Change Detection on Land Use and Rainforest Cover at Paragominas Region, Brazilian Amazon

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Abstract. Paragominas region, at Eastern Pará, is one of the oldest colonisation centers of Amazonia. The objective of this work was the change detection of land use in colonisation settlements of that county, focusing forest cover, using LANDSAT satellite imagery (MSS-1981; TM-1988). The methodology adopted included the examination of NDVI (normalized difference vegetation index), supervisioned classification (minimum distance) and the change detection technique. Results evidenced rainforest regeneration at Uraim Colony, a settlement that showed successful socio-economic characteristics.

INTRODUCTION :

In Brazil, where there is the largest remaining area of tropical rainforest, in the last decade, it was observed a rapid conversion to agriculture and other purposes. National economic problems, the demands of native populations now tied to a cash economy, local demographic growth, and an expanding colonist frontier mean that a reliance on traditional indigenous techniques alone is no longer tenable for Amazonia (MUSE, 1989).

Solutions to increasing problems require that forest residents gain additional skills if they are to be effective managers in a new political and economic environment. Without such knowledge, colonists migrating to Amazonia will continue the practices that have already proven destructive and impoverishing (BROWN, 1990).

The general objective of this paper was to present new

data concerning land use of colonization settlements in Amazonia, thus offering subsides for further discussions about management practices adopted by the colonists.

The specific objective of the study was, with the application of remote sensing and geographic information systems (GIS), the detection of changes in patterns of land use of colonization settlements of Paragominas region, focusing the transformations occurred in vegetation cover.

The work was developed into a training program offered by The Woods Hole Research Center (MA/USA) in cooperation with Universidade Federal Fluminense (RJ/Brazil), which have a graduate program in environmental science, and financial support of Tinker Foundation Inc., which objective is contribute to to the on-going development process, the seeks for solutions, and the wide dissemination of results obtained.

There is an urgency to the provision of assistance to those who will produce the leadership necessary both to preserve the positive gains already achieved and to formulate the strategies which can lead the region along the path of sustainable growth and development (MUSE, 1989). With the application of the expertised acquired to a case history study in Amazonia, other result aimed was the capacitation of Brazilian human resources, within a group already involved with superior education on the tropics (BROWN & LACERDA, 1986; BROWN, 1989).

HISTORIC OF COLONISATION IN AMAZONIA :

The Amazon and its affluents represent the greatest river basin on Earth. In Brazilian Amazon, colonization initially had followed the major rivers, pattern that changed in the decade of the seventies, with the building of roads of national integration across the Amazon basin (MORAN, 1984). Colonists were installed in government projects, but spontaneous settlements were also important in areas that received intense fluxes of migrants, such as Rondônia, Acre, and Pará. These are all centers of intense deforestation (FEARNSIDE, 1982).

The deforestation process itself is exceedingly difficult to control for cultural, institutional and practical reasons. Trends in other parts of Brazil affecting migration to Amazonia include the government encouraged production of alcohol from sugarcane and, even more importantly, financing the continued replacement of labor-intensive coffee plantations with mechanised soya-bean and wheat cultivation (FEARNSIDE, 1982).

Since earlier, as in Paraná and Mato Grosso States in the fifties, and Pará State in the sixties, titling had been a means of buying political support or paying political favours. But the principal motive for titling was actually economic gain. Colonisation in Pará has traditionally failed to overcome the continuing isolation of the frontier regions. Apart from the early colonization of Bragantina zone (near to the State capital), and the Japanese colony at Tomé-Açú, no state sponsored colonisation had met with much success (FOWERACKER, 1981).

The social and demographic motives for colonization in

Amazonia were given the most attention during 1971-72. The TransAmazon Highway and its attendant colonization were hailed as solutions to underemployment and drought in Northeast Brazil, to inequities in access to land throughout Brazil, and to underpopulation of Amazonia (MORAN, 1984).

The numbers of small scale agriculturalists had been rapidly supplemented by spontaneous settlement, made possible by the construction of roads, as in Rondônia and Roraima (LOVEJOY,1985).

The final result was that by 1974, incoming President Geisel announced that the development of Amazonia by means of small-farmers had failed. Seven thousand, rather than a hundred thousand families had migrated. But the colonisation projects did not end in 1975, as many of these small-farmers are still on their plots (MORAN, 1984).

HISTORIC OF COLONISATION IN THE STUDY AREA :

The town of Paragominas, in Eastern Pará State, has 27.000 Km^2, situated at coordinates 2° 59′ S and 47° 31′ W, is one of the oldest colonization centers of Amazonia. The records of colonisation in that area are from the late fifties, when pioneer peasants begun to arrive ahead of the Belém-Brasília Highway (BR-010), followed by colonising companies, that shortly failed. Even before the arrival of those peasants, entrepreneurs from Goias penetrated the dense forest to survey and title land. In this way, Paragominas was founded with land from PARA, daring from GOias, and capital from MINAS Gerais (FOWERACKER, 1981).

In Paragominas, sharp practice and sharp shooting served to expand the large estates and squeeze the peasants into areas of minifundio. In such a climate of violence, attempts at colonisation had no chance of success. Once the shooting was over and the land divided, the pattern of land-holding could be made legal, and Paragominas became the administrative center for one of the largest Federal projects. The frontier, at that time, had almost completed its cycle (SCHMINK, 1982).

With links to both northern and southern markets by the Belém-Brasilia Highway, paved in 1969, the city grew rapidly, and by 1985, 24% of the municipality was converted from forest to pasture (NEPSTAD & UHL, 1991).

There can be no doubt that the surge of migration and economic activity stimulated by the highway contributed to widespread deforestation on the region. By the seventies, the devastation and apparent abandonment of land on either side of the road, gave the appearance of a "ghost landscape" to the area around Paragominas. Although the relative contribution of different activities to this deforestation is uncertain, the conversion of forest to pasture had undoubtedly been a leading cause (MAHAR, 1989).

In the early sixties, when the first asphalt puhed through the forest, the settlers of Paragominas town were ranchers. But today, in an unexpected twist, the source of prosperity of this Amazonian frontier town is not cattle, but timber. With about one hundred sawmills within city limits, logging supplanted ranching in the

eighties. It assumed a greater importance in the county's economy, making Paragominas recently, the main logging center of southwestern Amazon. The shift toward timber has been eased by the relative proximity of Paragominas to the furniture and construction industries of southern Brazil. But its status as a middle aged frontier town may offer insights into the future life cycle of newer Amazonian settlements (BROOKE, 1990).

METHODOLOGY :

*** Field Reconnaissance :**

The field reconnaissance of the region was realized prior to remote sensing approach, in order to select the colonisation settlements of Paragominas region, to which would be it applied.
There are presently twenty colonization settlements at Paragominas county. Several colonies that did not resist to the battles against cattle ranchers and gun-men have disappeared.

Two settlement colonies of Paragominas were selected, for having contrasting socio-economic characteristics : URAIM and REUNIDA.

The URAIM colony, begun in 1969, situated at 12 Km from the center of the county, was considered successful. The colonisation was realized by the state government - ITERPA, and the farmers have legal documents for ownership of the land. In 1980, an association of producers was created, counting with 200 families. The colonists grow mainly perennial crops, as pepper, cocoa, citrics, rubber. There is a strong constructed infra-structure, as community deposit, health center, school, church, bar.

The REUNIDA colony, begun in 1983, located at 18 Km from the center of the municipality, was considered unsuccessful. The colonisation was made by federal government - MIRAD, and farmers are "posseiros", as they do not have official documents for the ownership of the land. In this colony, severe conflicts occurred with the police and ranchers. There is not an association, and mainly annual crops are produced. The infra-structure is limited to a school and health center.

The current knowledge about Fazenda Vitoria, a ranch at Paragominas area, was used as the ground-truth for this approach. The area of this ranch is well known by the group of researchers, as it has been surveyed in last years, concerning the forest regeneration in degraded lands (NEPSTAD et al, 1990; 1991).

*** Remote Sensing Approach :**

Satellite imagery has been shown as an important tool for the evaluation of changes in land use / cover type in areas of Brazilian Amazon that show high colonisation rates, as presented in other works realized in these areas : (WOODWELL et al, 1986; BROWN & STONE (1989), at Rondônia; STONE & WOODWELL (1988), at Mato Grosso; STONE & SCHLESINGER (1990) and PIRES et al (1990) at Marabá region, STONE et al (1989) and MEDEIROS & AMARO (1990), at Paragominas region, both at Eastern Pará State.

The State of Pará is the second largest Brazilian State,

covering 1,246,833 Km^2. Originally, 88% was covered by upland tropical moist forest. By 1975, 8,654 square kilometers of the forest had been cleared, in 1978, the area cleared had increased to 12,445 square kilometers, and in 1988, to 88,741 square kilometers (INPE, 1988).

Two images of the Paragominas region, used in this work, were acquired from Brazilian Space Agency (INPE - Instituto de Pesquisas Espaciais): A Lardsat Multispectral Scanner (MSS), taken in August, 6, 1981 (ID M 2-33296, path/row 239/62) and a Landsat Thematic Mapper (TM), taken in September, 1, 1988, ID TM 5-23953 C001, path/row 222/62).

The image processing work was performed at the Remote Sensing Laboratory of The Woods Hole Research Center, Woods Hole, MA. The hardware system utilized is composed by IBM compatible personal computers (20 mHz 386), with hard disk drivers of 150 Mb and VGA monitors, a tape drive with 6250 bits per inch, and a line and a color printers.

The image processing software adopted was the ERDAS 7.4 (Earth Resources Data Analyses System), and the geographic information system software used was the IDRISI 3.0 (A Grid-Based Geographic Analysis System).

RESULTS AND DISCUSSION :

The The MSS-8 image was rectified (co-registered) in relation to the TM-88 image, because there were not available maps with appropriate scale and/or the necessary accuracity. After this step, subscenes were created, with the same number of pixels, comprising the areas of the colonies studied. Over these subscenes, the boundaries of the two colonies were plotted, and their areas isolated.

The first approach was to examine the distribution of Normalized Difference Vegetation Index (NDVI) data, determined by subtracting the red light reflectance from the near-infrared reflectance, and normalizing by deviding by their sum. This index is correlated to the amounts of photosyntetically active vegetation and green-leaf biomass (STONE et al, 1989).

Numerical values of NDVI results were sampled ramdomly in all subscenes. In forest areas, on both MSS and TM images, the values found were between 0.54 and 0.66. STONE et al (1989), studying Paragominas region, found a mean value of 0.57 for forests, and MOZETO et al (1990), approaching vegetation in Rondônia State, found values between 0.56 and 0.69 for different forest types. The ranges found for non-forest areas were all positive in MSS-81 (0.13 to 0.32), but appeared negative in TM-88 (-0.13 to 0.39). These negative values were interpreted as recently burned areas, considering that STONE & WOODWELL (1988) obtained negative values on fields at Mato Grosso State, where the ground had been blackened by fire.

Supervised classification was performed using as ground-truth the Fazenda Vitoria, based on the field knowledge of the area of the ranch. Signatures were created, for forest cover type, non-forest cover type, and the polygons that represented clouds and shadows.

The blocks that correspond to each colony were classified using the supervised minimum distance classification algorithm, that it is more effective when the number of training pixels for each spectral class is limited. Following, the area of each class was calculated.

For REUNIDA Colony, with a total area of 27.9 Km^2, and only beginned in 1983, MSS-81 subscene exhibitted all surface of intact rainforest. The TM-88 subscene showed that an area of 2.6 Km^2 was deforested. In this five-year period, 9.2 % of forest cover of the colony was supressed for loggin and agricuulture purposes.

For URAIM Colony, with a total area of 43.6 Km^2, MSS-81 subscene showed an area of 35.0 Km^2 as rain forest, in comparison to an area of 22.8 Km^2 in TM-88. In this seven-year period, 28 % of the forest cover of the colony was transformed in cattle raising and agriculture plots.

The change detection technique, as applied by WOODWELL et al (1986) to Rondônia forests. provides an estimate of temporal changes in land cover types. It was used to determine the amounts of clearing, forest regrowth, as well as the areas that remained unchanged. The 1981 classified image of each colony was subtracted from the 1988 image.

The resulting categories were separated into classes of different values. As the clouds represented a small percentage, it was assumed for this step tha that the area covered by them had no change in the period. The area of each of these classes was determined, and calculations of rates of deforestation and vegetation regrowth performed.

Change detection in REUNIDA Colony showed that only occurred the change from forest to non-forest cover types. Same situation was observed by WOODWELL et al (1986), at Rondônia, where in a five-year interval, no transformations from non-forest classes was determined, suggesting that all forests cleared were not permitted to restore. In fact, it was told during field interviews that lots of REUNIDA Colony were commonly sold and re-sold exclusivelu for logging purposes.

Change detection in URAIM Colony, as presented in Figure 1, showed that part of the area suffered no change, as the 22.4 Km^2 (class 1), that remained as forest cover, and the 7.0 Km^2 (class 3), that was kept as non-forest fields, in the seven-year period studied. Otherwise, transformations occurred from forest to non-forest 12.6 Km^2 (class 2), and an area of 1.6 Km^2 evidenced change from non-forest to forest vegetation.

CONCLUSIONS :

The image processing and geographic information system permitted the observation of the effects of land use over soil cover of Paragominas forests. Change detection evidenced the transformation from non-forest to forest cover type, a result not obtained by researchers that approached other areas of intense deforestation in Amazônia, as Rondônia (WOODWELL et al, 1986), and Mato Grosso (STONE & WOODWELL, 1988).

The colonization settlements contributed, besides ranching and logging, to the rainforest destruction on a

meaningful scale. The challenge ahead now is the integration of sustainable management practices into the production strategies of the existing rural properties, by turning people into better forest managers (BROWDER, 1990; SAWYER, 1990).

Other autors commented about similarities observed at URAIM Colony, as described in field reconnaissance, in well-succeded colonisation settlements : Prosperous communities surged on North Paraná, after agricultural and social services were provided (FOWERACKER, 1981); spontaneous settlers tend to have better education and greater success, than those who migrate under government subsidy (MORAN, 1984); perennial tree-based land management is sustainable on an environmental basis, as protects fragile Amazonian soils (FEARNSIDE, 1982).

Despite the fact that forest regeneration is nowadays observed in the older colonisation settlements at Bragantina zone, URAIM Colony, after more accurate studies approaching vegetation characteristics, can offer insights into the future of land use of other colonisation settlements of Amazonian territory.

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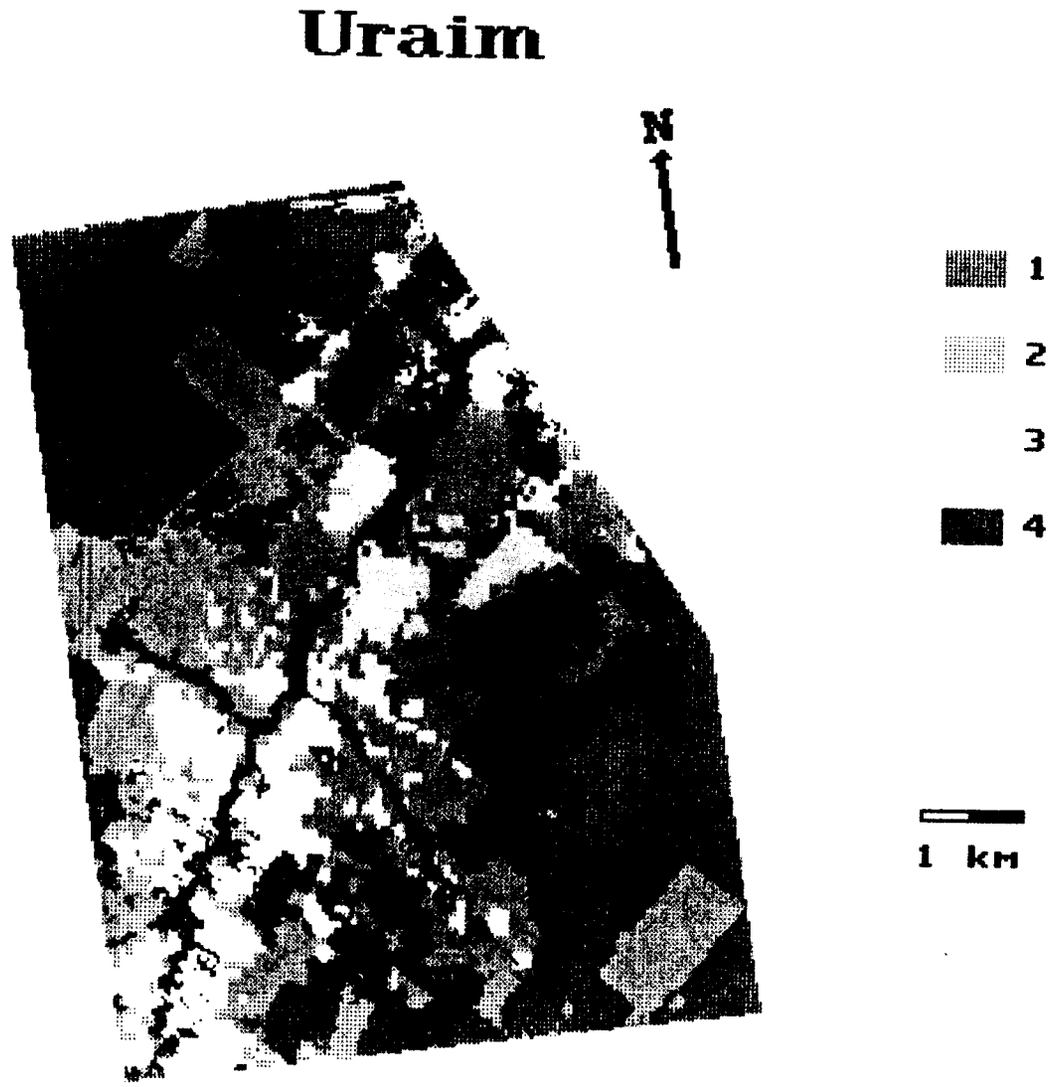

Figure 1 : Change Detection at URAIM Colony, Paragominas, Brazilian Amazon