Changes in forest cover applying object-oriented classification and GIS in Amapa-French Guyana border, Amapa State Forest, Module 4

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Abstract. In recent decades, processes of land use and occupation have reduced the original forest cover in tropical countries, affecting biodiversity and ecological integrity of ecosystems. Knowledge of the land clearance and of the processes involved is essential to establish public policies for reducing deforestation. The state of Amapá has more than 70% of its territory with conservation units.The aim of this work is applying the object-oriented classification method and spatial analysis in GIS for recognize and analyze changes in the forest cover and its relation with land use and occupation on the Module 4 of the conservation unit of Forest of Amapa State-FLOTA/AP. Two scenes Landat satellite, sensor TM5 were processed using the method of object oriented classification. Geospatial vector data and data collected *in situ* were used for validation of the land cover and land use classes. The GIS was used to qualify and quantify the land cover and land use classes. Six patterns of land cover were identified (forest, cloud, cloud shadow, altered areas, surface waters and outcrops). The pattern of alteration mapped corresponded to pasture for ranching, cultivated areas by agriculture; excavations for gold mining, roads for transport and communication and soil built for urban areas. These alterations are concentrated along the Federal Highway (BR-156) and State Highway (AP-260). The results will help to quantify the rate of deforestation and identify pressures to apply the resulted in the study of ecosystem services in this region.

Keywords: object-oriented classification, land use and land cover, Amazonian-Amapa.

1. Introduction

In recent decades, processes of land use and occupation have reduced the original forest cover in tropical countries, affecting biodiversity and ecological integrity of ecosystems. Knowledge of the land clearance and of the processes involved is essential to establish public policies for reducing deforestation.

The state of Amapa has more than 70% of its territory with conservation units.The large extent of State Forest of Amapá (FLOTA/AP) - area of 2,369,400 ha – has great potential to provide ecosystems services. In particular module 4 of FLOTA/AP - border area with French Guiana. Changes on current scenario of pressure on natural resources are expected, especially in areas with better road infrastructure.

The aim of this work is applying the object-oriented classification method and spatial analysis in GIS for recognize and analyze changes in the forest cover and its relation with land use and occupation on the Module 4 of the conservation unit of Forest of Amapa State-

FLOTA/AP (Figure 1). The result of the study will help to understand the pressure associated the change in forest cover in this region.

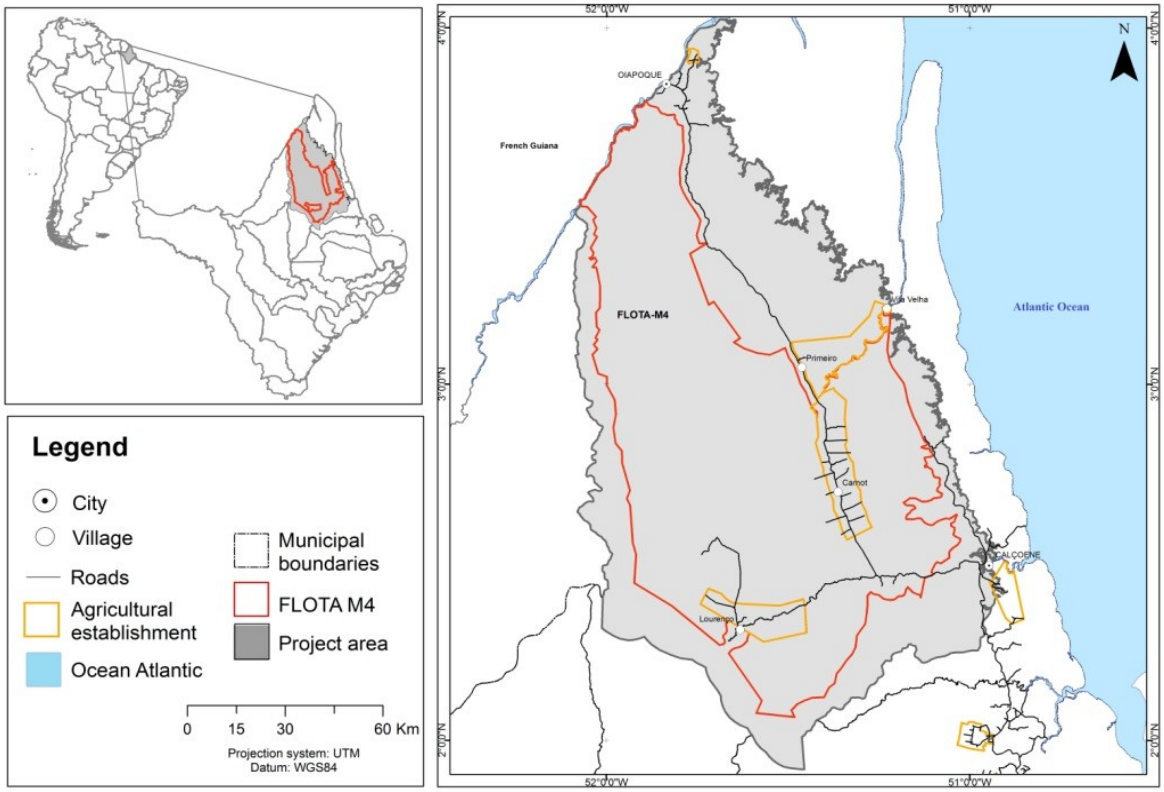

Figure 1: Overview of the study area in Module 4 of the conservation unit of Forest of Amapa State-FLOTA.

2. Methodology

2.1. Data of Satellite images and processing

Two scenes of Landsat TM5 (Table 1) were obtained from the collection of the Division of Image Generation - DGI of the National Institute for Space Research - INPE (http://www.dgi.inpe.br/CDSR/).

Table 1: Spectral and spatial characteristics of the images used in this work.

Sensor/ satellite	Orbit/ point	Acquisition Date	Space Resolution (m)	Bands	Data source
TM 5 LANDSAT	226057 226058	19/08/2008	30	5 (0,63-0,69µm) 4 (0,76-0,90µm) 3 (1.55-175µm)	http://www.dgi.inpe.br/CDSR/
ETM+ 7 LANDSAT	226057 226058	06/09/2000	28,5	5 (0,63-0,69µm) 4 (0,76-0,90µm) 3 (1.55-175µm)	http://glcfapp.glcf.umd.edu:8080/esdi/index.jsp

The dark pixel subtraction method (CHÁVEZ, 1988) was used for the atmospheric correction of the images applying the algorithm ARICONST, available in PCI Geomatic software.

Two scenes ortoretified of the Landsat 7 satellite, sensor ETM+, of 18 of november of 2000 (TUCKER et al. 2004) were used as image base for the geometric register. Twenty two control points were used for each scene. The results of RMS (Mean-Square Error) were 0.49 (orbit/point 226057) and 0.51 (orbit/point 226058). One mosaic was made using the module Georeferenced Mosaic and cropped by interest region using the the ENVI program.

2.2. Object-oriented classification

The object-oriented classification was performed at Definiens Developper software and applied to a mosaic of the region of interest. The segmentation for multiresolution were applied in two hierarchical levels applying the top-down method. Remote sensing indices used for the segmentation were NDVI, NDWI and RS and the functions used are presented in the Tabele 2. The scale, compactness and shape parameters applied were 100, 0.5 and 0.1 to level 1 and 40, 1, 0 to level 2.

Table 2: The remote sensing index and functios used in the object-oriented classification.

Level	Class	Remote Sensing Índex	Functions
Level 1	Interest	Mean PIR	 Boleana >
	Not interest	Not interest	-
Level 2	Cloud	Britness	 >
	Cloud Shadow	Mean PIR	 <
	Water	NDWI	 <
	Forest	Mean RED	 full class
	Savane	NDVI	 full class
	Altered areas	NDVI	 full class
	Bare exposed rocks	NDVI	 full class

2.3. *In-Situ* Data

Five field campaigns were made in different regions of the Module 4 of the FLOTA/AP during years 2010 and 2011 (Figure 2). GPS points and tracks associated with photographic records were used to validate the patterns of land cover and land use on the geographically referenced images. Interviews with local people using structured questionnaires were made to correlate the pattern of land cover identified in the image with the pattern of land use.

2.4. Geospatial vector data

Geospatial vector data were used to validate the patterns of land cover altered and to understand the types of land use associated with the alteration in the area. These data were provided by several institutions of the State of Amapá as geospatial vector data in shapefile format (Table 3).

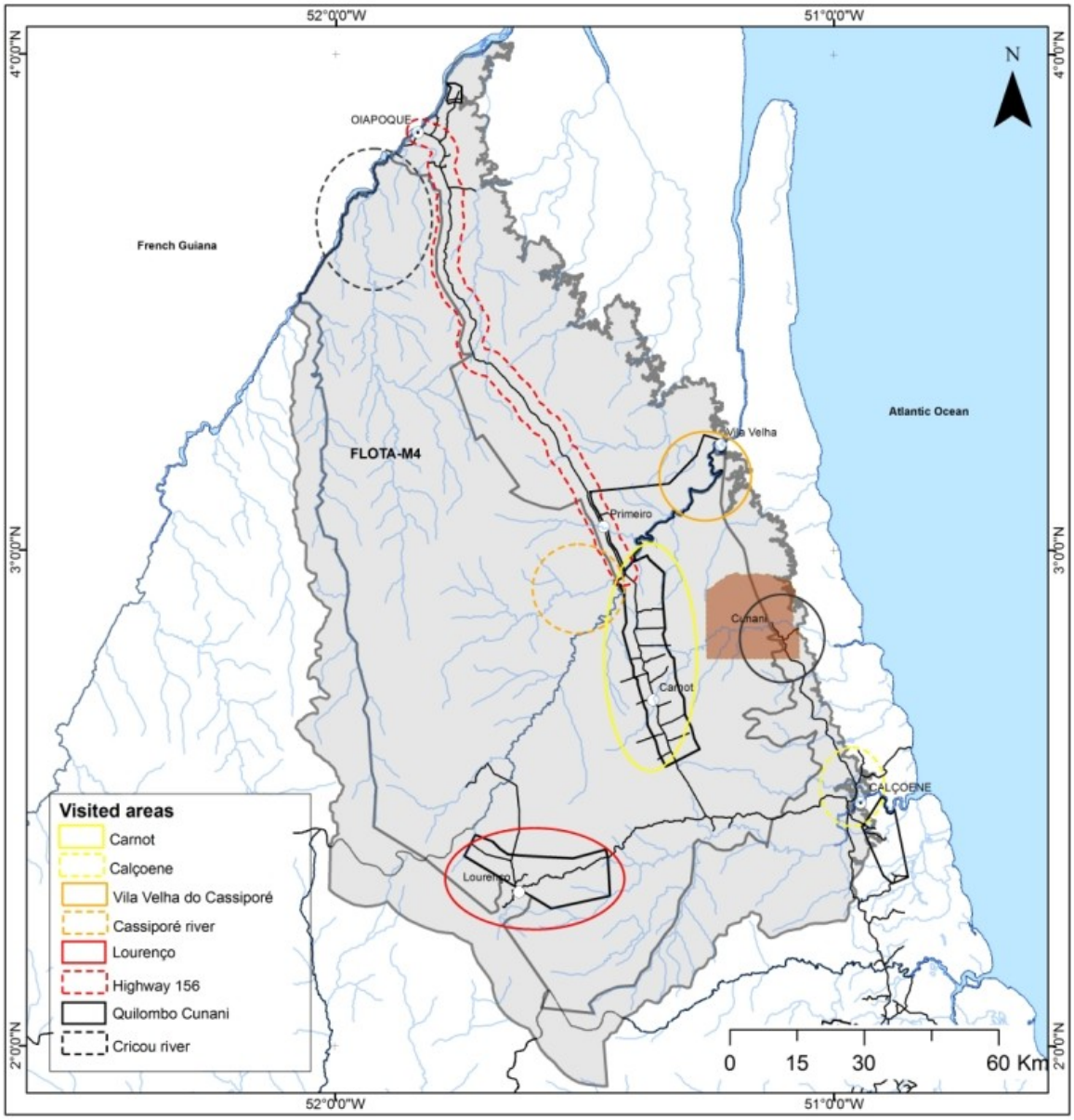

Figure 2: Location of the field works between the year 2010 e 2011.

Table 3: Geospatial vector data used for validate the pattern land cover.

Date	Type	Source
Agricultural settlements	Poligon	INCRA, 2010
Ranching	Poligon	MAPA, 2008
Gold Mining	Point	IEPA/COT, n.d.

2.5. Classification system used for land use/land cover

An identification key was prepared with the purpose of correlate patterns of land cover observed in the satellite images with the information of use and occupation of the areas altered. The identification key was elaborated from the information contained in questionnaires collected *in situ*, interviews with local people and from the maps of the region. For the nomenclature of altered classes was adopted the classification system for land use and land cover from Anderson et al. (1976) with modifications.

The land use pattern of the altered areas was classified according with its geometry and distribution in the satellite image.

2.6. Data integration - SIG

The Geographic Information System - GIS (ArcGIS v. 9.1) was used to correlate the cover classes changed with the data collected *in situ* and colateral spatial data. Each cover class changed was labeled according to the nomenclature established in the identification key producing the land cover/land use map. Quantification of each cover classes changed was performed in two regions: inside and outside the Flota Module IV.

3. Results and discussion

3.1 Land cover in project area

Six land cover classes were identified: forest (6111.2 km^2; 80.8%), cloud (669.9 km^2, 8.8%), cloud shadow (522.3 km^2, 6.9%), altered areas (236.4 km^2, 3.1%), water (23.2 km^2, 0.3%), and bare exposed rock (13.7 km^2, 0.1%) (Figure 3).

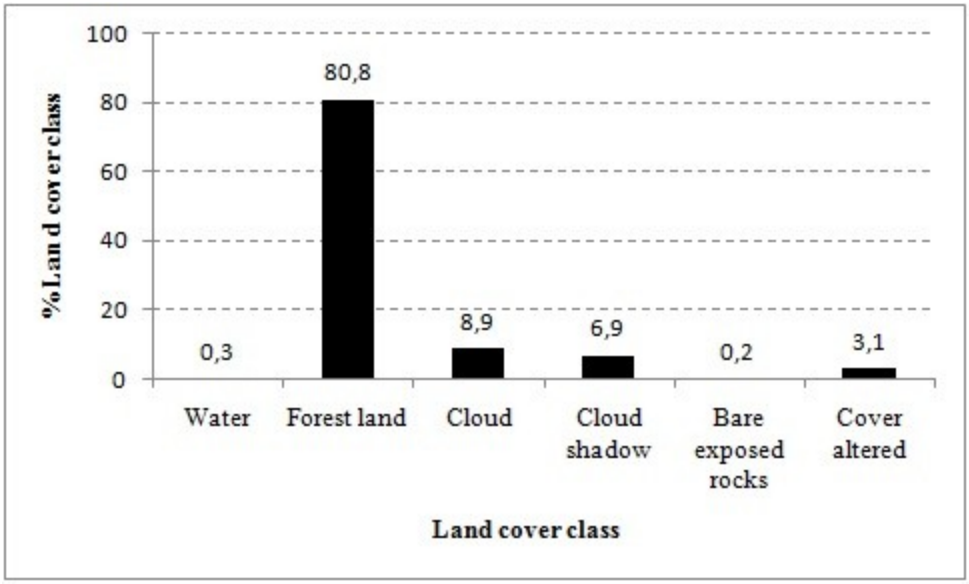

Figure 3: Land cover class identified by object-oriented classification in the project area.

Results show the predominance of forest cover in the project area (Figura 4) and the small representation of altered areas indicates low pressure on the forest cover. Bare exposed rock category includes areas of bedrock exposure. This category can be misunderstood with the altered areas, however, the application of NDVI remote sensing index allowed distinguish this land cover. The land cover of water is associated with the fluvial system and includes rivers, canals and other linear water bodies of the region.

3.2 Land use pattern

Three pattern of land use were recognized on the altered areas: fishbone pattern, irregular pattern and linear pattern. Table 3 shows the patterns of land cover and land use related to these areas. The Figure 4 shows the distribution of land cover and land use patterns on the project area.

Tabela 3: Land cover and land use pattern related to changed areas on the project area.

Main Land Use	Land Cover	Land use pattern	Spatial distribution
Ranching	Pasture	rectangular pattern	Around the roads (BR 156) and the agricultural settlement
Agriculture	Cropland	fishbone pattern and irregular	Around the roads (BR 156), agricultural settlements, indigenous and "quilombo" areas.
Mineral extraction for gold mining	Baren land: excavation	irregular	Around the roads (AP 260) and inside the forest
Urban	Built-up land: residential	reticular and irregular	Around of the border of roads (BR 156 and AP 260)
Transport/Communication	Built-up land: paved highways Baren land: unpaved roads, vicinal and trails .	linear	Along of the roads (BR 156 and AP 260)

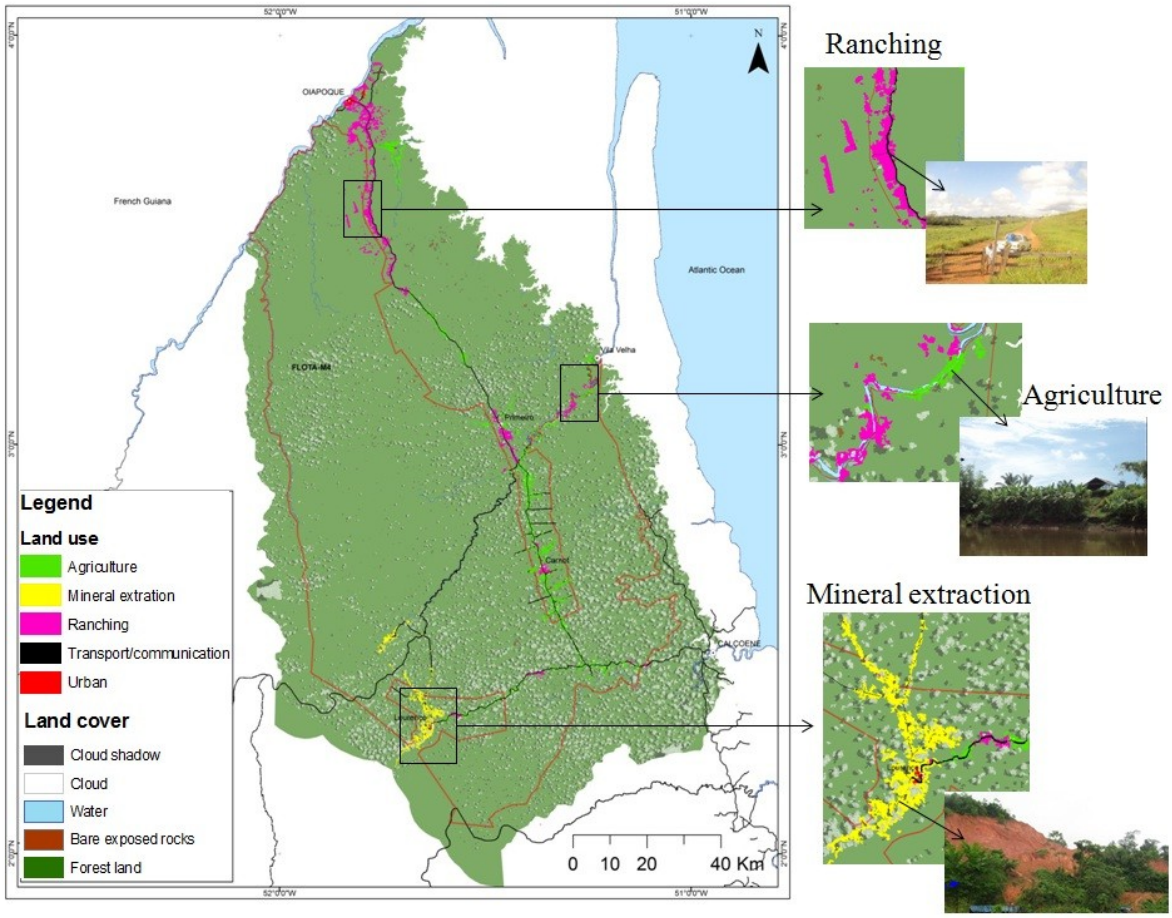

Figure 4: Distibution of land cover and land use on the project area.

Land use for ranching presents the rectangular and irregular pattern. This topology of land use was identified mainly around the highway (BR 156) in the nord region (Figure 4). The campaign in situ reveal the existence of cultivated areas in this region, however, this areas could not be classified on the images.

The cropland areas are related with the agricultural settlements (PA Carnot, PA Lourenço e PA Vila Velha). This land use are associated with small cropland. This land use were also observed around the roads. This land use presented irregular pattern inside the indigenous land and along of the fluvial channels (Figure 4).

3.3. Land cover land use and pressure under the Module 4 of the FLOTA/AP

Comparing results of the land cover and land use classification, inside and outside of the Module 4 of the FLOTA/AP, we can observed that the mineral extraction for gold mining is the land use with major pressure on the forest land cover inside the conservation unit. This pressure is located around the Lourenço District and in the sources of the Cassiporé and Araguary river (Figures 4 and 5).

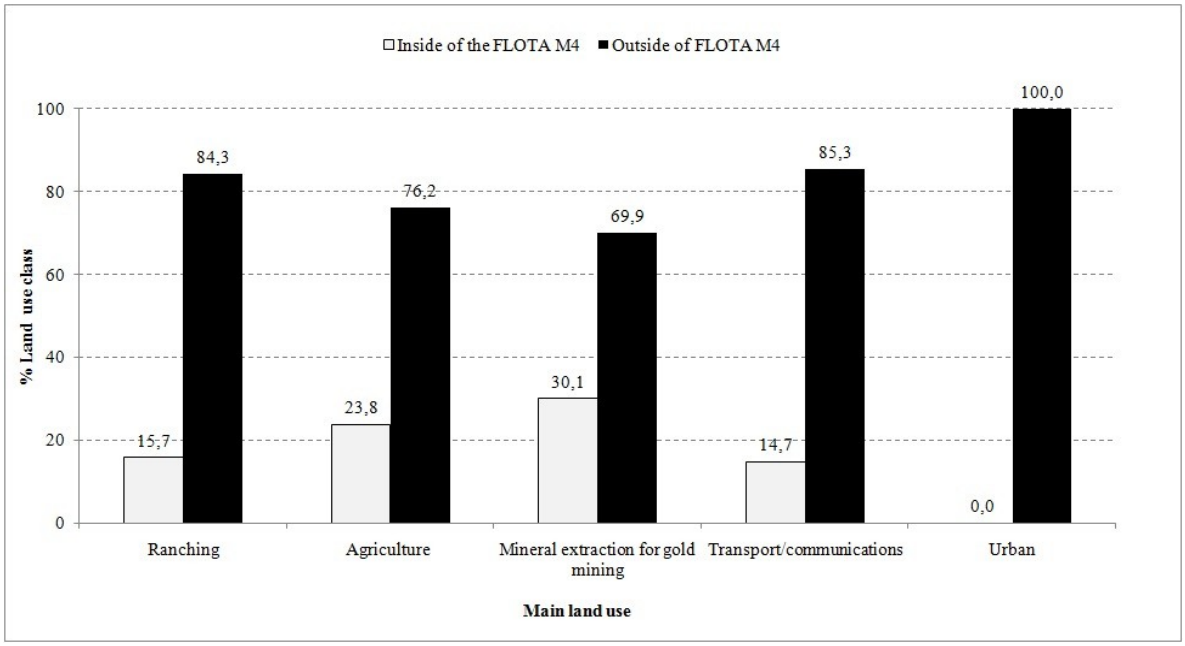

Figure 5: Land use inside and outside of the Module 4 of FLOTA/AP.

Agriculture with conversion of the forest cover in cropland, is the second vector of pressure of this type of land use inside Module 4 of the conservation unit.

Ranching and infrastructure for transport and communication (roads) contribute with less of twenty percent of the pressure of each activity inside of the Module 4 of the FLOTA. The urban land use is observed only outside of the conservation unit.

These pressures identified over the cover land reflect the land situation of the territory before the creation of the conservation unit of the FLOTA/AP.

4. Conclusions

The paper summarizes recent estimates on changes in forest land cover in the border of Amapa State and French Guyana. The analysis of altered areas distribution associated with land use indicated that these changes are concentrated along the Federal Highway and State Highway.

Despite of the forest area be the principal land cover, the results indicated that the roads and ranching are the principal factor for deforestation on the border of the conservation unit, how in others regions of the forest on the Amazonian,

The changes on the land cover can altered the land cover changing the goods and ecosystemic services, such as the forest biomass stock.

Cloud and cloud shadow continue to be an problem for the classification of land cover and land use, due the geographical localization under the influence of the Intertropical Convergence Zone. In this way, is necessary to apply others methods of classification to minimize the interference of the cloud in this region.

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