PROCESSES OF LAND USE AND COVER CHANGE IN TWO MINING REGIONS: IMPLICATIONS FOR CONSERVATION IN THE AMAZON FOREST

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ABSTRACT

Indirect deforestation induced by mining development can cause consequences beyond the mining leases, transforming the surrounding landscape due to land use and cover changes. This work analyzes the processes of land use and cover change in mining regions. Two areas in different stages of mineral extraction in the Brazilian Legal Amazon were chosen for discussing the influence of the stage of mining development, existing infrastructure, natural barriers and protected areas in the land use change in the period 2004-2014. The analysis showed that pressure of mining projects can induce deforestation in protected areas and most of land conversion in these areas occurs in the surroundings of the existing roads and rivers.

Keywords — Brazilian Amazon; Mining; Change detection; Land cover change.

1. INTRODUCTION

Mining regions are characterized by the concentration of mineral resources which undergo severe processes of land use change due to the combination of mining and non-mining activities [1]. The construction of new roads and urban settlements to shelter new mining workforce, agricultural frontier and biomass plantation, are some of the competitive uses in mining areas. The induced deforestation caused by mining infrastructure establishment and associated secondary forest clearing, such as that associated with new roads, urban expansion and indirect economic activities stimulated by mining, is more significant than that caused by the intensive land use inside mining leases [2]

In order to advance the understanding of the dynamic conversion of land and development in mining regions, previous research comparing mining and non-mining regions [3] evidences four main processes of land use change: (i) the direct footprint of mining expands over time; (ii) the offsite footprint of mining is extensive and also often expands; (iii) environmental and social impacts are caused by the footprints of mining; (iv) land use change in mining regions is driven by global factors, such as international commodity markets.

Part of the literature about land use change in mining regions focus on understanding processes of land use change and land cover conversion. In the vicinity of the Carajás region [4], it was shown that in the Itacaiúnas river watershed, forest was mainly converted to pasture and the majority of remaining forest stands are found inside protected areas. A study in the Iron Quadrangle found that conversion of forest to mining varies across the years, going from 5% (1990-2000) to 18% (2004-2010) [3].

In the Amazon forest, the influence of roads, rivers, agricultural suitability and urban settlements in mining-induced deforestation was investigated. [2] found that induced deforestation is 12 times larger than that direct losses inside mining leases. In the Peruvian Amazon, an intensive gold mining extraction is revealed [5], causing significant forest loss and deforestation in protected areas [6]. However, still few works seek to investigate differences of land use change processes in areas with different stage of mining development [3].

The present study aims at analyzing the processes of land use change in mining regions. Two different areas with different level of mineral extraction in the Brazilian Amazon forest were analyzed for determining the main drivers of change considering the different level of mining development.

The analyses were conducted in two mining regions in Brazilian Legal Amazon. One is named Renca (National Reserve of Copper and Associates), a region with unofficial gold mining extraction that recently was in central debate about mining environmental impacts in protected areas. The location comprises a considerable number of Protected Areas (PA) and indigenous lands. The second region is around the Mineração Rio do Norte (MRN) project, the major Brazilian bauxite producer. Close to Trombetas and Amazon rivers and the town of Oriximiná, the mine is near “quilombolas” and protected areas. These two areas were chosen for discussing the influence of different levels of mining extraction, existing infrastructure, natural barriers and protected areas in the processes of land use change.

2. MATERIAL AND METHODS

The methodology encompasses the steps of data collection, spatial analysis and change matrix calculation. The high spatial resolution land use and land cover maps from TerraClass project was used [7]. The thematic maps composition based on Landsat-5/TM images classification using linear spectral mixture model, threshold slicing, and visual interpretation supported by temporal information extracted from NDVI MODIS time series. The available public data used was from 2004 and 2014, exploring the recent land use changes.

To capture the induced deforestation, two buffer polygons for each area were drawn. According to [2] the significant induced deforestation is up to 70km far from the mining leases. Because of this, two thresholds were used - 35km and 70km - to test if the patterns change with the proximity of the leases. However, this threshold is relevant considering only the Amazon forest biome. For other regions, such as the Iron Quadrangle, the effects of offsets areas influence the threshold of deforestation around 300m of the mining leases explained by the conservation areas purchased in the surroundings of mining leases [3]. The buffer's polygon and final maps were elaborated in ArcGIS 10.5. For the processes of land use change evaluation, the change matrix was calculated in the DINAMICA EGO software (Soares-Filho et al., 2002). It presents the values of cells in each class transition and the percentage of change is calculated based in the total amount of cells conversion.

2.1. Renca

Renca is a National Mineral Reserve on the border between Pará and Amapá (Figure 1) created in 1984 as an area where mineral research exploration was restricted [8]. Recently the Ministry of Mines and Energy declared the intention of removing such prohibition. This initiative fomented the debate about the mining activities in protected areas in the Amazon.

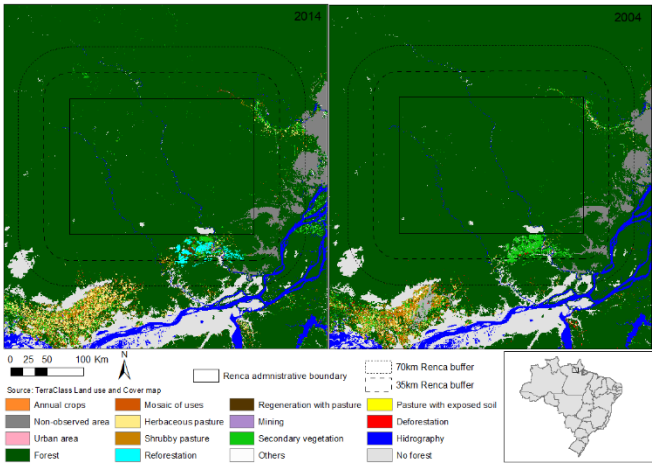


Figure 1 – Land use and land cover in the Renca region

The region encompasses nine Protected Areas, three with full protection, four aimed at sustainable use and two indigenous lands. According to Federal Law 9985/2000, the National System of Conservation Units, mining it is not permitted in units in the full protection category. Furthermore, according to the Federal Constitution it is not possible to legally mine in indigenous lands. Inside Renca, mining is allowable in only one PA (Floresta Estadual do Paru) [8]. In case Renca is extinguished, mine leases could be conceded in this area considering the current state of legislation.

2.2. MRN

The other study region is situated in western Para on the border with Amazonas State (Figure 2). The mining concession comprises the area of 112,743 ha. The MRN project started operation in 1979 and is the major producer of bauxite in Brazil and the third biggest in the world. The operations in the region encompasses ore extraction, processing, rail transportation, drying and shipment. MRN's structure includes an ore-drying industrial park, 24 wastewater and water storage dams, a 28-kilometer railroad, bauxite shipping port and two thermoelectric power plants. There is also a company town with 6000 employees and respective families.

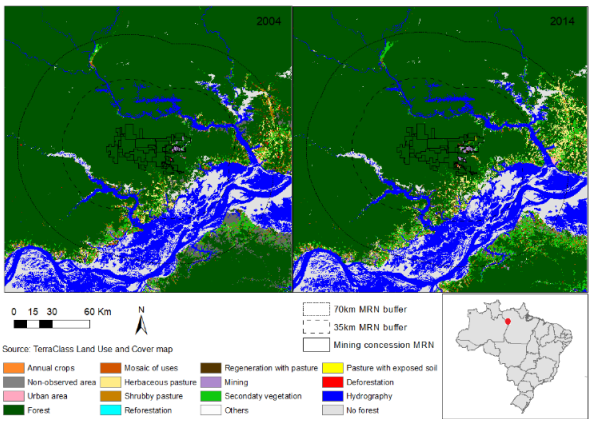


Figure 2 – Land use and land cover in MRN

3. RESULTS AND DISCUSSION

The two areas present different level of mining development. MRN operates since 1980's, therefore the analysis of the ten years (2004 – 2014) capture changes in consolidated areas, with already existing mining ancillaries, infrastructure of transport and urban settlements. Renca is an unofficially explored area with drivers of occupation in the surroundings and most part of its territory covered by protected areas.

The observed patterns are similar for both buffers (35km and 70km) from the MRN mining leases and Renca region, showing that the processes have mainly the same drivers considering both thresholds. Figure 3 shows the percentages of changes that occur in the buffer of 70km in the Renca region. The mining activities are mainly derived from forest (96%) (Figure 3). Such percentage represent 10% of the original forest area. Moreover, 6% of the total herbaceous pasture was converted to mining. Most of pasture are from forest, 96% of the area with pasture with exposed soil and 73% of shrubby pasture came from forest cover. Such area corresponds to, respectively, 2% and 6% of the total forest cover in 2004. Besides that, 78% of the secondary vegetation areas is from herbaceous pasture, indicating a process of regeneration in the region. However, the degradation also can be noted by the conversion of herbaceous pasture from secondary vegetation (98%), pasture with exposed soil from forest (96%) and shrubby pasture from forest (73%) (Figure 3). One interesting percentage could be seen from forest to reforestation (37%). This is because of the Jari project located in the south of Renca boundaries (Figure 1).

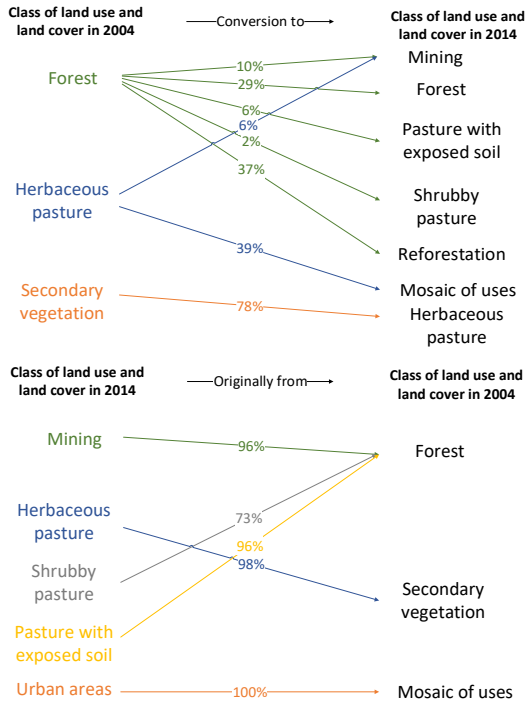
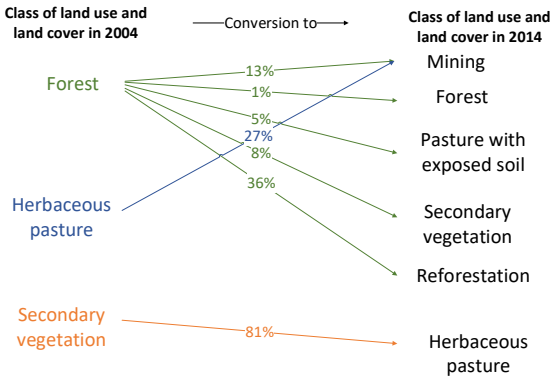


Figure 3 - Processes of land use change in Renca with percentages from the region up to 70km.

Figure 4 depicts the processes of change of MRN region and it is structure as the previous scheme. With mining activities since the 1980's, the MRN region present 88% of the total new mining areas after 2004 converted from forest (Figure 4). This area represents 13% of total native forest in total area. However, the percentage of herbaceous pasture that is converted to mining is larger (26%) than in Renca (6%). The right side shows that the secondary vegetation came from mainly forest cover (83%) and the herbaceous pasture mainly from the secondary vegetation (89%). Only 1% of forest in 2004 are forest in 2014, and 36% became reforested areas.



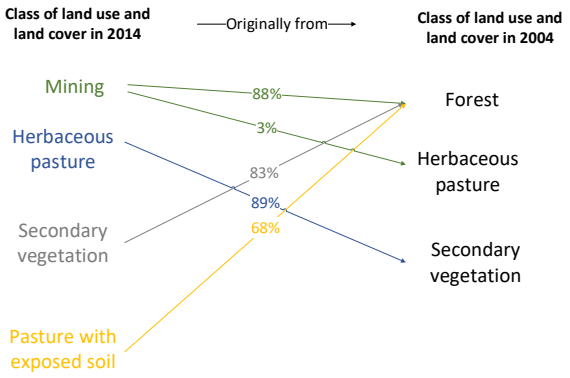


Figure 4 – Processes of land use change in MRN with percentages from the region up to 70km.

The processes of changes in the two regions follow the trend described in the literature of forest conversion to pasture [3;4]. [4] identified a great pasture conversion but also new mining and urban areas. In contrast, the analysis of Iron Quadrangle reveals few new urban areas since there are more consolidated cities in the region. There is no significant urban expansion in Renca region between 2014 and 2004. To MRN the urban settlements are probably joint in the class of mosaic of uses and do not present relevant changes from 2004 to 2014. Besides that, the process of urbanization in MRN occurred during the initial stage of mining development (1980's).

Figure 5 shows the detail of the land use and cover of the new mining projects in the region. It is possible to note a fragmentation pattern of fishbone caused by roads. In the MRN region, the existence of the Amazon and Trombetas river represent a physical barrier for expansion of mining induced deforestation. The major changes close to mining regions occurs in the margin of Amazon river, with more pasture and secondary vegetation (Figure 6).

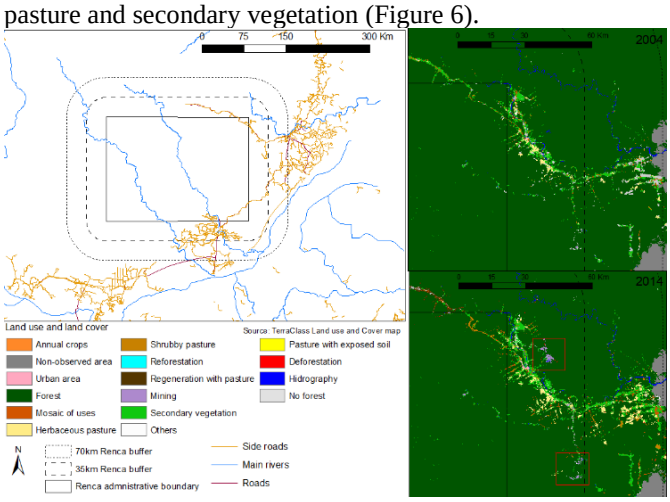


Figure 5 – Detail of the Renca changes

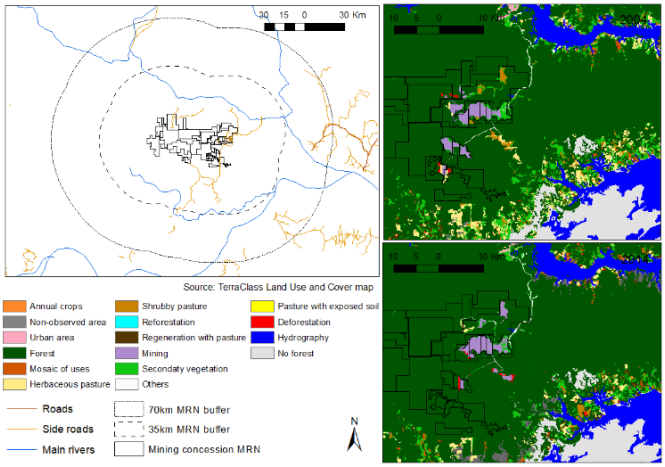


Figure 6 – Detail of MRN changes

The development of new mining projects in the area caused induced deforestation inside the Renca administrative boundary (Figure 5). The mining concession in the Renca's border encompasses the total area of 39,346 ha, representing 35% of total area of MRN mining concession. The induced deforestation inside Renca represents 18% of the forest conversion in the surroundings of 70km of those mining concessions. This induced deforestation occurred in a protected area of sustainable use. Although, is permitted some human interference in the area, the boundaries of the protected area are not effective in conserving the integrity of the forest.

The analysis of the project's surroundings allows us to perceive the distinguished land use change given the level of mining extraction and project size [4]. Especially, the size of mining companies indicates the level of commitment of the industry to mitigate, avoid and compensate its impacts in the environment. [9] points out the existence of initiatives such as research and development, stakeholder's engagement and management systems based on environmental standards. However, these mechanisms are not implemented in small mining companies and the unmitigated cumulative effects of small companies operating in the same region should be relevant and further investigated, especially considering the existence of gold mining [6].

Besides that, further works are welcome to explore the cumulative effects of the induced and intensive land use change. Renca should be more investigated since the pressure of existing mining projects in the vicinities and the speculation of further investments in the area represent a significant drive for deforestation. The cumulative effects of the induced deforestation should be assessed before further investments in the area.

4. CONCLUSIONS

This work reveals distinguished processes of land use change considering the degree of mining development. Even projects in the same biome, the level of mining development and natural boundaries influence the degree of induced deforestation. The MRN region show the major new dense occupation in the margin of Trombetas and Amazon river and a higher percentage than in Renca of new mining land use converted from pasture. In Renca region the occupation occurs mainly in the surroundings of side roads. The new mining projects after 2004 close to Renca induced a forest conversion inside the administrative boundaries, revealing that mining projects can potential affect the protected areas in the region. Therefore, especially in areas to be mined, a comprehensive investigation should be done about the cumulative effects of the deforestation, such as fragmentation and habitat loss.

5. ACKNOWLEDGEMENTS

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