Analysis of the fragility of the Environmental Protection Area Alto Rio Doce, MG, Brazil

Análise da fragilidade da Área de Proteção Ambiental Alto Rio Doce, MG, Brasil

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Abstract

Currently, the Atlantic Forest is one of the most fragmented biomes. The objective of this study was to diagnose the environmental fragility of Alto Rio Doce Environmental Protection Area(EPA) in Minas Gerais, through characterizationof the distribution of local fragmentation, as well as the provision of pressure on vegetation. The vegetation was characterized using a supervised classification of an image captured by the OLI sensor aboard Landsat 8. Only 22.3% of the entire extension of the EPA, which contains 23,329 hectares, has vegetation, which is composed of many small fragments. In addition, the EPA is intersected by roads, one being a state paved road, which accelerates habitat fragmentation, causing damage to both animal and plant species. We conclude that in order to achieve its objectives, the area is in need of a management plan, as well as initiatives to educate the general public about the EPA.

Keywords: Protected area; Georeferencing; Fragmentation

Resumo

Atualmente a Mata Atlântica é um dos biomas mais fragmentados. O objetivo deste estudo foi diagnosticar a fragilidade ambiental da Área de Proteção Ambiental (APA) Alto Rio Doce em Minas Gerais, por meio da caracterização da distribuição da fragmentação local, bem como da pressão sobre a vegetação. A caracterização da vegetação foi feita por classificação supervisionada, por meio da imagem captada pelo sensor OLI presente no Landsat 8. Apenas 22,3% de toda a extensão da APA, que contém 23.329 hectares, apresenta vegetação, sendo composta por muitos pequenos fragmentos. Além disso, a APA é cortada por estradas, sendo uma delas pavimentada e estadual, o que agrava a situação da fragmentação dos habitats, causando danos tanto a espécies animais quanto vegetais. Concluiu-se que para atingir seus objetivos é preciso a elaboração de um plano de manejo para a área, além de alternativas que permitam a popularização da APA tornando-a mais conhecida pela população local.

Palavras-chave: Área protegida; Georreferenciamento; Fragmentação

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Introduction

The Atlantic Forest biome is known for the richness and diversity of its species, although it has been continually subject to impacts throughout the centuries. Currently the landscape is composed of small islands of vegetation, which are becoming increasingly isolated as a result of intense forest fragmentation (CALEGARI et al., 2010). This scenario likely interferes with the maintenance of biodiversity (KNÖRR; GOTTSBERGER, 2012).

Currently, about 12% of its original area remains in small, isolated parts, 84% of which are less than 50 hectares. Although under threat, between 2016 and 2017, 12,562 ha were deforested in the Atlantic Forest, the lowest since 1985. The state of Minas Gerais, which had led the ranking of deforestation since it was created, accounting for half of destruction of the biome from 2010 to 2016, with a total of 10,752 hectares of the lost biome and increase in deforestation rate of 70% between 2011 and 2012. Currently, the state occupies second place with 58% decrease in deforestation rate and maintains a coverage of 11.6% of the original Atlantic Forest (SOS MATA ATLÂNTICA, 2018).

The creation of Protected Areas (PA) has been encouraged as the most effective way to conserve the forest remnants. PAs represent the chief strategy to conserve nature, protecting species, genetic resources and landscapes of great scenic beauty, as well as guaranteeing areas for scientific research, environmental education, outdoor recreation and ecotourism (BUTCHART et al., 2010). In addition, they promote the rational and sustainable use of natural resources and represent economic development for many municipalities through the direct and indirect use of these areas.

The creation of Protected Areas in states and municipalities allows new agents to become involved in the discussions of the global conservation network, enabling new political, social, cultural and environmental connections (MARTIN et al., 2016). Protected Areas should function as decentralization mechanisms that allow connectivity between federal lands, promoting better land use and cooperation among managers from different spheres of government (FREITAS LIMA; RANIERI, 2018).

Among the various categories of PA in Brazil, the Environmental Protection Area (EPA) is the least restrictive category (SALVIO et al., 2016). EPAs, inspired by the Natural Parks of Portugal, has the central objective of enabling peaceful coexistence between conservation and natural resource use through productive activities. Since 2000, EPAs have proliferated throughout Brazil, chiefly as a means of guaranteeing the implementation of a PA in those municipalities of the states like Minas Gerais where the Ecological ICMS laws have been enacted (OLIVEIRA et al., 2012). The Ecological Goods and Services (or ICMS Ecológico) tax essentially allows municipalities greater access to state funding than those to which they are already entitled if they comply with or exceed certain criteria in state environmental laws. However, the limited restriction of this category of management, leads in a direction of the function of this model to a land use planning, to the detriment of conservation itself.

Despite the low restriction of this category of PA, there are those who see opportunities in them to develop strategies for sustainably managing natural resources (MURADIAN et al., 2010). On the other hand, many consider them ineffective from a conservation point of view. In practice they cite their inability to provide adequate environmental, contributing little more than a buffer zone to other protection categories or to guarantee ecological corridors. In the best of situations, this category would lend itself to the sustainable use of resources and not to the protection of the natural patrimony (SALVIO et al., 2016).

On the land area of Minas Gerais, 9.26% are formal Protected Areas, of which 69.9% are Environmental Protection Areas (EPA), that despite their low restriction have a great appeal and, due to this attractive name gives a false impression of conservation (SALVIO, 2017). The Atlantic Forest, one of the most important global biodiversity hotspots, is vulnerable to being "protected" by EPA. Only 1.53% of the area of Minas Gerais is protected under so-called "Integral Protection"

regimes (SALVIO *et al.*, 2016). In this way, letting such an important biome protected by this category can compromise its integrity in the medium term.

The environmental fragility is a term used by Ross (1994) that shows the human influence under the popular ecosystem in dynamic balance. Although the genetic characteristics on the area can impact this dynamic, the human intervention can disbalance faster than natural conditions, according to the author. This way, the environmental fragility can be influenced by vegetal coverage, slope, soil type and mainly by land use, such as urbanization, agriculture and livestock.

The objective of this study was to diagnose the environmental fragility of Alto Rio Doce EPA in Minas Gerais, through characterization of the distribution of local fragmentation, as well as the provision of pressure on vegetation.

Material and method

The Alto Rio Doce Environmental Protection Area is located in the municipality of Alto Rio Doce, Minas Gerais (Figure 1), at 24°00' W and 21°04' S. It has 23,329 hectares, representing 40.15% of the municipal territory and it borders with the municipalities of Senhora dos Remédios, Desterro do Melo and Mercês. It is in the geomorphological unit Planalto Sul Mineiro / Depressão de Belo Horizonte, with an average altitude of 828 meters. The climate is classified in Tropical of Altitude, or Cwb, according to the classification of Köppen, with average annual temperature of 19.1 ºC and average monthly precipitation of 126 millimeters (ALVARES *et al.*, 2014). The area lies within the morphoclimatic domain of the Atlantic Forest, with vegetation predominantly of Seasonal Semi-deciduous Forest.

Figure 1 – Location of the Alto Rio Doce Environmental Protection Area (EPA) in relation to the Alto Rio Doce municipality in Minas Gerais

Figura 1 – Localização da Área de Proteção Ambiental (APA) Alto Rio Doce em relação ao município Alto Rio Doce em Minas Gerais
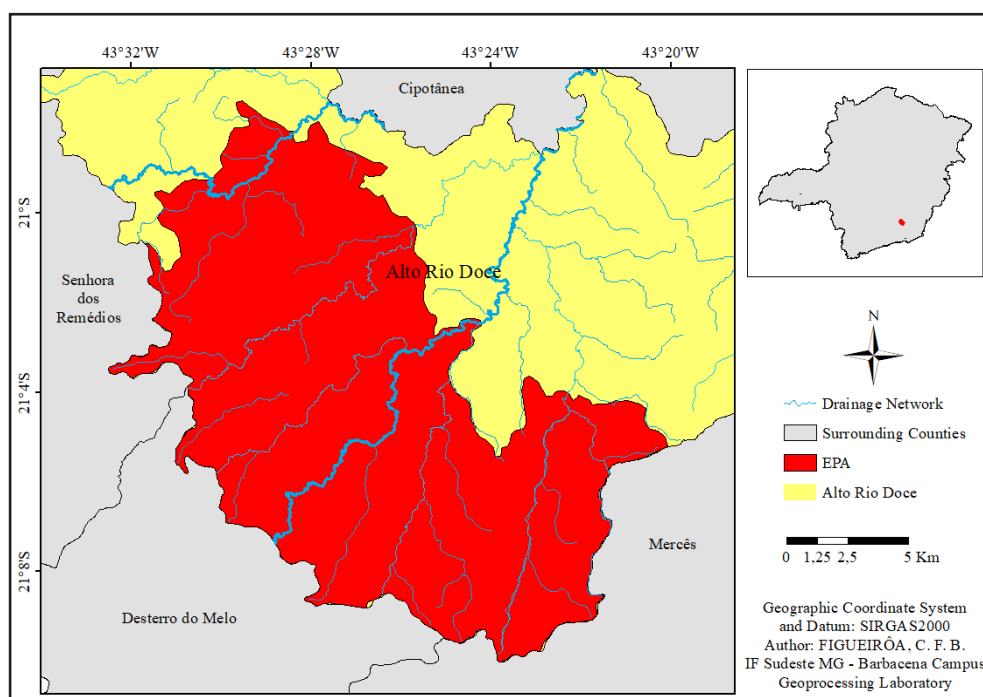
Source: Authors (2020)

The EPA vegetation was mapped by means of the supervised classification method of satellite imagery, using a Maximum Likelihood classifier in the ArcGIS 10.5.1 software package and for further accuracy analysis for classification was used the kappa coefficient, which varies between 0 (poor) to 1 (very good) (RITTL *et al.*, 2013). The base image was the captured by the OLI sensor on the Landsat 8 satellite platform (Track 217, Row 075, acquired on August 29, 2017) and has a spatial resolution of 30 m. The bands used for this research was the false colors infrared was displayed as 5, 4, 3, commonly applied to show vegetation. Two classes were determined to generate thematic image: non-vegetation and vegetation. The non-vegetation class was designated as all land that has undergone anthrogenic influence, such as urban areas, agriculture and pastureland, while the vegetation class represents all kinds of arboreal vegetation, natural or not. It should be noted that it was beyond the scope of this analysis to distinguish between native and planted vegetation due to a lack of adequate reference information and since the scale of the preserve and made it unfeasible to acquire ground truth data ourselves.

Another factor of relevance to the analysis was the topographic relief of the area, which fits a profile that according to Massa and Ross (2012), may indicate the possibility of erosive processes, landslides and floods, depending on the degree of slope. The hierarchical slope classes used in the study (Table 1) were elaborated by Ross (1994). Topographic slope was mapped by processing the Satellite Shuttle Radar Topography Mission (SRTM) DEM product (FARR *et al.*, 2007) for our study area, which was then downscaled to 15 meters resolution. Subsequently, slope was calculated using the slope tool in the ArcGIS 10.5.1 software.

Table 1 – Hierarchical classification of the slope of the relief developed by Ross, 1994

Tabela 1 – Classificação hierárquica da declividade do relevo desenvolvida por Ross, 1994

Slope Classes	
Up to 6%	**Plan**
Between 6% and 12%	Soft corrugated
Between 12% and 20%	Corrugated
Between 20% and 30%	Strong corrugated
Above 30%	Mountainous and / or steep

Source: ROSS, 1994

Geographic information on roads, rural communities and urban areas was acquired through data processing of the municipality's Municipal Sanitation Plan in shapefile format, and through visual analysis of the images available on Google Earth Pro.

Results and discussion

The Alto do Rio Doce Environmental Protection Area is vegetated in 22.3%, with the remaining 77.7% representing human altered land (Figure 2), mostly occupied by agriculture and pastureland activity. The kappa coefficient was 0.715, considered as good. Similar land proportions were found by Souza *et al.* (2014), in the Coqueiral EPA, in Minas Gerais (28% vegetation), suggesting that the mild restrictions placed on native vegetation in that Protected Area (PA) limits the possibility of monitoring action and control of impacting agents. Often pressures to which vegetation is subject in PA, is the result of agricultural activities (MORAES; MELLO; TOPPA,2017). Those authors affirm that the Porto Ferreira State Park, in the state of São Paulo is also composed of a matrix of the agricultural land with isolated fragments of

vegetation cover. That landscape closely mirrors the landscape in the Alto Rio Doce EPA, while pasture land predominates.

Figure 2 – Proportions of vegetation and non-vegetated areas in the Alto Rio Doce Environmental Protection Area (EPA) in Minas Gerais

Figura 2 – Proporções de vegetação e áreas não vegetadas na Área de Proteção Ambiental do Alto Rio Doce (EPA) em Minas Gerais
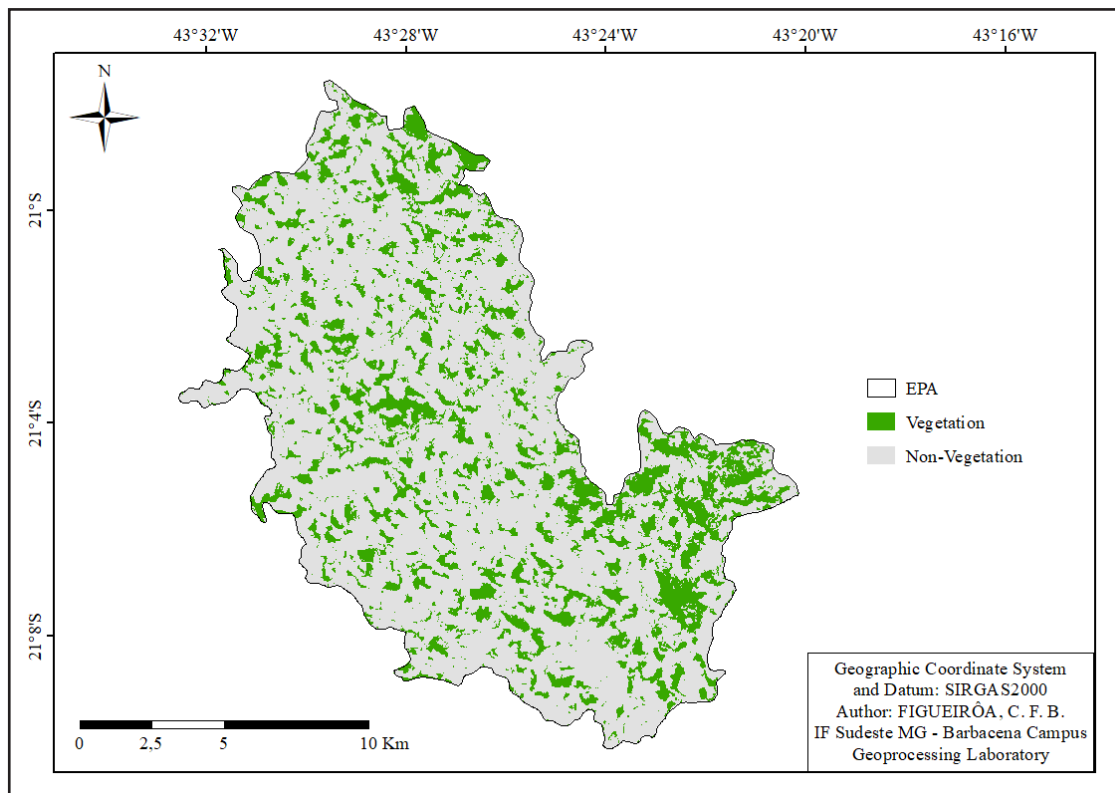
Source: Authors (2020)

The landscape matrix of the EPA (Figure 2) shows significant fragmentation, with an average size of 2.9 hectares. Souza *et al.* (2014) also found a large proportion of small fragments in the Coqueiral EPA, Minas Gerais, corroborating for the indication of the wide fragmentation in the state, as well as the study of forest fragments by Calegari *et al.* (2010). The negative effects of this scenario are known both for animals (BARBOSA *et al.*, 2017) and for forest species (GROSS *et al.*, 2018), which suggests a significant habitat fragility in the region.

The presence of roads within the EPA represents another threat to the ecological integrity of the site. Several roads cross the EPA, among them a paved state road, MG-132, which runs 21.5 km inside the area (Figure 3).

Despite their benefits, roads negatively impact the environment by fragmenting and destroying habitat (VAN DER REE *et al.*, 2011), by increasing noise (FREIRE *et al.,* 2011), by instigating behavioral changes in fauna, often leading to roadkill (HOLDEREGGER; DI GIULIO, 2010), by altering genetic pools (HOLDEREGGER; DI GIULIO, 2010; JACKSON; FAHRIG, 2011), by altering physical and chemical changes in the environment, and by the indirect suppression and introduction of species coincident with the increased human use of the area (VAN DER REE *et al.*, 2011).

Although there is no legal restriction to the existence of roads within EPAs, the structure

restricts the movement of wildlife. The results of the study by Andrade and Moura (2012) on a highway that cuts Biological Reserve in the state of Pernambuco, Brazil, shows that the road might acting like a barrier to the animal flow, once that was register of run over, temperature and sound effects has a potential influence on an urofauna deslocation. Negative impacts on the population of other animals, such as birds (BAGER; ROSA, 2012), bats (BERTHINUSSEN; ALTRINGHAM, 2012), large mammals (SWITALSKI; NELSON, 2011) and invertebrates (BEIROZ; ZAU; CASTRO, 2010) have also been reported in several regions intersected by roads, especially in Protected Areas.

Figure 3 – Roads, districts and rural communities present in the Environmental Protection Area (EPA) of the Alto Rio Doce in Minas Gerais

Figura 3 – Estradas, distritos e comunidades rurais presentes na Área de Proteção Ambiental (APA) do Alto Rio Doce em Minas Gerais
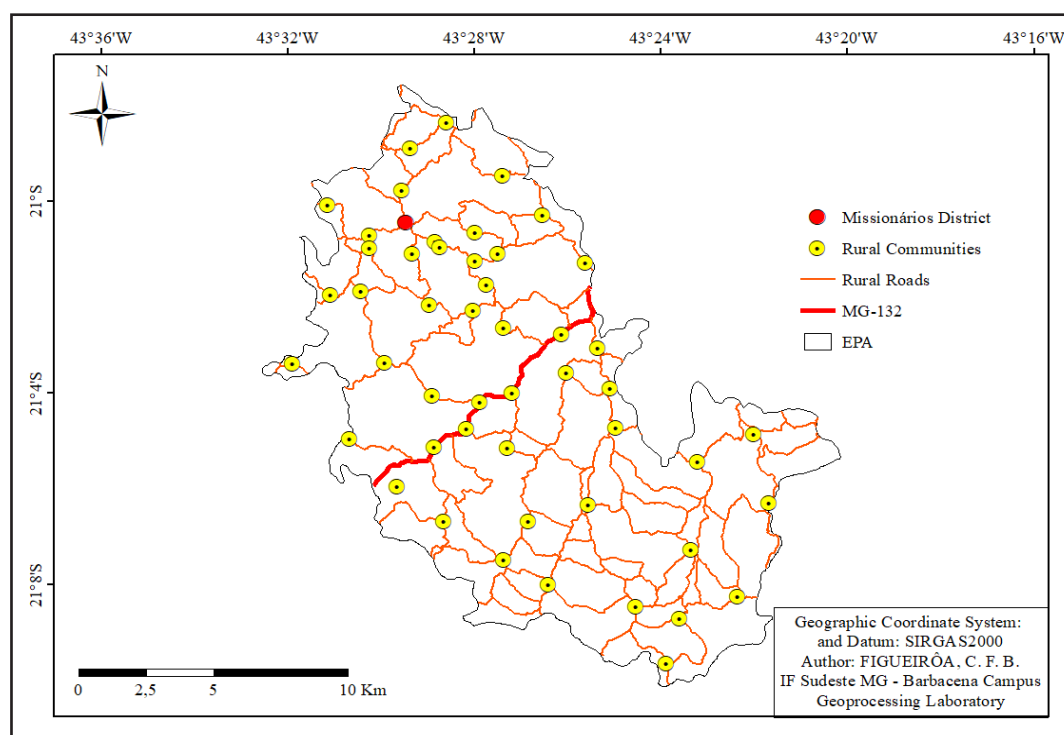
Font: Authors (2020)

The Alto do Rio Doce EPA contains 319.5 km of rural roads. Although the vehicular traffic is reduced on these unpaved roads, the very construction of these roads and their subsequent extension, results in negative impacts such as increased fragmentation within the EPA territory.

Within the EPA there is only one consolidated urban area, the District of Missionários, of the municipality of Alto Rio Doce, and 41 other small rural communities (Figure 3). The district represents less than 1% of the territory of the EPA, suggesting that much of the human-impacted area that exerts pressure on the vegetation represents agricultural activities. Another factor underscoring the pressure of agricultural activities is high fraction (27.3%) it represents of the overall the Municipal Gross Domestic Product (GDP) (CIRINO; GONZÁLES, 2011), well above that of neighboring municipalities.

The topography of the area varies from mild to moderately hilly over most of the EPA, representing 89.2% (Figure 4). When any given transect is examined, there is an apparent direct relationship between slope and the amount of vegetation (Table 2), with intact vegetation

often found on the steepest slopes. This common pattern stems from the historical difficulties associated with clearing or extracting timber from steep slopes, as well as the inability of agricultural machinery to operate in these areas (GRISA *et al.*, 2015).

Figure 4 – Topographic slope of the Alto Rio Doce Environmental Protection Area (EPA) in Minas Gerais

Figura 4 – Inclinação topográfica da Área de Proteção Ambiental (APA) do Alto Rio Doce em Minas Gerais
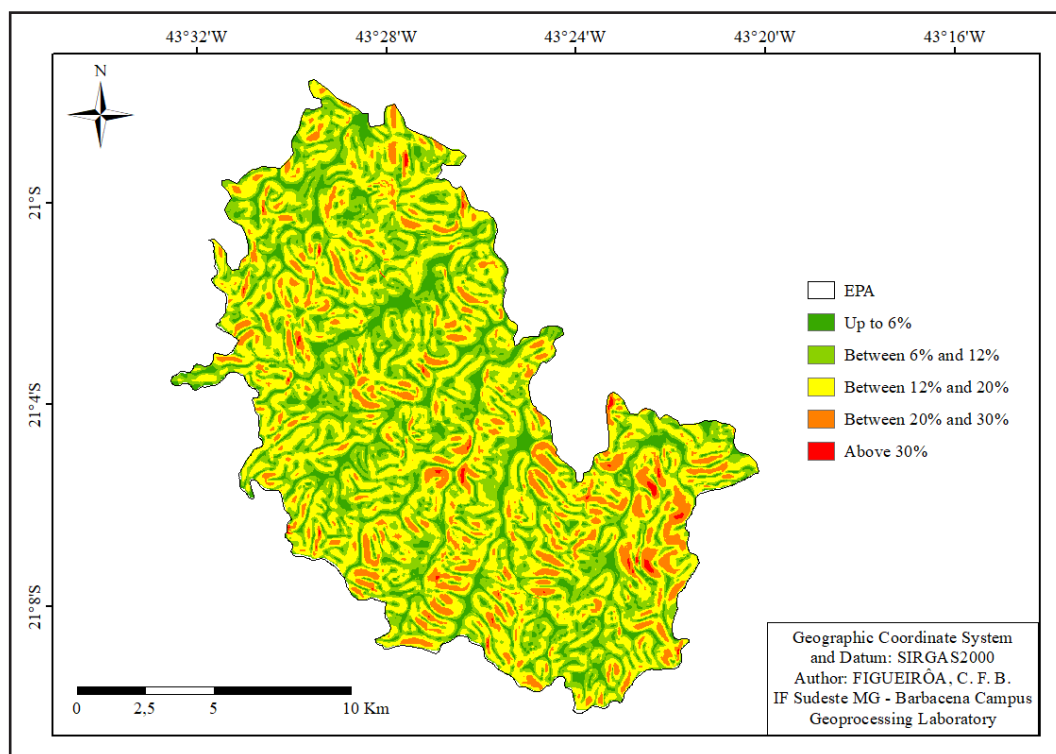
Font: Authors (2020)

Table 2 – Area with vegetation present by slope class in the Alto do Rio Doce Environmental Protection Area (EPA) in Minas Gerais

Tabela 2 – Área com vegetação presente nas classes de declividade na Área de Proteção Ambiental Alto Rio Doce (APA) em Minas Gerais

Slope Classes	Vegetation Area (%)
Up to 6%	14.64
Between 6% and 12%	32.41
Between 12% and 20%	42.11
Between 20% and 30%	10.51
Above 30%	0.33

Font: Authors (2020)

Conclusions

Our results suggest that the Alto do Rio Doce Environmental Protection Area remains in a very fragile state reinforcing the need to implement a Management Plan predicated upon local dynamics. In spite of the low restriction of this category of Protected Area, an adequate Management Plan, which could appropriately direct the creation of a plan for recreational activities, such as trails and interpretive elements that promote environmental education, would increase its effectiveness and contribute to public awareness. Currently the public is generally unaware of the existence of the EPA, which impedes the effectiveness of conservation efforts.

In this study we highlight a high degree of fragmentation and human intervention, which should generate concern in the reader as the conservation of these remnants becomes essential for the preservation of the Atlantic Forest, a biome which has become since human occupation. The concept of the biodiversity hotspot was created to general public concern and galvanize action to area around the world of specific biological concern, and although there is no single recipe for conservation action, effective conservation action begins with local concern for local landscapes.

Acknowledgment

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