

EVALUATION OF REMOTE SENSING AND GIS TECHNIQS IN THE MONITORING OF THE ATLANTIC RAIN FOREST IN BRAZIL

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Abstract

The Atlantic Rain Forest Foundation (a Non-Governmental Organization) and the Brazilian Space Research Institute (INPE) executed during the years 1991 to 1993 a project to map and evaluate the transformations that were happening in the Atlantic Rain Forest. The total area evaluated had the dimension of 1.400.000 Km², in 10 different states in Brazil (Bahia, Espirito Santo, Minas Gerais, Rio de Janeiro, Sao Paulo, Parana, Santa Catarina, Rio Grande do Sul, Mato Grosso do Sul and Goias), presented in 104 charts. The scale adopted was 1:250.000, and the study aimed to evaluate the changes in the distribution of the Atlantic Rain Forest between 1985 and 1990. This work was done using visual interpretation of LANDSAT TM paper images, in a color composition (5R 4G 3B), for the two periods studied (1985 and 1990). The themes considered were: forest, mangrove and restinga (name of the pioneer vegetation that grows in sandy areas, near the Atlantic Ocean in Brazil). In each of these themes there were considered: the maintenance of the vegetation cover during the period studied, the deforestation and the possibility of regeneration. Field work was conducted to check the fotointerpretation, to improve the accuracy of the data achieved and to register the transformations in the area. It was possible to verify a deforestation of more than 5% of the forested area and to the restinga vegetation in the area, but the alterations in the mangrove areas were not noticed because of the scale adopted.

The data were registered in a Geographical Information System (SGI, developed in INPE) to obtain quantitative data and as a first step in the sistematic monitoring of the region. The next data collection to this monitoring should be done with 1995 data and must consider the results obtained and the necessary improvements. This work intends to evaluate the efforts done during the project, the techniques adopted, the remote sensing and GIS solutions, in what refers to scale, pattern identification, geographical references and graphical definitions, to define a proposal of how it could be improved. It considers the other data bases that were realized in the area during this period, and tries to create a basic reference that makes it possible to analyse more detailed information about the Atlantic Rain Forest with the general data of its distribution and area (in a 1:250.000 scale)

1. Introduction

The development of an operational project using remote sensing and GIS techniques is a challenge. The need of recent spatial data for many areas of study and the potencial of those instruments in producing such data is a rare opportunity, but to work with those technical restraints and to understand their meaning in the results is another challenge.

The need to present and discuss operational remote sensing experience is presented in Rasch (1994) [4]. Many of the problems and solutions shown here are similar and confirm those presented by this author. This article shows the concern that some variables acquire in the need of a result. Those variables include: schedule, material and human resources, intense interaction with future users, the comprehension of their needs and opinions, for instance.

The bibliographical references and the experiences already obtained are essential in drawing up a project. To reevaluate what has been done, to use the experience acquired, may result in improvement for future work.

The study that is being discussed here is the second realized in cooperation by the Atlantic Rain Forest Foundation and the Brazilian National Research Space Institute upon the Atlantic Rain Forest in Brazil using remote sensing technics [1]. The first one, finished in 1990 used a 1:1.000.000 scale. The results obtained allowed advances in the discussion of how to preserve this forest, made it one of the most endangered on the planet. The evaluation of the results obtained and their potencial made it possible to make another survey in a 1:250.000 scale and considering the need of temporal evaluation, to the years 1985 - 1990, provides the real monitoring through Geographical Information Systems technics

There was an effort during the project to keep the schedule, because of the information needs in time to ECO 92. The aim was to obtain an evaluation of the situation of this ecosystem as a contribution to this event. But " ... a project always takes longer time to execute than is planned." (Rasch, 1994). The efforts were then decided in the favor of the presentation of partial data - in a state by state basis - to serve as a tool in the protection of the Atlantic Rain Forest.

2. Evaluation of the methodology adopted

The area of study chosen was the Atlantic Rain Forest Domain established as the original areas of the Atlantic Rain forest. This definition is based in the Brazilian Vegetation Map [3], in a scale of 1:5.000.000, resulting in limitations to more detailed information. In 1500, this "...was an extensive forest of over one million square kilometers. Today, this area comprises a little over 95 thousand square kilometers, but maintains an immense biological diversity..." [2]. This definition in the Atlantic Rain Forest Domain resulted in some limitations when applied to a 1:250.000 scale, mainly because those limits are not discret, but continuous in most cases. Therefore the limit of the Atlantic Rain Forest Domain was not as accurate as it should; this problem occurred in the States of Mato Grosso do Sul, Goiás and Rio Grande do Sul. The other problem detected was the presence of cloud cover and the small size of the remnants in the Northeast region. In many areas there were not images with less than 40% of cloud cover. This is why the area of study was defined from Salvador, in Bahia state to the south.

The possibility of using digital image processing was taken into consideration but the operational restrictions turned this option in a perspective to be adopted in for future studies.

2.1 Cartographic basis

The scale adopted was 1:250.000, because of the extension of the area, resulting in 104 maps. To give a more general view of the results, they were reduced and shown in ten mosaics, state by state, and this form was very important in the presentation of the results to non specialized people. The smallest area mapped for all themes under study was 25 hectares on the ground (4 sq. mm. on the images).

The synthesis with the all area would result in a not usable instrument because of the fragmentation of the remnants, resulting in an information that could not be reduced to a scale of 1:5.000.000.

2.2 LANDSAT TM Images

The color composition (3R 4G 5B) was chosen for two reasons: the main one was the availability of images already processed in this composition that made it easier to obtain those images in time, and

not to delay the schedule, the other was that technicians already had experience in working with that color composition.

This composition may not be the most precise in the distinction of different stages of deforestation and regeneration but enables the survey of the remnants. The use of other compositions, was suggested but it would also be necessary a most precise definition on the vegetation stages to be classified as rain forest. As there were many images that were already processed it was hard to make the best choice.

To the selection of the images, some criterion should be carefully considered in other works: to choose for rainy or dry season images according to the region; to get a standard date to approximate precision and analysis of the data in an annual basis; to limitate cloud cover areas; and to consider if it would be interesting to cover some areas with microwave band images to avoid cloud cover and as a test to other surveys.

The project used 80 scenes of TM images to each of the both periods (1985 - 1990) considered. In most of the areas the cloud cover was less than 4% in the images, but in Bahia it was around 13% of the analyzed area.

2.3 Legend

The legend adopted was not detailed because of the small size of the remnants that could not be classified in terms of different formations and regeneration stages with enough accuracy. The following subject matter Atlantic Rain Forest, Restinga and Mangroves were considered. Some problems verified in each characterization are described below.

The Atlantic Rain Forest is too reduced and is in a very inhabited region, as it is in a humid and warm region the regeneration of the forest is intense although the regenerated areas do not maintain keep the composition and biodiversity of the original forest. In orbital images, in a scale of 1:250,000 it is impossible to distinguish. It is hard to establish how to evaluate the changes in primary and regenerated vegetation areas. This problem gets worst when considering the regional diversity of the rain forest. To improve the classification of the various forms of the rain forest, it would be useful to include some previous information of the different forest formations that compound these grouped ecosystems and to make a better definition of their limits.

Restinga is the name given to the sandy coastal soil vegetation, including scrub, bush and woodland formations. In many regions those areas are very degraded and it is very hard to classify them either as original herbaceous vegetation or as degraded arbustiva vegetation. This problem is increased because of the scale, many times not enough to the dimension of the restinga vegetation remnants. The need to include information about restinga situation is enormous because of its location on the seaside, that makes it very endangered.

The scale is the main problem in the survey of the mangrove areas. Mangrove areas are very often too small to be present in this scale. This problem gets worst when dealing with mangrove deforestation.

2.4 Field work

The field work was limited to one week to each state. It should be *more dense and systematic*, but limitations of time and resources together with the extense distribution of the Atlantic Rain Forest remnants made this impossible.

To have the best field information, in most states the field work was done by regional environmental agencies that could complement the data with other sources of information and that already knew the studied areas.

In spite of this fact, one way of reducing mistakes was to consult local specialists as reviewers. This was a way to control the data obtained. This was also important in generating a wide group of technicians who knew what was being done, contributed with criticisms and suggestions and made it easier to work with the products generated, defining the comprehension of its potencial and restrains.

2.5 Aerial documentation

The first results obtained indicated a deforestation of 3.2 % of the Atlantic Rain Forest remnants, between 1985 - 1990, in Rio de Janeiro state. This deforestation rate was, afterwards, seen as the smallest verified. The need to understand the reasons to this deforestation, resulted in the decision of taking aerial surveys. The aerial surveys realized had two objectives: to obtain a photographic documentation of what was happening in the different areas and to try to understand the changes in those areas.

The aerial survey was useful also as a check up of the work that was already been done. The results would be much more profitfull if the aerial survey was predicted and planned when the project started.

2.6 GIS procedures

The use of GIS technics was used in this project as a first step in the idea of monitoring the Atlantic Rain Forest. It was the generation of a data basis including the main rivers, highways and railroads, administrative boundaries and urban areas. The need of detailed information was added to the need of other kinds of information, like the location of the Conservation Units, and the limits of the cities.

The GIS was really effective in the production of the quantitative information. The main problems verified in the use of the GIS were related to the enormous volume of data. The problems were noticed in the entrance of the data and in their edition and plotting. The need of more powerful equipment should be considered in the future.

2.7 Results

The data produced showed the high degree of deforestation in the Atlantic Rain Forest in the years between 1985 e 1990. The general rate of deforestation in this period was 5% of the remnants, a deforestation of more than 536 thousand hectares (more than 5360 square kilometres). This rate is surprisingly similar to the 1% a year verified in a project made in Philippine in 1987 and 1988 [4].

Drawing up a project in a very large region turns it difficult to predict the data that will be obtained. It is harder to choose the meaningful data. In some regions the deforestation rate seemed to be the biggest issue. This is the case of the State of Parana, where the deforestation rate was 8.76% in the period evaluated. In other cases the rate of forested areas is the question. This is the case of Minas Gerais, where the forested area that was in the order of 50% in 1500, is now about 1.5% of this state's area.

The comprehension of the data and of its meaning can be discussed later, and for a long time, but the first results expected should be decided early in the project. Those principles should be studied when generating the project. It should be kept in mind the relations between the process of producing the

information, the execution tasks and the analysis. The relation between numerical and graphical data should also be considered

3. Proposal to the 1995 survey

The data base, including images, cartographic maps and the maps produced in the project are available to users. The critics and contributions received are registered for future projects.

Bringing up to date some data is not necessarily easier than to generate them. The need to improve is a must. Some tasks could transform the data available about the Atlantic Rain Forest into a more substantial information for its adequate preservation.

To provide a better definition of the external limits of the Atlantic Rain Forest, before the beginning of the images interpretation, would result in a more consistent survey of those regions. And the same will happen with the inclusion of the information about the various forest formations in those areas. It is possible that the accuracy in the interpretation of the restinga vegetation would improve if only the forested areas would be taken into consideration, eliminating the herbaceous and gramineous restinga vegetation.

Perhaps because of scale problems, mangroves should be kept as a reference information, just to get a general evaluation of this ecosystem. Otherwise, they should be shown in a more detailed study, in a scale of 1:100.000 or 1:50.000.

The aim of a new project should search for the best equilibrium between time, costs and level of generalization. The processing of the images takes time, tightening the schedule, if not predicted. The adequacy of the aerial surveys and of the field work, considering the data already available would make the development of a more accurate result possible.

References

- [1] Fundação SOS Mata Atlântica - Dossier Atlantic Rain Forest . São Paulo, 1992.
- [2] Fundação SOS Mata Atlântica e Instituto Nacional de Pesquisas Espaciais - Relatório Mata Atlântica, São José dos Campos, 1993.
- [3] Instituto Brasileiro de Geografia e Estatística - IBGE (Brazilian Institute of Geography and Statistics) - Mapa de Vegetação do Brasil. Rio de Janeiro, 1989.
- [4] Rasch, H. Mapping of vegetation, land cover, and land use by satellite - Experience and conclusions for future project applications. *Photogrammetric Engineering and Remote Sensing*, 60 (3): 265 - 271, March, 1994.