cheapest for a more incisive action of the state government, the MCSP manager, given that it is still possible to reverse the imbalance process. Fahrig (2017) points out that although fragmentation is always considered bad for biodiversity, some studies have found the contrary. Whether they are generalist species, specialists, or threatened, some species may not suffer impacts or benefit from habitat fragmentation.

However, if we analyse the impact of fragmentation, it is necessary to observe all biodiversity, not just one species. If only one species benefit, others can be negatively affected because none responds similarly to the process (GARCIA, 2011). The effects of fragmentation can be pretty complex and challenging to translate into management tools since they tend to be highly specific for each group and vary greatly according to the spatial scale, ecological processes, and landscape type and structure (VILLARD, 2002).

Protected areas such as MCSP play an essential role in maintaining biodiversity. Regarding the Caatinga, there are currently 36 conservation units, just over 7.5% of protected areas, and only 1% are under complete legal protection (FREIRE *et al.*, 2018).

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The MCSP is part of the small percentage under complete protection that protects the biome, highlighting that this is an important ecotone area. Therefore, the MCSP is important in the conservation of Caatinga. This biome has been rapidly degraded and has few conservation plans, even with great geological and anthropological richness, that deserves attention.

The anthropisation drives away native fauna species and enables the contact of wildlife with domestic animals, preying on farm animals and causing conflicts with residents, as reported in a field expedition. Zoonose transmission from domestic animals to wildlife is also noteworthy. These significant impacts need to be better measured in the MCSP.

We observed that fragmentation is not consolidated but can occur if habitat loss progresses in a disordered way. Therefore, the efforts should focus on reducing fragmentation, preserving larger patches and continuous habitats, and creating corridors to connect areas, keeping the focus on areas with low historical disturbance (GILBERT-NORTON *et al.,* 2010; HADDAD *et al.,* 2017; BETTS *et al.,* 2019; PUTTKER *et al.,* 2020; ARASA-GISBERT *et al.,* 2021). In addition, the management to maintain and restore connectivity is crucial to ensure the survival of many species and preserve biological diversity (LARREY-LASSALLE *et al*., 2018).

All these steps, such as the reduction of habitat loss, and the creation of corridors, necessarily pass through the essential land regularisation and the recovery of spaces in their natural aspect; after all, it is a protected area. While this does not happen, one should consider the insertion of these communities in environmental programs that direct efforts to improve the quality of life in these spaces, preventing conflicts between residents and species in the region.

5. FINAL CONSIDERATIONS

In this sense, we encourage new studies that consider how each species responds to habitat loss in the MCSP, thinking of large-scale information on areas sensitive to fragmentation for better effectiveness of efforts. Simultaneously, the research efforts should be extended to sensitive areas worldwide (OLSOY *et al.,* 2016).

Our study observed areas with a high level of anthropisation and degradation, such as the Barracão Community region. The areas are in the centre of the MCSP and can be defined as a priority for compensation and land regularisation. A greater government presence is also necessary for these areas to give this population a better perspective of

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life while waiting for dreamland regularisation. This government presence will also curb illegal practices practised inside the protected area, especially hunting, buying and occupying new areas.

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