https://dx.doi.org/10.22161/ijaers.6.5.11 ISSN: 2349-6495(P) | 2456-1908(O)

Impacts of Mining in Conservation Units in the Brazilian Amazon

Diego Freitas Rodrigues[1], Alan do Nascimento Pedrosa[2], Letícia Alves de Araújo[3], Janaína Accordi Junkes[4]

[1]Professor of the Graduate Program in Society, Technologies and Public Policies, University Center Tiradentes.
[2]Master of Society, Technologies and Public Policies, University Center Tiradentes.
[3]Environmental Engineer, University Center Tiradentes.
[4]Professor of the Graduate Program in Society, Technologies and Public Policies, University Center Tiradentes.

Abstract**—** *The aim of the study was to investigate the relationship between the intensification of environmental degradation, measured as deforestation, and authorized mining activities within Conservation Units in the Amazon biome using a mixed methodology combining the use of the Leopold matrix and analysis of satellite images obtained through Google Earth and Qgis. The hypothesis was that mining activities in federal Conservation Units, indirectly increase deforestation at the edges of, and even inside, Conservation Units due to interest from other sectors of the economy. In order to determine mining incidence, the characteristics of institutional environmental management mechanisms in Conservation Units, and the profile of requests for and issuance of mining licenses in protected areas, a sample of 30 cases was selected and studied. Databases from several agencies were also employed and the Leopold matrix was used to identify and classify different types of environmental impact and detect correlations among them.*

Keywords**— Amazon biome, Environmental Impact Assessment, Greenhouse gases, Mining Activities, Protected Areas.**

I. INTRODUCTION

Protected areas are defined spaces set aside for environmental conservation or preservation, and according to the International Union for Conservation of Nature (IUCN, 2013), they cover approximately 14.6% of the Earth's surface and are fundamental policy tools for biodiversity conservation. In Brazil, the establishment of Conservation Units (COUNs), following either a sustainable use model or a full protection model, fulfills that goal from the environmental policy perspective (Rodrigues, 2014), but these models have legal loopholes that allow economic activities with high environmental impact, especially in sustainable-use COUNs. These activities are mostly related to agriculture, animal farming, and plant and mineral extractivism, which mainly cause vegetation loss, soil impoverishment, flooding and river silting, temperature increases, and habitat loss for plants and animals.

Habitat destruction is one of the main environmental impacts of mining. According to Gomes, Palma and Silva (2001), during mining activities, it is frequently observed that the species with greater locomotion escape, and sessile and sedentary species are crushed to death. In this study, we adopt the definition of environmental impact by Sánchez (2006) as an environmental unbalance caused by economic activities and address mining in particular.

The aim of the present study was to evaluate the incidence of legal mining in COUNs in the Brazilian Amazon, main source of natural products in the world (Andrade, 2007). Deforestation was considered the dependent variable. A sample of 30 cases was selected to determine mining incidence, the characteristics of institutional environmental management mechanisms in COUNs, and the profile of requests for and issuance of mining licenses in protected areas of the Amazon biome.

II. MATERIAL AND METHODS

The methodology was based on descriptive statistics. The Leopold matrix was used to identify and classify different types of environmental impact and detect correlations among them. Satellite images were analyzed using Google Earth Pro software and Qgis software, and 30 cases of mining were identified within the states composing the Amazonia Legal. The existing mining activities were studied, a check-list model of the resulting impacts was proposed, and a correlation matrix was created for these impacts.

Databases from several agencies were used. The Amazon Deforestation Monitoring Project (Projeto de Monitoramento do Desflorestamento na Amazônia Legal – PRODES) database was used to develop the deforestation indicator, and data on the characteristics of COUNs and the National System of Conservation Units (Sistema Nacional de Unidades de Conservação - SNUC) were obtained from the Chico Mendes Institute for Biodiversity Conservation (Instituto Chico Mendes de

Biodiversidade - ICMBio). Data on mining operations were obtained from the National Department of Mineral Production (Departamento Nacional de Produção Mineral - DNPM).

III. PROTECTED AREAS AND CONSERVATION UNIT MODELS IN BRAZIL

Protected areas are defined and delimited geographical spaces whose main function is the conservation and/or preservation of natural and cultural resources (Medeiros, 2003). In Brazil, environmental resources are of little political value, and there is little coordination of environmental policy (Wanderley, 2009). A perverse effect of this from the environmental perspective is public policies related to infrastructure development and energy safety that have required land-use changes in federal CUs without due assessment of the economic potential of the ecosystem services provided by the protected areas, such as climate regulation or erosion control (Vatn, 2010).

The economic potential of COUNs is related to activities such as (1) the exploitation of forest products; (2) carbon reserves, which are especially important to the governmental goal of restricting greenhouse gas (GHG) emissions; and (3) the production and conservation of water resources (Rodrigues, 2014; Shiki, S., Shiki, S. F. N, 2011). Act 9985 of 07/18/2000 created the SNUC to establish and regulate COUNs, which are designated as either fully protected or sustainable-use units. The political and institutional mechanisms that create COUNs (except for Ecological Stations and Biological Reserves) are participatory; namely, they require public consultation to decrease the possibility of friction during their establishment.

Fully protected COUNs include Ecological Stations, Biological Reserves, National and State Parks, Natural Monuments and Wildlife Refuges, and sustainable-use COUNs include Environmental Protection Areas, Areas of Relevant Ecological Interest, National and State Forests, Extractive Reserves, Fauna Reserves, Sustainable Development Reserves, and Natural Heritage Reserves (ICMBio, 2011). These areas quantitatively and qualitatively benefit a variety of economic sectors such as the considerable water resources composing the reservoirs of hydroelectric plants that supply energy to cities and industries. However, these benefits have little social and political value (Medeiros *et al*., 2011), and they are not considered viable indicators of economic growth in political evaluations, thus exacerbating the tradeoff between economic growth and environmental conservation (Rodrigues *et al*., 2015).

Regarding their potential to decrease GHG emissions in Brazil, COUNs maximize the potential for fighting climate change (through forest carbon sequestration), especially through changes in soil use (Domingues; Bermann, 2012). Deforestation is a predominant factor in the Brazilian emission framework because it was responsible for more than 60% of the total Brazilian GHG emissions in 2005. According to Medeiros (2003), in addition to avoiding emissions due to forest burning, conservation units prevent the emission of gases originating from activities such as animal farming and agriculture, especially methane (CH_4) and nitrous oxide (N_2O), which have higher global warming potential than CO_2; these gases were responsible for 10% to 19% of the Brazilian greenhouse gas emissions in 2005.

Approximately 80% of global GHG emissions originate from the burning of fossil fuels, meaning that economic activities mobilize and release C that has been deposited and retained in the subsoil for millions of years into the atmosphere (IPCC, 2007). Although the actual value is unknown, forest carbon sequestration under an optimistic scenario may be equivalent to approximately 12 to 15% of fossil fuel emissions (at the current emission rates) over the next 50 years (Brown *et al*., 2001).

Although this is a positive scenario from the perspective of Brazilian environmental assets and the use of COUNs for carbon sequestration, as well as the reduction of GHG emissions, there is a gap between the existing resources (capacity of COUNs for forest carbon sequestration) and the effective political valuation of COUNs in national climate change policies. The economic, as well as the fundamentally political (because they directly and indirectly affect human populations), importance of ecosystems resides in the diversity of their benefits to humans, called environmental services, such as climate regulation, carbon storage and sequestration, biodiversity conservation, and soil conservation and regeneration (Daly, 1990).

Many of the environmental services provided by COUNs are seriously compromised due to the incredibly fast pace at which externalities are imposed by a high-carbon economy and the very poor and inadequate economic (and consequently political) valuation of environmental goods and services, by both the market and the government (Fearnside, 1997).

It should be highlighted that although the type of use model determines whether communities have greater or less access to COUNs, as well as the presence of extractive activities, conflicts over land-use planning in areas that encompass COUNs may communicate a false dilemma regarding the implementation of conservation measures that either restrict direct and full human interference or allow extractive activities that affect the environment but are regulated by the responsible environmental management agency. Ostrom (1990) noted the limitations of exclusive approaches to the management of common goods, such as the environmental assets in COUNs.

https://dx.doi.org/10.22161/ijaers.6.5.11 *ISSN: 2349-6495(P) | 2456-1908(O)*

The inclusion of the communities within or around sustainable-use COUNs in their co-management (through a Management Council) affects the distribution of power in decision making and political participation, resulting in higher responsiveness and transparency in policies and practices related to sustainable extractive activities (Almeida, 2012; Colchester, 2004). Because sustainability is a broad concept with little cohesion from the political policy perspective, extractive activities with high environmental and social impact, such as mining, are included in COUNs, or COUNs are in areas directly influenced by mining activity (Sánchez-Vázquez, L. *et. al*, 2016; Rodrigues, 2016; Walter, M, 2008). To evaluate the incidence of mining as a vector of deforestation in COUNs in the Brazilian Amazon biome and its dependence on the characteristics of the mining permit profile and COUN management, the following aspects are of interest.

IV. RESULTS AND DISCUSSION

4.1 ENVIRONMENTAL IMPACT OF MINING: CASE STUDIES IN THE AMAZON BIOME

In addition to impacts that directly affect the interior of COUNs, deforestation around COUNs are of equal concern because they are predictive of future actions that will impact the protected area, especially in a scenario where lack of political interest has implicated in the lack of control of deforestation processes, such as the reality in the Amazonian ecosystem (Fearnside, 2006). These impacts occur as edge effects; i.e., forest fragments located in the middle of the CUs remain intact, while trees on the edges of those fragments may be removed or slowly die, increasingly exposing the edges to external actions that can alter the environment and may decimate an entire area (Martins, 2012).

Edge effects may result from exposure to climate, the presence of parasites, the introduction of invasive species, and other biological and/or chemical factors that degrade the environment (Odum, 2013). Additionally, edge effects alter the transition areas between plant communities; these areas are known as ecotones and are very important to the functional consolidation of COUNs and biodiversity conservation. However, deforestation was adopted as an indicator of environmental degradation in the present study, so possible edge effects are considered because agricultural, timber extraction, and mining activities tend to expand according to their goals and may destroy habitat near protected areas.

4.2 CONSERVATION UNITS DIRECTLY IMPACTED BY MINING

The deforestation of the Amazon, especially illegal logging, has been one of the great challenges in Brazil. The UN climate summit (COP 21) in Paris in 2015 established the goal of eliminating illegal deforestation throughout Brazil, intensifying the challenge of meeting that goal (Bastian, 2016).

Mining, the independent variable and object of the research in the present study, is an indicator of deforestation in COUNs in the Amazon biome. Mining Titles in the Brazilian Amazon is shown in Fig. 1. Generally, mining activities directly impact either Extractivist Reserves or National Forests. The case of the state of Pará, the second largest producer of minerals in Brazil, illustrates this incidence of mining activities in protected areas of the Amazon biome.

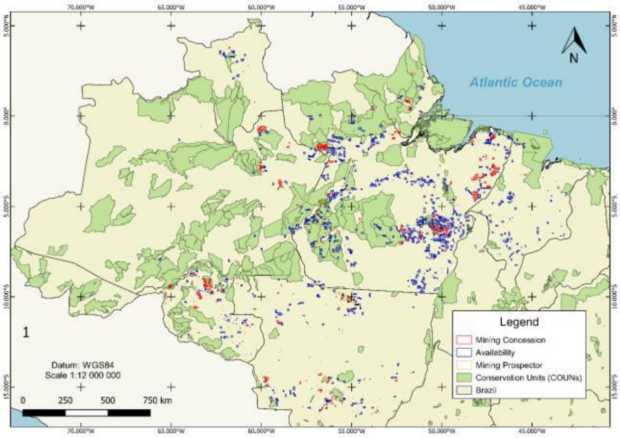

Fig. 1: Mining Titles in the Brazilian Amazon
Source: Qgis (Image altered by authors, 2017)

An analysis of 30 COUNs, including a study of deforestation up to 2014, identified mining activities within and around COUNs, Fig. 2. These activities in protected areas and their resulting impacts can be observed by analyzing satellite images from Landsat satellites specifically prepared for analyzing the Earth.

This correlation between mining and the degradation of the surrounding is observed when we consider the relationship between mining interests, assessed based on processes initiated by the DNPM that range from permits for mineral prospecting to extraction licenses, and deforestation in CUs, which is measured in km² by the National Institute of Space Research (Instituto Nacional de Pesquisas Espaciais – INPE).

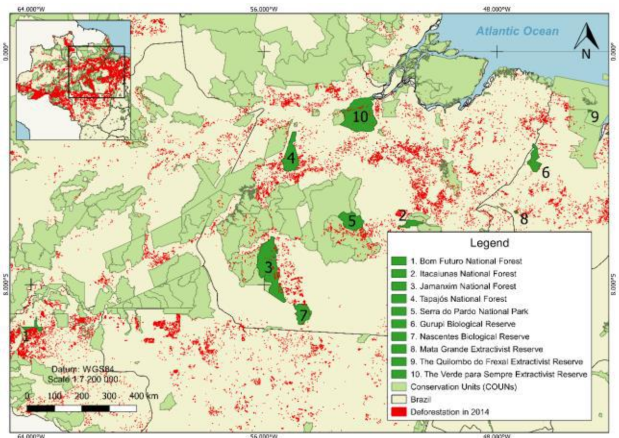

Fig. 2: Spatial Association between Deforestation and Mining

Source: Qgis (Image altered by authors, 2017)

According to data from PRODES (2016), both deforestation and the mining interests in COUNs in the Amazon biome increased between 1997 and 2005. Of the 30 studied COUNs, the following 10 exhibited the highest deforestation between 1997 and 2014:

The Quilombo do Frexal Extractivist Reserve (Maranhão) is an extractive reserve in which deforestation reached 100.11%; i.e., the amount of original vegetation cover removed exceeded the delimited area of the COUN, according to data from the INPE. Similar to other COUNs, an area licensed for mining is located at the border of the Quilombo do Frexal Extractivist Reserve.

The second COUN with the highest level of deforestation was also an extractive reserve; 91.2% of the vegetation was removed from the Mata Grande Extractivist Reserve (Maranhão). Although the cause of the deforestation was not identified, there are several licensed mining areas around this COUN, namely, a 24.89-hectare area located 607 meters away.

Itacaiunas National Forest (Pará) is currently the third most deforested COUN, with a 42.91% vegetation loss. There is intensive mining activity around this forest originating from the Carajás mining complex.

The Sossego Mine, one of the largest mines in the region with an area of 9.33 km² and a perimeter of 30.4 km, is 32.8 km from the COUN, and the Carajás Mine, with an area of 42 km² (4,204 hectares) and a perimeter of 53.0 km, is 38.6 km away.

Additionally, the Bom Futuro Mine has a 32.3-km perimeter and an area of 19.7 km²; it is located approximately 19.5 km from Bom Futuro National Forest (Rondônia) and is responsible for the deforestation in this region. The largest open pit mine, for bauxite extraction, has had the greatest impact. Bauxite is used in aluminum production, and its extraction may result in illegal hunting and deforestation in addition to hydrological disturbances. Other types of environmental damage originating from this mine can be identified in the impact matrix (Fig. 3).

https://dx.doi.org/10.22161/ijaers.6.5.11 ISSN: 2349-6495(P) | 2456-1908(O)

ACTIVITIES/INFRASTRUCTURE							GOLD MINING ENVIRONMENTAL IMPACT MATRIX - BOM FUTURO MINE		ENVIRONMENTAL IMPACTS: BIOPHYSICAL ENVIRONMENT										ENVIRONMENTAL IMPACTS: ANTHROPOGENIC ENVIRONMENT														
Mining complex	Open pit excavation	Tailings disposal	Ore processing	Waste disposal	Support services	Transport of inputs and equipments	Factor classification: Δ Significant factor ■ Less significant factor	Impact classification: ● Very important impact ◆ Less important impact	Soil quality loss	Soil contamination	Groundwater level reduction	Water availability reduction	Surface water quality deterioration	Groundwater quality deterioration	Air quality deterioration	Habitat loss	Changes to aquatic ecosystems	Resource base reduction	Visual impact	Discomfort	Degradation of the built environment	Loss of cultural resources	Possible injuries and deaths	Impacts on human health	Spread of infectious diseases	Reduced agricultural production	Increase in commercial activity	Increased demand for public services	Population growth	Disturbance to community life	Workforce training	Increased tax revenue	Decreased disposable income
■		■					RESOURCE CONSUMPTION	Raw materials	◆																								
Δ			Δ		Δ			Energy																									◆
								Manufactured goods																			◆					◆	
							WATER CONSUMPTION	Groundwater				◆		◆																			
■	■	Δ	Δ					Surface water					◆																				
Δ	Δ			Δ			LAND USE	Soil degradation	●							◆		◆															
				Δ				Groundwater pollution																									
Δ				Δ				Erosion	◆																								
■	■			■				Animal migration	◆							◆																	
Δ	■			Δ				Vegetation loss	◆				◆			◆																	
								Irregular occupation of soil								◆																	
Δ	Δ						AQUATIC EMISSIONS	Diffuse sources					◆	◆																			
								Point sources					◆	◆																			
■	Δ					■	ATMOSPHERIC EMISSIONS	Gases and smoke							◆									◆									
Δ			Δ			Δ		Particulates													◆			◆									
Δ							SOIL EMISSIONS	Solid waste		◆																							
	Δ		Δ	Δ	Δ			Soil infiltration																									
	■		Δ			Δ	OTHER EMISSIONS	Noise																						●			
			Δ					Seismicity																						◆			
								Radiation																									
	Δ						ACCIDENTS	External spills		◆			◆																				
Δ								Mining area spills											◆			◆		◆	◆					◆			
Δ			Δ		■	■	SOCIAL ASPECTS	Employment generation															◆	◆			●	◆	◆				
Δ			Δ					Professional training																							●		
■			Δ					Demand for goods and services																			●						
■								Business opportunities																			●	●					
								Tax revenue generation																								●	

Fig. 3: The Leopold Matrix
Source: Prepared by the authors

https://dx.doi.org/10.22161/ijaers.6.5.11 ISSN: 2349-6495(P) | 2456-1908(O)

The Leopold matrix is a checklist of human actions that may cause environmental impacts and the environmental components that may be affected by those actions. However, the Bom Futuro National Forest was likely already impacted as it is possible to verify in the Fig. 4, referring to the period from 1996 to 2016, with 10 years gap between images. The COUN showed already a deforestation in the initial registry (1996) and, in 2006, had a deforestation registered in 36.55%. The deflorestation was expanded as can be seen in the image of 2016.

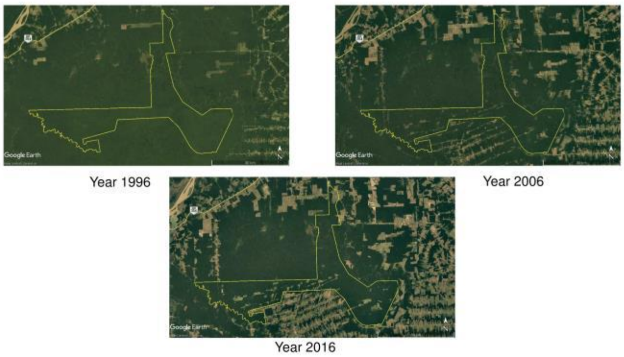

Fig. 4: Deforestation in Bom Futuro National Forest (Years – 1996, 2006, 2016)
Source: Google (Image altered by authors, 2016)

The Gurupi Biological Reserve (Maranhão) was the COUN with the fifth highest degree of deforestation, although no mining or extractive activities were identified around this COUN. However, the DNPM has identified many mining interests within and outside its borders. In this COUN, 28.53% of the original vegetation has been removed, and in addition to mining requests, there is great interest in mineral prospecting and extraction.

The Nascentes Biological Reserve in the Cachimbo Mountains had the sixth highest degree of deforestation, 16.7%. A large area that had been deforested for pastures and plantations was identified along the northern border of the reserve. Regarding mining, only prospecting permits were found for this COUN, but current data from the DNPM (2016) indicate that there is a request for mining in a 2.72-km² deforested area with a 13-km perimeter located a few meters from the CU. Therefore, it directly influences the CU.

Jamanxim National Forest (Pará) was the COUN with the seventh highest loss of original vegetation at 11%, and because this forest is very near the Nascentes Biological Reserve in the Cachimbo Mountains, it is affected by the same impacts described above (Fig. 5).

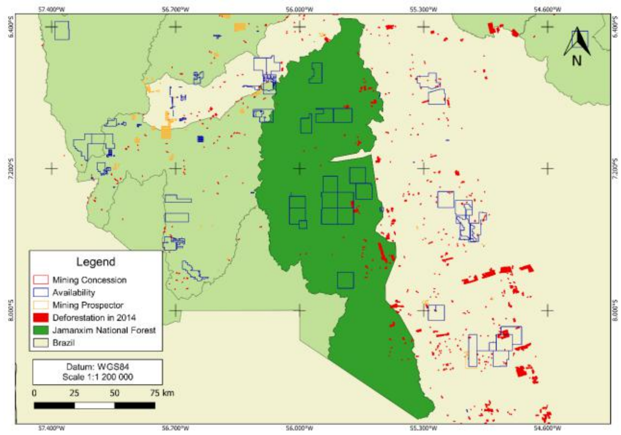

Fig.5: Incidence of mining titles in the National Forest Jamanxim
Source: Qgis (Image altered by authors, 2017)

However, although there is mineral prospecting in this COUN, it is more affected by the deforestation in its surroundings that is fueled by highway BR 163, which directly affects both the Nascentes Biological Reserve and Jamanxim National Forest among other COUNs.

Serra do Pardo National Park, with a deforested area of 6.6%, is also located in Pará, the state with the highest mining activity in the country. The entire area to the south of this COUN is occupied by mining interests, most of which are in prospecting or prospecting request phases.

Tapajós National Forest is also located in the state of Pará, and it presents 6.5% deforestation within its protected area and 47.3 km of deforestation in a "fishbone" pattern in its surroundings due to the construction of a highway. There are many requests for mining and mineral prospecting, especially gold mining, in the surroundings of this COUN.

The Verde Para Sempre Extractivist Reserve, also in the state of Pará, presented a 4% deforested area, and an analysis of Google Earth images identified more than five licensed mining areas 74.9 km to the west. However, most deforested areas are to the south, where the first cuts within the COUN were also observed.

4.3 AREAS OF INFLUENCE AND MANAGEMENT MECHANISMS

To evaluate whether the impact of mining is in fact reflected in the COUN, influence areas, which are the areas experiencing possible physical, biotic, and/or socioeconomic changes resulting from mine implantation and/or operation, were established. Criteria were established to categorize COUN Indirect Influence Areas (IIA), Direct Influence Areas (DIA), and Directly Affected Areas (DAA) by mining operations.

In the present study, IIA were considered the areas bordering mines at a distance up to 20 km and up to 500 m from the licensed area when the area was considered of interest but currently without extraction. Directly Affected Areas were the areas with mining operation infrastructure, and DIA were considered the licensed areas of interest without current extraction.

Regarding the management mechanisms, this study considered cases where the COUN was managed by management councils, management plans, or other management tools. Institutional activities characterized by a higher level of shared responsibility seem to facilitate the implementation of public policies (Ostrom, 1990). However, environmental policies are characterized by their pronounced transversal character, so to increase their efficacy, these measures should, in general, use the same actors throughout the environmental policy formulation and implementation cycle. Public resource management is characterized by political transversality in that it involves several institutions with their own "environmental agendas" that will ultimately influence each other in terms of environmental quality due to the low degree of political coordination between different government sectors and civil society (Sanchez, 2013).

Of the 30 COUNs evaluated, only 16 possessed all the mechanisms conducive to good management. Of the remaining 14, there was no management plan for the Quilombo do Frexal Extractivist Reserve, and there was no management mechanism for the Mata Grande Extractivist Reserve, Bom Futuro National Forest, and Itacaiunas National Forest, except for the COUN establishment document. These were among the most deforested areas in the Amazon biome

V. CONCLUSION

The present data revealed the importance of mining to the Brazilian economy; mining generates jobs and income and strengthens bonds with other countries through international commerce. By contrast, mining is considered a threat to species diversity in natural areas and the main hydrographic basins.

Analysis of the data on mining in COUNs within the Amazon biome revealed that Pará is the state with the most mining interests, presenting several licenses in the areas surrounding COUNs, ranging from prospecting licenses to the presence of already active mines extracting minerals to supply several branches of industry.

Gold is the most abundant mineral in the Amazon biome, which is worrying because gold extraction generates large amounts of waste material contaminated with heavy metals, typically in concentrations that are harmful to the health of humans, environment, and the species present.

There were mining operations in the surroundings of Itacaiunas and Bom Futuro National Forests in the state of Pará and the Mata Grande Extractivist Reserve in the state of Maranhão that directly affected the COUNs. The remaining COUNs also presented mining interests in their surroundings, but these were considered of indirect influence.

Despite the evident mining interests in the surroundings of Jamanxim and Tapajós National Forests, the main cause of environmental degradation identified through satellite image analysis was the construction of the state highway. This does not rule out impacts resulting from mining, but their effect was minimal compared to that of the highway.

Of the 30 cases studied, only COUNs with internal management tools exhibited no significant internal deforestation. This was the case for Serra da Cutia National Park, which possesses both a management plan and a management council and has experienced no significant deforestation since its creation. In contrast, mining licenses existed in most cases where there was pronounced deforestation, including the 10 cases highlighted in the present study, even when the COUN and its surrounding areas were classified as ecological corridors. Although no extraction was identified within the COUNs, these licenses indicate a trend toward increasing environmental impact in the protected areas.

Thus, it can be stated that mining activities are positively correlated with increased deforestation in federal COUNs.

In conclusion, there was a spatial association between the existence of mining licenses and deforestation in the studied Amazon COUNs that were most heavily impacted. It should be highlighted that this association is related to other local economic activities, especially animal farming, and to infrastructure, such as highways, bordering the COUNs. The character of COUNs demands internal management mechanisms (such as management councils and management plans) that restrict external pressures and their risks. However, institutional conflicts over environmental policies allow for incongruence between the goals of a government sector such as the DNPM, the holder of a mining operation within the perimeter of a protected area, and environmental regulation and monitoring agencies such as ICMBio that conflict with these directives when they act to protect COUNs. In a sensitive biome such as the Amazon, not only is greater protection necessary for COUNs, but also, greater and dully responsive protection is needed for the institutions that manage mining operations in Brazil and the COUNs.

REFERENCES

[1] ANDRADE, AL. (2007). Indicadores de sustentabilidade na Reserva de Desenvolvimento Sustentável do Piranha, Manacapuru, Amazonas, Brasil. Acta Amaz. 37(2):401-412. doi: 10.1590/S0044-59672007000300011.

[2] ALMEIDA, AWB de. (2016). Territórios e texrritorialidades específicas na Amazônia: entre a "proteção" e o "protecionismo". Cad. CRH,

v.25(64):63-71. 2012. doi: 10.1590/S0103-49792012000100005.

[3] BASTIAN, MEGDA.(2016) O acordo de Paris como solução efetiva às questões climáticas a partir do uso de sanções premiais. Dissertation, Universidade Federal do Rio Grande do Sul, Porto Alegre, 115p.

[4] BROWN, L. (2001). Rising Sea Level Forcing Evacuation of Island Country. Earth Policy Institute. Available in: (http://www.earth-policy.org/Updates/Update2.htm). 2001. Acessed on 08 jun. 2017.

[5] COLCHESTER, M. (2004). Conservation policy and indigenous peoples. Environ Sci & Policy 7: 145-153. doi: 10.1016/j.envsci.2004.02.004.

[6] DALY, HE. (1990). Sustainable Development: From Concept and Theory to Operational Principles. Popul. Dev. Rev. 16: 25-43. doi: 10.2307/2808061.

[7] DNPM. Departamento Nacional de Produção Mineral. (2016). Anuário Mineral Brasileiro. Brasília: 40p. Available in (http://www.dnpm.gov.br/dnpm/publicacoes/serie-estatisticas-e-economia-mineral/anuario-mineral/anuario-mineral-brasileiro/anuario-mineral-brasileiro-2016-metalicos). Acessed on 08 jun. 2017.

[8] DOMINGUES, MS, C BERMANN. (2012). O arco de desflorestamento na Amazônia: da pecuária à soja. Amb. & Soc. 15(2):1-22. doi: 10.1590/S1414-753X2012000200002.

[9] FEARNSIDE, PM. (1997). Environmental services as a strategy for sustainable development in rural Amazonia. Ecol. Econ. 20:53-70. 1997. doi: 10.1016/S0921-8009(96)00066-3.

[10] FEARNSIDE, PM. (2006). Desmatamento na Amazônia: dinâmica, impactos e controle. Acta Amaz. 36(1):395-400. 2006. doi: 10.1590/S0044-59672006000300018.

[11] ICMBIO - Instituto Chico Mendes de Conservação da Biodiversidade. (2011). Unidades de Conservação. Available in: (http://www.icmbio.gov.br/portal/biodiversidade/unidades-de-conservacao/biomas-brasileiros.html). Acessed on 18 oct. 2016.

[12] IUCN - Internation Union for Conservation of Nature. (2013). Annual Report. Available in: (https://portals.iucn.org/library/sites/library/files/documents/IUCN-2014-017.pdf). Acessed on 30 aug. 2016.

[13] MARTINS, A. (2012). Conflitos ambientais em unidades de conservação: dilemas da gestão territorial no Brasil. Rev. elect. geo. y ciencias soc.17(989)1-22. doi unavailable.

[14] MEDEIROS, RA. (2003). Proteção da Natureza: das Estratégias Internacionais e Nacionais às demandas Locais. Doctoral thesis, Universidade Federal do Rio de Janeiro/Programa de Pós-Graduação. Rio de Janeiro, 391p.

[15] MEDEIROS, R, CEF YOUNG.(2011). Contribuição das unidades de conservação brasileiras para a economia nacional. Relatório Final UNEP-WCMC, Brasília, 120p. Available in: (http://www.icmbio.gov.br/portal/images/stories/comunicacao/estudocontribuicao.pdf). Acessed on 15 apr. 2017.

[16] ODUM, EP, GW Barrett. (2013). Fundamentos de Ecologia. Ed. Cengage Learning, São Paulo.

[17] OSTROM, E. (1990). Governing the commons: the evolution of institutions for collective action. Ed. Cambridge University Press, New York.

[18] PARRY, OF, JP CANZIANI, PJ PALUTIKOF, VD LINDEN, CE HANSON. (2007). Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, IPCC. Ed. Cambridge University Press, Cambridge, UK.

[19] PRODES. (2015). Desmatamento: Dados por unidade de conservação. Available in (http://www.dpi.inpe.br/prodesdigital/prodesuc.php). Acessed on 02 nov. 2015.

[20] RODRIGUES, DF et al.(2014). A política brasileira de mudanças climáticas: competição, cooperação e diversidade institucional. Ed. Edições UFC, Fortaleza.

[21] RODRIGUES, DF. (2015). A sustentável leveza da democracia? Os efeitos da qualidade democrática sobre o desempenho ambiental. Desenv. e Meio Amb. 33:81-99. doi: 10.5380/dma.v33i0.

[22] RODRIGUES, DF. (2016). Paraísos Perdidos? Investimento Estrangeiro Direto em Mineração e Conflitos Ecológicos Distributivos no Brasil, na Colômbia e no Peru. Teor. & Pesq., 25: 96-133. doi: 10.4322/tp.25303.

[23] SÁNCHEZ, LE. (2006). Avaliação de Impacto Ambiental: Conceitos e Métodos. Editora Oficina de textos, São Paulo.