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RESEARCH ARTICLE OPEN ACCESS

THREAT AND ANTHROPIC PRESSURE MAPPING IN JAMANXIM NATIONAL PARK

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ABSTRACT

Jamanxim National Park is an integral protection area located in a region of use conflicts and high deforestation rates in the Brazilian Amazon region. This park was established, in conjunction with other protected areas also located in the region of influence of BR-163 highway, with the aim of stopping native forest deforestation close to the road. This study used publicly accessible georeferenced data, referring to deforestation values, forest cover conversion, fire hotspots and rural properties, to generate an environmental diagnosis of anthropic phenomena in the protected area region, presenting the dynamics, growth and spatialization of the phenomena associated with environmental degradation that can be monitored by satellite. The obtained results showed that the park works as a buffer against deforestation in the region and that the juxtaposition of this protected area added to other protected areas further reduces the advance of environmental degradation, yet the environmental pressure in the region reaches portions of the unit, which presents features of deforestation in its interior.

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INTRODUCTION

The Amazon is a biome of global importance due to its unique biodiversity, its extensive hydrographic basin and vast area of tropical forest. These same attributes have made it the focus of several attentions, motivated by the interest in the exploration of mineral and forest resources and in the use of the region's land, a process that culminates in illicit, irregular exploitation and without any commitment to sustainability (VITEL, 2009). The Amazon's deforestation causes loss of opportunities to apply sustainable systems and mechanisms for trade and forest products, reduces biodiversity and the possibility of discoveries related to species, also affecting water cycle, since the forest evapotranspiration process is responsible for the release of more than 8 trillion m³ of water vapor per year into the atmosphere (FEARNSIDE, 2006). Pará's southwest is the region with the most intense deforestation process, when compared to other regions of the biome (INPE, 2021). In a context of intense deforestation processes, protected areas are mechanisms for the conservation of biodiversity, but also potential targets for the exploitation of natural resources for economic purposes. This dual character of protected areas in zones of intense anthropogenic changes enables a more evident study of deforestation processes in the region (VERÍSSIMO *et al.,* 2011). This research aims to map changes in land coverage, identifying threats and anthropogenic pressure from the integration of forest monitoring data, making it possible to assess deforestation trends, its relationship with the territory and subsequent uses, and the incidence of fires and their relationship with the legal and illegal occupation of the region,

generating a demonstrative diagnosis of deforestation pattern in an integral protection area inserted in a zone of land use conflicts.

MATERIALS E METHODS

Area of Study: Jamanxim National Park is an integral protection area, a category created specifically by the Brazilian environmental legislation that does not allow the direct use of natural resources, nor human occupation in its territory, aiming for the preservation of natural ecosystems (BRASIL, 2000). It is located in the southwest of the state of Pará, in the Brazilian Legal Amazon, inserted in the influence area of BR-163 highway, which connects the city of Cuiabá, in the state of Mato Grosso, with the city of Santarém, in the state of Pará, being crossed by the road (Figure I). The establishment of neighboring areas in dense native forest regions represents an access way for people to vulnerable ecosystems of great economic interest.

Anticipating the increase in deforestation and land grabbing on the margins of BR-163 highway, which is located in portions of native Amazon forest, protected areas delimited along the highway were created, in order to legally safeguard these forest portions and avoid the exploratory process. Among them is the Jamanxim National Park (BRASIL, 2006; FEARNSIDE, 2007). The area of study chosen for this research is the interior of the mentioned park, an area of 862,605,042 hectares, plus a 10 km buffer, covering 572,918.173 hectares. The comparative analysis of these areas allows to illustrate the intensity of deforestation in the region and its different impact on protected and non-protected areas.

Data Analysis: The forest diagnosis of the area of study was carried out through the joint analysis of georeferenced data on land coverage, fire hotspots, deforestation and rural property registration for the years of 2008 to 2019 in a GIS environment.

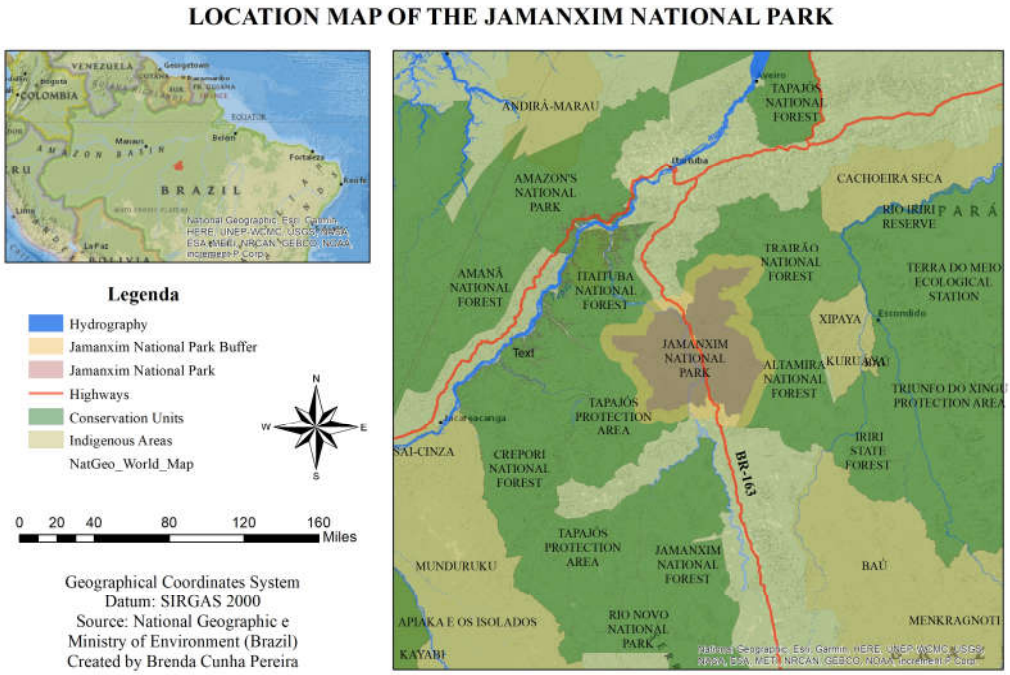


Figure 1. Location map of the area of study
Source: Authors, based on MMA (2021)

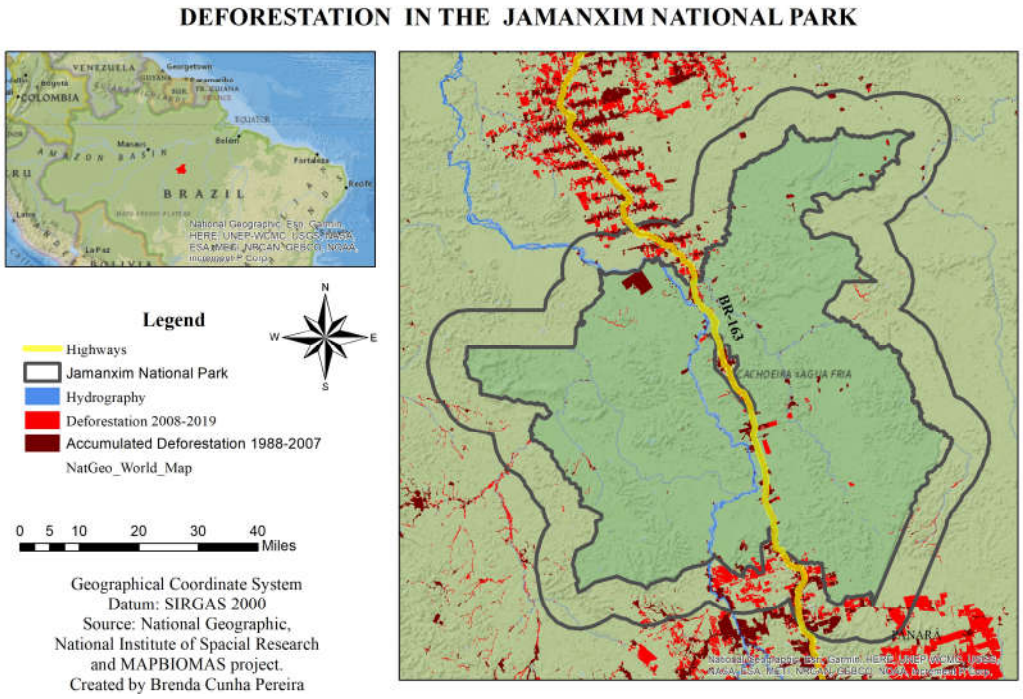


Figure 2. Deforestation map in Jamanxim National Park
Source: Authors, based on MMA and INPE (2021)

The choice of this timeline is given by decree 6,514 of 2008, which hanges the penalty for environmental crimes since this year, which is also the initial date for making complete data available for analysis. The software was ARCGis 10.8. Deforestation data were obtained by the PRODES project, from the National Institute for Space Research, in shapefile format, showing the deforestation polygons for the analyzed years. Adapting the methodology presented by Campanharo (2017), the raster-type satellite images classified according to land coverage were crossed with data referring to the official limits of protected areas, hydrography, municipal limits and highways, in order to observe usage and location relations. The analysis of land coverage classes was performed using raster data classified by the MAPBIOMAS project. The tabulated land coverage data were used to generate a transition matrix (PONTIUS et. al., 2004) of the features regarding 2008 and 2019, in order to compare the use dynamics. Another step was the analysis of fire hotspots incidence, which is an important mechanism for interpreting anthropogenic phenomena in a natural area, especially in the case of tropical rainforests such as the Amazon biome. The analysis points out fire hotspots detected through satellite images and provides information about the nature of the impact. The analysis of fire hotspots in the area of study was performed using shapefile data, made available by the Brazilian Forest System, of the Ministry of the Environment, through the i3Geo georeferenced data platform (MELO-NETO et al., 2019). To complete the analysis, the rural property registration data of the Brazilian Forest System were obtained through the i3Geo platform and simultaneously applied with data related to the other phenomena observed in order to analyze the relationship between geolocations of rural properties and occurrences of deforestation, burn and the types of use and coverage.

RESULTS AND DISCUSSION

Deforestation: Data from Jamanxim National Park pointed to an accumulated deforestation of 4,358 hectares between 2008 and 2019 (Table I). There is an increase of deforestation from 2017 to 2019, much more expressive in the surroundings than in the interior of the protected area. Within the protected area, the value of deforestation in 2019 (621,994 ha) is the second highest in the studied period, only behind the year of 2008 (1,132,555 ha). In the surrounding area, 2019's value is the highest in the entire period of interest (2,841.176 ha) and the fluctuating values, marked by large amplitudes of annual variation, show a growing trend from 2017 onwards. From 2008 to 2019, the Park's interior had 0.509% of its areas deforested, while the surroundings presented an increase of more than 3% of deforestation in relation to its total area. The surroundings, despite being smaller, almost always present higher values in deforestation. In the map of figure 02, it is possible to observe that these deforestation areas are clustered in two main points around the park. Deforestation in Jamanxim National Park is expressed to a greater degree in the "exits", located in the northern and southern portions of the area, where BR-163 highway passes on its edge. Thus, it can be said that deforestation in the region surrounding the park follows BR-163, then "retracts" when crossing the protected area and expands again when leaving it. This spatial pattern indicates the influence of the highway in the degradation process of the specific forest region (FEARNSIDE, 2007) and the role of protected areas in the conservation process of native ecosystems. It is also possible to observe the existence of deforestation areas in the park's interior, along the BR-163, however, they present themselves as small spaces dispersed in a region, much smaller than the deforestation found in the "exits" of the protected area. This spatial relationship between highway deforestation is a point that consolidates the association of highways with the expansion of deforestation in the Amazon region (FEARNSIDE, 2006).

Table 1. Annual deforestation data in the interior and surroundings of Jamanxim National Park (2008-2019)

	DEFORESTATION AREA (HA)		DEFORESTATION AREA (%)	
YEAR	INTERIOR	SURROUNDING	INTERIOR	SURROUNDING
2008	1.132,555	2.112,347	0,131%	0,369%
2009	305,644	945,333	0,035%	0,165%
2010	180,851	1.235,208	0,021%	0,216%
2011	101,364	1.118,322	0,012%	0,195%
2012	179,465	842,374	0,021%	0,147%
2013	540,729	2.145,280	0,063%	0,374%
2014	198,763	986,823	0,023%	0,172%
2015	595,379	2.032,410	0,069%	0,355%
2016	236,552	1.920,332	0,027%	0,335%
2017	20,353	428,876	0,002%	0,075%
2018	279,141	754,407	0,032%	0,132%
2019	621,994	2.841,176	0,072%	0,496%
TOTAL	4.392,791	17.362,886	0,509%	3,031%
PROTECTION AREA	862.605,042	572.918,173	100,000%	100,000%

Source: Authors, based on Terra Brasilis (INPE, 2021a)

Table 2. Annual values of fire hotspots incidence in Jamanxim National Park (2008-2019)

	FIRE HOTSPOTS		DENSITY (FOCUS/KM²)	
YEAR	INTERIOR	SURROUNDING	INTERIOR	SURROUNDING
2008	39	33	0,004521189	0,005759985
2009	36	49	0,004173405	0,008552705
2010	52	48	0,006028251	0,00837816
2011	17	24	0,001970774	0,00418908
2012	39	60	0,004521189	0,0104727
2013	11	16	0,001275207	0,00279272
2014	26	35	0,003014126	0,006109075
2015	45	65	0,005216756	0,011345425
2016	20	22	0,002318558	0,00383999
2017	68	63	0,007883098	0,010996335
2018	4	14	0,000463712	0,00244363
2019	29	51	0,003361909	0,008901795
TOTAL	386	480	0,044748173	0,083781598

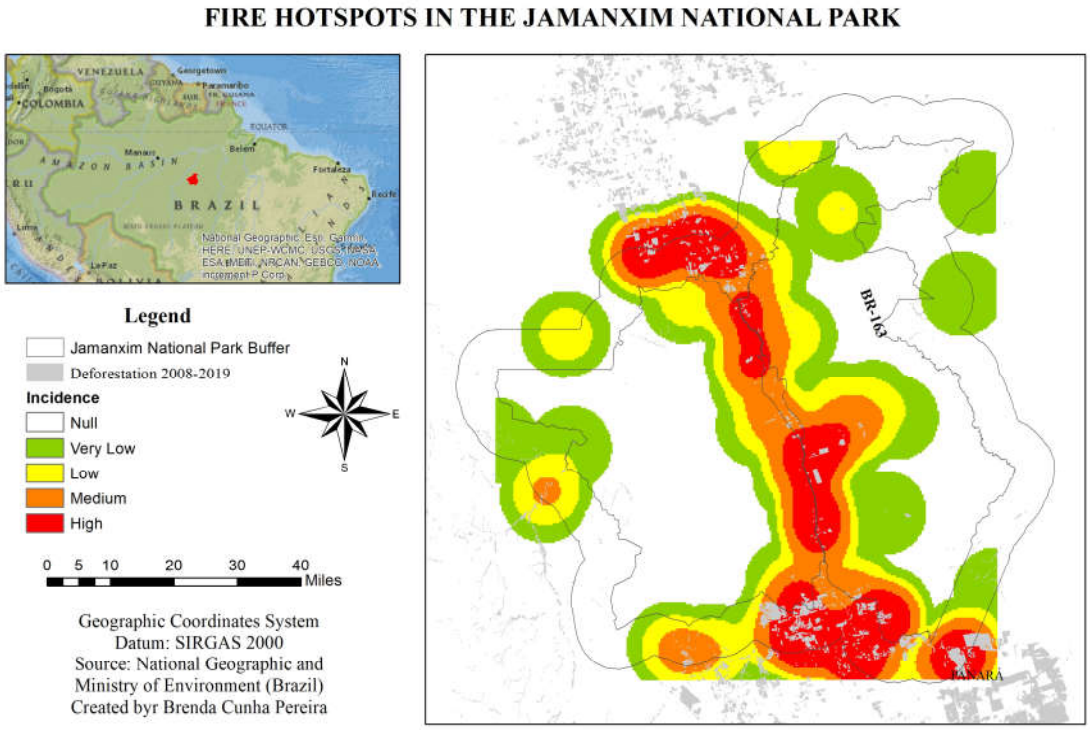
Source: BDQueimadas (INPE, 2021b).

In this process, an integral protection area still maintains deforestation areas concentrated outside its limits (FERREIRA, 2005).

Fire Hotspots: The values of heat sources obtained show that, between 2008 and 2019, there was a record of 386 fire hotspots inside the Jamanxim National Park and 480 around it (Table II).

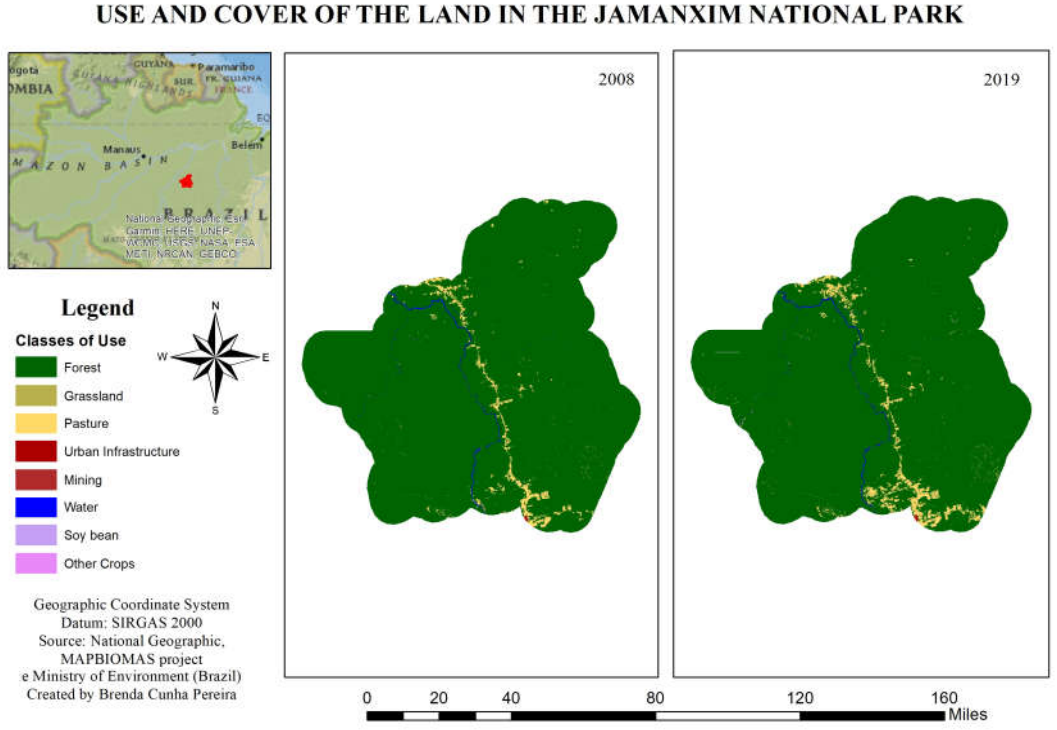
Inside the park, the incidence of fire hotspots dominates a very small portion of the territory and concentrates its highest values in the most anthropized portion. These focuses are concentrated in the "corridor" formed by BR-163, in the portion that divides the protected area into two modules with the passage of the highway, also being present in the surrounding portions, in a more dispersed way. In Figure III, it is possible to observe the spatialization of fire hotspots and their overlap with the deforestation areas. In Jamanxim National Park, fire hotspots are detected in the same points where deforestation areas are found.

Land Coverage: Regarding the land coverage (Figure IV), Jamanxim National Park has mining areas in its surroundings. The park presents as intact in a good part of its forest formation, with some areas classified as "pastures" disposed in its surroundings in the proximities of BR-163 and in its interior across the central portion of the protected area. In the surroundings of the protected area (Table III), the class that lost the most areas over the analyzed period was the "forest", which had its area reduced by 11,348,152 ha.



Source: Authors, based on INPE (2021).

Figure 3. Incidence map of fire hotspots in Jamanxim National Park



Source: Authors, based on MAPBIOMAS (2021).

Figure 4. Land use and coverage map in Jamanxim National Park (2008 and 2019)

The class that gained the most areas was the “pasture", which had its area expanded by 11,114,148 ha. Other areas of anthropic use also had an expansion, from the largest to the smallest: "other crops" (112.206 ha), "urban infrastructure" (28.843 ha), "mining" (4.448 ha) and "soybean" (0.826 ha). In addition to “forest”, the “grassland” is another natural class that lost areas (9,292 ha).

The anthropogenic classes “other crops” and “mining” had low persistence values, which indicates a great alternation of occupation areas. Inside the integral protection area, the natural classes “forest” and “grassland” gained pasture areas, however the positive balance is behind a transition of use and coverage that transformed 3,060,095 ha of pasture into forest and turned 3,019,467 ha of forest into pasture.

Table 3. Land use and coverage data in Jamanxim National Park surroundings (2008 and 2019)

SURROUNDING	2008		2019		2008-2019	
CLASS	AREA (HA)	AREA (%)	AREA (HA)	AREA (%)	AREA (HA)	AREA (%)
FOREST	549.785,274	84,054%	538.437,122	78,434%	-11.348,15	-5,619%
GRASSLAND	204,909	1,246%	214,201	1,028%	9,292	-0,218%
PASTURE	20.355,083	14,045%	31.469,231	19,731%	11.114,14	5,686%
URBAN INFRASTRUCTURE	309,733	0,003%	339,576	0,004%	29,843	0,001%
MINING	0,433	0,000%	4,881		4,448	0,000%
WATER	2.247,514	0,644%	2.324,902	0,632%	77,388	-0,012%
SOYBEAN	-	0,000%	0,826	0,030%	0,826	0,030%
OTHERCROPS	15,228	0,008%	127,434	0,140%	112,20	0,132%
TOTAL	572.918,173	100,000%	572.918,173	100,000%		

Source: Authors, based on MAPBIOMAS (2021).

Table 4. Land use and coverage data within Jamanxim National Park (2008 and 2019)

INTERIOR	2008		2019		2008-2019	
CLASS	AREA (HA)	AREA (%)	AREA (HA)	AREA (%)	AREA (HA)	AREA (%)
FOREST	850.269,281	98,570%	850.506,374	98,597%	237,092	0,027%
GRASSLAND	160,809	0,019%	169,727	0,020%	8,919	0,001%
PASTURE	8.315,012	0,964%	8.280,772	0,960%	-34,241	-0,004%
WATER	3.844,971	0,446%	3.608,274	0,418%	-236,697	-0,027%
OTHERCROPS	14,969	0,002%	39,896	0,005%	24,927	0,003%
TOTAL	862.605,042	100%	862.605,042	100%		

Source: Authors, based on MAPBIOMAS (2021).

Table 5. Land use and coverage transition matrix in Jamanxim National Park surroundings (2008-2019)

SURROUNDING	CLASS 2019							
CLASS 2008	FOREST	GRASSLAND	PASTURE	URBAN INFRASTRUCTURE	WATER	SOYBEAN	OTHERCROPS	TOTAL
FOREST	545.479,656	899,526	48.068,864	2,898	368,736	0,005	117,989	594.937,67
GRASSLAND	239,809	6.283,208	110,564	0,900	13,135		14,757	8.820,65
PASTURE	6.853,433	27,962	91.389,406	4,207	75,714	210,165	850,963	99.411,85
URBAN INFRASTRUCTURE	0,086	0,117	0,162	22,092	0,074			22,531
WATER	433,546	63,347	44,041	0,477	4.016,670		0,421	4.558,50
OTHERCROPS	0,002	3,175	46,059				7,365	56,601
TOTAL	555.164,817	7.277,334	139.659,096	30,573	4.474,329	210,170	991,495	707.807,81

Source: Authors, based on MAPBIOMAS (2021).

Table 6. Land use and coverage transition matrix within Jamanxim National Park (2008-2019)

INTERIOR	CLASS 2019					
CLASS 2008	FOREST	GRASSLAND	PASTURE	WATER	OTHERCROPS	TOTAL
FOREST	846.983,666	33,985	3.019,467	223,329	8,834	850.269,281
GRASSLAND	11,756	117,763	9,535	7,774	13,980	160,809
PASTURE	3.060,095	2,495	5.233,240	2,320	16,862	8.315,012
WATER	450,272	15,484	4,364	3.374,850	-	3.844,971
OTHER CROPS	0,584	-	14,166	-	0,220	14,969
TOTAL	850.506,374	169,727	8.280,772	3.608,274	39,896	862.605,042

Source: Authors, based on MAPBIOMAS (2021).

In the park's interior (Table IV), regarding the difference between 2008 and 2019, as the classes "forest" and "grassland" present positive values, indicating area gain, each class expanded 237,082 ha and 8,919 ha, respectively, which would indicate a process of plant regeneration. The “pasture” class has negative values, which suggests a loss of 34,241 ha, while “other crops” has positive values (24,927 ha).

Jamanxim National Park use and coverage matrix (Table V and Table VI) indicates that: Around the protected area, the “forest” class lost area to all anthropogenic classes, except “soybean”, having lost the vast majority of the total lost areas to “pasture”. The “pasture” class, with the greatest gain in areas, gained them mainly from the “forest” class, with little contribution of other classes to its expansion, its persistence being 80% of the areas. Another class with high persistence is the “urban infrastructure”, which maintained almost 100% of its territory in 2008, not expanding too much.

The class with the greatest persistence among the anthropogenic classes (pasture and other crops) is pasture, with more than 60% persistence, and the other has the lowest persistence rate, with less than 1% of remaining 2019 areas from the same locations as 2008.

DISCUSSION SECTION

The phenomena involving deforestation in the Jamanxim National Park are less evident because they are less latent. However, the pattern of burning as a deforestation tool for the implantation of pastures is seen in the protected area: pasture corresponds to almost 1% of the park territory, a percentage that should be zero considering the use restrictions. Anthropic activities developed around the area cause impacts in its interior, mainly because they are, among the use classes, activities such as mining and urban infrastructure. Inside the protected area, the vegetation points to a regeneration process, however anthropic activities are maintained and the increase in

deforestation continues to be positive and on a rise. When overlapped on deforestation points, rural properties are located in the most affected region, revealing the existence of registered properties within the strict protection policy. The overlapping of Rural Environmental Registry areas with deforestation occurs in the BR-163 region. The Rural Environmental Registry areas located around and far from the highway do not indicate deforestation. Deforestation data, fire hotspots and land coverage show that pressure and threat vectors are more persistent around the park than inside it. Although timid, the anthropic pressure placed on the unit exceeds the expected limits for an integral protection area. The threat appears close to BR-163, but it remains suffocated by other units juxtaposed to Jamanxim National Park that impede the development of deforestation (PEDROSO-JÚNIOR, MURIETA AND ADAMS, 2007). With the Jamanxim National Park, it is possible to observe how much the construction of a juxtaposed protected area mosaic can suppress forest degradation in a zone of intense pressure.

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