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THE BRAZILIAN FOREST COVER MONITORING PROGRAMME

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THE BRAZILIAN FOREST COVER MONITORING PROGRAMME

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SUMMARY

This paper presents an overview of the Brazilian forest cover monitoring activities which are based on the visual and computer assisted interpretation of Landsat MSS data.

The activities are chiefly concerned with the periodic detection, analysis and control of all changes occurring in the Brazilian Amazon forest cover, as a result of human action.

In addition, the control of all planted forest areas (Eucalyptus spp and Pinus spp) as well as integrated (multidisciplinary) surveys of all Brazilian national parks are discussed.

1. INTRODUCTION

The Brazilian forest policy planning and development are responsibilities of the Brazilian Institute for Forestry Development - IBDF the Forest Service of Brazil, whose activities are related principally to the reforestation, conservation, protection and utilization of Brazilian renewable natural resources.

In face of the growing demand of wood in recent years, emphasis has been given to the reforestation of central and south Brazilian regions.

That reforestation programme was implemented with financial support from the national tax credit programme. In other words, the government allowed participants to draw upon tax credits for financing reforestation activities.

Today, 3.4 million hectares of forest have been planted chiefly with Eucalyptus spp and Pinus spp.

The problem is how to monitor and operationally control, in a real time basis, these forests and those to be established in the coming years.

The second very important problem for IBDF is concentrated in the Amazon region. In view of the high rate of colonization, the construction of new roads and hydroeletric plants and the implantation of many extensive livestock projects, the forest resources of this region are being heavily cutover in a number of specific areas.

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The third area of interest is the monitoring of Brazilian national parks, which are responsible for the conservation, preservation and protection of the national flora and fauna.

The area of these parks represents only 0.28% of the total national territory but, they are constantly exposed to external aggression on the form of illegal wood exploration, growth of urban zones and agricultural and industrial expansion, which could in near future, seriously affect the structure and nature of these parks.

The three problems are of utmost importance to the future of the Brazilian forest resources.

However, the periodic monitoring, assessment and control of natural and man-made forests of a country like Brazil is not an easy task.

The most effective, economic, and operational way of solving the problem was the use of multiespectral and multitemporal data of the landsat programme, associated in some cases, with color infrared (small scale) images to obtain the first (basic) stage of information.

By the end of 1977 a contract was signed between the Brazilian Institute for Forestry Development - IBDF and the National Institute for Space Research - INPE with the purpose of investigating the potential application of Landsat MSS data, under Brazilian conditions, to serve as the main tool for the monitoring of Brazilian forest cover.

The initial programme was therefore divided into three projects:

- Deforestation (Brazilian Amazon region);
- Reforestation (Central Brazil);
- National Parks.

2. DEFORESTATION PROJECT

The Federal Territory of Rondonia, situated between 8º00' and 12º00' of Latitude South and 61º30' of Longitude West, was selected as a test area in view of the growing colonization projects occurring in this area, which are constantly affecting the original forest cover of the region.

This region is covered by moist semi-deciduous forests, moist evergreen forests, periodic or seasonal swamp forests, savanna and steppe formations.

For the present area, Landsat MSS images at scales of 1:250.000 and 1:1000.000 (bands 5 and 7) were visually interpreted (see Santos, et alii, 1979).

A very intensive field programme as well as many low altitude flights were carried out.

The flights were conducted at an average height of 350 meters and about 13 hours of low flight were necessary.

Approximately 2000 km were covered by car for field work surveys over a period of ten days. About 220 sample points were visited.

The entire territory could be covered with 4 Landsat scenes and the area of study was occupied by 12,240,000 ha. From these, approximately 286,339 ha. had already been cutover (that is, 2,4% of the total area), as a result of colonization and urban expansion.

In view of the successful results obtained in the pilot study, the project was enlarged in 1979, to the whole Brazilian Amazon, that is, 58% of the Brazilian territory, corresponding to an area of 5 million square kilometers (see figure 1).

The global results of the first deforestation mapping are illustrated in table 1. These results come from 26 maps, produced in scale of 1:500,000 of the whole Amazon region.

From 1980 on, global observations of the entire region will be carried out but the survey is mainly concentrated in the critical (endangered) areas, with periodic mapping, estimation and control of these areas, as well as a utilization analysis of the forest that is being removed.

3. REFORESTATION PROJECT

The objective of this project is to map on an annual basis all reforestation, in order to concern, accompany and analyse the establishment of all planted forests in Brazil.

This will enable IBDF to have a rigid control of its investments in this field, (the majority of the forests are planted with government funds through the fiscal incentive programme).

For this project, not only visual but also computer assisted interpretations of Landsat data are used.

As in the case of the deforestation project, a pilot area was chosen in order to establish the real potential of Landsat data for meeting the specific goals of the project.

The pilot study was carried out in the State of São Paulo in an area of approximately 7764 km^2 corresponding to 12 counties situated between 21°00'-22°20' of South latitude and 47°00'-48°00' of West longitude (see figure 1).

Landsat scenes corresponding to three dates (August 18, 1975; February 7, 1977 and July 1, 1977) were used.

For the visual interpretation, black and white paper prints corresponding to bands 5 and 7 in scale of 1:250.000 were used.

For the automatic interpretation two programmes were developed: A pre-processing programme called "Theme uniformization" and a classification programme - MAXVER (maximum Likelihood).

Figure 1. Area of the deforestation project (Brazilian Amazon).

Table 1.　Deforestation of the Brazilian Amazon region

Federative Units	Area of Federative Units - ha.	Deforested areas ha. through 1975/1976/1978 A	B	Increment % (B/A-100)	Total ha.	%
Federal Territory of Amapá	13,906,800	15,250	1,800	11,80	17,050	0,122
State of Pará	122,753,000	865,400	1,379,125	159,36	2,244,525	1,828
Federal Territory of Roraima	24,300,400	5,500	8,875	161,36	14,375	0,059
State of Maranhão*	25,745,100	294,075	439,325	149,39	733,400	2,848
State of Goiás*	28,579,300	350,725	678,125	193,35	1,028,850	3,600
State of Acre	15,258,900	116,550	129,900	111,45	246,450	1,615
Federal Territory of Rondonia	23,010,400	121,650	296,800	243,98	418,450	1,818
State of Mato Grosso	88,100,100	1,012,425	1,823,075	180,07	2,825,500	3,218
State of Amazonas	155,898,700	77,950	100,625	129,08	178,575	0,114
Brazilian Amazon - Total	497,552,700	2,859,525	4,857,650	169,88	7,717,175**	1,551***

*　These states are not totally inside the area of the Brazilian Amazon.

**　From this area a gross volume of about 850,124,000,00m^3 was deforested (average volume = 110,16 m3/ha. and standard deviation = 35,32 m3/ha); from this volume, approximately 163,063,900,00m^3 was of class I (export wood), 321,806,190,00m^3 was of class II (national market).　The difference corresponds to class III wood (regional market) and non commercial wood (estimation based on sample plots inventoried by project Radambrasil).

***　Considering the tropical forest area only (280,000,000 ha.) the rate of depletion is 2,00%.

Average annual rate of deforestation = 22,78%

Area estimates were made by using the "Theme Areas" programme.

The presentation of results was obtained through the Dicomed implemented in the 1-100 system.

3.1 Visual Interpretation.

Table 2 shows the interpretation key used for identifying the forest covers in the study. It was based on the differences in their spectral pattens.

Table 2.   Interpretation key used for visual interpretation.

Class	Band 5	Band 7
Pinus spp.	Dark gray	Dark/medium
Eucalyptus spp.	Dark gray	light/medium

As can be observed from this table, the separation would have been difficult using only band 5. On the other hand, this band was very efficient in separating these two classes of forest cover from other existing targets.

With the help of band 7, the separation was very easily made.

The evaluation and overall mapping accuracy of the reforested areas is shown in table 3.

Table 3.   The overall mapping accuracy estimation for areas of Pinus and Eucalyptus spp.   — Visual interpretation.

Class	Ground Thuth-ha	Landsat ha.	Relative Difference %
Eucalyptus spp.	58,867,77	60,337,75	+ 2,5
Pinus spp.	3,849,04	3,645,00	+ 5,3

3.2 Computer assisted classification

The study area was separated in five moduli, each of which was intensively studied and mapped.

Table 4 illustrates the results obtained by the automated classification.

Table 4.   The overall mapping accuracy estimation for areas of Pinus and Eucalyptus spp.   Computer assisted classification.

Class	Ground Truth-ha	Landsat ha.	Relative Difference %
Eucalyptus spp.	58,867,77	66,847,83	8,85
Pinus spp.	3,849,04	3,555,49	0,47

3.3 Conclusions about the Visual interpretation

- It was possible to differentiate the genus Pinus from Eucalyptus spp. and band 7 was more efficient in that separation;
- The delimitation of reforested areas was more efficient on band 5;
- In areas smaller than 20ha. the characterization is almost impossible to be made;

3.4 Conclusions about the automatic interpretation.

- The separation of Eucalyptus spp. and Pinus spp. was possible;
- The scale of 1:250,000 showed to be satisfactory for this work;
- The genus Eucalyptus spp. presented spectral variations making a sub-division necessary;
- Bands 6 and 7 were the most efficient in defining the Eucalyptus spp. and Pinus spp. genus serving also to define two sub-classes of Eucalyptus spp.

In view of the successful results obtained in this phase, during 1979, the man-made plantations of the state of Mato Grosso do Sul (see figure 1) were mapped using the same procedure - see results in table 5 - and, in 1980, the project is being extented to all of Brazil.

4. NATIONAL PARKS PROJECT

The general objective of this project is to develop a methodology for controlling the natural resources of the twenty one Brazilian national parks by using remote sensing techniques.

Specific objectives are, among others, to carry out integrated surveys (soil, geology, geomorphology, vegetation, land use) of all parks as well as, periodic mapping of all endangered areas.

As in the case of the deforestation and reforestation projects, a test area was chosen for testing a proposed methodology. The pilot area was the Amazonian national park (Tapajós) situated in the state of Pará, north Brazil, between the coordinates of 3º50' of south latitude and 56º16'-57º32' of west longitude (see figure 1), corresponding to an area of 1 million hectares.

Table 5. Results of the Reforestation project in the state of Mato Grosso do Sul – stand July, 1978
Visual interpretation

Class	Area selected to reforestation		Area reforested with Eucalyptus spp.		Area reforested with Pinus spp.		Total		
	Ground Truth ha	Landsat ha	Ground Truth ha	Landsat ha	Ground Truth ha	Landsat ha	Ground Truth ha	Landsat ha	%
Study area	49,192,17	48,827,50	222,594,07	229,532,00	12,815,36	13,593,36	284,601,60	291,952,50	2,58

Automatic Interpretation*	Landsat ha	%
Eucalyptus spp.	83,567,30	4,94
Young Eucalyptus plantations	50,283,50	2,98
Plowed soil	122,662,70	7,25
Savanna	1,086,841,60	64,26
Unclassified	347,924,90	20,57
Total	1,691,280,00	100,00

* The gender Pinus was not introduced in the classification due to the small area of distribution (less than 1% of the total area)

Maps of geology, geomorphology and vegetation of the park, in scale of 1:250,000 were produced, by using Landsat visual interpretation as the base data. A very intensive field work as well as low altitude reconnaissance flights were also conducted.

In the period 1980/1981, similar mapping of all national parks will also be made, using computer assisted interpretation. In those parks for which maps already exist, an analysis of change will be carried out.

5. FINAL CONSIDERATIONS

The pilot studies confirmed the mapping potential of Landsat MSS data for the Brazilian Forest Cover Monitoring Programme.

Small scale color infrared airphotos will help considerably in monitoring endangered areas.

The programme is supporting Brazilian forest authorities with up-dated information on the nations natural and planted forests.

The information generated are necessary for planning medium and long term management programmes, for short-term forest policy decisions and, as cited by Nyyssonen (1978),..."under appropriate arrangements, the information compiled will also serve the purpose of a national forest inventory".

6. LITERATURE CITED

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