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MULTISENSOR REMOTE SENSING DATA AND GIS TECHNIQUES FOR MONITORING PRESERVATION AREAS: A CASE STUDY

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ABSTRACT

The objective of this paper is to present the capability of remote sensing and GIS techniques for detecting and monitoring the anthropic alterations (mainly, fire action) which sometimes occur in preservation areas. For example, in the Brazil Central region occupied by savanna ("cerrado"), the vegetation burning procedure is commonly employed in the process of implantation and management of cattle raising and agricultural activities. During this annual burning process, fires even reach the environmental protection areas such as National Parks. For this study, the Emas National Park, located in the South-western of Goiás State, Brazil, between 52°40'W to 53°10'W and 17°50'S to 18°25'S, was selected as the study area. This National Park had its area frequently burned in the dry season, as well as in August, 1988. In this investigation, the TM/Landsat data from July 29, 1988 (before the fire) and August 14, 1988 (after the fire) and AVHRR/NOAA data obtained in this period covered by TM images were used for monitoring the biomass burning. The TM images were registered to a topographic map in order to build a database including information such as drainage, roads, elevation and vegetation type for this National Park. Pixels classified as burned areas using band 3 (3.55 um to 3.93 um) of AVHRR images were overlayed on the map derived from the database. The SITIM (Image Processing System) and SGI (Geographic Information System) developed by INPE were utilized in this research. The integration of elevation, TM multitemporal data and information extracted from AVHRR images is a valuable tool for the managers to detect and evaluate the damage occurred as well as to monitor the regeneration process of land cover.

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1.0 INTRODUCTION

The land surface on the world has been suffering all kinds of alterations caused by human activities. For example, in the North region of Brazil, namely Brazilian Amazon, the deforestation and burning process has provoked alterations on this ecosystem. Other Brazilian region that has been affected by the human activities is the Central-West region occupied by savanna ("cerrado") vegetation. In that region, considered for last two decades important for the cattle raising and agricultural productive process of the country, has suffered extense conversion of its natural vegetation cover due to the human activities. The vegetation burning procedure, commonly employed in the process of implantation and management of cattle raising and agricultural activities, according to Delany et al. (1985), reaches about 20% of this region during the dry season. In this process, the fire has even reached conservation units located in this savanna region, as can be cited the burning occurred in the Brasília (DF) and Emas (GO) National Parks.

The launching of the first satellite for natural resources assessment (Landsat) has encouraged several investigators for utilizing this kind of data for land use and vegetation survey. Since then other orbital platforms have been launched with improving spatial, spectral and temporal characteristics of the sensors carried onboard that make remote sensing technology a valuable tool for studying the Earth resources. The Thematic Mapper (TM) sensor onboard the Landsat-5 with fine spatial resolution (30 meters), and acquiring information in several intervals of the electromagnetic spectrum has been used commonly for natural resources assessment as well as for evaluating the anthropic alterations such as deforestation in the Brazilian Amazon (Tardin and Cunha, 1990) and biomass burning (Ponzoni et al., 1986; Shimabukuro et al., 1989). On the other hand, the Advanced Very High Resolution Radiometer (AVHRR) sensor carried onboard the NOAA satellite series with very high temporal resolution (daily) and coarse spatial resolution has been used for global studies such as deforestation on the Amazon region (Malingreau and Tucker, 1987; Cross, 1990). In addition, AVHRR has three bands located in the thermal region, which permit to acquire information about the land surface temperature. Especially band 3 (3.55 μm - 3.93 μm) has been used to detect fires on the Brazilian Amazon region (Matson and Holben, 1987; Pereira, 1987; Setzer et al., 1988; Pereira et al., 1990). Nowadays, several authors have been trying to explore the better spatial characteristics of the Landsat images and the better temporal characteristics of the NOAA data for monitoring land surface such as deforestation studies (Stone and Schlesinger, 1990) and evaluating damage caused by fire (Shimabukuro et al., 1989; Pereira et al., 1990). Recently, with the advent of Geographic Information Systems, which allows to merge remote sensing data with ancillary information such as elevation, drainage, roads, etc., changes occurred on the land surface could be detected and monitored. The objective of this work is to present the capability of remote sensing data and GIS techniques for detecting and monitoring the anthropic alterations (mainly, fire action) which sometimes occur in the preservation areas. The Emas National Park was selected and Thematic Mapper (TM), Advanced Very High Resolution Radiometer (AVHRR), and available ancillary data were used for this study area. The AVHRR data were used to monitor the fire action while the TM images were used to evaluate the damage caused by fires on the vegetation physiognomic units in this National Park. In addition, this information has been included in the database constructed from the ancillary information such as elevation, drainage, roads, etc.

2.0 METHODOLOGY

2.1 STUDY AREA

The Emas National Park is located in the Southwestern of Goiás State, Brazil central region, between 52^{o} 40' W to 53^{o} 10' W and 17^{o} 50' S to 18^{o} 25' S, comprising about 131,000 hectares with savanna vegetation (Figure 1). Detailed information about this National Park can be found in IBDF/FBCN (1978) which contains its management plan and in Pinto (1986) which presents a study of this preservation area utilizing remote sensing data.

2.2 ORBITAL AND ANCILLARY DATA

For this study, the TM (Thematic Mapper)/Landsat-5 data, path 220/row 73, corresponding to the overpasses of July 29, 1988 and August 14, 1988 and the AVHRR (Advanced Very High Resolution Radiometer)/NOAA-9 data acquired on July 29 and 30 and on August 01, 02, and 03, 1988 were utilized to detect and evaluate the damage caused by fire in the Emas National Park. TM3 (0.63 µm - 0.69 µm), TM4 (0.76 µm - 0.90 µm) and TM5 (1.55 µm - 1.75 µm) images with 30 meters spatial resolution and the AVHRR bands 1 (0.58 µm - 0.68 µm), 2 (0.725 µm - 1.1 µm) and 3 (3.55 µm - 3.93 µm) with high temporal resolution (daily) were used. In addition, topographic map in 1:100,000 scale was used as ancillary data.

2.3 METHODOLOGICAL APPROACH

This work utilizes remote sensing data with different spatial, spectral and temporal characteristics (TM and AVHRR) and ancillary (elevation, drainage, roads, etc.) information for monitoring the preservation areas. The AVHRR data due to its high temporal resolution (daily) and TM images with better spatial resolution (30 meters) were considered to detect and evaluate the burned vegetation in the Emas National Park.

First, several AVHRR band 3 images from July 29 to August 03, 1988 were analyzed (Pereira et al., 1990). The analysis of these information allowed to select two TM images in order to have one image before and other one after the fire occurred in this National Park in the 1988 dry season. The fire points identified on these images show the evolution of the fire action. The methodology to detect fire points can be seen elsewhere (Matson and Holben, 1987; Pereira, 1987).

Following, it was analyzed two TM images. The Maximum Likelihood algorithm has been used to classify the vegetation cover types on the TM image acquired before the fire and to estimate the burned areas on the TM image acquired after the fire.

Additionally, it was built a database for the Emas National Park. The TM images (original bands and the classification results) were registered to the topographic map in a 1:100,000 scale.

The results provided by this study are: classification of vegetation cover types, identification and area extent estimation of burned areas. Since the information from different sources (remote sensing and topographic map) are registered in the Universal Transverse Mercator (UTM) reference system, they can be manipulated for generating the required information such as synthetic images derived from Digital Elevation Model (DEM) and TM images.

The remote sensing data were processed utilizing the Image Processing System (SITIM) (Velasco and Lima, 1982) and the construction of the database including the remote sensing and ancillary information was done by utilizing the Geographic Information System (SGI) (Engespaço, 1989).

3.0 RESULTS AND DISCUSSION

Figures 2 and 3 show the Emas National Park before (TM4 band of July 29, 1988) and after (TM5 band of August 14, 1988) the fire, respectively. The analysis of TM images acquired on July 29, 1988 allowed to identify four vegetation cover classes, i.e., savanna grassland, wooded savanna, savanna woodland, and flooded areas. The classification obtained is available in a color photography but is not presented here. Table 1 presents the area extent occupied by each one of the vegetation cover classes classified in the study area.

Figure 4 shows the fire points identified on the AVHRR band 3 images acquired on July 29, 30 and August 01, 02, 03, 1988 (Pereira et al., 1990). Analyzing this information in a temporal sequence, it can be seen that the fire points were outside the Park for July 29 and 30 (Figure 5). Analyzing the fire points identified on the images for August 01, 02, and 03, it can be seen that the vegetation was burned in this period of time. Also, it can be seen that the fire inside the Park started on July 31, however, unfortunately the AVHRR image for this date was not available.

Now, analyzing the TM image acquired on August 14, 1988, the damage caused by the fire action detected on the AVHRR images can be estimated. Figure 6 shows the burned areas and Table 2 presents the total area of burned vegetation (73,884 ha), as well as the area extent of vegetation burned on each one of the vegetation cover classes.

This information was included in a database constructed for the Emas National Park which contains information about elevation, drainage, roads, and National Park border. Figures 7 and 8 show the synthetic images of the Emas National Park utilizing the DEM and TM band 5 from July 29 (before the fire) and August 14 (after the fire), respectively.

The integration of elevation, TM multitemporal data and overlaying the information extracted from AVHRR images is a valuable tool for the managers to detect and evaluate the damage occurred as well as to monitor the regeneration process of land cover.

4.0 CONCLUSIONS

The TM images are very useful to classify and evaluate the area extent of the vegetation cover classes and the burned vegetation. On the other hand, the AVHRR images, especially band 3 (thermal infrared), are very useful for detecting fire points occurred on the land surface. Without these kind of data monitoring fire action becomes very difficult to perform. For this kind of study it is necessary to use data collected by sensor systems with different spatial, spectral, and temporal characteristics.

A Geographic Information System (GIS) permits the cartographic integration of physical characteristics of the land surface (elevation, for instance), drainage, and the land cover classes derived from remote sensing data. Utilizing the daily information provided by AVHRR sensor into this database, a system to control and prevent the fire action can be developed taking into account the biomass and phenological condition of the vegetation affected.

5.0 ACKNOWLEDGEMENT

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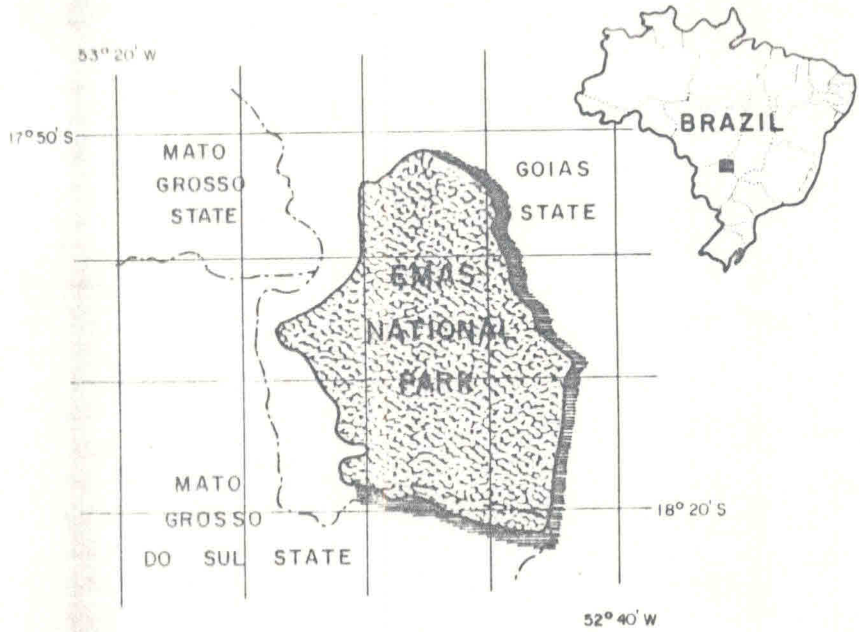

Figure 1. Localization of the Emas National Park.

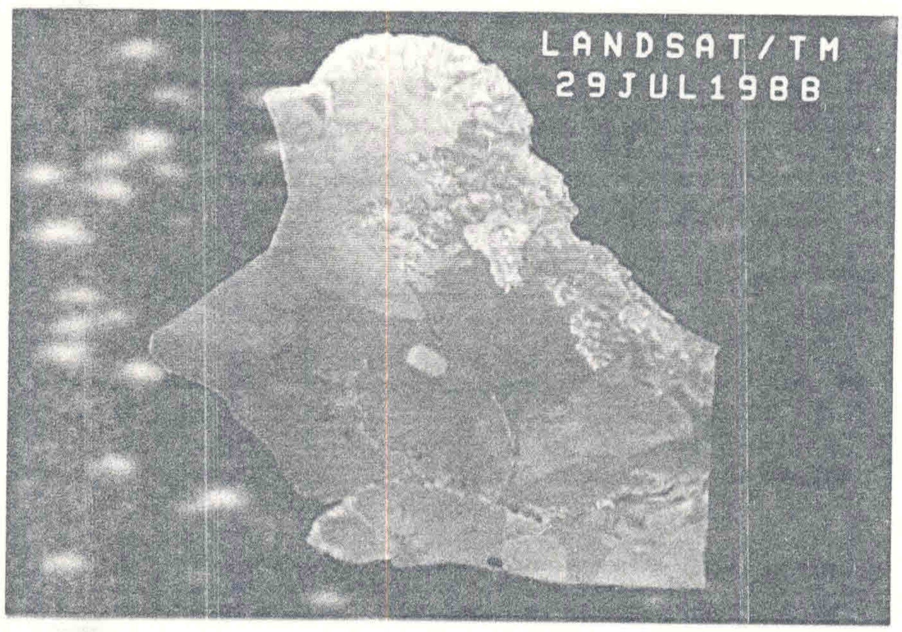

Figure 2. Emas National Park shown on July 29, 1988 (TM4 before the fire).

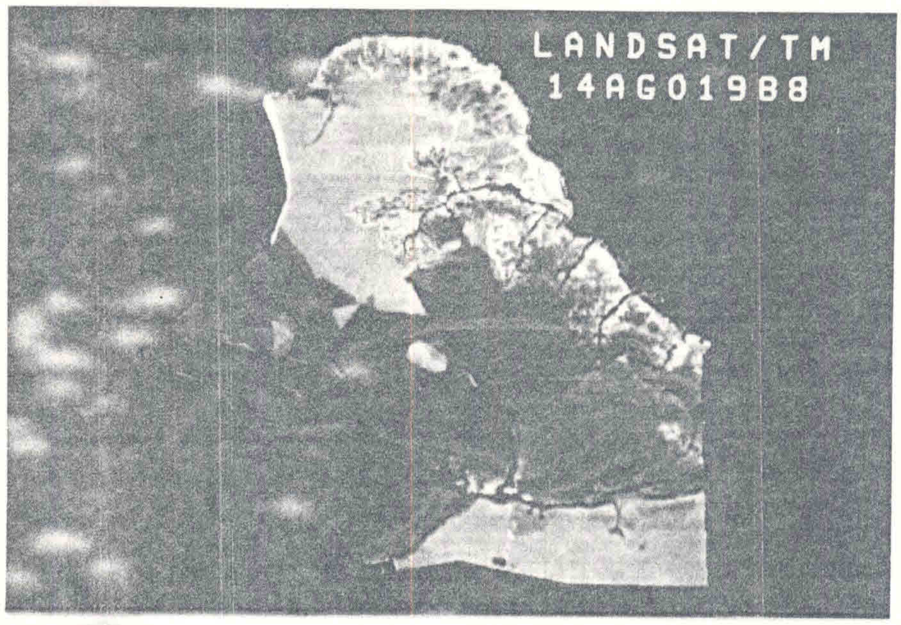

Figure 3. Emas National Park shown on August 14, 1988 (TM5 after the fire).

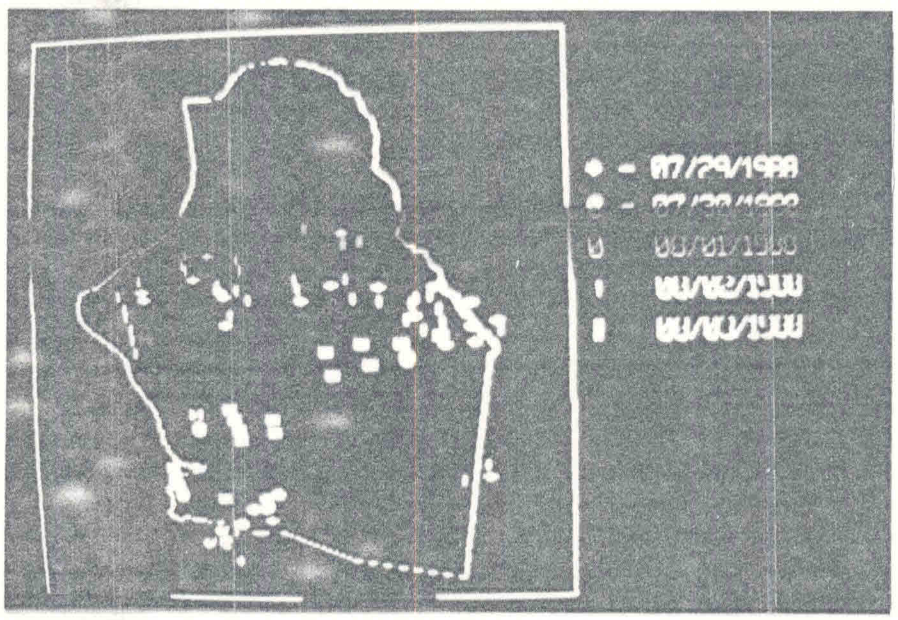

Figure 4. Fire points identified by the AVHRR band 3 on July 29 and 30 and August 01, 02, and 03, 1988 (Pereira et al., 1990).

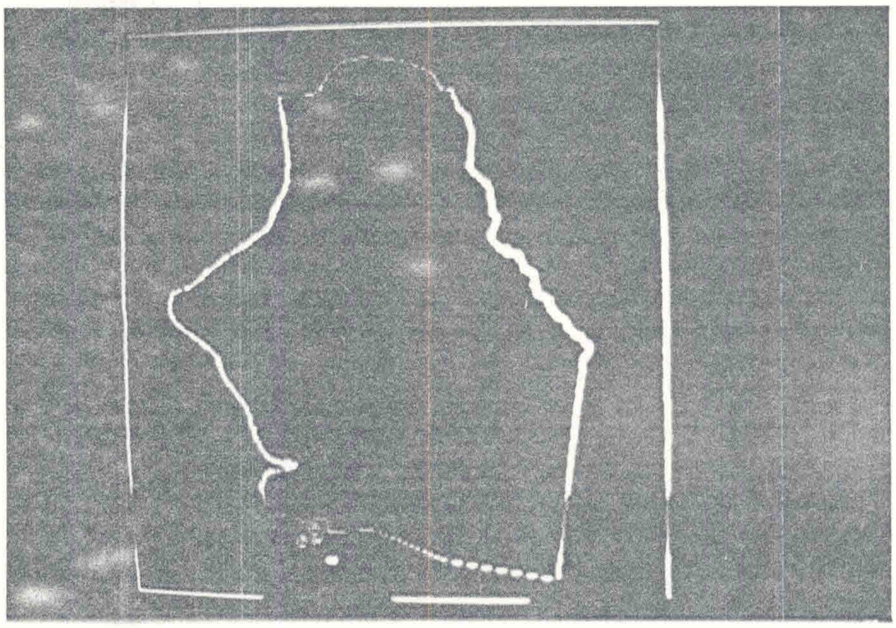

Figure 5. Fire points identified by the AVHRR band 3 on July 29 and 30, 1988 (Pereira et al., 1990).

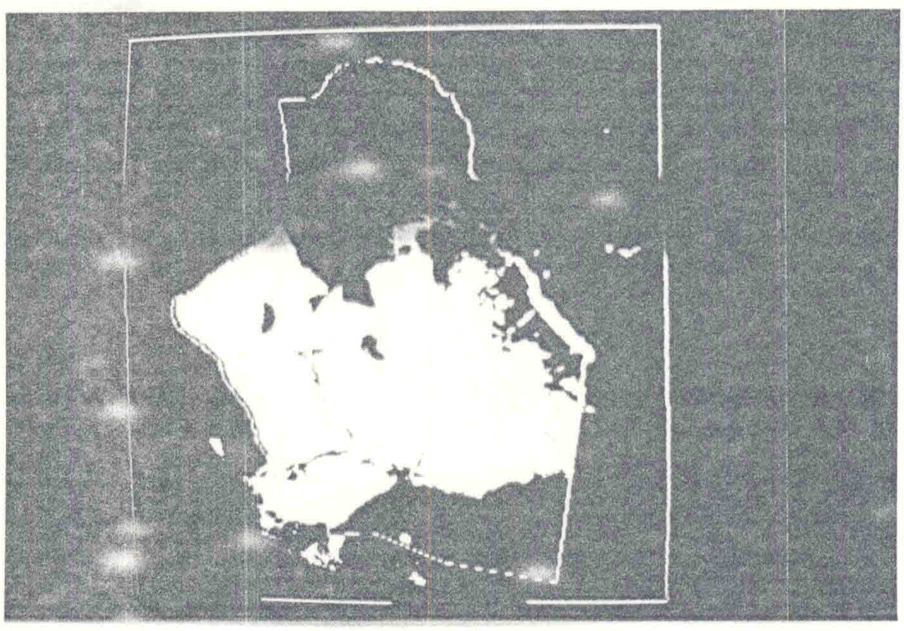

Figure 6. Classification of burned vegetation in the Emas National Park.

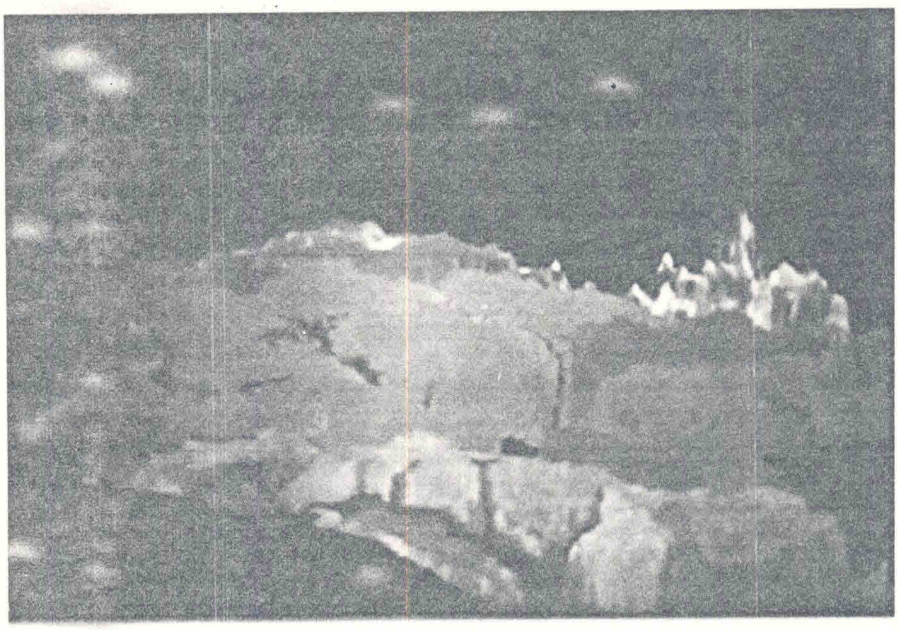

Figure 7. The synthetic image of Emas National Park derived from DEM and TM band 5 on July 29, 1988 (before the fire).

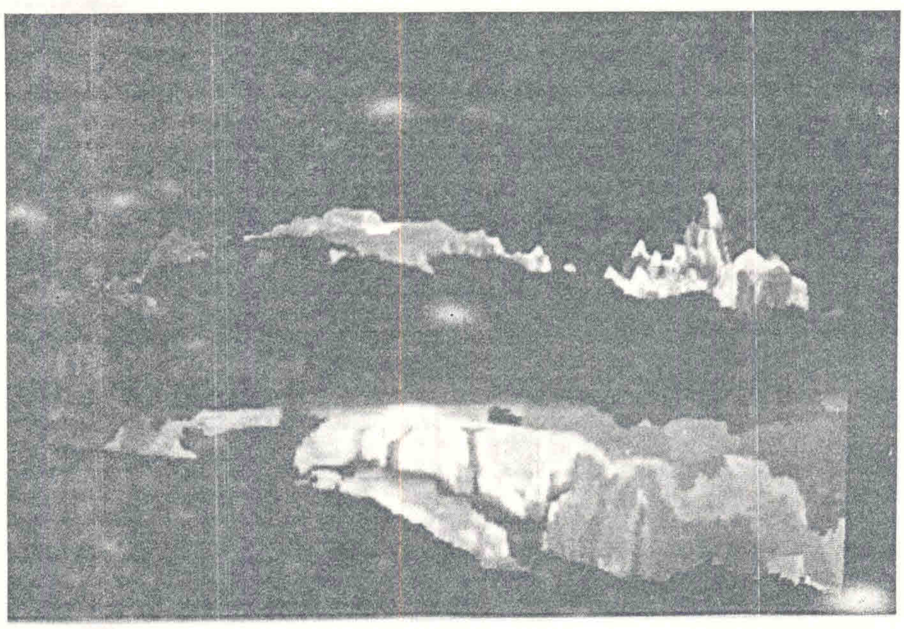

Figure 8. The synthetic image of Emas National Park derived from DEM and TM band 5 on August 14, 1988 (after the fire).

Table 1. Distribution of vegetation cover classes in the Emas National Park (Goiás State)

Class	Area (ha)	% of Park
Wooded savanna	33,644.6	25.6
Savanna grassland	55,916.9	42.5
Savanna woodland	33,960.1	25.8
Flooded areas	6,383.1	4.9
Other	1,556.1	1.2
Total	131,461.0	100.0

Table 2. Distribution of burned areas per vegetation cover classes in the Emas National Park (Goiás State)

Class	Burned Areas		
	Area (ha)	% of Class	% of Park
Wooded savanna	13,027.1	38.7	9.9
Savanna grassland	47,803.1	85.5	36.4
Savanna woodland	11,396.6	33.6	8.7
Flooded areas	1,657.4	25.9	1.3
Total	73,884.2		56.3