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TYPE III FINAL REPORT

COLLECTION OF RELEVANT RESULTS OBTAINED WITH THE ERTS-1 SATELLITE IMAGES BY THE INSTITUTE FOR SPACE RESEARCH - INPE

January 1975
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SERVIÇO PÚBLICO FEDERAL
CONSELHO NACIONAL DE PESQUISAS
INSTITUTO DE PESQUISAS ESPACIAIS
São José dos Campos - Estado de S. Paulo - Brasil

COLLECTION OF RELEVANT RESULTS OBTAINED WITH THE ERTS-1 SATELLITE IMAGES BY THE INSTITUTE FOR SPACE RESEARCH (INPE)

The material contained in this report on the images of the Earth Resources Technology Satellite (ERTS-1) was authorized by the undersigned. The analysis presented here are done by specialists, from different groups of INPE, in order to show the potentiality of the uses of the ERTS-1 images for Brazil.

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Fernando de Mendonça

General Director

COLLECTION OF RELEVANT RESULTS OBTAINED WITH THE ERTS-1 SATELLITE IMAGES BY THE INSTITUTE FOR SPACE RESEARCH - INPE

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- Dr. Gilberto Amaral (Mineral Resources)
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TYPE III FINAL REPORT

Jan. 1975

INSTITUTO DE PESQUISAS ESPACIAIS (INPE)

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(See pages vii and viii for abstracts of the five chapters.)

PREFACE

This final report describes the significant contribution obtained by the Brazilian Institute for Space Research (Instituto de Pesquisas Espaciais - INPE) in the areas of Sea Resources, Mineral Resources, Soil Resources and Geography, performed with the MSS/ERTS-1 Satellite images.

It is divided into five Chapters as follows:

Chapter I - Introduction - It is a brief description of the Brazilian Remote Sensing main activities.

Chapter II - Sea Resources - It describes the usage of the MSS/ERTS-1 images for bathymetric studies; coastal sedimentation (distribution, transport and deposits);carthographic correction and control of the coastal lines to nautical charts atualization; information of the coastal circulation processes based on sediments distribution; identification of polluter centers.

Chapter III - Mineral Resources - It indicates the value of ERTS imageries for the several geological purposes as mineral prospection, hydrogeology and geological engineering.

Chapter IV - Soil Resources - It shows how the MSS/ERTS-1 images could be used for soil resources purposes specially vegetal coverage aspects and soil properties under the pedologic point of view.

Chapter V - Geography - It presents how the MSS/ERTS-1 images could be useful for several geographic purposes specially geomorphological and hydrographic mappings and studies of demographic inference.

This report has 2 volumes (I and II). Chapters I, II and III belong to the First and IV,V to the Second Volume.

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SOIL RESOURCES

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CHAPTER IV

SOIL RESOURCES

IV.1 - INTRODUCTION

The Soil Resources Group has used the MSS/ERTS-1 images since October 1972. It has tried to conduct researches in accordance to the Brazilian proposal to NASA for utilizing ERTS data but also keeping in mind the economical importance to define the priority of such studies.

First of all, the ERTS images have been analyzed for general purpose of surveying agricultural features. After that, the ERTS images were used in more specific researches such as natural vegetation mapping, forest inventory, deforestation control.

Other researches using ERTS and SKYLAB images are being carried out including soil maps, studies of crop forecast data and rangeland management.

The following pages present in more details the work the Soil Resources Group is dealing with.

IV.2 - PRELIMINARY ANALYSIS OF ERTS-1 IMAGES WITH SPECIAL REFERENCE TO AGRICULTURE AND FORESTRY

IV.2.1 - Introduction

The purposes of this work are to define the ERTS-1 images potentiality for agricultural surveys and to provide basic information for further research. Owing to the short period of study and the absence of ground truth data, the results reported here are therefore of a preliminary nature. We call attention that some vegetation types are described in item IV.3.2.2.1.

IV.2.2 - Methodology

The preliminary analysis presented here was basically done using black and white photographic copies, on the scale 1:1,000,000 of the four ERTS-1 channels. However, some particular cases appear where magnified images were used as well as other remote sensing information sources, in addition to the ERTS-1 images.

Figure IV.1 shows the Brazil map where the ERTS images were numbered to put in evidence the frames under study.

IV.2.3 - Image E-1047-12274 - Paraíba River Valley Region

IV.2.3.1 - Introduction

In this analysis use was made of the above mentioned image

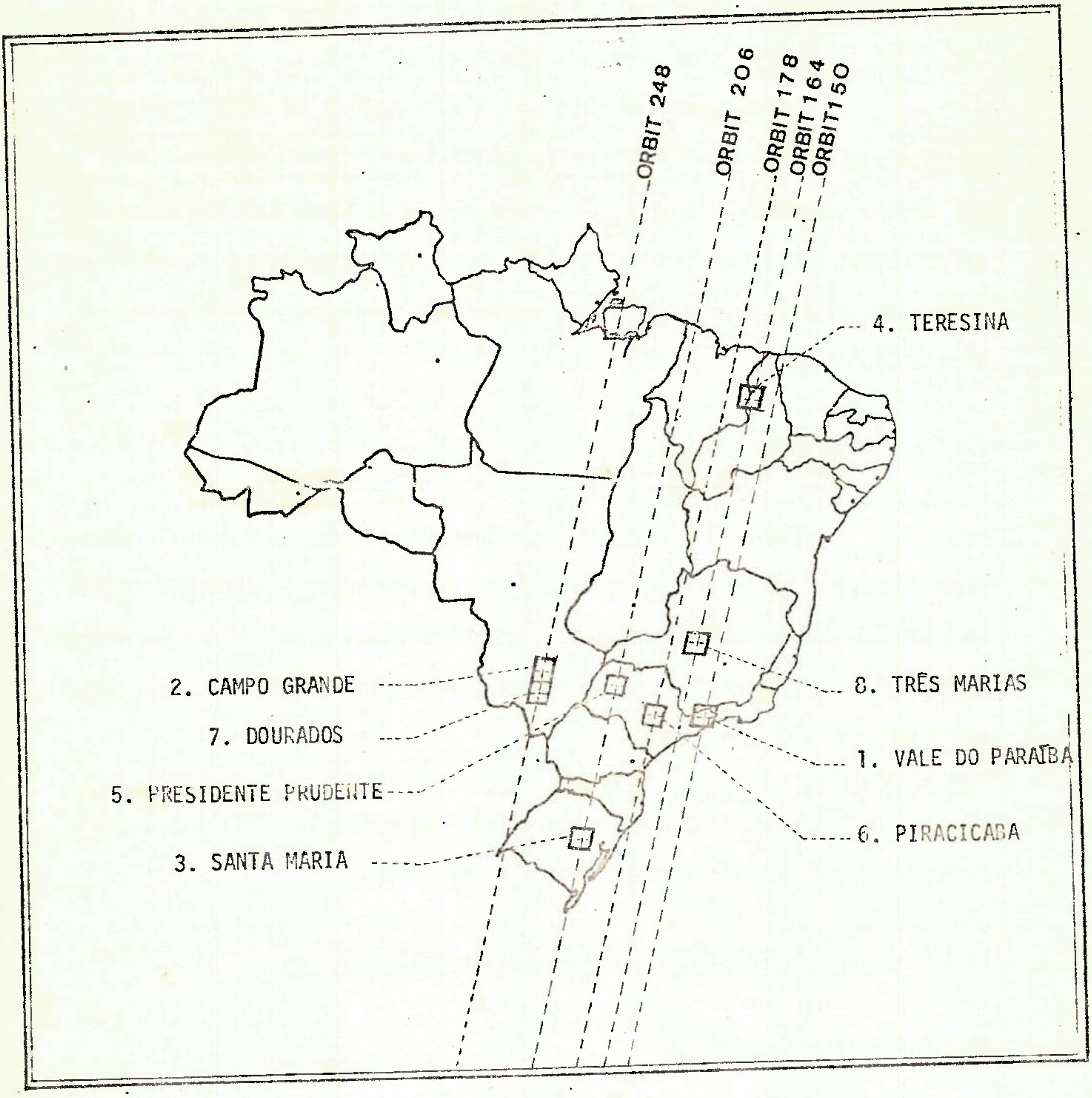


Fig. IV.1 - Brazil map showing the analyzed frames.

with image center coordinates 23°06'S and 45°17'W, dated September 8,1972. This image embraces the Paraíba River Valley, "Serra do Mar" and part of the Paulista coastland. This region varies greatly in topography, climate and vegetation. Cattle breeding is a major activity in the area.

IV.2.3.2 - Available Information

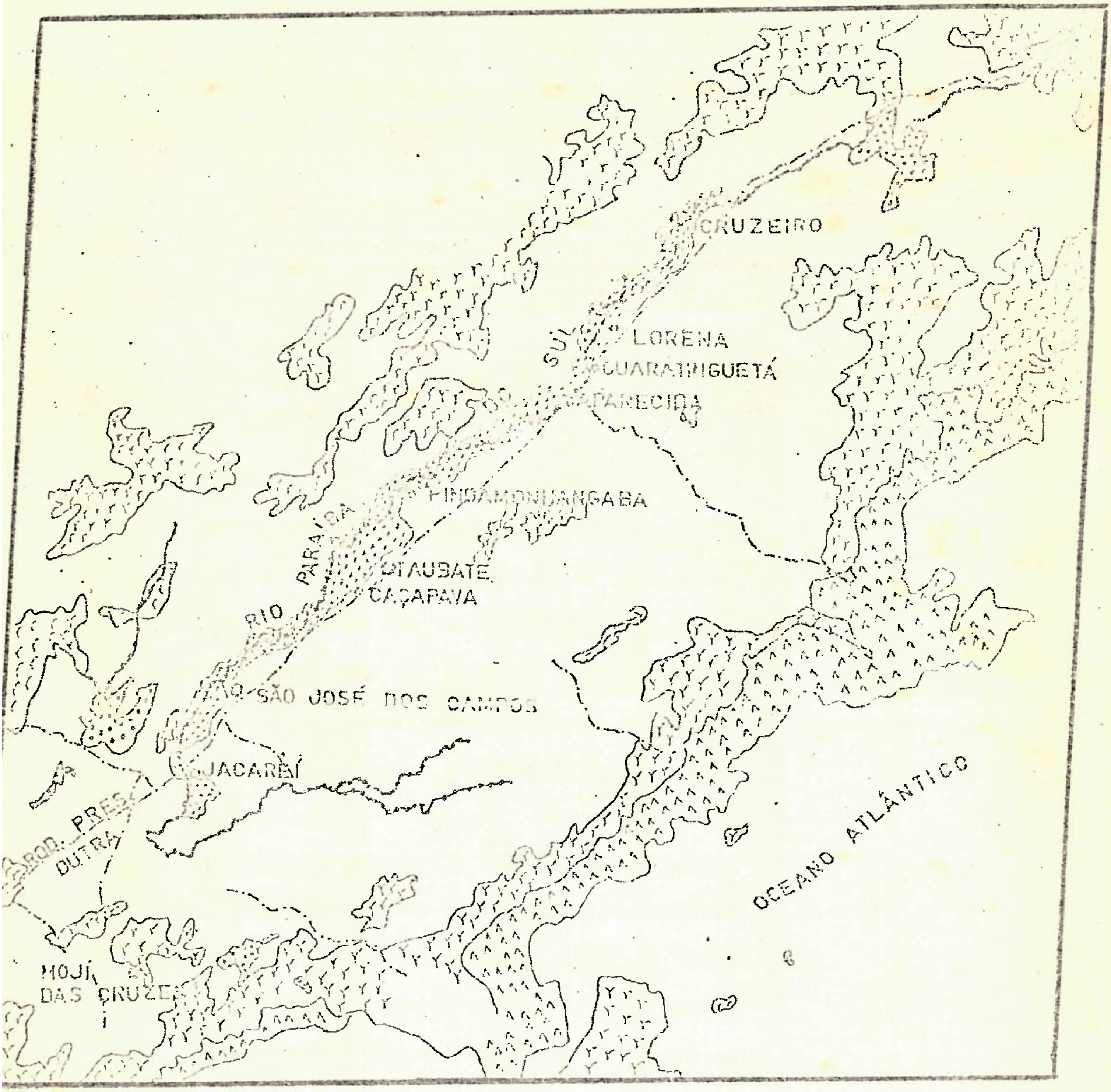
1 - Based on the analysis a thematic map was done (Fig. IV.2) which could be compared with the channel 5 image (Fig. IV.3). The boundary establishment of the mapped units was done over the channel 5, to present a better contrast, although the identification was done also using the other channels .

2 - the landforms aspects are better evidenced through channels 6 and 7.

3 - Vegetation information are more easily obtained using tne channel 5 image where the variations from dark to light gray tones indicate a graduation from dense vegetation (forests) to sparse vegetation, corresponding to areas with herbaceous species and grassland.

IV.2.3.3 - Conclusions

1 - The information acquired from the orbital ERTS-1 images are of great importance to plain agriculture activities because it permits a previous knowledge of the area, when speaking in a global way.



DENSE VEGETATION (FOREST)

DAMS

HIGHWAY AND ROADS

RIVERS

FOREST ON THE "SERRA DO MAR" (MAR RANGE) SCARPS

PARAÍBA RIVER VALLEY

Fig. IV.2 - Thematic map of the Paraíba River Valley.

Fig. IV.3 - ERTS image E-1047-12.274 - Channel 5 - Paraíba River Valley Region.

2 - Based on a summary analysis of another image set for this same area, taken at different ERTS-1 coverage periods, it is possible to accompany the evolution of agricultural activities (crops evolution).
The ERTS-1 repetitivity permits a better forest monitoring due to the official government policy stimulating and controlling reforestation.

3 - It is important to point out that the thematic map presented here was obtained using only the MSS/ERTS-1 images, without additional costs for field works; besides it was done in a short time.

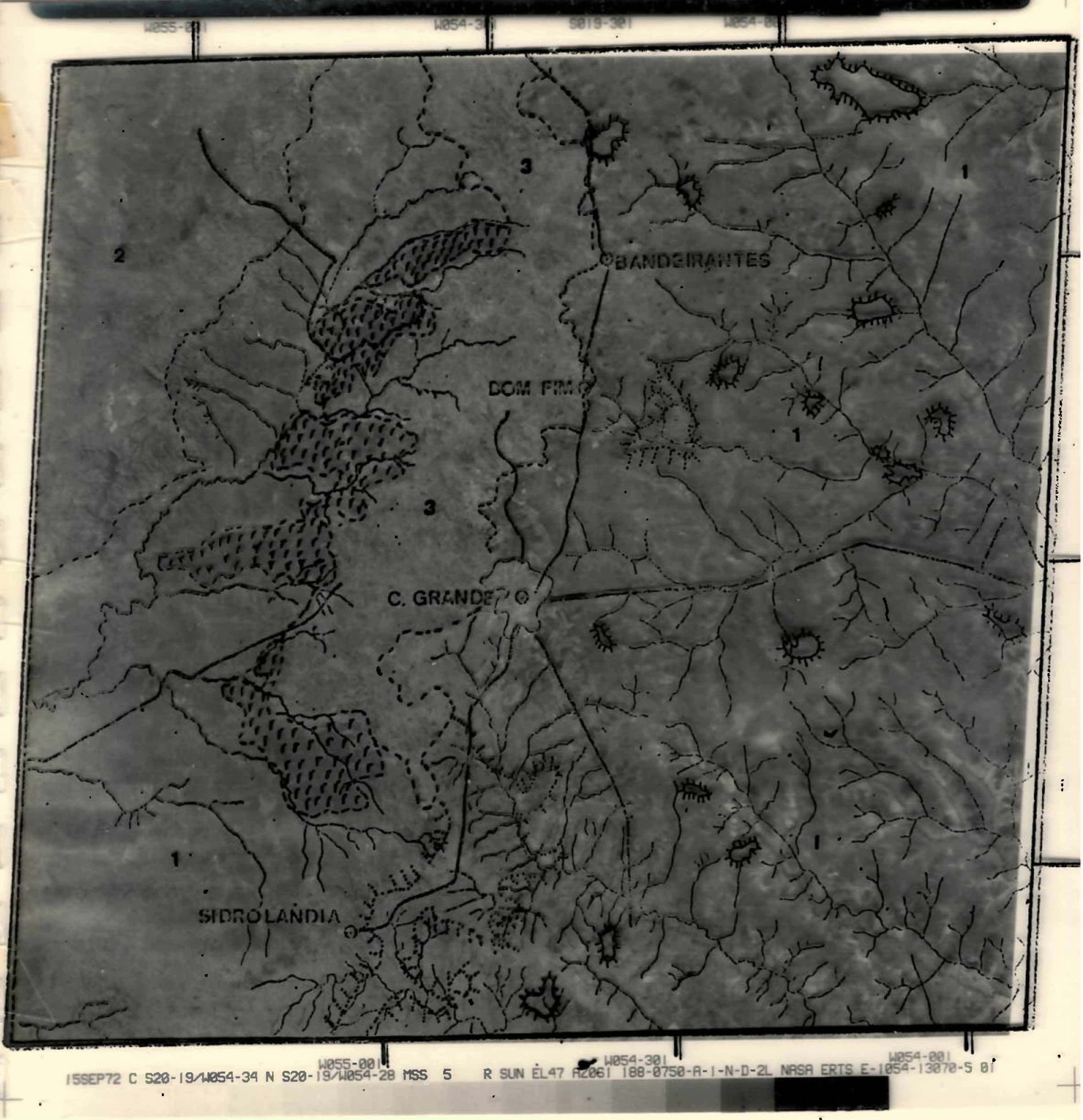
IV.2.4 - Image E-1054-13070 - Campo Grande Region

IV.2.4.1 - Introduction

The area selected is located in the center-west part of Mato Grosso State, with image center coordinates $20^{o}19'S$ and $54^{o}34'W$, taken in September 15, 1972. It shows the Campo Grande City in the image center.

IV.2.4.2 - Available Information

1 - The cities of Campo Grande, Bom Fim and Sidrolândia were easily located through channel 5 (Fig. IV.4). In this same channel the highway networks specially the



ROADS
RIVERS BASED ON CHANNELS 5 AND 7
WET AREA
WET MIXED WITH DRY AREA
"CERRADÃO" - FOREST
1,2,3 UNITS

Fig. IV - ERTS image E-1054-13070 - Channel 5 - Campo Grande Region.

Cuiabá - Campo Grande and Campo Grande - São Paulo highways can be identified.

2 - Channel 5 shows two drainage systems oriented in different directions, one Southwesterly directed and the other to the West.

3 - Several vegetal units and land use are shown in the transparency over the figure IV.4 as:

unit 1: Area occupied with natural vegetation, typical of Central Brazil, named "cerrado". It appears in light gray tones to the East and Southeast of the area indicating soils which are more eroded. The left side of the image appears in darker gray tones, evidencing denser vegetation, with well integrated drainage pattern, with an erosion degree from light to moderate.

unit 2: Area with "cerrado" vegetation including pasture, situated at a higher level and which at a first sight appears as areas without agricultural uses.

unit 3: It presents mottled gray tones indicating strong agricultural activities related to crops and pasture. This is more evidenced in the vicinities of Campo Grande city expanding toward Cuiabá city.

4 - Channels 6 and 7 show areas in dark gray tones and with well defined geometric forms indicating irrigated rice crops.

IV.2.4.3 - Conclusions

1 - The areas with agricultural activities appear surrounding the urban centers.

2 - Some areas are suffering a strong erosion action needing some soil conservation measures.

3 - There exist two drainage systems. One in direction to the Paraguai River and the other, at the opposite side, in direction to the Paranã River.

4 - The area does not present a good transportation routes' system. Just some railways and few paved roads.

5 - This region possesses great variety of soil types indicated through the natural vegetation and land use differences. In the areas to the West the soils trend to be better.

6 - There are great quantity of rivers in the area which permits one to say that a well-planned agricultural activity would not suffer from water shortage.

7 - The relief of this area is flat, presenting itself at the Northern and Northeastern regions a little more irregular.

IV.2.5 - Image E-1105-12532 - Santa Maria Region

IV.2.5.1 - Introduction

The above referred image (center coordinates $30^{o}17S-53^{o}03W$),

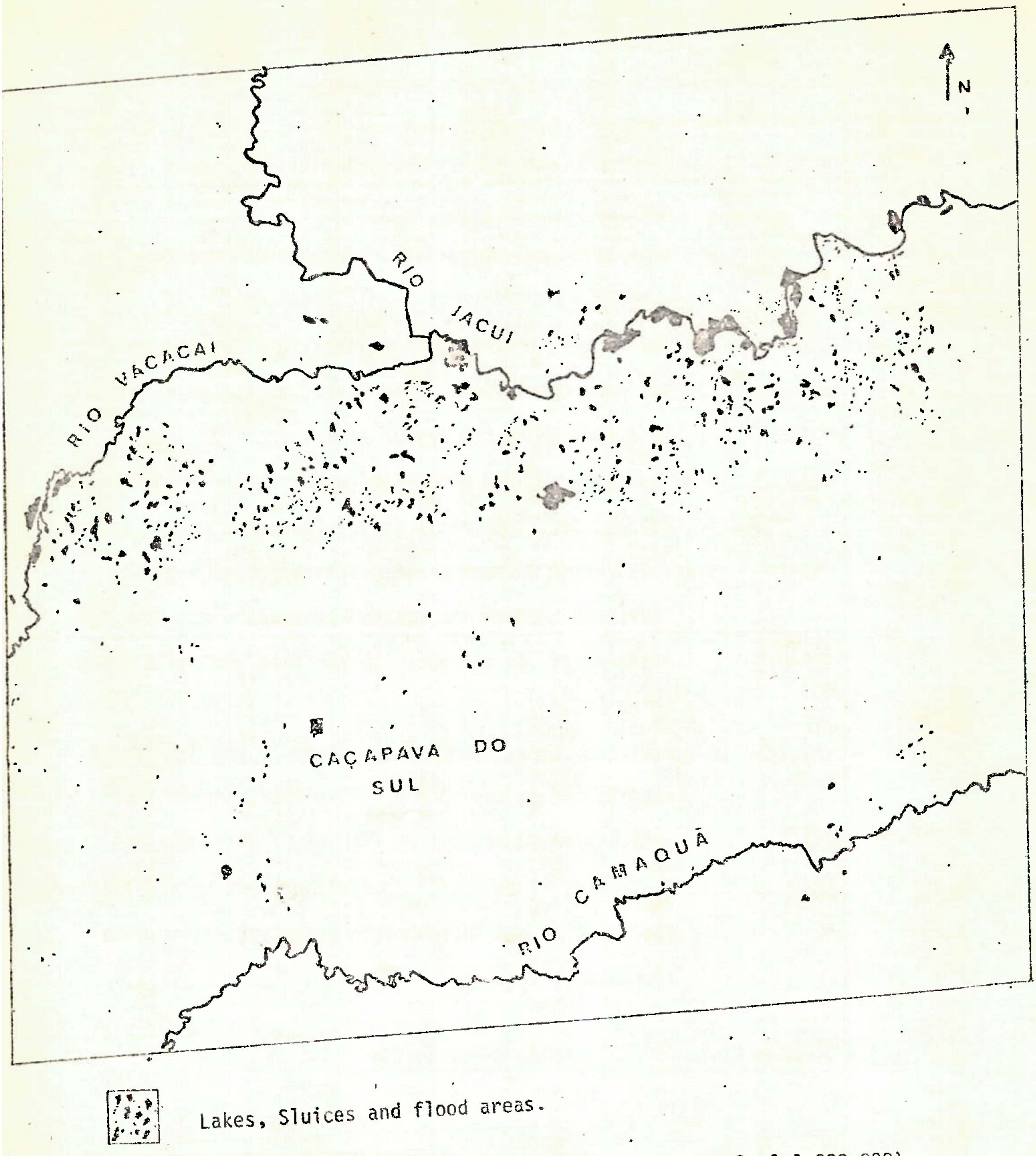


Fig. IV.5 - Map done over the channel 7 image (scale 1:1,000,000).

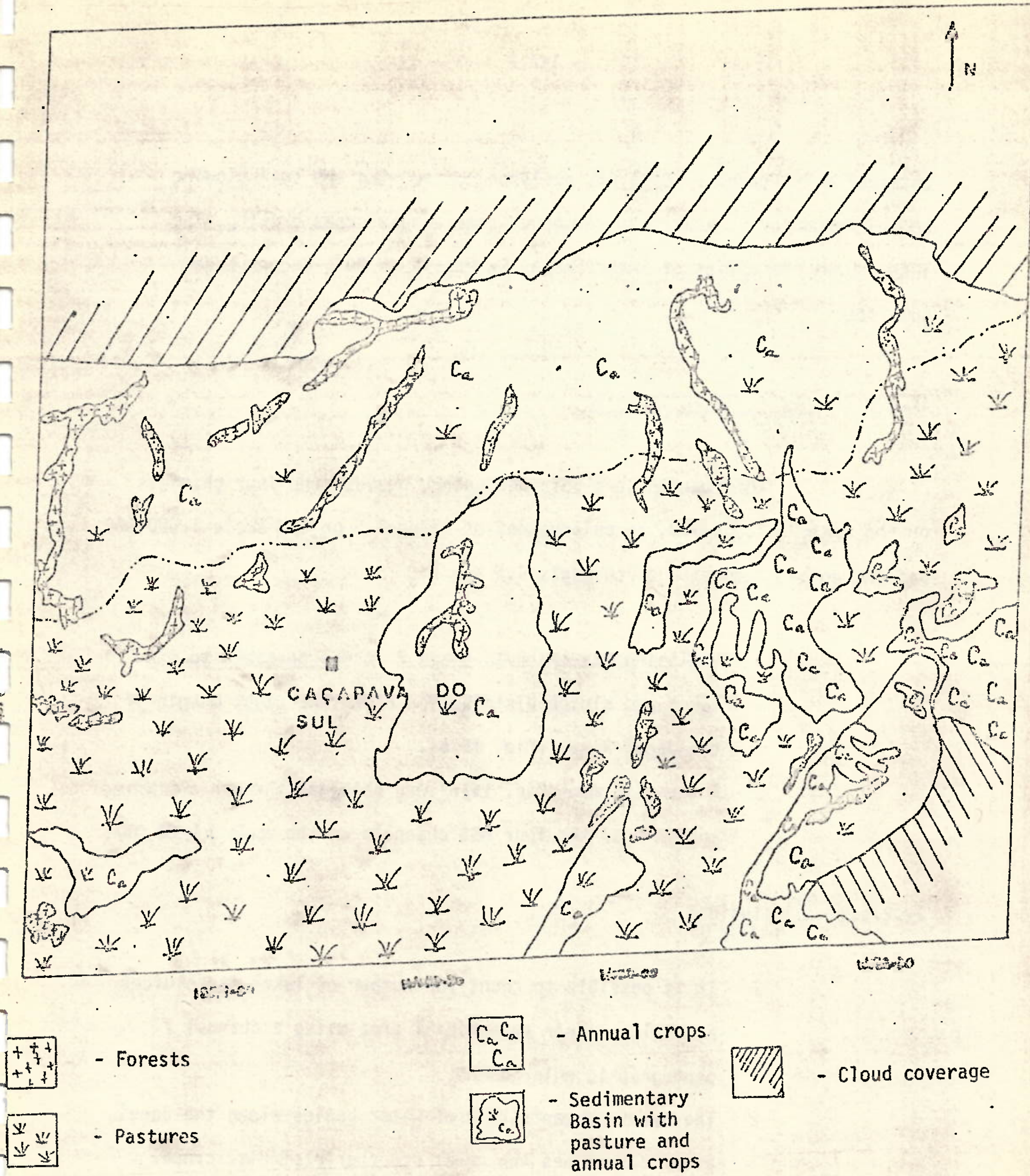


Fig.IV.6 - Land use thematic map - Santa Maria Region original scale 1:1,000,000.

obtained at 5 November 1973, was analyzed considering the soil plowing and planting period and the begining of some annual crops growing. The image shows the cities of Santa Maria, Cachoeira do Sul, Caçapava do Sul, etc.

IV.2.5.2 - Available Information

Information were obtained using, besides the four channels on the scale 1:1,000,000, an enlargement of channel 5 on the scale 1:500,000 and one color composite of channels 4,5 and 7.

1 - Utilizing the channels 6 and 7 it was possible to map lakes and sluice distribution along the right margin of the Jacuī River (Fig. IV.5).

2 - A thematic map (Fig. IV.6) was obtained through a combined analysis of the four MSS channels on the scale 1:1,000,000.

IV.2.5.3 - Conclusions

1 - It is possible to count the number of lakes and sluices as well as their superficial area using a channel 7 photographic enlargement.

2 - The great concentration of water bodies along the Jacuī River determines the great occurrence of rice crops.

3 - It was easy to separate the following categories: annual crops, pasture and forests.

4 - The outline of woodland, remaining in the area,could be delimited.

5 - The analysis of image sets, taken at different dates, through the different growing crop cycles, with regional specialists support and also with aircraft sampling, at intermediate scales over test sites areas previously selected on the ERTS images, would permit more detailed results about the present and potential land use in this region.

IV.2.6 - Image E-1048-12282 - Teresina City Region

IV.2.6.1 - Introduction

The image under analysis has the central coordinates: 05°49'S and 42°28'W, taken at September 9,1972. It includes the city of Teresina and parts of the Parnaíba and Poti Rivers. To the West of the Parnaíba River appears the Maranhão State and to the East part of this river the Piauí State.

The vegetation in this area is predominantly natural varying from small and sparse "cerrado" vegetation, used as pasture, to "cerradão" (vegetation of forestal size) with some agricultural activities. It also presents in its lowlands and river beds the "babaçu" vegetation, one of the main sources of vegetal oil extration of that region.

IV.2.6.2 - Available Information

Information were obtained not only using ERTS images (1:250,000) but also from infrared photographies enlargements to the scale 1:130,000, SLAR (RADAR) mosaic on the scale 1:250,000 and previous field observations from part of this region.

The analysis of these images could be summarized through a thematic map as shown in figure IV.7 which was drawn over the channel 5 of the ERTS image (Fig. IV.8).

Several types of features were plotted on the ERTS image and in the case of some of them the RADAR image correlated quite well, while other features were not perceptible in the radar such as those microcosms with boundaries in tracing.

Basically the following were the types of vegetation and soil use established through the images:

Area 1 - Area 1 is characterized by a rather dense savanna vegetation, of the "cerradão" type, with a large number of cultivated areas. It presents good agricultural activity in spite of its rather accentuated relief. A patch, in the shape of horseshoe near the parallel of 6^{o}S, crossed by the high-voltage power line of the "Boa Esperança" Hydroelectric Company (COHEBE), has been identified. Both in the RADAR and in the infrared images cultivated areas are found near this horseshoe. In the ERTS image this area is unfavourably located, too near the left edge, and this resulted in blurred details.

Area 2 - This area is characterized by "cerradão" vegetation and small agricultural activity, which is due to relief (shown by vertical arrows) as a limiting factor. In this microcosm we find yet another area well characterized in the ERTS and in the RADAR images (area 2.1). Patches F and G, which are not well delimited in the RADAR image, but are well characterized in the ERTS images, belong to the type 4 vegetation. The vertical arrows indicate the most hilly part of the area.

Area 3 - Areas characterized by number 3 classified as "cerrado" vegetation, that is, a less dense savanna type identified by a fine texture in RADAR and a medium gray tone in the ERTS images. The index of each area indicates the variation of their respective reliefs as well as the parts where agricultural activity can be inferred.

Area 3.1 - This area shows parts covered by "cerrado" with flat relief as well as great agricultural activity in other parts. It comprises the environs of FEITORIA, ÁGUA BRANCA and SÃO PEDRO DO PIAUÍ. Cultivated areas can be perceived both in the RADAR as in the infrared images. The texture of this area in the RADAR is well characterized (fine texture) and the relief is smooth.

Area 3.2 - The 3.2 areas differ from the foregoing only by the higher relief.

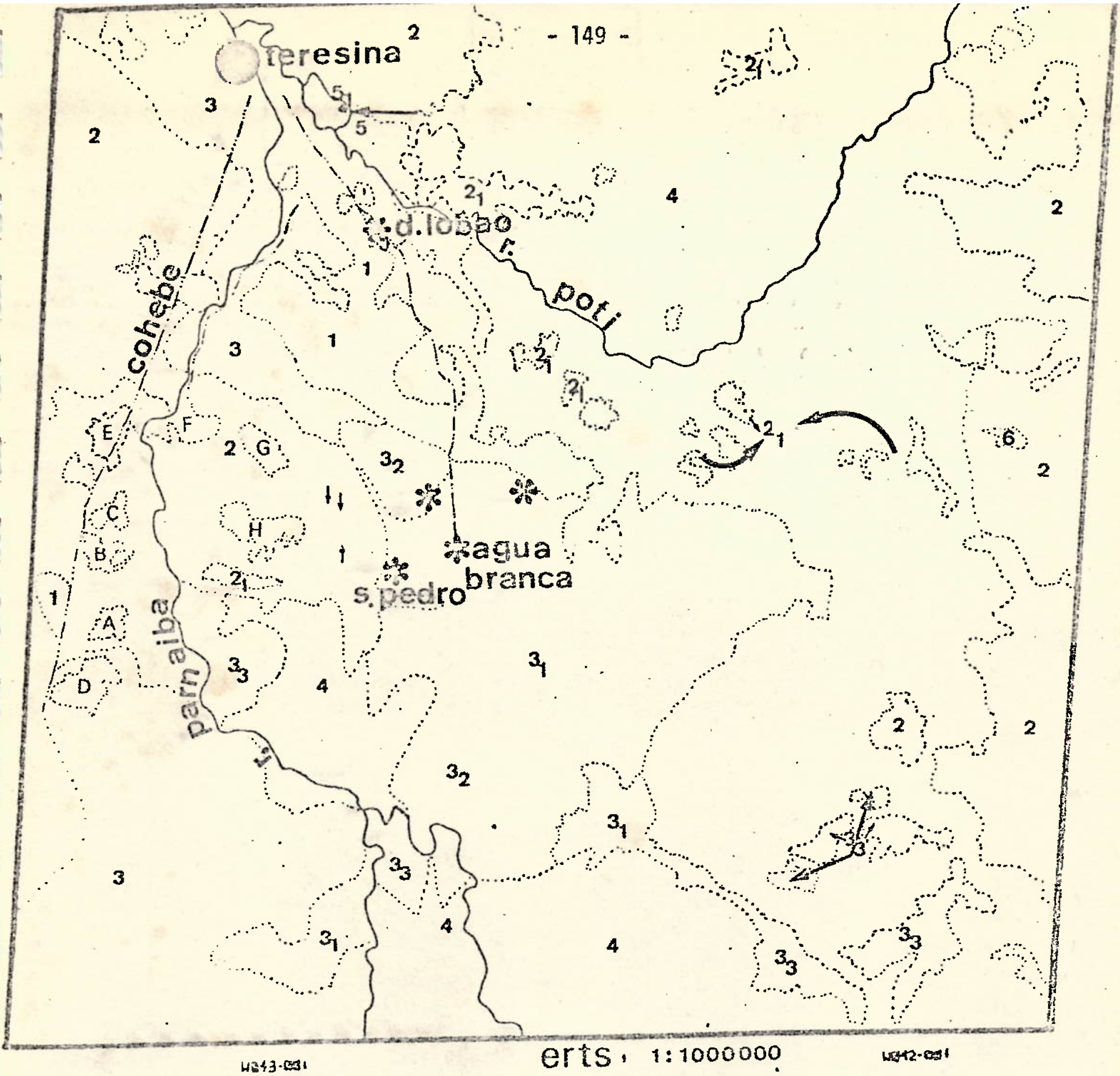
Area 3.3 - Areas in 3.3 show the same characteristics as the previous two, differeing only in the degree of certainty as to the existing agricultural areas. The area as a whole is of agricultural potential.

Area 4 - Microcosm number 4 comprises a large part of the wuadrilateral under study and is characterized by vegetation so sparse that the reflectance of the soil has influence on the light gray tone, characteristic of vegetation in the ERTS image under study. In the RADAR image individual areas are not well characterized in terms of relief and texture but some boundaries have been plotted which allow comparisons.

The whole number 4 area can be considered, in a general way, as sparse savanna unfit for agriculture.

Area 5 - The area delineated as nº 5 is similar to area nº 1, but shows well the agricultural areas near the poti River. Sub-area 5.1 is well evidenced, in the ERTS image, as a darker gray spot. Predominanting vegetation in the proximity is of "cerradão" type of almost like it. Area indicated by arrow, near this region, probably belongs to group 4 and is perfectly characterized in all the images.

The spots marked with letters A to H have sparse vegetation, with varied relief and no agricultural activity.



<u>LEGEND</u>

1) "CERRADÃO" WITH CULTIVATED AREAS
2) "CERRADÃO WITHOUT CULTIVATED AREAS
3) "CERRADO" 1 - FLAT LAND AND CULTIVATED AREAS
   2 - UNDULATING TO ROLLING LANDS AREAS
   3 - WITH POSSIBILITIES OF AGRICULTURAL ACTIVITIES
4) "SPARSE CERRADO" WITHOUT AGRICULTURAL ACTIVITY CONDITIONS
5) "CERRADÃO" WITH SEVERAL CULTIVATED AREAS
6) HUMID AREAS
   A THROUGH H - SPARSE VEGETATION, DESCRIBED IN AREA 5.

Fig. IV.7 - Interpretation of ERTS images with the support of Radar Mosaic and Infrared False Color images.

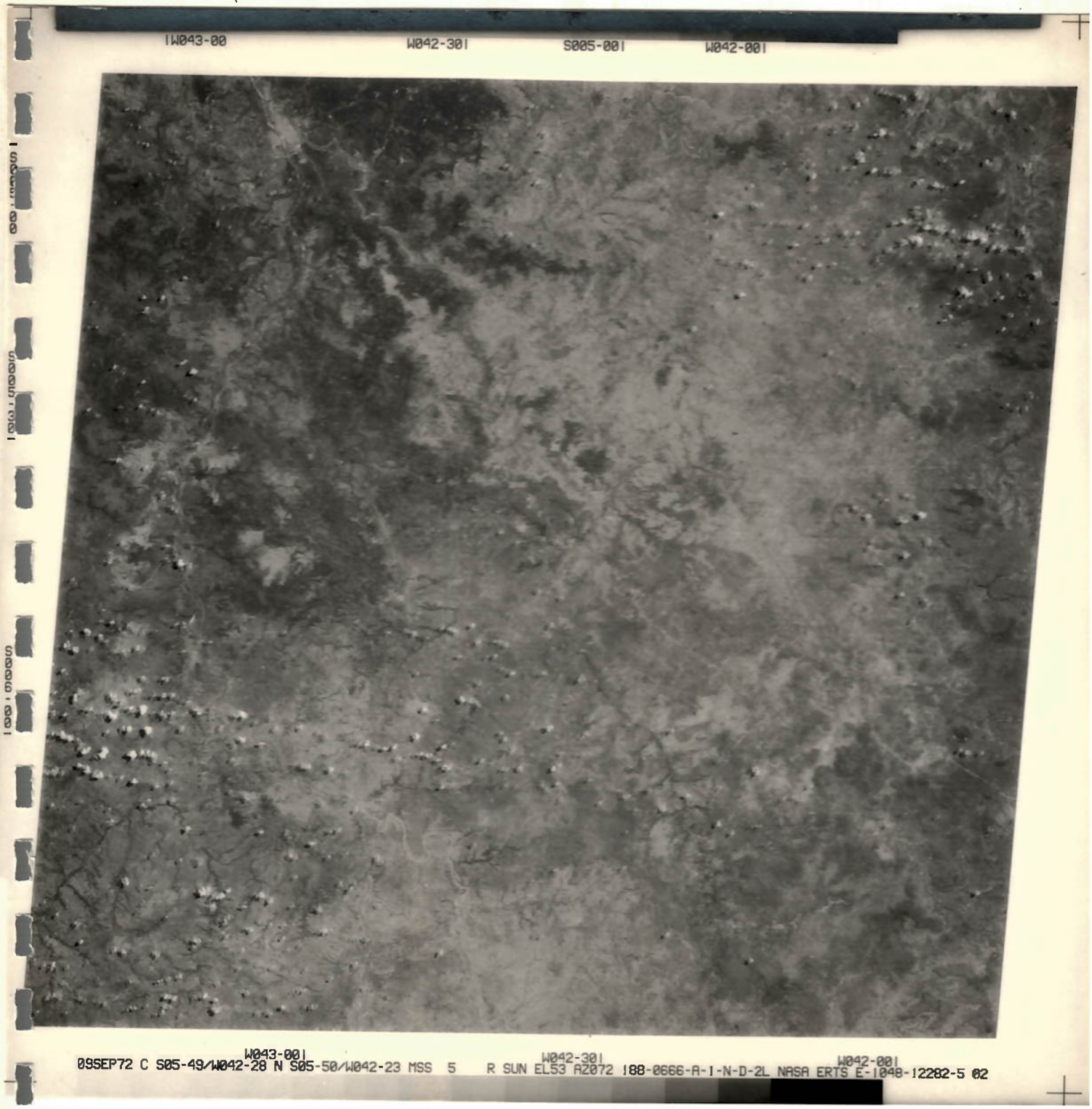


Fig. IV.8 - ERTS image E-1048-12.282 - Teresina Region. Channel 5.

They probably indicate soils of low fertility and appear all over the image quadrilateral.

Area 6 - These are humid areas which show up well in channel 7. They have fallen outside of the RADAR mosaic which does not fully correspond with the area covered by the ERTS image.

IV.2.6.3 - Conclusions

1 - Altough a thematic map is presented here only with the great mapped units, it is possible to obtain a more detailed level of study on a 1:250,000 scale map using a channel 5 photographic enlargement.

2 - The unit 1 area, in spite of being intensely cultivated, was not clearly evidenced in the MSS images due to the reduced size of the planted areas located closely together and from the same stage of growth, reducing in this way the contrast among them. In area 2, channels 4 and 5 show the existence of agricultural areas.

3 - Through this preliminar interpretation it was not possible to separate the "babaçu" vegetation from the "cerradão" neither at the false color infrared images, due to the inferior quality of the images.

4 - ERTS channel 5 images to the scales 1:1,000,000, 1:500,000 and 1:250,000 allow a good characterization of large vegetation types of the area under study. A good subsidy in relation to relief and texture was given by the RADAR 1:250,000 images. The joint use of the two

types of images makes for a much better interpretation than the use of either one of them in isolation.

5 - The additional information obtained from the 1:130,000 infrared images was of great importance in this stage, in which interpretation techniques is not yet fully developed. The infrared images gave details not perceptible in other two types of images studied, but unfortunately with bad quality in terms of cloud coverage and color enhancement.

6 - Water bodies are equally well characterized both in ERTS channel 7 as in RADAR images. Relief shows up better in the RADAR image but geometrical accuracy is better in the ERTS images.

IV.2.7 - Image E-1123-12510 - Presidente Prudente Region

IV.2.7.1 - Introduction

The analysis referred to the above mentioned image with center coordinates $21^{o}36'S$ and $50^{o}42'W$ taken at Nov. 23, 1972, corresponds to the region of Presidente Prudente, Marīlia and Andradina cities located at the São Paulo State.

IV.2.7.2 - Available Information

1 - In extense areas along the Tietê River it is possible to observe a deffícient drainage evidenced by the dark

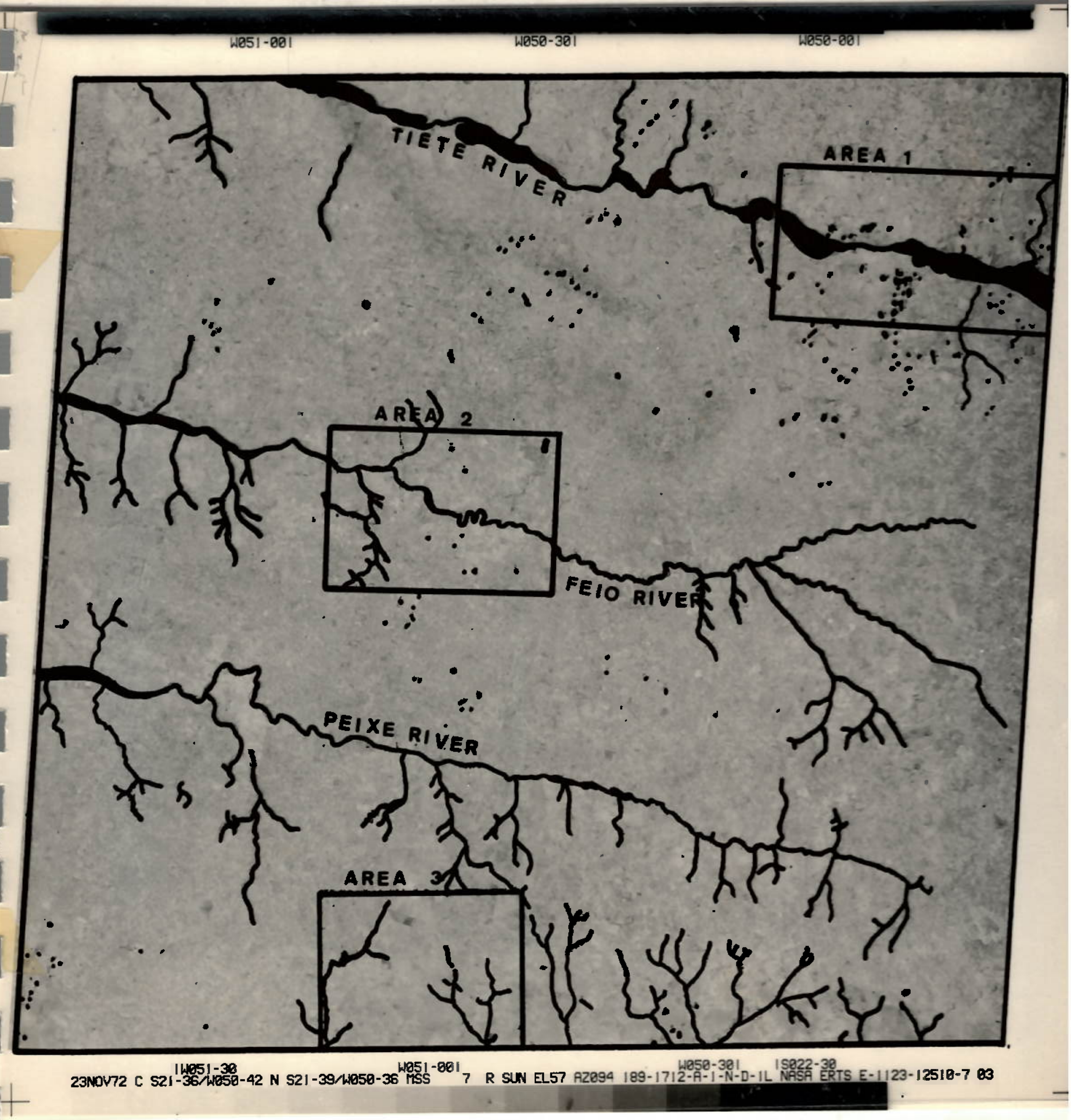


Fig. IV.9 - ERTS image E-1123-12.510 - Presidente Prudente Region
channel 7.

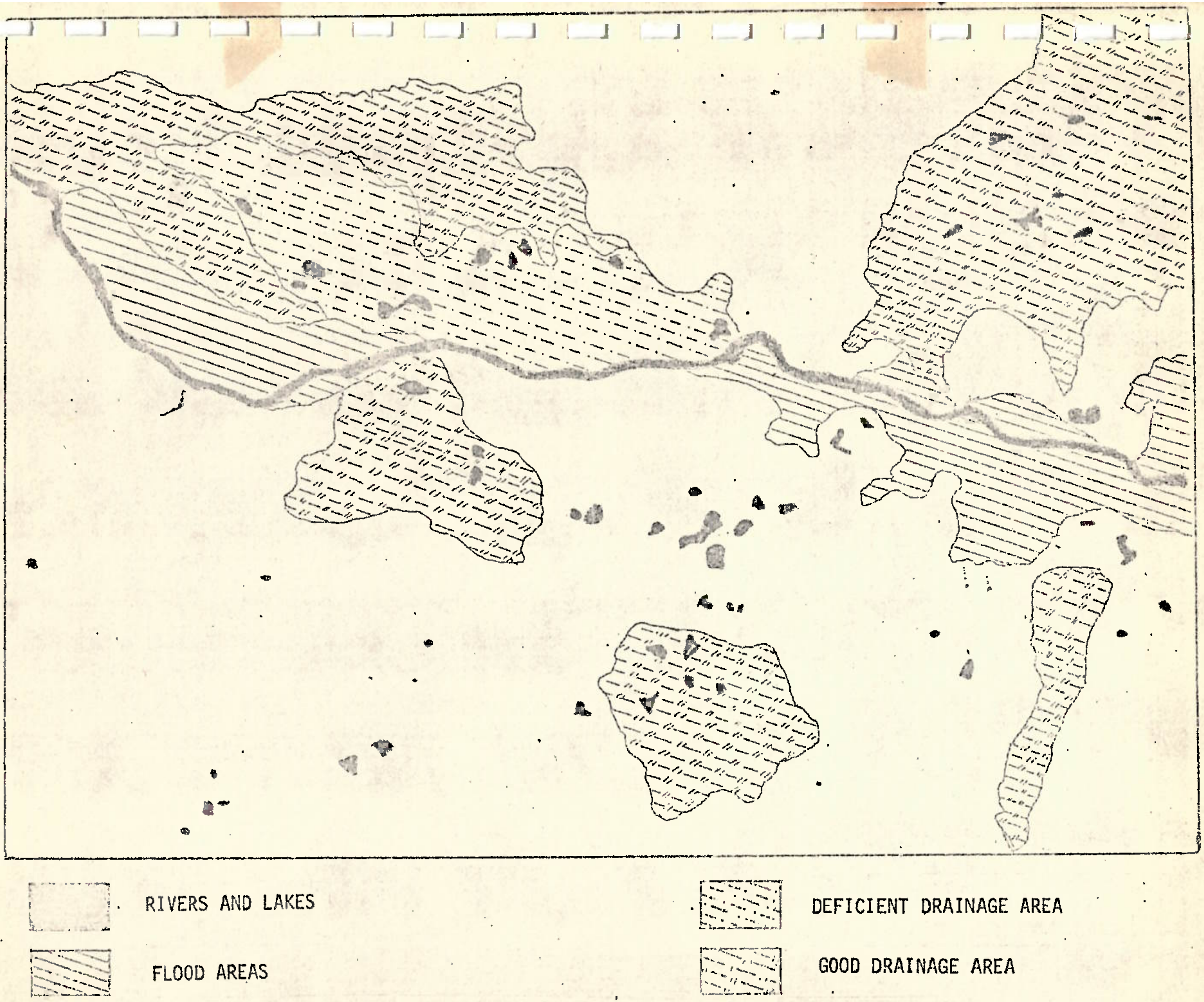


Fig. IV.10 - Map done over channel 7 image enlargement - Area 1 - Tietē River.

gray tone in channel 7. In this same area a great number of lagoons is also observed.

2 - Areas of bare soil, of a good drainage, evidenced by light tones in both 5 and 7 channels.

3 - The transparency done using channel 7 (figure IV.9) shows the main drainage system orienting itself parallelly toward the Paranã River, to the West of this image and not shown in the above mentioned figure, as well as innumerable small lakes, dams and areas influenced by flood along the Tietê River.

4 - Figure IV.10 shows a map done over the same photographic enlargement on the scale 1:130,000, of the marked area, at the upper right part of the channel 7 transparency (area 1). This area under the influence of the Tietê River shows lagoons, part of this river as well as areas close to its river bed with various degrees of humidity.

5 - Figure IV.11 shows the map done over the same channel 7 transparency, in its lower part (area 3), situated near the Presidente Prudente city. It is possible to note the presence of two dams and areas of bare soil, with different moisture degrees, indicating differences in the drainage capacity.

6 - Figure IV.12 shows the thematic map done over the channel 5 photographic enlargement on the scale 1:130,000, at the central part of the image, near the Feio River area (area 2). In this region the existance of forests areas and areas prepared for plating, etc. was verified.

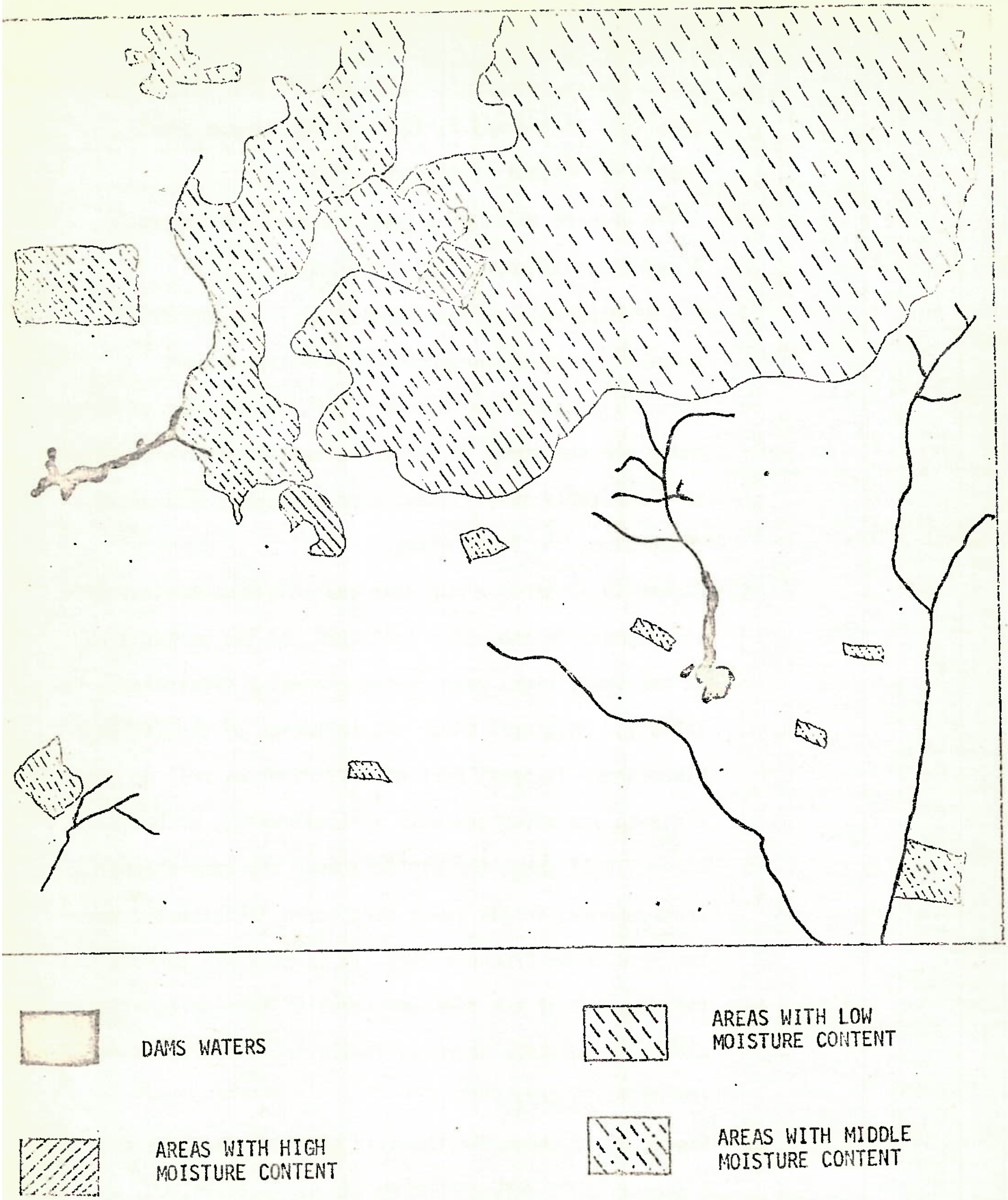


Fig. IV.11 - Map done over channel 7 image enlargement - Area 3 near Martinópolis São Paulo State.

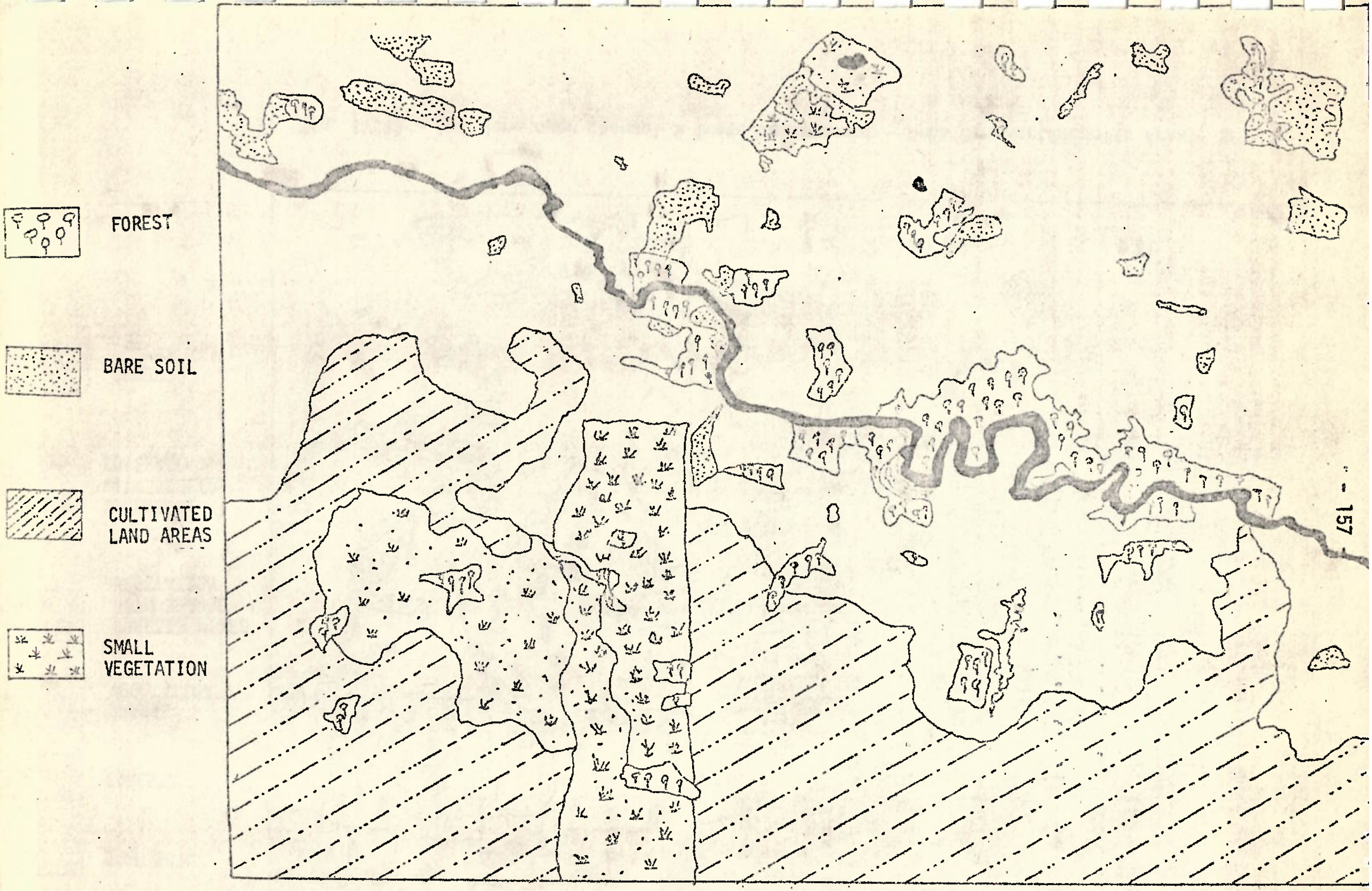


Fig. IV.12 - Map done over channel 5 image enlargement - Area 2 - Feio River Area.


FRANCISCO RIVER
BASIN REGION
45°30'W
45°00'W
17°00'S
17°30'S
18°00'S
S. FÉ DE MINAS
MONTES CLAROS
BOCAIUVA
JEQUITAÍ
PIRAPORA
VARZEA DA PALMA
SERRA DO ESPINHAÇO
SERRA DO CABRAL
RIO JEQUITAÍ
RIO JEQUITINHONHA
RIO ARAÇUAÍ
RIO FORMOSO
RIO SÃO FRANCISCO
RIO DAS VELHAS
RIO DO SONO
RIO PARACATU
SEDIMENTARY
TABLELANDS
INTRUDED VAL
SYNCLINAL
ANTICLINAL
EROSIVE SCAR
FAULT SCARPS
RESIDUAL PEA
DRAINAGE

The "Serra do Cabral", although spatially separated from the great Espinhaço structure, is part of it through similarities of lithology, structure, geomorphology, drainage system and image photogeomorphological characteristics. It is formed by two big anticlines and one syncline, besides other foldings perceptible in the image. In the axis of these two anticlines appear quartzits highly resistent from the Lavras Series, whose altitude is reflected in the saw format.

2 - Intermountainous Depressions

They appear in the image with rough texture and light grey tones for both channels, although lighter in channel 7. Distinguish itself perfectly as an eroded area, emerging older subjacent rocks which are delimitated by clear erosive scarpments in the contact among soils of the Minas Series, formed by sandstones, clays, conglomerate and pebble of metasandstone.

A clear example seen in this image is the Itacambiruçu River and its tributaries depression, whose sub-dendritic drainage is truely representative.

These scarpments were originated from erosive processes and constitute themselves in a water division between the Itacambiruçu and Jequitinhonha River Basins.

B - Sedimentary Plateaux

This unit was identified in the image through a very dark gray tone in channel 5 and light in channel 7 with smooth and uniform texture and with low drainage density and limitated by well defined scarpments.

Geologically it corresponds to sandstones dated from the Cretaceous Period, highly porous, horizontally disposed furnishing the necessary conditions to the appearance of structural tableforms surfaces.

Spatially present itself descontinuous and is an example for more intense surfaces westerly localized in the São Francisco River Basin.

It is covered by denser "cerrado" vegetation than the adjacent areas, infered through the light tonality in channel 7,representing the high vegetation reflectance in the near infrared band.

Topographically represents surfaces maintaining altimetric levels from 800 to 900 m.

C - Tablelands

They were differentiated in the image through a light tone in channel 7 and a dark one in channel 5. the rough texture on this unit boards clearly shows the erosive scarpments that constitute the link element with inferior levels of the tablelands.

Over all this unit the drainage presents a sub-dendritic pattern suggesting the presence of horizontal or sub-horizontal rocks with uniform resistance and with a smooth regional slope.

Geologically speaking this is a unit formed by rocks of the Bambuī Group, where limestones, slate and conglomerates emerge.

Morphologically it is represented by plateaux strongly eroded with occurrence of erosive scarpments and forms of Karstique relief in the areas of calcareous rocks outcrops.

Among the Espinhaço Range and the cretacic sedimentary tablelands this unit presents two distinct altimetric levels: one westerly located in the "Serra do Espinhaço" and at the east of the sedimentary plateaux and the other intruded between both, at an lower altimetric level. This compartment division is specially done by the presence of scarpments at both size of the Guavinipã River Valley.

An evident image aspect is the tablelands at west of the "Serra do Espinhaço" which is less eroded than the one located at east of the sedimentary plateaux.

D - Intruded Valleys in the Tablelands

This unit was delimitated through its smooth and uniform texture, through the localization close to the principal channels and through low density of secondary drainage.

Geologically they correspond to rocks of Vazante Formation which are deposits of the Quaternary Period, already consolidated and in an reimprovement phase. They follow the São Francisco River Valley and the valley of their main tributaries.

The horizontally layers form smoothly inclinated tableland reliefs in direction to river beds which maintain themselves at middle altitudes of 500 m.

Close to the Velhas and São Francisco Rivers in the limit of this unit through relatively abrupt scarpments.

At the right border of the Paracatú River also appear small scarpments while at the left border they do not appear.

V.2.5 - CONCLUSIONS

From the preliminary results of this geomorphological mapping one can conclude that:

- The MSS/ERTS-1 images could be considered as a valuable instrument for a synoptical vision of the relief compartmentation and of the structural influences.
- Related to localization, extensions and limits of the geomorphological units the images permit the introduction of modification in the already existing maps.
- The images offer possibilities to infer about morpho-climatical processes and their dynamism through repetitive analysis of the same area.

V.3 - HYDROGRAPHIC MAP USING ERTS IMAGES

V.3.1 - Introduction

The hydrographic system is subordinated to geomorphological, structural, lithologic and climatic conditions of a given region.Therefore it is a valuable element for environmental research. A detailed study of the drainage system furnish a series of important information to the determination of a region ecological scene. It is considerably important in the preparation of hydrographic maps as an auxiliar element in the investigation for other parameters.

This map was initially made aiming to support geomorphological interpretation of the area covered by the Belo Horizonte Chart and exemplifying the drainage mapping. The images used corresponded to the same area used to exemplify the geomorphological mapping of the previous work (Fig. V.7).

Through the above mentioned map it was possible to have an idea of the area compartiment division in function of drainage and of the drainage patterns.

Till the present moment only a qualitative analysis has been done of the hydrographic system, although quantitative studies will be done with the use of Hortton and Sthraler morphometric indexes.

V.3.2 - Drainage: General Organization

Through visual analysis of a drainage system (Fig. V.9) it was possible to distinguish two great hydrographic sets separated one from the other by the Espinhaço range and plateaux.

The Espinhaço alignment operates as water divisor separating the drainage oriented to the east (Jequitinhonha River and its tributaries) from the westerly oriented system (São Francisco River and its tributaries)

The rivers flowing to the São Francisco River present a

HYDROGRAPHIC MAP OF THE UPPER COURSES OF THE SÃO FRANCISCO AND JEQUITINHONHA RIVERS

superficial dendritic pattern and a high density of secondary rivers. The Jequitinhonha River Basin drainage already present itself less dense, reflecting even in the less important tributaries a great structural control with a sub-retangular pattern.

Correcting the drainage map with the geologic map of the area, it is possible to verify whether the drainage is denser and dendritic in the areas of rocks occurrence of the Bambuí Group. In the areas of calcareous occurrence Karst topography can be found. The superficial circulation in the Karstique region equally elaborate deep cannyons as the one formed by the Velhas River in the region of Santa Lagoon.

Where the climatic conditions do not permit the appearance of Karstique relief, the calcareous works as a non-permeable rock making possible a rich superficial drainage.

In the recent alluvium areas from the Vazante Formation, the drainage is less dense, perhaps reflecting an increase in the porosity of the rocks.

In the place where occurs more ancient terrains of the Brazilian Shield the drainage appears less dense in the images. This, however, does not totally reflect the reality. What happens is that in these regions it is difficult to obtain drainage details through the images which allows to map only the most important rivers. This is due to two facts: Firstly this region present itself covered by humid forest diminishing the contrast in the targets and this reduces the image resolution. Secondly, this is an area where the drainage branching is great, presenting small and narrow rivers, more difficult to be detected.

V.3.3 - Conclusions

By the drainage analysis using ERTS-1 images it is possible to conclude:

- The image provide information very close to reality, attaining a level of detail much better than the ones of the chart in the same scale.
- By the facility of drainage mapping, the ERTS-1 images are favorable to hydrical potential studies, as well as to the study of fluvial channels with the objective to plan river transport.

V.4 - DEMOGRAPHIC INFERENCE USING ERTS IMAGES

V.4.1 - Introduction

Among the different ERTS satellite image application possibilities, those concerned with demographic studies seem to be some of the most appealling.

In general it is possible to observe that urbanized areas in ERTS images are well defined which really facilitates the delimitation of these areas with fair accuracy. This fact inspired us to verify the viability of the ERTS images utilization in demographic inferences in the Brazilian territory.

At present, Brazil has approximately 100 million inhabitants, with a population growth of 2.9% per year, in the period of 1960-1970. Demographic Census are done here every 10 years, hence some appropriate techniques are necessary to estimate the population in the inter-census periods as well as to accompany the main urban expansion trends. Frequently it is noted that the Brazilian population is concentrated in highly populated agglomerations. The percentage of people living in clusters of more than 10,000 inhabitants has been increasing considerably in the last few years.

Due to the intense urbanization process presently occurring in Brazil it is necessary to keep track of the increasing growth rate within the urban areas as well as to monitor the expansion of the urbanized areas.

The frequent ERTS satellite data acquisition makes possible the detection of the urban expansion tendency and the observation of regional developments, making it possible to update regional planning related to urbanization studies.

Trying for the first time in Brazil to use ERTS images applied to population inference, this work verified the correlation existing between the data of urbanized areas, as infered from the images, and the respective population data, obtained in the last Brazilian Demographic Census (1970).

Images used in this work were selected according to their clarity in defining urban areas.

V.4.2 - Methodology

The data used in the development of this research were obtained by ERTS-1 Satellite MSS Sensor. Channel 5 (0.6 - 0.7μ) was used because it was the one which best identified urban areas. The urban areas present high reflectance in this channel compared with their surroundings. Through the radiation density cities could be delineated with a relative accuracy. An example of two utilized images in the work are shown in figures V.10 and V.11.

The scale of the images used in the determination of the urbanized areas was 1:500,000.

Cities were identified using 1:1,000,000 map of Brazil publisned by the I.B.G. (Brazilian Geography Institute).

The determination of city areas in the ERTS images was made with a planimeter. The arithmetic average of 5 area measurement was used.

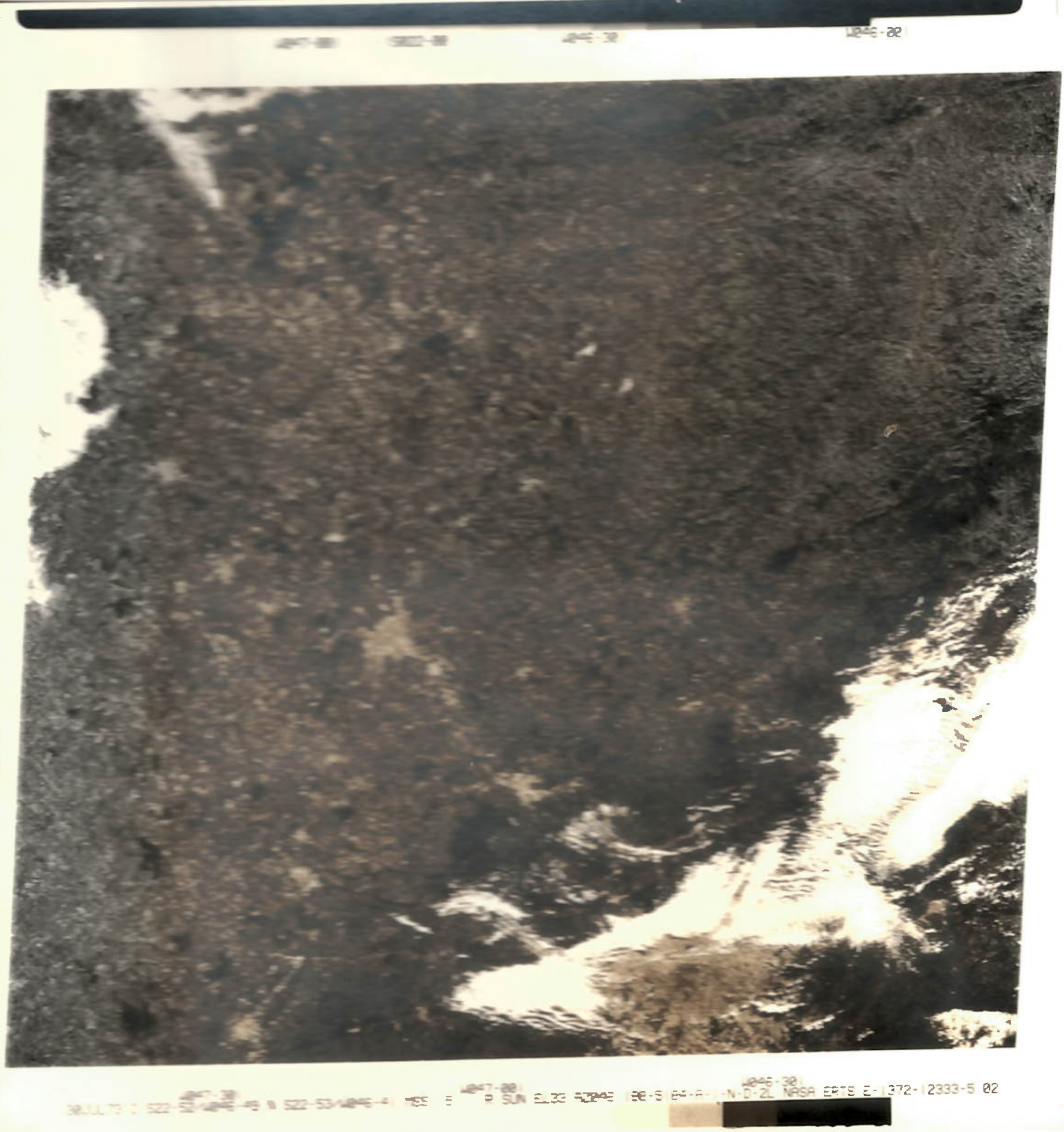


Fig. V.10 - ERTS image E-1372-12.333 - Channel 5.

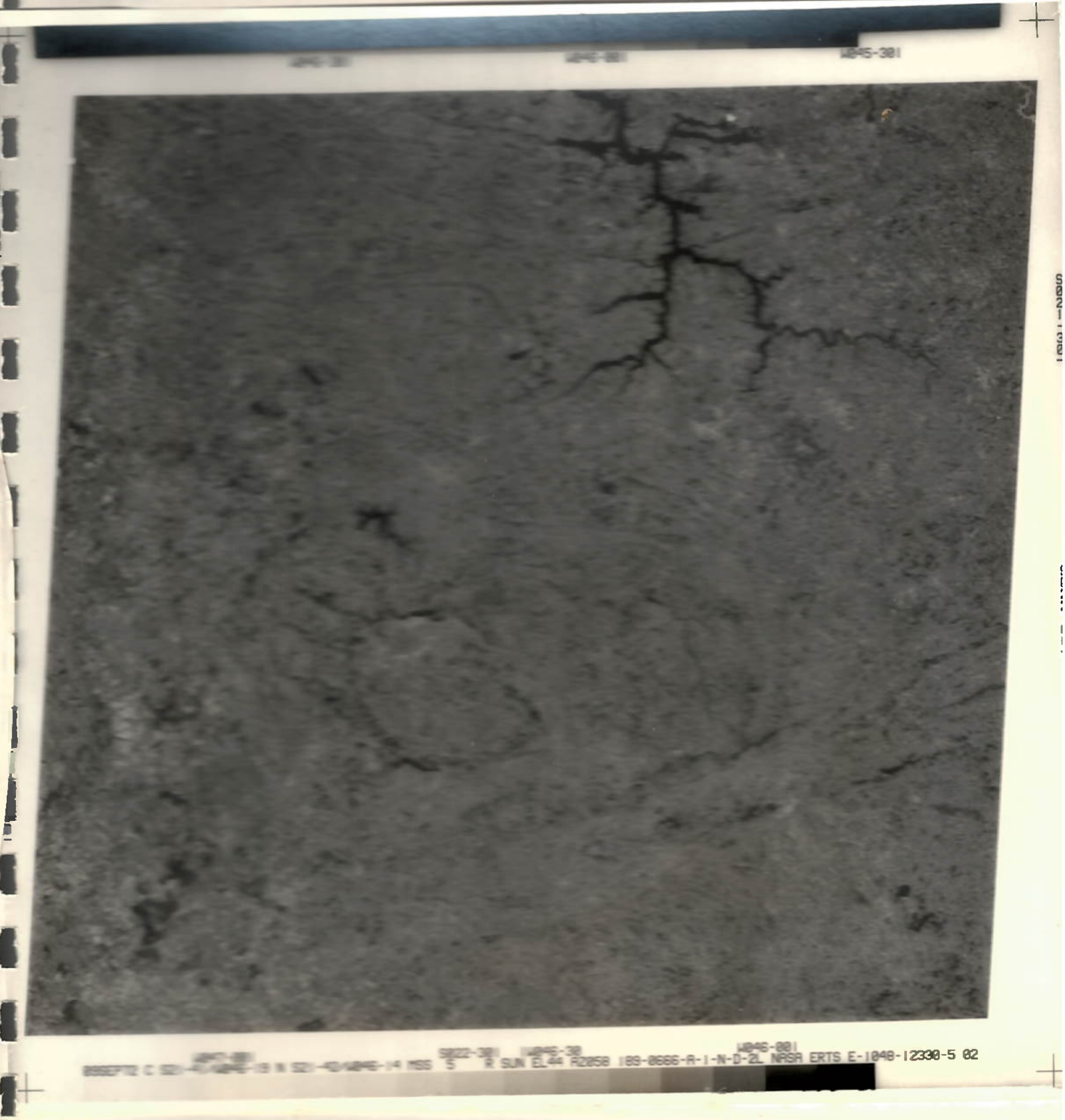


Fig. V.11 - ERTS image E-1048-12.330 - Channel 5.

The area data were correlated with official statistical population data of the Brazil 1970 Demographic Census.

As the first step to analyse the data an attempt was made to establish the correlation index between two variables: the area and the population. Then a linear regression was used in order to estimate the population corresponding to a given urban area. The next step was to apply the Student Test with 90% probability.

Intervals were established from the data obtained by the simple linear regression methods with a statistical distribution of population resulting for each area interval.

V.4.3 - Discussion of the Results

This work is still in the first phase of development and the results to be discussed here should be considered as preliminary ones.

From the ERTS images selected for analysis, 280 Brazilian cities were identified (Fig. V.12). A list was made with information about the place of each city by state, data on spatial area obtained from the images, and population totals acquired from the last Brazilian 1970 Demographic Census. The 280 Brazilian cities identified vary greatly with area ranges of 0.5 km^2 to 45.20 km^2 and population totals from 559 inhabitants to 185,000 inhabitants.

Fig.V.12 - Brazil map with the localization of the studied cities.

LIST OF THE 280 BRAZILIAN CITIES ALREADY STUDIED

NAME	STATE	AREA (KM²)	POPULATION
ABADIANIA	GO	1.60	985
ADAMANTINA	SP	4.10	21020
AGRICOLANDIA	PI	.50	1302
AGUA BRANCA	PI	2.80	5589
AGUA LIMPA	GO	2.40	672
AGUAI	SP	9.40	9508
AGUAS DE LINDOIA	SP	5.00	5362
AGUDOS	SP	4.80	11901
ALEXANIA	GO	4.80	2627
ALFENAS	MG	5.00	20806
ALTEROSA	MG	5.20	2856
ALTINOPOLIS	SP	10.40	5328
ALVORADA DO SUL	PR	1.00	3036
AMARANTES	PI	4.50	4410
AMERICANA	SP	18.00	62397
ANDRADAS	MG	2.60	7477
ANDRADINA	SP	9.00	43465
ANHANGUERA	GO	.50	943
APARECIDA	SP	8.00	23136
APUCARANA	PR	7.20	41900
ARACATUBA	SP	35.00	85560
ARAGOIANIA	GO	3.20	941
ARAGUARI	MG	34.40	48792
ARAPONGAS	PR	7.50	36478
ARARAS	SP	10.00	40945
ARARUAMA	RJ	1.20	8891
ARAUJOS	MG	2.00	2505
ARCOS	MG	4.80	9678
ARIZONA	GO	6.00	2766
ASSIS	SP	23.80	45531
AVANHANDAVA	SP	2.00	3733
AVARE	SP	5.60	29878
BACABAL	MA	8.20	29251
BAGE	RS	15.80	57036
BANDEIRANTES	MT	2.50	2522
BARRA MANSA	RJ	6.00	75006
BARRO DURO	PI	2.20	1875
BARROSO	MG	4.00	9003
BELA VISTA DO PARAISO	PR	1.40	7295
BETIM	MG	17.60	17571
BILAC	SP	4.00	2535
BIRIGUI	SP	9.50	27154
BLUMENAU	SC	6.00	85402
BOA ESPERANCA	MG	6.60	12003
BOITUVA	SP	2.00	5666
BOM DESPACHO	MG	8.20	18783
BOM JESUS DA PENHA	MG	1.40	638
BOM SUCESSO	MG	2.60	7846
BOTUCATU	SP	15.60	42252

NAME	STATE	AREA (KM^2)	POPULATION
BRAGANCA PAULISTA	SP	12.00	30573
BRUSQUE	SC	3.50	32127
BURITAMA	SP	2.50	5646
CACAPAVA DO SUL	RS	3.60	9596
CACHOEIRA DE MINAS	MG	1.80	1969
CACHOEIRA DO SUL	RS	5.50	50930
CACHUCHA	MA	2.00	1500
CAETE	MG	6.20	18524
CALDAS NOVAS	GO	3.70	2636
CAMBE	PR	3.20	13332
CAMBORIU	SC	6.50	2076
CAMBUQUIRA	MG	2.20	6688
CAMPO ALEGRE DE GOIAS	GO	1.60	578
CAMPO BELO	MG	11.00	20174
CAMPO DO MEIO	MG	2.60	3870
CAMPOS ALTOS	MG	8.20	5803
CAMPOS GERAIS	MG	5.00	6316
CANDIDO MOTA	SP	1.40	8837
CARAGUATATUBA	SP	4.30	10755
CARAVELAS	BA	5.40	3652
CARMO DA MATA	MG	2.80	4672
CARMO DO CAJURU	MG	3.80	3803
CARMO DO PARNAIBA	MG	5.80	10243
CASA BRANCA	SP	4.60	11660
CASTELO DO PIAUI	PI	2.60	4504
CATALAO	GO	24.20	15003
CATANHEDE	MA	1.20	1789
CENTENARIO DO SUL	PR	1.00	5914
CERQUEIRA CEZAR	SP	6.40	5900
CERQUILHO	SP	3.20	3978
CIANORTE	PR	4.80	22957
CONCEICAO DAS ALAGOAS	MG	4.40	5239
CONCEICAO DOS OUROS	MG	3.60	2023
CONCHAS	SP	1.00	4469
CORNELIO PROCOPIO	PR	8.00	25031
CORUMBAIBA	GO	4.40	2412
CRISTAIS	MG	2.80	2691
CRISTALINA	GO	7.60	5638
CROMINIA	GO	2.80	1523
CUBATAO	SP	12.00	37255
CUMARI	GO	2.60	2348
DIVINOPOLIS	MG	17.80	68872
DORES DO INDAIA	MG	1.90	12511
DRACENA	SP	20.00	23997
EDEIA	GO	3.20	2637
ELOI MENDES	MG	4.40	6789
ENCRUZILHADA DO SUL	RS	1.10	6706
ESPERANTINOPOLIS	MA	1.00	2276
FLORESTAL	MG	4.20	1645
FLORINEA	SP	3.30	1612

NAME	STATE	AREA (KM^2)	POPULATION
FORMIGA	MG	10.00	28719
FORMOSA	GO	6.80	12255
FRANCA	SP	36.60	86852
GARUVA	SC	4.00	1407
GOIANDIRA	GO	8.40	3517
GUAPO	GO	11.60	3579
GUARAMIRIM	SC	7.60	2289
GUARATINGA	BA	3.00	3122
GUARATINGUETA	SP	7.80	55069
GUARIROBA	GO	11.00	24392
GUAXUPE	MG	5.00	17319
HELIODORA	MG	2.60	1241
IBIPORA	PR	3.10	12391
IBIRACI	MG	1.20	2200
IGARATINGA	MG	3.20	1280
INDAIATUBA	SP	4.00	22359
IPAMERI	GO	24.80	11572
IPIXUNA	MG	1.80	2104
ITABIRA	MG	16.00	40143
ITABIRITO	MG	3.00	17469
ITAGUARA	MG	2.40	3258
ITAJAI	SC	11.00	54134
ITAMARAJU	BA	2.80	10689
ITAPECIRICA	MG	4.80	8757
ITAQUAQUECETUBA	SP	1.60	22094
ITATIBA	SP	3.00	20765
ITAUNA	MG	7.40	32731
ITIRAPINA	SP	3.60	4376
ITU	SP	13.00	35907
ITUIUTABA	MG	10.40	46784
ITUMBIARA	GO	5.60	29917
JACAREI	SP	2.10	48684
JALES	SP	5.40	21468
JANDAIA DO SUL	PR	1.60	1934
JAU	SP	6.40	40299
JOAO MONLEVADE	BA	16.80	38689
JOAO PINHEIRO	MG	3.80	8654
JOINVILLE	SC	38.00	77760
JUNDIAI	SP	41.00	145785
JUNQUEIROPOLIS	SP	7.30	8723
LAGOA FORMOSA	MG	4.20	3871
LARANJAL PAULISTA	SP	2.40	7509
LAVRAS	MG	16.20	35482
LAVRAS DO SUL	RS	1.20	3910
LEANDRO FERREIRA	MG	2.00	1038
LEOPOLDO DE BULHOES	GO	2.20	2119
LIMEIRA	SP	24.00	77243
LONDRINA	PR	24.00	156670
LORENA	SP	2.20	39665
LUTECIA	SP	6.20	1110

NAME	STATE	AREA (KM²)	POPULATION
LUZ	MG	5.60	7061
LUZIANIA	GO	5.60	9132
MAIRINQUE	SP	2.00	5723
MAIRIPOTABA	GO	2.80	790
MANDAGUARI	PR	2.40	11452
MARZAGAO	GO	2.00	684
MARIALVA	PR	7.60	6912
MARILIA	SP	26.24	73165
MARINGA	PR	15.00	51620
MARTINHO CAMPOS	MG	4.20	3478
MARTINOPOLIS	SP	3.00	8897
MATEUS LEME	MG	3.40	2851
MATOES	MA	.50	1020
MEDEIROS NETO	MG	2.80	869
MIRADOR	MA	1.70	973
MIRANDOPOLIS	SP	4.40	11033
MOCOCA	SP	6.80	21082
MOEMA	MG	1.60	2450
MOGI DAS CRUZES	SP	26.00	90330
MONCAO	MA	2.00	1965
MONTANHA	ES	2.60	9461
MORRINHOS	GO	5.10	14100
MUCURICI	ES	1.80	1337
NANUQUE	MG	5.20	34714
NEPOMUCENO	MG	3.40	6396
NOVA ODESSA	SP	3.80	6260
NOVA SERRANA	MG	1.00	2507
NOVA VENEZIA	ES	2.40	9417
NUCLEO BANDEIRANTES	GO	8.00	11133
OLIVEIRA	MG	8.80	18557
OURO FINO	MG	3.40	9122
OUVIDOR	GO	2.00	705
PACAEMBU	SP	3.70	5935
PALMEIRAS DE GOIAS	GO	3.20	5847
PAPAGAIOS	MG	5.60	3121
PARA DE MINAS	MG	5.40	24071
PARACATU	MG	18.20	17453
PARAGUACU	MG	12.20	7114
PARAGUACU PAULISTA	SP	6.00	13318
PARAIBUNA	SP	3.80	4991
PARANAGUA	PR	16.00	51519
PARQUE GAMA	GO	18.50	71556
PASSA TEMPO	MG	1.40	3251
PASSOS	MG	13.80	39184
PEDREIRAS	MA	6.00	19539
PEDRO LEOPOLDO	MG	6.20	11856
PENAPOLIS	SP	13.50	24597
PERDIGAO	MG	1.00	1995
PIAUI	MG	2.80	11960
PINDAMONHANGABA	SP	1.70	28213

NAME	STATE	AREA (KM^2)	POPULATION
PINHAL	SP	4,00	18172
PINHEIROS	ES	1,60	8336
PIRACEMA	MG	1,00	1463
PIRACICABA	SP	18,40	125490
PIRAPEMAS	MA	1,20	2469
PIRES DO RIO	GO	11,30	13362
PITANGUI	MG	3,40	8687
PLANALTINA	GO	5,00	18484
PLATINA	SP	5,00	667
POCAO DE PEDRAS	MA	1,40	3735
POCOS DE CALDAS	MG	12,00	51844
POMPEU	MG	5,20	7991
PONTE NOVA	BA	5,00	28665
PORECATU	PR	3,60	7261
PRADOS	MG	6,80	3045
PRESIDENTE PRUDENTE	SP	25,00	91188
PROMISSAO	SP	14,00	15262
RESENDE	RJ	10,00	25517
RIBEIRAO DAS NEVES	MG	3,60	3808
RIBEIRAO DO PINHAL	PR	3,00	5369
RIO BONITO	RJ	4,40	16724
RIO CLARO	SP	20,00	69240
RIO DAS PEDRAS	SP	1,60	5021
ROLANDIA	PR	4,60	19302
RUBINEIA	SP	6,40	1419
SALTO	SP	13,00	19060
SANTA BARBARA	SP	5,20	22358
SANTA BARBARA	GO	1,40	932
SANTA CRUZ DE GOIAS	GO	2,60	559
SANTA INES	MA	4,40	14805
SANTA ISABEL	SP	3,30	9231
SANTA LUZIA	MG	7,20	13090
SANTA MARIA	RS	35,00	120667
SANTA RITA DO SAPUCAI	MG	3,20	11606
SANTA TEREZINHA DE GOIAS	GO	3,40	1262
SAO BENTO DO SUL	SC	5,20	9406
SAO BERNARDO	MA	3,00	1331
SAO FRANCISCO DO SUL	SC	2,80	12868
SAO GABRIEL DA PALHA	ES	1,10	6572
SAO GONCALO DO SAPUCAI	MG	3,80	10186
SAO GOTARDO	MG	2,20	7515
SAO JERONIMO DA SERRA	PR	2,00	1209
SAO JOAO DA BOA VISTA	SP	23,00	33051
SAO JOSE DO RIO PARDO	SP	7,80	16425
SAO JOSE DOS CAMPOS	SP	33,90	130118
SAO JOSE DOS PINHAIS	PR	5,20	21184
SAO LOURENCO	MG	2,60	18124
SAO PEDRO DA ALDEIA	RJ	1,80	5249
SAO PEDRO DO PIAUI	PI	2,80	2287
SAO ROQUE	SP	3,80	16474

NAME	STATE	AREA (KM²)	POPULATION
SAO SEPE	RS	2.10	7602
SAO TOME DAS LETRAS	MG	1.60	630
SERRANIA	MG	4.80	2303
SIDROLANDIA	MT	2.40	2220
SOBRADINHO	GO	10.00	30008
SOROCABA	SP	40.00	165000
SUMARE	SP	1.60	11731
TAGUATINGA	GO	15.00	106320
TAPIRATIBA	SP	4.80	2338
TATUI	SP	5.20	30805
TAUBATE	SP	12.00	98233
TEIXEIRAS	MG	2.00	2876
TERESINA	PI	31.80	185000
TERRA ROXA	PR	3.00	5906
TIETE	SP	4.00	10602
TIMON	MA	7.60	16038
TRES CORACOES	MG	6.00	25707
TRES PONTAS	MG	4.20	14209
TRES RANCHOS	GO	4.40	1023
TUPA	SP	7.80	34763
TUPACIGUARA	MG	6.00	12400
UBATUBA	SP	7.00	8834
UBERABA	MG	45.20	108576
URUTAL	GO	6.40	1575
VARGINHA	MG	7.50	36447
VERISSIMO	MG	8.80	841
VESPASIANO	MG	4.20	5287
VICOSA	MG	4.60	15552
VINHEDO	SP	4.80	7417
VOLTA REDONDA	RJ	22.00	122645
VOTUPORANGA	SP	11.60	29128

With the application of the correlation coefficient to the variables, areas and population, the obtained index was 0.80 which indicates a relatively high correlation between the two variables.

The Dispersion Diagram (Fig. V.13), shows a linear dependence between area and population. The dispersion from linearity observed for some points in this figure probably indicates a peculiar space expansion of these cities with respect to its population distribution. In these cases some parameters should be taken into account, such as: regional localization, topographic characteristics, functional and economic characteristics of the city, etc.

Later on, with the application of the simple linear regression statistical method it was possible to classify the area and the population in intervals, resulting for each area interval a statistical population distribution. About 21 classes were obtained as shown in Table V.1.

These classes were established in order to infer the population of a given sample area.

The results obtained for the less populated cities are quite different from the more populated ones. For the less populated cities the relationship between their areas and respective population was found to be quite linear. However this linearity does not exist for the most populated areas. Table 1 displays the area intervals used in this work. The corresponding classification and population data are also shown

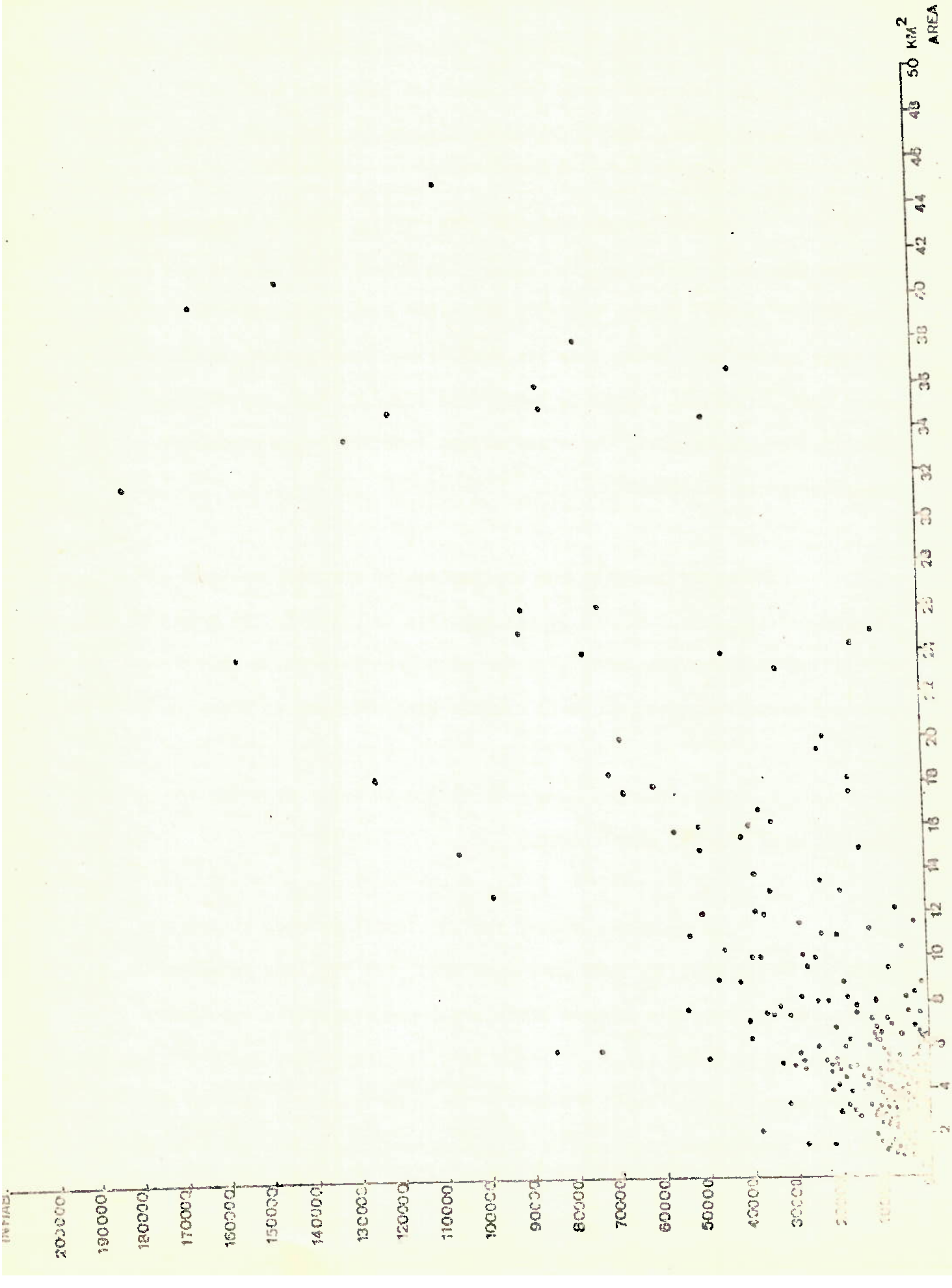


Fig. V.13 - Dispersion Diagram.

in Table 1 and in Figure V.14.

These results (although relatively good for the population estimate can be considerably improved if more samples are considered. There is the need of data collection for a larger quantity of cities, and also the need of other parameters which influence the geographical expansion of the cities. Parameters such as regional localization, kind of relief, economic and functional characteristics should be analized and computed in order to obtain more precise results in demographic inference.

Based on these preliminary results one concludes that the ERTS images really offer great potential in demographic studies and in tracking the expansion of urban areas. However in the case of demographic inference more precise results are necessary and could perhaps be obtained in a further phase of this research.

The next phase of this research will be developed utilizing the IMAGE-100 GE equipment. Through this equipment more precise results of the urban areas will be obtained. Other parameters interfering in the urbanization process will be used in this second research phase. The objective of this investigation will be the reaching of models to permit the inference of urban areas population with the best possible precision grade.

TABLE V.1

CLASSES	AREA	POPULATION	CITIES NUMBER
1	0 to 2 km^2	0 to 6,838 inhabitants	49
2	2.1 to 4 km^2	2,941 to 12,702 "	77
3	4.1 to 6 km^2	9,222 to 18,653 "	57
4	6.1 to 8 km^2	15,720 to 24,710 "	29
5	8.1 to 10 km^2	21,801 to 25,322 "	14
6	10.1 to 12 km^2	28,365 to 37,135 "	11
7	12.1 to 14 km^2	33,654 to 43,466 "	7
8	14.1 to 16 km^2	41,775 to 49,847 "	6
9	16.1 to 18 km^2	45,228 to 56,262 "	5
10	18.1 to 20 km^2	50,958 to 62,702 "	5
11	20.1 to 22 km^2	61,787 to 69,158 "	1
12	22.1 to 24 km^2	64,628 to 75,626 "	4
13	24.1 to 26 km^2	68,034 to 82,103 "	4
14	26.1 to 28 km^2	73,818 to 82,881 "	1
15	30.1 to 32 km^2	89,552 to 100,920 "	1
16	32.1 to 34 km^2	95,486 to 107,740 "	1
17	34.1 to 36 km^2	96,899 to 111,314 "	3
18	36.1 to 38 km^2	103,113 to 121,065 "	2
19	38.1 to 40 km^2	112,711 to 127,568 "	1
20	40.1 to 42 km^2	115,534 to 130,819 "	1
21	44.1 to 46 km^2	127,394 to 144,481 "	1

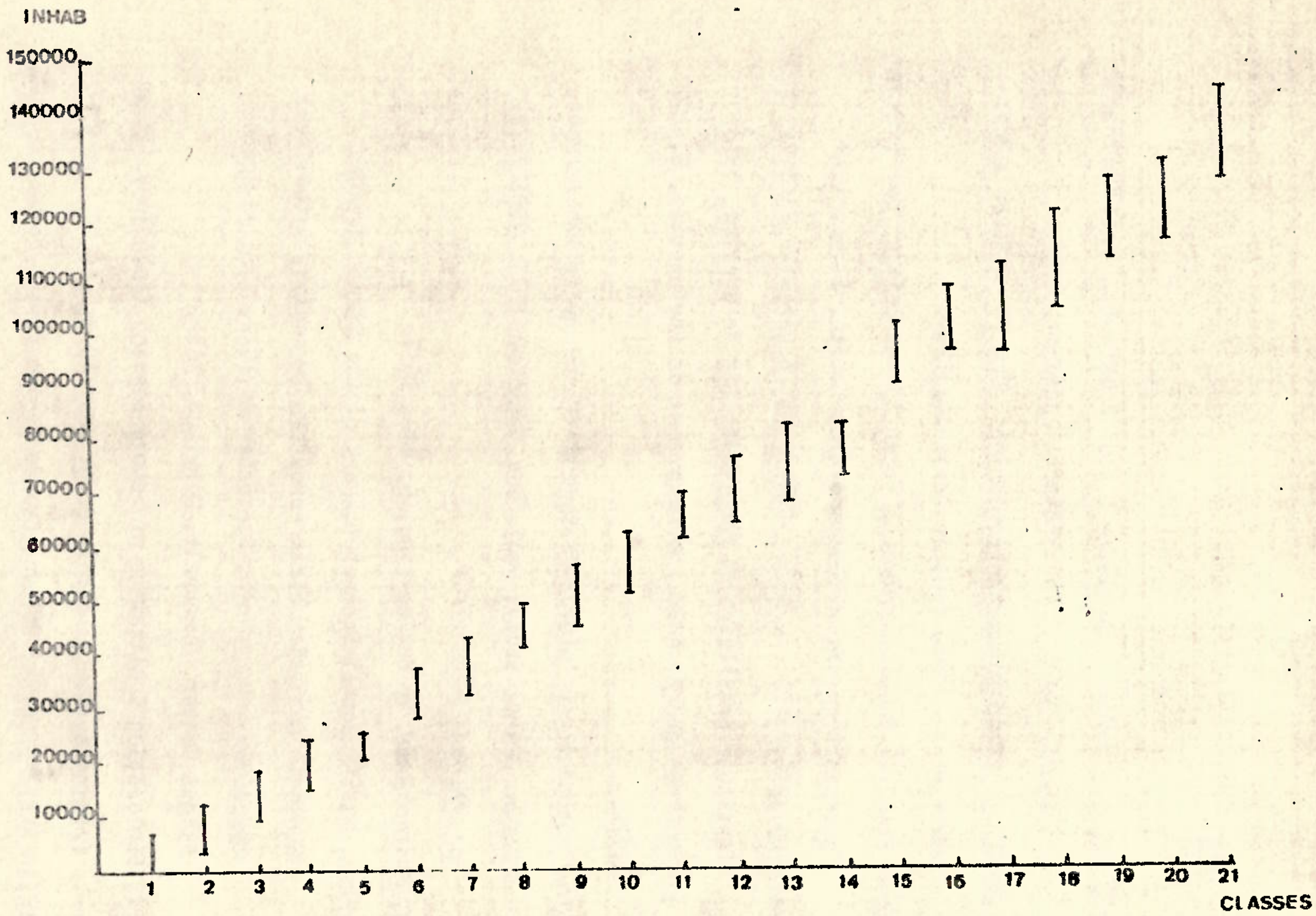


Fig. V.14 - The vertical bar represents the probability of 90% of the population interval for a given class (area).

V.5 - BIBLIOGRAPHY

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND 20771

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

1916

REPLY TO
ATTN OF: Code 902

MAY 28 1975

Dr. Fernando de Mendonca
Director General, I.N.P.E.
C.P. 515 - Sao Jose dos Campos
Sao Paulo, Brazil

Dear Dr. de Mendonca:

In accordance with the Provisions for Participation in the NASA LANDSAT (ERTS) Project, a review was made by the Scientific Monitor of the drafts of the Type III Final Reports which represented the completion of the Institute for Space Research's (INPE) multidisciplinary program for the study of LANDSAT imagery. The volume of the reports demonstrated that an in-depth study of the utility of this imagery was made. It was noted that the large amount of information produced by the three Principal Investigators was screened and combined into a single report. This is an excellent mechanism for cataloging the relevant results of the INPE program. It effectively demonstrated the outstanding contribution of the Brazilian investigators to the LANDSAT program.

In his review of the Volume I, Chapter II, SEA RESOURCES (CF Emmanuel Gama de Almeida) investigation, the Scientific Monitor stated that it was a complete, well prepared and well organized report with an appropriate format that adequately addressed each of the objectives outlined in the original proposal. The report gives a good introduction to the investigation and touches lightly on the interaction of LANDSAT, Nimbus, Apollo-8, and Skylab video data products. Elaborate background information is supplied for each study area. Excellent use is made of transparent overlays on the LANDSAT images. The major detriment in this chapter is the lack of an introductory map of Brazil showing the locations of the five test sites.

Unfortunately, there are a number of content deficiencies that should be corrected before the Final Report is submitted. These are:

- Page 27 to 30: Reference is made several times to MSS channel 4, 5, and 6 imagery but only a channel 5 image is included in the text. In fact, channel 5 imagery is duplicated on pages 24 and 28. Is this in error?

- Page 45, first paragraph: Last sentence, "1500 m" should read "15.00 m".

o Page 45, third paragraph: Author refers to oceanic tides of the "daytime kind". Author probably means "diurnal - a tide having only one high water and one low water each tidal day (every 24.84 hours)".

o Pages 56, 57, and 59: Reference to Fig. 11.20 and 11.22 is made by stating the acquisition date of the image, 26 June 1973. Reference to this illustration should be by Fig. number. Near bottom of page 56, reference to this Fig. is 26 July 1973. One of these must be incorrect.

o Page 62, Paragraph II.3.1: The first sentence in this paragraph needs clarification.

o Page 76, Paragraph II.3.5.3: Reference is made to a blowup of Guanabara Bay showing river discharges. No LANDSAT image is included to show this important result.

o Page 81, third paragraph, line 3: "the <u>isoline</u> of <u>35%</u> surface salinity" should be "ischaline of 35 0/00 "since salinity is measured in parts per thousand (0/00).

o Page 88, third paragraph: Reference is made to items B, C, and D in Fig. II.32 but not to item A.

In his review of the Volume I, Chapter III, MINERAL RESOURCES (Dr. Gilberto Amaral) investigation, the Scientific Monitor stated that it represented a detailed and well illustrated report with an appropriate format that addressed most of the objectives outlined in the original proposal. An objective not addressed was the proposed study of the "main geotectonic units of central and southern Brazil and their relation to known mineral deposits". No discussion of the application of the structural data to these mineral deposits was made. In addition, no information regarding the "establishment of the best parameters for aircraft mission planning for specific problems" was presented.

In addition, there are some content deficiencies that should be corrected before the Final Report is submitted. These are:

o Page 114, line 12: The sentence "The main differences..." is not a complete sentence.

o Page 114, line 22: "geologists <u>who</u> have"

o Page 115, line 8: "impl<u>emen</u>tation of software..."

o Page 117, line 19: "... <u>has</u> surveyed..."

- Page 117, line 20: "... were spent for the acquisition of the imagery alone."
- Page 122, line 7: "... diagnosis..."
- Page 123, line 9: "...maintenance..."
- Page 123, line 11, 12: "costs about US $0.15 while the... have cost about..."
- Page 123, line 16: "cost/effectiveness ratio... when compared with the SLAR ratio.
- Page 123, line 21: "Cambrian age"
- Page 125, line 3: "...the previously available map."
- Page 126, line 11: "...geological community."
- Page 126, line 14: "...cost/effectiveness..."
- Page 126, line 18: Should read: "Only conventional photo-interpretation techniques were used."

APPENDIX III

- Page 13, line 15: "different"
- Page 25, line 10: A period should follow "differentiation." The next word, "they" should be the first word of the following sentence.
- Page 25, line 19: "fine grained", "graywackes"
- Page 26, line 2: "are mainly dates"
- Page 26, line 11: "argillaceous", "siltstone"
- Page 27, line 1: "Ladeira et al", "designated"
- Page 28, line 7: "graywacke and arkosic sandstone."
- Page 31, line 3: "...separated mainly by tonality;..."
- Page 31, line 12: "...are in unconformable contact with..."

- Page 32, line 21: "It is unconformably overlying the units mentioned above."

- Page 33, line 1: "The area north of the Furnos Dam belongs to..." (no comma needed).
- Page 34, line 16: "thoroughly"

No reference is made to Plate 2 in the text. Also, the plates are referred to in a random order (Plate 3, Palte 1, Plate 1, Plate 4, etc.). Additionally, the plates should follow immediately after the first reference to them, rather than being grouped together at the end.

Map 1 should follow after the first reference to it on page 20. Likewise, Map 2 should follow directly after on page 31.

In his review of Volume II, Chapter IV, SOIL RESOURCES (Dr. Fernando de Mendonca) the Scientific Monitor stated that this report completed the analyses relevant to the stated objectives of the investigation. The investigation went a long way in identifying promising and economical applications of remotely sensed earth resources data in the field of agronomy. Technical details in the form of LANDSAT imaging illustrations, overlays, and maps were amply provided. In addition, the usefulness of LANDSAT imagery in other discipline areas of land use and demographic studies was explored. Unfortunately, the study is labeled as preliminary because of the absence of ground truth data.

The content deficiencies that should be corrected before the Final Report is submitted are:

- Page 141, Paragraph IV.2.4.3.6: This statement needs clarification.

- Page 145, Paragraph IV.2.5.3.4: This statement needs clarification.

- Page 149, Fig. IV.7: Only 4 area types are described in the Legend although 6 area types are discussed in the accompanying text.

- Page 150, Fig. IV.8: No reference is made to this Fig. in the text.

- Page 151, Paragraph IV.2.6.3.2: This statement needs clarification.

- Page 155, Paragraph IV.2.7.2.3: There is a discussion of the Parana River but it is not designated in Fig. IV.9.

- Page 161, Paragraph IV.2.8.2.5: This statement needs clarification.

- Page 177, line 16: Refernece to Fig. IV.20 should be Fig. IV.21.

- Page 179, Section IV.3.2.2.1 Legend: It is unfortunate that the terms "cerrado", "cerradao", etc. were not defined earlier in the text.

Will you kindly consider incorporating these comments into your draft before submitting eight (8) copies of the Final Report to:

Goddard Space Flight Center
Greenbelt, Maryland 20771
Attn: Scientific Investigation Support
Code 902.6

Sincerely,

James C Broderick

James C. Broderick
LANDSAT Technical Monitor