Original Research Article

Influence of hypometry in the occupation of semiarid areas

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ABSTRACT

Aims: This research aims with the help of geotechnologies to map the different uses and coverage of the earth by analyzing its effects in relation to the altitudinal gradient in semiarid regions.

Methodology: In order to do so, RapidEye images were acquired in the year 2014, after the organization of the database the digital processing of the acquired scenes was carried out which were performed contrast technique, segmentation, identified eight classes of use and land cover and submitted to Maximum Likelihood classification.

Results: The relationship between forest cover and different uses indicates that the most representative class was Agriculture and Livestock, as a consequence of the local economy being based on subsistence culture and the Baixada environment is the most affected. In addition, it is verified that there is a lower degree of anthropization in the tops evidencing that in the Lowland environment persists a greater density of native vegetation.

Conclusion: this research confirms the hypothesis that the process of fragmentation of the native vegetation of the semi-arid region changes in relation to the altitudinal gradient, since the higher the altitude, the lower the degree of isolation and, consequently, the high forest coverage.

Keywords: dry forest, fragmentation, geoprocessing, remote sensing.

1. INTRODUCTION

With the intensity of the anthropic actions in the environment, there is a high process of substitution of the natural landscapes for other uses and occupations of the soil. As a result, forest suppression in semi-arid regions has increased, especially for cattle and agricultural expansion. This disorderly occupation and overuse of unplanned land exposed to strong erosion processes and the potential for environmental degradation associated with scarce water resources [14] transform extensive and continuous forest areas into fragments, affecting the availability and the quality of natural resources, resulting in an imbalance between supply and demand in the semiarid regions.

In the last decades, native vegetation has been deforested not only for the expansion of agriculture and livestock, but also for the extraction of wood by shallow cutting, aiming the production of firewood to supply the industries by compromising the fauna and flora of the region, causing high environmental and landscape impact [4].

Therefore, the identification of land use and occupation is essential for understanding the environment and requires the use of cutting-edge technologies in the surveying of existing natural resources, to promote the rationalization of their use and to ensure their sustainable development.

Thus, geotechnologies bring significant advances in the development of research, in planning actions, in the management process and in several others referring to the Geographic space structure [8] and among the main geotechnologies used in environmental research, the most important are Remote Sensing and Geographic Information Systems-GIS. According to [10] Remote Sensing and GIS are the "most important holistic tools" for landscape analysis, planning and management, that is, these tools understand the phenomena in their entirety.

On this, this research aims with the help of geotechnologies to map the different uses and coverage of the earth by analyzing its effects in relation to the altitudinal gradient in semi-arid regions.

2. MATERIAL AND METHODS

2.1. Location and characterization of study areas

The work was developed in the region of Araripe, domain of the Brígida River Basin and located in the western part of the state of Pernambuco, Brazil. The region has a pronounced semiaridity in the lower part, with precipitated annual totals varying between 400 and 500 mm and in the part corresponding to the Chapada do Araripe, rainfall increases, reaching averages between 700 and 800 mm; and the temperature ranging between 24°C and 26°C [11].

The landscapes analyzed presented different dimensions, because they were pre-defined for future research. Thus, for the mapping and analysis of the landscape, the buffer with 2.5 km distance of each area was executed, avoiding the overlap where the landscapes composed by each area and their respective buffers were analyzed. Sampling was carried out in three environments with different altitudes, being the Lowland environment with altitude of up to 600 m, the Hills environment with heights between 600 and 750 m and the Plateau environment with altitudes above 750 m. The total sampling was in nine areas, being three in each environment and located in the cities of Araripina, Ipubi and Exú (Figure 1).

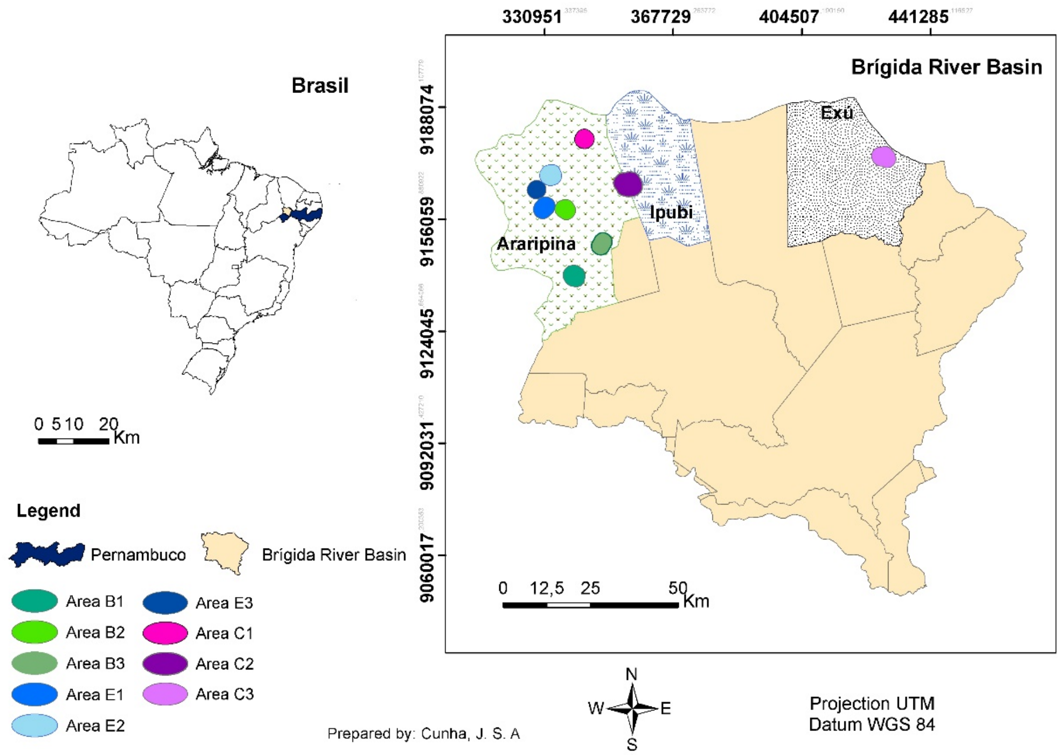

Figure 1: Location of study areas in semi-arid regions.

2.2. Data base

Initially, RapidEye images were acquired with scenes covering the study region (Table 2). The scenes were provided by the Federal Government distributed in the GeoCatálogo of the Ministry of the Environment [13] and orthorectified (level 3A) with pixel size in the field of 5 (five) meters.

Table 1. Characteristics of the RapidEye images obtained by the MOE (Ministry of the Environment) for the studied region.

IMAGE	CENA	DATA
RAPIDEYE	2435508	05/08/2014
	2435607	04/06/2014
	2435608	05/08/2014
	2435609	31/07/2014
	2435611	31/07/2014
	2435612	26/05/2014
	2435507	22/07/2015

2.3. Digital image processing

The digital image processing, vector mapping and visual interpretation were performed in ArcGis 10.2.1 software. The images were imported to perform the mosaic and trimming of the buffers, comprising a distance of 2,5 (two and a half) km. The images were analyzed by the color composition (R5G3B2) of the bands, along with contrast enhancement, and then segmented.

It was found dense vegetation (arboreal forest formations) and sparse vegetation (shrub and bush vegetation), agricultural and livestock, exposed soil, bodies of water, urban, cloud and shade. After defining the class standards, the samples were trained for the spectral recognition of the class, and the images were submitted to the classification supervised by Maximum Likelihood. Thematic maps were prepared for the nine areas and the reliability of the digital classification of the study areas was performed by the confusion matrix and classified using the Kappa coefficient [3] ranging from -1 to 1 (Table 3).

Table 2. Quality of use classification and land cover according to Kappa coefficient intervals.

Kappa value	**Quality of Classification**
< 0,00	Terrible
0,0 – 0,20	Bad
0,20 – 0,40	Reasonable
0,40 – 0,60	Good
0, 60 – 0,80	Very Good
0,80 – 1,00	Excellent

3. RESULTS

The error or confusion matrix was used to determine the accuracy for the categories presented in the three environments. For the Kappa index values for the Lowland environment of 0.60, 0.70 and 0.84 for the areas B1, B2 and B3, respectively, allowing to consider the quality of the classification from good to very good.

Regarding the Hill environment, the values were 0.87, 0.88 and 0.69 for the areas E1, E2 and E3, respectively, indicating a good to very good classification. As for the Plateau environment, all areas were identified with excellent quality in their classifications, because the index values for areas C1, C2 and C3 were 0.97, 0.91 and 0.93.

The Lowland environment in the three areas studied has a high representation of the Agriculture and livestock class (Figure 2), which is the main economic activity in the region. The survey carried out in the field showed that there is agricultural exploitation in the three areas of this environment, especially the bean and corn crops, causing pressure on the native vegetation and affecting the habitats of endemic species.

In B1 area, the Forest class has approximately 37% of the area studied and the Agriculture and Livestock class holds about 40%, which together with the exposed Solo class account for 63% of the total area. B2 and B3 Areas also present high values for the association of the Agriculture and Livestock and Soil classes exposed with 45.5% and 48%. The Lowland environment has areas with high disturbance. However, in the Lowlan environment, areas B2 and B3 are similar to Forest values of 53% and 52%, respectively. This increase of the class, in these areas, when comparing with B1, occurs due to their proximity to watercourses, even intermittent ones.

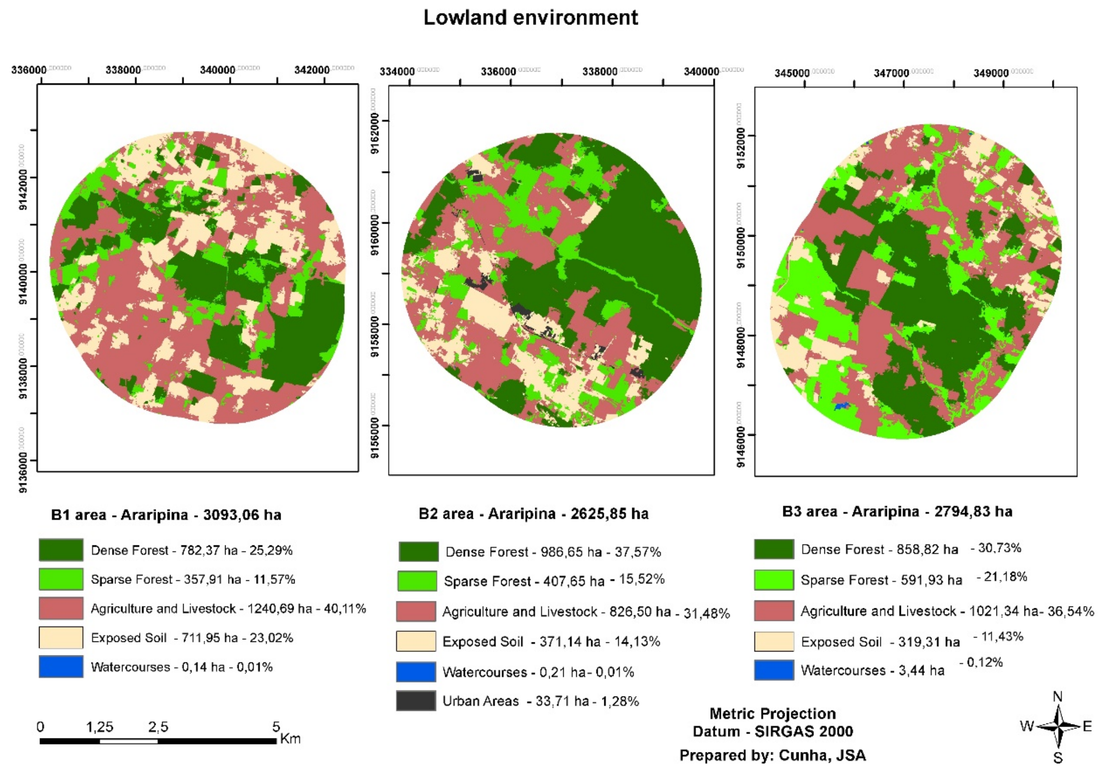

Figure 2: Map of use and land coverage in 2014, of the areas inserted in the Lowland environment in semi-arid regions.

The Hill environment (Figure 3) considering the combination of the Agriculture and Livestock and Soil classes exposed shows values of 56% for area E1, followed by area E3 with 47% and with the smallest percentage of E2 that holds only 26% of its area with presence of these classes.

E1 area has the lowest value for Forest, about 44% of its total area followed for area E3 with approximately 52%; even the E3 area with a forest matrix, the data are relatively low and probably these values of the two areas (E1 and E3) are due to their proximity with urban perimeter. On the other hand, the E2 area has no proximity to urban areas and has 74% of its total of Forest area, showing the interference of the proximity of other areas to urbanization.

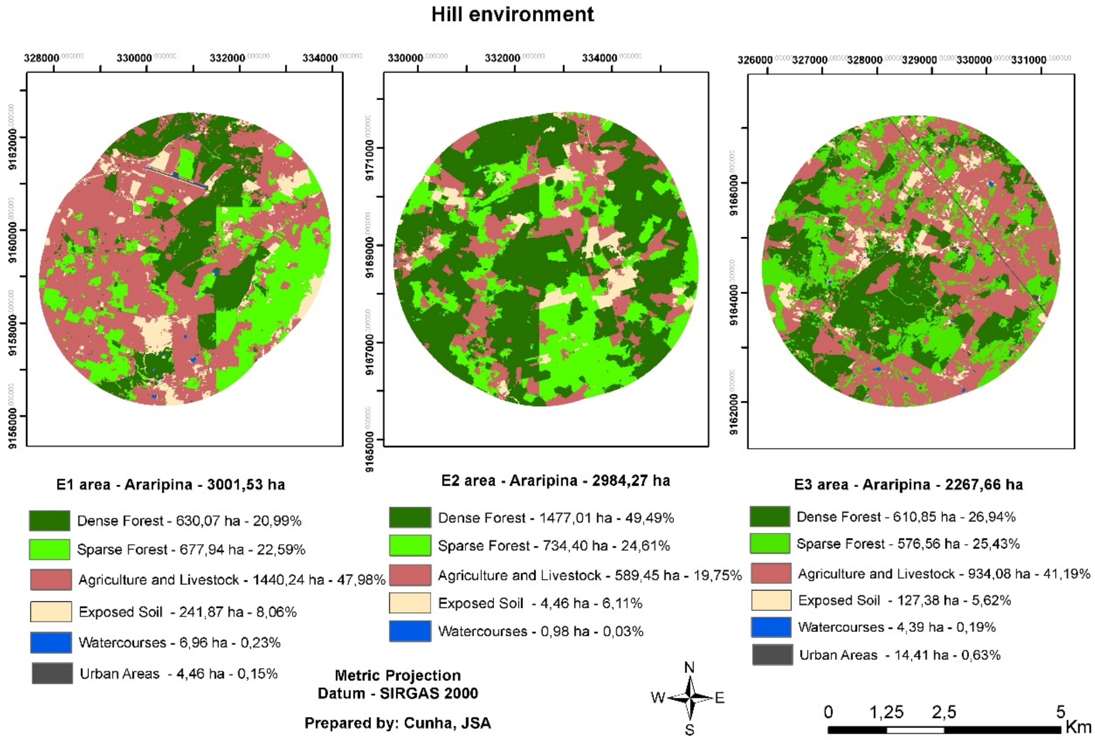

Figure 3. Use and land coverage map in 2014, of the areas inserted in the Hill environment in semi-arid regions.

In the Plateau environment, it is observed that the Agricultural and Livestock class has low percentages with 16%, 12% and 12% and for the Exposed soil class of 10%, 2% and 4% of the total areas of C1, C2 and C3, in that order (Figure 4). It can be noticed that these values found for the Agriculture and Livestock and Exposed soil classes in this environment are less expressive than in the previous environments and that the matrices of the three areas of the Plateau environment are of Forest, since C1 holds 75% of its total area, C2 has 81% and C3 has 85%.

In evaluating the average percentage of land use and land coverage categories (Figure 5), it was found that in the Lowland and Hill environments, the Agriculture and Livestock class is more prominent and it is observed that there is a decrease in the Exposed soil when moving from environments and, consequently, from altitudes. These data may be associated with the dense and sparse Forest categories that increase with this change, showing that the Plateau environment that holds the highest altitudes has the lowest percentage of exposed soil and the highest average percentages for the Forest categories.

When correlating the quantifications of Forest classes (dense and sparse forest) by the classes of Agriculture and Livestock, Exposed Soil and Urban Areas, for all areas of the three environments, the anthropization value of 53.14% is estimated for the Lowland environment; 42.80% for the Hill environment and; 17.30% for the Plateau environment. Introducing the Lowland environment as the most pressured by the anthropization of the different uses in the landscape increasing the vulnerability of these areas.

In regards to the percentage of forest coverage, there is a small difference between the Lowland and Hill environments, with 46.81% and 57%, respectively. However, in the Plateau environment with 80.51% of its landscape is covered by forest vegetation. Evidence that there is a positive relationship between the number of forest species and the increase in altitude.

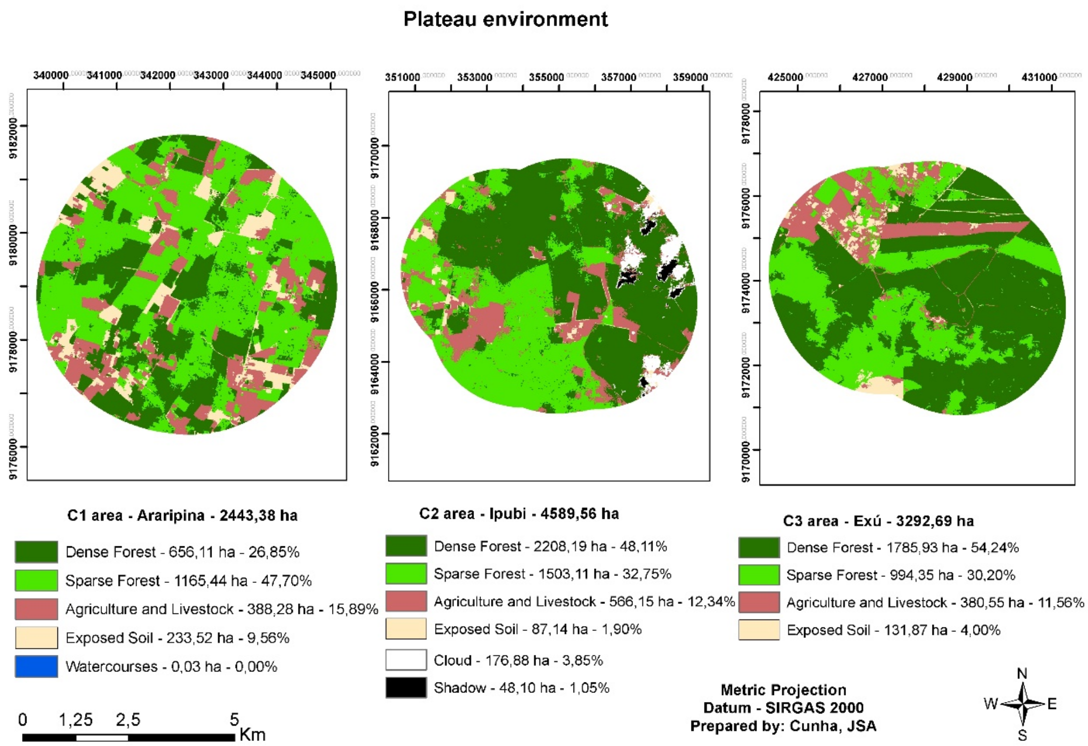

Figure 4. Map of land use and coverage in 2014, of the areas inserted in the Plateau environment in semi-arid regions

4. DISCUSSION

In the region there is a rotation of uses in the same area. According to personal communication with residents who explain that after the suppression of vegetation, the exposed soil is used for agricultural cultivation. In dry periods, the area encompasses another activity, livestock, and at the beginning of the rainy season, the area that was used for grazing returns to agriculture as its main activity. [9] further state that the historical form of shifting agriculture itself is a contributing factor in reducing the biodiversity of native vegetation, as farmers deforest, burn and plant in a period (around two or three years), and change to other areas repeating the same practice. Thus, Brazilian semi-arid agriculture develops in a context of disordered and impacting occupation, with no tradition of planning and, consequently, with a disordered use of natural resources and, generally, without taking into account the equilibrium of environmental systems [5].

This lack of planning is evidenced in the Lowland environment, especially in B1 area, resulting in remnants immersed in a non-forest matrix, because of the combination of the Exposed Soil and Agriculture and livestock classes that sum 63% of the total area. Thus, defined as a matrix, because the elements in question consisted of more than 50% of the total area analyzed [10].

B2 and B3 areas have similar low values for the Forest class and even if the numbers indicate that these two areas are inserted in a forest matrix, this amount of Forest is extremely low. According to [7], these values contribute to the increase of degraded areas susceptible to soil erosion, because these areas of exposed soil are former pastures transformed into desertified areas due to overgrazing.

This disorderly use of resources promotes degraded areas, and other authors highlight this issue. [20], [1], [6], [18] state that the forest coverage of the semi-arid region has been reduced over the years. The deforestation of the native vegetation of the region has different uses and one of them is in the use of firewood for the industry [16], favoring the process of vegetation conversion.

In addition, the Permanent Preservation Areas of the streams and water bodies of the studied landscapes also suffered, since the agricultural and livestock farm, is notorious in the margins of the rivers because they present greater fertility due to the greater content of humidity and the flat areas management facilities. As a consequence of this removal of the vegetation the bare areas were voluntarily replaced by the exotic species Algaroba (*Prosopis juliflora* (Sw.) DC.) that, according to [16], the species is disseminated by animals that consume the fruit (pod) and drink water at the edge of the waterways.

In the Hill environment areas E1 and E3 hold the lowest percentage of Forest and this is allied to the proximity to urbanization. As the population increase leads to an increase in vehicular traffic, the introduction of residential, commercial and industrial areas, as well as the opening of local roads, which can interrupt the movements of animals that are seed dispersers. Furthermore, this increase interferes with natural drainage, waterproofing the soil, reducing feed to aquifers, and producing solid waste that, when not properly collected and / or intended, becomes a risk not only to human health, but also to coverage [17].

However, the E2 area is not introduced in an urban perimeter and presents the matrix of native vegetation in this area, which acts as a filter for the movement of species by the landscape. In addition to the urban actions, in these semi-arid regions the climate is quite irregular with low rainfall and prolonged dry periods, which exerts more pressure on the vegetation coverage, added to the extraction of wood, construction of houses and / or roads and the expansion of agriculture and livestock , further damaging the native forests, resulting in fragments immersed in non-forest matrices.

Plant and animal populations immersed in these matrices are imbalanced by reducing the number of specialized taxa, since groups with low dispersibility are particularly sensitive to reducing the connection between the fragments, so a smaller distance in the landscape can be a limiting factor for the movement of some species [12].

The Plateau environment demonstrates the opposite verified in the areas of the other two environments, the areas in the Plateau environment exhibit inexpressivity of the classes Exposed solo and Agricultural and livestock and an amplitude in Forest. These good results are due to the Forestry Policy of the State of Pernambuco [15], which establishes that forests and other forms of natural vegetation located at altitudes above 750 meters are considered Permanent Preservation Areas, corroborating with the results of the Forest category in this environment and showing the importance of intervening in this accelerated process of devastation of native vegetation, which is due to the irrational use of this natural resource.

Despite this, still vegetation removal is replaced in a fast and progressive way by pasture and agriculture areas [2], mainly by cassava (*Manihot esculenta* Crantz) crops that contribute to the livelihood of local residents.

Thus, the distribution of vegetation in the environment is associated with climatic factors, the physiographic characteristics of the terrain and the anthropic activities. In the case of the Brazilian semi-arid region, there are major changes in vegetation coverage, because the climate of this region has as its main characteristic the seasonality with two well-defined climatic seasons, a dry season and a rainy season. These alterations are due to the poor distribution of rainfall in the time and space during the year, where different rainfall rates are observed between two seasons, summer (rainy) and winter (dry), providing rapid responses to environmental changes. However, anthropic action has intensified the degradation of the environment in recent decades. With this unbridled search of man for natural resources, which is carried out without any awareness and planning.

5. CONCLUSION

The natural vegetation of the semi-arid region is quite fragmented, due to the disorderly suppression and the rotation of land use and occupation, mainly in the Lowland environment, which has low altitudes, facilitating this process of replacing forest areas.

There is a lower degree of anthropization in the tops, proving that in the Plateau environment a greater density of native vegetation persists and a lower one in the Lowland Environment. Thus, the vegetation density native to the semi-arid region is interconnected to the altitudinal gradient. That is, the fragmentation of the native vegetation changes with respect to the altitudinal gradient, since the higher the altitude, the greater the connectivity of the fragments, and consequently, the greater forest coverage.

The functionality of the natural areas will be compromised, due to the reduced connectivity of the fragments, if this exploitation is continued. In this way, public policies are needed to stop this process, aiming at a more sustainable exploitation of forest products timber and non-timber. As well as the recovery and maintenance of the permanent preservation areas, in this region, it is of total relevance for the improvement of the integrity of the landscape.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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