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A Tentative for Vegetation Classification Using Landsat-5 Thematic Mapper-Imagery Covering an Area around Manaus City-Amazon

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Introduction

A remote sensing is a technology that allows us to obtain any information based on materiality without physical contact; for example, the satellite's sensors have been supplied with the property of collecting some features as well as any object's spectral reflectance permitting the analyses and identifications.

Nowadays, the use of this technology has been getting increasingly prevalent in the diverse fields of study, and in the forest field, this remote sensing technology has been used to identify and to study the changes in forest-areas, besides evaluating the forest landcover as well as being used as a tool for preparing the inventory and for enhancing the management of the forest through forest-stratifications, which are intended to make the strata as homogeneous as possible with respect to the desired characteristics, improving the accuracy of the results of the forest inventory, as well as of making the management-unit more uniformed.

Satellite-image-data have advantages over other data-sources for large-area landcover classifications, in part because of their frequent repeat cycles, large-area sample, wide spectral range, and amenability to automated classification[3].

Being based on the remote sensing technology, the present study is a tentative for the practical utilization to be undertaken in order to classify the vegetation types by using one scene from the satellite Landsat-5 Thematic Mapper (TM), covering an area around Manaus City, AM, Brazil.

Materials and Methods

1. Study area

The study area is located in the Amazon State, situated around Manaus City between 60° W longitude and 3°S latitude (Fig. 1). The utilized scene (170 km by 185 km) covers in addition to large vegetation area the Manaus City.

This region presents an annual mean-temperature of 27℃, with an annual mean-rainfall of 2,500 mm. In general, the soils are extremely devoid of nutrients and quite acid (pH between 4.5 and 5.5). Nutritional reserve that is indispensable for preserving the forest is

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generally obtained from its fitomass[16].

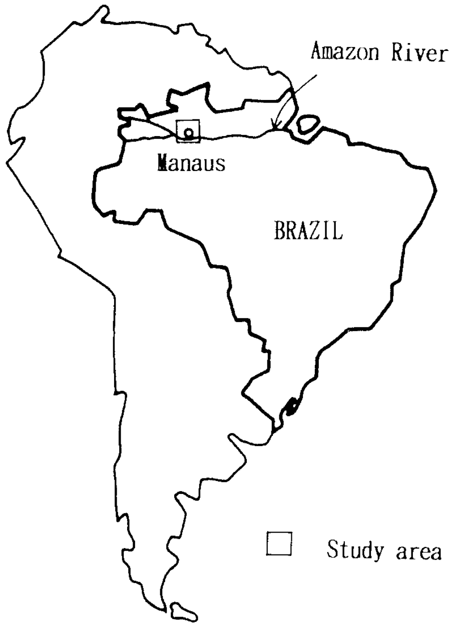


Fig. 1. Location of study area.

(1) General characteristics of the main vegetation type covered by the scene

The main vegetation type covered by the scene, according to Brazilian Institute of Geography and Statistic (IBGE) has been classified as a dense forest. This forest type occupies the largest area in the Amazon region, and has the greatest amount of biomass. Its occurrence is confined at a region where the environmental conditions are optimal and there exist no limiting factors such as a scarcity or an excess of water[16]. In the superior stratum the dense forest presents trees whose heights vary from 30 to 40 m. Few species such as cedrorana (*Cedrelinga catenaeformis*), angelim-pedra (*Dinizia excelsa*), and castanha-do-para (*Bertholletia excelsa*) can exceed this limitation, growing up to 50 m of height. The mean-commercial volume, considering the diameter at breast height (dbh) starting from 20 cm, is between 150 and 400 m^3/ha with basal area between 20 and 40 m^2/ha.

2. Image-data description and classification-techniques

A Landsat-5 Thematic Mapper (TM) image, collected on the 12th, July: 1987, covering an area of 170 km by 185 km (one unit of scene) was used for classification. The image had few areas covered with clouds. The analyses were performed on a personal computer (NEC/PC 9801RA 32-bit). The software developed by the Remote Sensing Technical Center (RESTEC) and the Lodia software (ver. 6) were utilized. Using RESTEC software, a full image enhancement was performed throughout several band-combination-attempts. Bell[2] has noted that combining of the data from several bands, each in a separate (arbitrary) color, generates a multi color image filled with all kinds of useful information, depending on which bands are utilized. Skillful choice of an assortment of colors revealing each object's unique spectral signatures-that is, its patterns of absorbing, transmitting, or reflecting radiations from several bands-can be used for classifying the type and health of vegetation.

After visualizing the diverse categories with which the scene is constituted, the spectral reflectances of these categories were measured through the single pixel training function (RESTEC software), for all the six non-thermal TM bands. The spectral reflectance of the same color category was measured from 12 to 30 times, depending on the category sizes; some discrepant spectral reflectance-values being excluded. Bolstad and Lillesand[3] reported that accuracy-assessment based on pixels from the sub-scenes used in spectral training may be biased even if the accuracy assessment pixels are not part of training sample.

By using the average values of the training spectral reflectance (both low and high) obtained for each category and Lodia software, several band-combinations were performed by the multi-spectral classification method, in which the decision criterion was dependent on the grey level distributions in various bands. The classified image supplied with the best band combination was sent to National Institute of Amazonian Research (INPA), Brazil, for the identification of vegetation categories.

Results and Discussion

In the Table 1 are presented the band combinations that have shown the best image-enhancements.

Table 1. The best band combinations and respective spectral reflectances for the full image enhancements

Image	Band	Spectral reflectance
	4	40, 70
a	5	25, 50
	7	5, 15
	3	80, 90
b	4	50, 80
	2	60, 100

The full image (Fig. 2a and 2b) enhancements were obtained by means of RESTEC software allowing the combination of three bands simultaneously. In the Fig. 2 is shown the

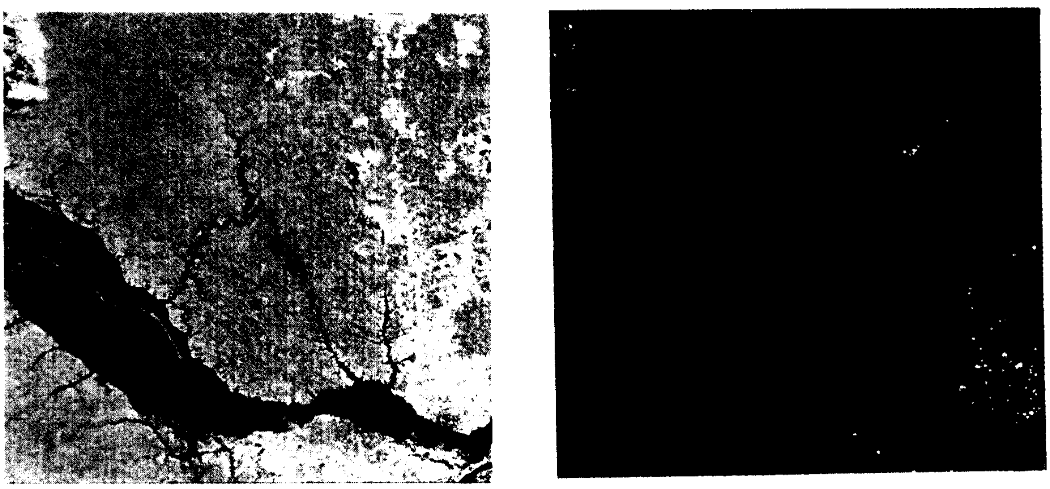


Image - a Image - b

Fig. 2. The final enhanced image.

final enhanced image.

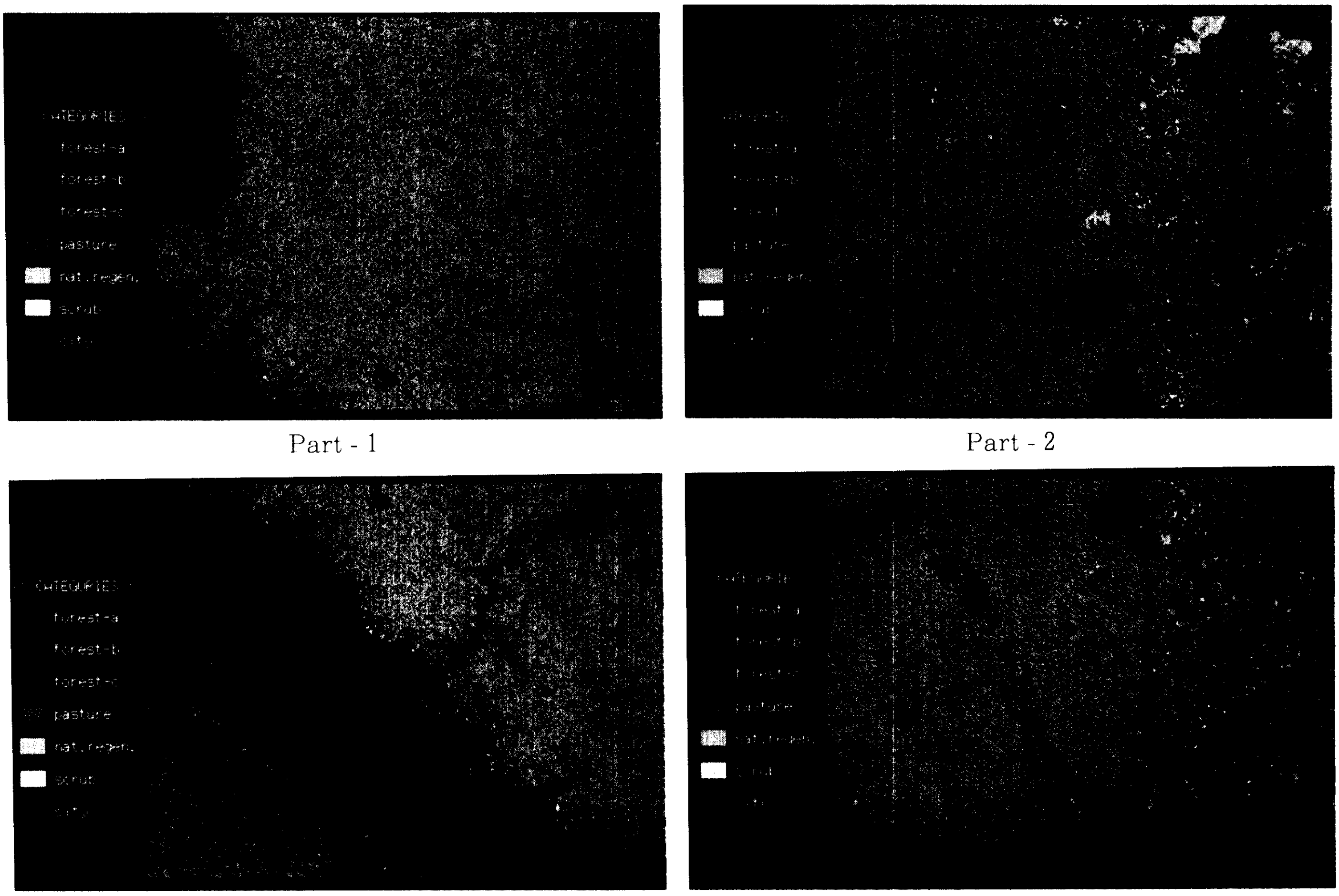
The category names and bands with corresponding spectral reflectances are presented in Table 2.

Table 2. Category names and bands with corresponding spectral reflectance

Category name	Band	S. reflectance	Category name	Band	S. reflectance
(forest a)	1	48, 53	(nat. regen.-e)	1	48, 53
	2	16, 19		2	18, 20
	3	11, 15		3	12, 15
	4	50, 58		4	79, 106
	5	35, 41		5	45, 59
	7	7, 10		7	9, 13
(forest-b)	1	48, 53	(scrub-f)	1	54, 60
	2	16, 19		2	22, 26
	3	11, 14		3	18, 23
	4	53, 64		4	71, 86
	5	35, 43		5	64, 79
	7	7, 11		7	17, 25
(forest c)	1	48, 52	(Manaus City)	1	72, 90
	2	17, 19		2	30, 45
	3	11, 14		3	32, 53
	4	50, 56		4	40, 60
	5	32, 37		5	69, 99
	7	6, 9		7	33, 51
(pasture-d)	1	56, 66			
	2	22, 28			
	3	21, 31			
	4	48, 62			
	5	68, 91			
	7	22, 34			

After several band-combinations had been performed, the best vegetation classification through multi-spectral-classification-method was obtained for combining the bands 1 (visible band), 4 (near infrared band), 5 and 7 (mid infrared band). Moore and Bauer[13] after the trials for classifying forest vegetations in North-Central Minnesota-USA, and Jaya; and Kobayashi[9] after the same trials made in Niigata-Japan, obtained the best spectral band combination for one band respectively from the visible, near infrared, and middle infrared bands. They also reported that many studies as certained the fact that no increasing of classification accuracies was brought about by the inclusion of four or five additional bands. Moreover, the same authors noted that the band 5 was extremely important for separating the vegetation cover types. Bolstad and Lillesand[3] reported that under northern Wisconsin forest conditions, the employment of three spectral bands, respectively from the visible, near-infrared, and mid-infrared bands captured nearly all the informations contained in TM data, and provided the best balance between the processing efficiency and the classification accuracy. Coleman et al.[6] reported that the differentiation among the selected pine age groups was feasible, using the band combinations of TM bands 5, 4 and 3. Horler and Ahern, cited by Drieman[7], reported that the combination of TM reflective bands 3, 4 and 5 was ascertained to be the optimum color composite display for the forest-cover-type discrimination. According to Bell[2], the bands in the visible and the near and mid-infrared detect the sun's radiation reflected off the earth.

The final classified image of the study-area is shown in the Fig. 3.



Part - 1 Part - 2

Part - 3 Part - 4

Fig. 3. The final classified image.

The division of the image into four parts was necessary because it was impossible for the utilized resources to classify the whole image at one time.

The image was classified into 6 main vegetation categories, which were identified as: lowland forest (c), pasture (d), natural regeneration (e), and scrub (f), by the INPA, in Brazil. Moore and Bauer[13] concluded that the increases in classification accuracy were more closely related to the higher spectral resolution of the TM than to its greater spatial resolution. However, the spatial resolution of TM images has been fixed to be of excellent quality, and may be of great use for image interpretation.

Between forest-a and forest-b the discrimination was not very clear, hence, it being proved to be necessary to make a better field checking, because, according to classified image, on the left Solimoes River margin the vegetation seemed to be different from that on the right margin (Fig. 3, Part 3). Jaya and Kobayashi[9] cited that, as noted by Leprier et al., differences in slope-angle and orientation caused the variable illumination angle and the reflection geometry. Justice et al., cited by Cherrill et al.[5] reported that the spectral reflectance of vegetation varied with aspect and gradient, and hence topographic effects were greatest in the rugged upland areas, and these might have been the causes of the classifications in different categories.

The Fig. 4 shows the discrimination of the four bands.

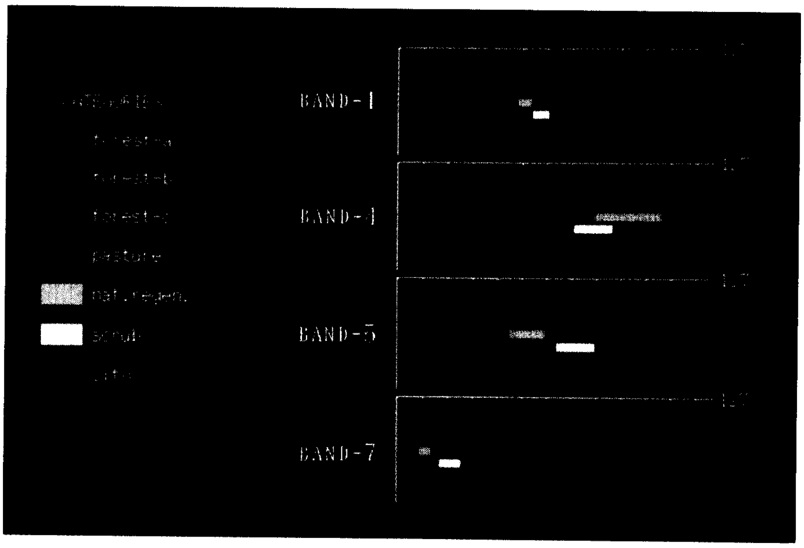


Fig. 4. Discrimination of the four bands.

Conclusion

For the Amazon vegetation classification, the combination of the bands 1, 4, 5 and 7 seemed to be useful for identifying vegetation-types for a better inventory and management of these resources.

In Brazil in comparison with many other developed countries, the use of the remote sensing technology is still in developing stage, and as possible as this technology should be used for evaluating, monitoring, and classifying the natural resources, and with the aid of geographic information system (GIS) technologies the works might be made easy and improved, mainly in large-area landcover classifications.

Summary

The purpose of this study was to set up a tentative for practical utilization of the remote sensing technology for classifying the vegetation types. By using a scene from Landsat-5 TM, covering an area around Manaus City, AM, Brazil, the vegetation classification was performed. The best full-image enhancement, with the use of RESTEC software, was obtained for bands 4, 5, 7 and for bands 3, 4, 2 combinations. For classifying the vegetation-types into 6 categories through multi-spectral classification method (Lodia software ver. 6), the best

band combination was obtained in: band 1 (visible band), 4 (near-infrared band), 5 and 7 (middle-infrared bands) under the various study area conditions.

In the large-area landcover classification like the one to be performed in such a region as Amazon, the remote sensing technology was considered to be an useful tool for classifying the vegetation types.

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