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**LAND USE PROGRAM - CIAT**



**COLLABORATORS**

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EMBRAPA

## **OBJECT**

To assist in the selection of one or two study areas in which CIAT, EMBRAPA, state agencies and local agencies can collaborate in an integrated approach to land use research, development and increasing profitable agricultural production while protecting the environment for the future.

## Foreword

This has been one of the most challenging studies of my career. I wanted to do it this way because I was convinced during collaborations with Dr. Simon Carter (then at CIAT) that the objective approach to regional classification was possible and had many merits. The troubles of lack of data, data inconsistency and plain human error in the complex analysis were not entirely unforeseen - just underestimated. The result has been delayed by half a year.

The computational facilities used were minimal, but I do not consider that these were the main problem. I think that if things had been easier to compute, many errors of data and algorithm would have slipped by us.

I believe that we now have a workable classification. This can be improved in the future using better data and drawing on the techniques that we have developed.

I wish to thank my coauthors; Mauricio Rincon and Luz Amira Clavijo at CIAT, my collaborators Jamil Macedo at CPAC and Beatrice Pinheiro at CNPAF. We are all grateful to Daniel Robison, Ignacio Sanz and other members of CIAT who have listened patiently to problems and allowed the solutions to emerge.

Finally, I wish to thank Mrs. Maria Luiza Guimaraes and Dr. Eicio Perpetuo Guimaraes for the translation of this manual into Portuguese.

P.G.Jones. July 1992.

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## AREA CLASSIFICATION AND MAPPING FOR THE CERRADOS REGION OF BRASIL

### INTRODUCTION AND SUMMARY

The Cerrados region is a large area in central Brasil covered with a varying pattern of grassland vegetation types interspersed with forests, both seasonal and dry. While the area is often referred to as a natural region there is considerable variation in soils, climate and land use. Historically, the main land use has been extensive cattle grazing but this is changing rapidly in many areas, not infrequently detrimental to the agricultural environment.

CIAT and EMBRAPA are interested in integrated studies of these processes to assist the move towards sustainable production increases in these areas. The present study is an attempt to subdivide the region and to start to describe the physical and ecological constraints.

While it is possible for agricultural scientists to impose an a priori classification on an area (the normal approach to land use capability), this subsumes a number of prejudices inherent in the specialists drawing up the classification. The present is an effort to step back from the techniques of farming or range management and to try to produce an objective classification based on available secondary data. Of course, it is recognised that the mere selection of the variates is a subjective matter. Because of this they have been kept as simple as possible.

Data on soils, landform, climate and land use were combined by sampling from GIS images, in a factor analysis. These factors were then reapplied to the

original GIS images and the images of the principal factors were obtained. Meanwhile the sampled points were subject to a cluster analysis to obtain an objective clustering of the land characteristics of the region. This process was iterative and went through review in March 1992 with colleagues from EMBRAPA.

The final clusters were recalculated as GIS images from the factor images to provide a complete mapping of the region in 18 clusters.

Collaboration with CPAC and CNPAF identified 12 centroids of areas of potential interest. These were chosen using previous EMBRAPA experience and the preliminary maps produced in CIAT. The task then set for CIAT was to describe these twelve case study areas from the limited data available and to try to put them into context for the cerrados as a whole.

As will become obvious, many data were not available for the whole area studied. Due to this, a secondary study of climate similarity was made using the CIAT Climate database. A map showing the regions of climate similarity to the 12 chosen areas was prepared. In the document that follows the classes resulting from the secondary data factor analysis and clustering techniques will be denoted 'CLASSES' and those resulting from the climate similarity analysis will be denoted 'CASES'.

The final classified CLASSES were mapped over the areas of interest denoted as CASES and the existence of each CLASS was measured by area. The result of this was that seven of the eighteen CLASSES could be discounted as constituting less than 10% of the area of any CASE area. This resulted in only eleven CLASSES remaining as significant in the analysis.

The document attempts to give a summary of the 12 CASES, the most

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important of the 11 CLASSES and a short exposition of their relationship and spatial importance in the cerrados.

CIAT does not presume, in this document, to prescribe particular CASE areas, but merely tries to elucidate the areas involved, their communalities and differences. Nonetheless it would appear that some clear indications do emerge.

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## OBJECTIVE CLASSIFICATION

This analysis incorporated data from many sources which can be broadly classed as Climate, Physical and Land Use.

### **1. CLIMATE DATA**

A digital elevation model (DEM) was constructed for the window 1°S 62°W to 24°S 37°W which includes all of the study area. The model was fitted at a pixel<sup>1</sup> size of 2 minutes (approximately 3.7km at the equator, somewhat less in longitude further south in the study area.)<sup>2</sup>

The method used for constructing the DEM was that of Hutchison (1989). Selected contours were digitized from the Carta do Brasil ao milionésimo and spot heights taken from the ONC 1:1,000,000 charts. Stream lines were taken from World Data Bank II (CIA 1977). Since the latter states that the nominal scale of digitization was 1:3,000,000 it was felt justified in producing the final classification maps at this scale. Extra point heights were added from the meteorological station records existing in the CIAT Climate database.

Mean monthly data were interpolated to this 2' grid by the method of inverse square weighted distance, correcting all temperatures to sea level and readjusting them to the value of the DEM using the lapse rate model developed in CIAT based on data from Riehl (1979).

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<sup>1</sup> A pixel is the picture element, in this case 2'x2' or 3.7km, a square of information.

<sup>2</sup> Note - all calculations were made in geographic coordinates (LAT-LONG) and all areas calculated were corrected for latitude.

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For each pixel in the image the potential evapotranspiration was calculated month by month by the method of Linacre (1977).

The number of growing season months (rainfall greater than 60% evaporation) was calculated (NRAIN). Rainfall total in the wettest month (RMAX) was recorded with the following estimates of temperatures.

- (TM) Minimum Temperature of the coldest month.
- (TX) Maximum Temperature of the hottest month.
- (TMEAN) Mean Temperature during the growing season.
- (TDIFF) Diurnal Temperature range during the growing season.

This gave six estimates of climate which could be of general importance to agriculture in the areas. CPAC had independently estimated the incidence of Veranicos in the Cerrados area and those data were useful in the final analysis.

## **2. LAND SYSTEM DATA**

At the start of this study, CIAT did not have a digitized version of the 1:1,000,000 soil map of Brasil. We are acquiring some coverage, but this will take time. The 1:5,000,000 map was recently digitized but lacked the correlation with soil properties that would be needed for such a quantitative study. We therefore fell back on the Land System Study (Cochrane et al 1984) produced in conjunction with EMBRAPA.

There are serious deficiencies in the coverage of this study as you will note from the maps produced. However the ease of producing data that mean something in terms of land type cannot be denied. We decided to use the most simple of the variables from the TTC database.



We had to digitize the original 1:1,000,000 sheets and somehow account for the many conflicts of nomenclature. I feel that in the end we have probably reduced the errors in the region of the cerrados to acceptable levels. This means that we can be reasonably sure of the type of landform and soil within the areas covered.

The digitized map sheets were rasterized to the 2' grid. The following variables were extracted from the newly digitized database, all as percentage of land covered by each property:

(ACID)	Proportion of land area with soils with pH less than 5.3.
(ALUM)	Proportion of land area with soils with aluminium saturation greater than 70%.
(PHOSP)	Proportion of land area with soils with high phosphorus fixation.
(FLAT)	Proportion of land area with well drained soils with slope less than 8%.
(ROLL)	Proportion of land area with slopes greater than 8%.
(SAVANNA)	Proportion of land area covered by savanna vegetation.
(DRAIN)	Proportion of land area covered by poorly drained soils.

### **3. LAND USE DATA FROM CENSUS 1970-75-80**

The municipal boundaries of Brasil were digitized at scales from 1:350,000 to 1:2,000,000 from the state road and political division maps (see list of maps). Different versions had to be used for different years of the census data. Census data from the Censo Agropecuario do Brasil were coded for the years 1970, 1975 and 1980. These data included:

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		Variable name
A	Census area	AREAS
B	Natural woodland	BOSNA
B	Planted woodland	BOSPL
B	Natural pastures	PASNA
B	Sown pastures	PASPL
B	Annual crops	CULTE
B	Permanent crops	CULPE
B	Fallow land	TIEDE
C	Head of cattle	GANBO
C	Population (men and women) employed in agriculture.	HOMOC, MUJOC

The data were assigned to the municipio images in the following manner:

- A. **(Census Area)** as proportion of the geographic area of the municipio as measured on the digitized image.
- B. **(Land Use data)** as proportion of the census area.
- C. **(Population, human and cattle)** as head per square kilometre.

Digitizing was done throughout the study using ATLAS/DRAW. Image processing by IDRISI (Eastman 1989). All images were produced by rasterizing to a 2' grid (pixels 3.6km on a side) in a window of 1°S to 24°S and 62°W to 37°W.

As IDRISI is much more efficient in processing single byte image data, much of the above were scaled to lie between 0 -255. This was an acceptable precision given the origin of the data and the scale of the final maps.

The Census data were converted by image overlay (thus avoiding the problems of change of municipio boundaries) into a set of average figures for 1970 - 1980 and a set of trends 1970 - 1980.

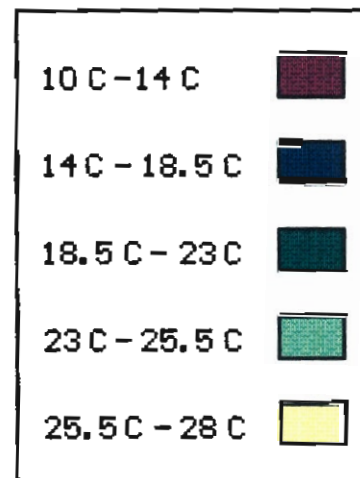
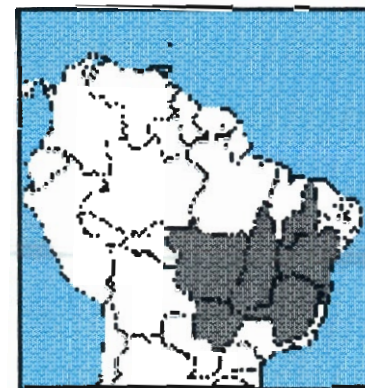
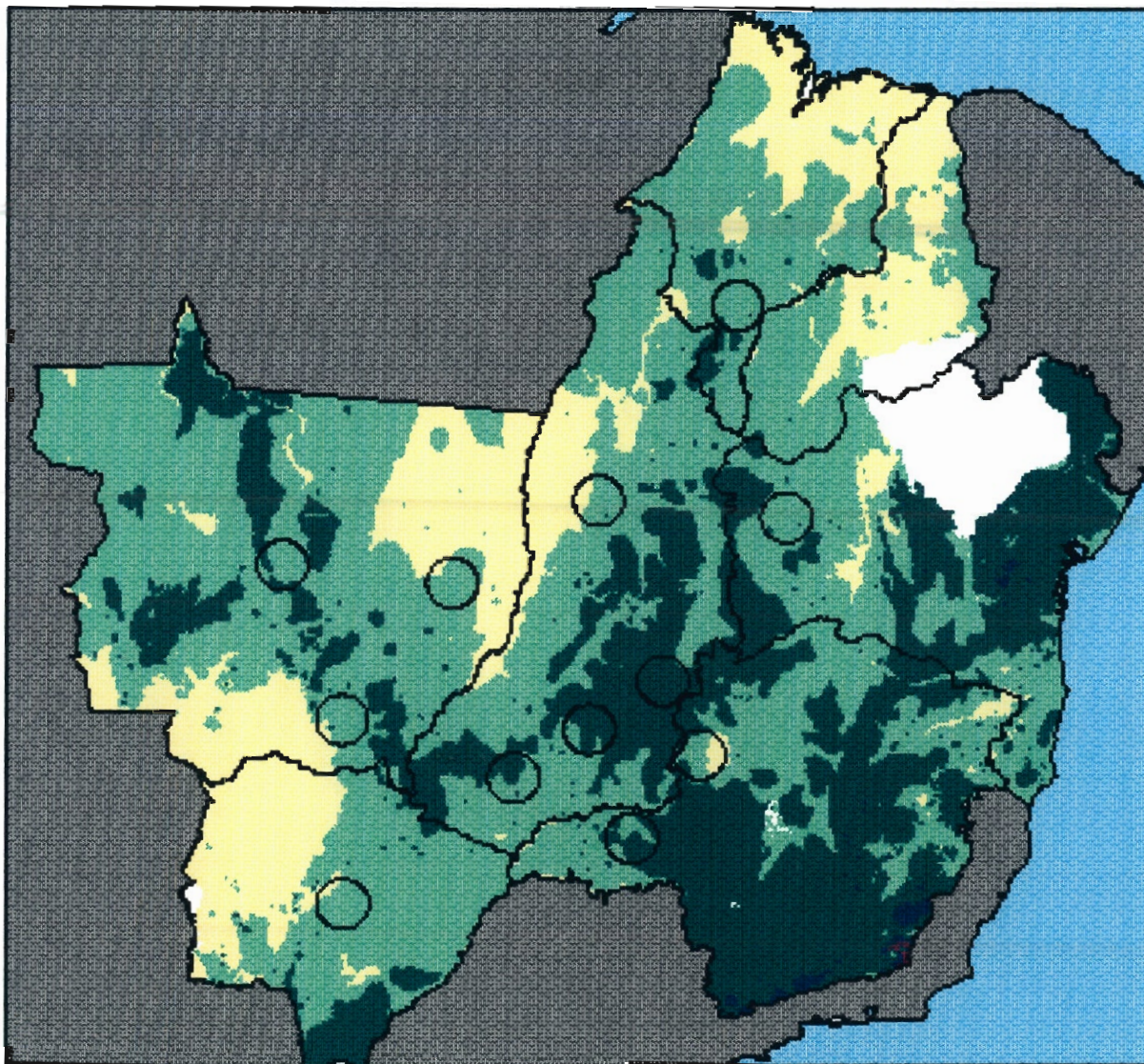
This gave four groups of data:

6 Variates for Climate	(CLIM)
7 Variates for Soils/Terrain	(LAND)
11 Variates for Mean Census data 70-80	(MEAN)
11 Variates for trends in Census data	(DIFF)

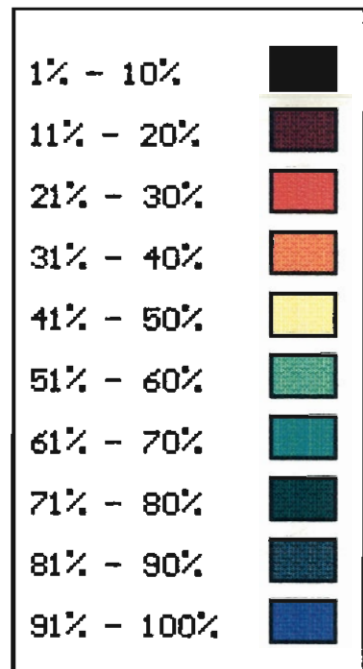
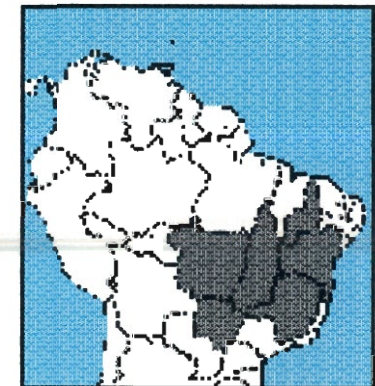
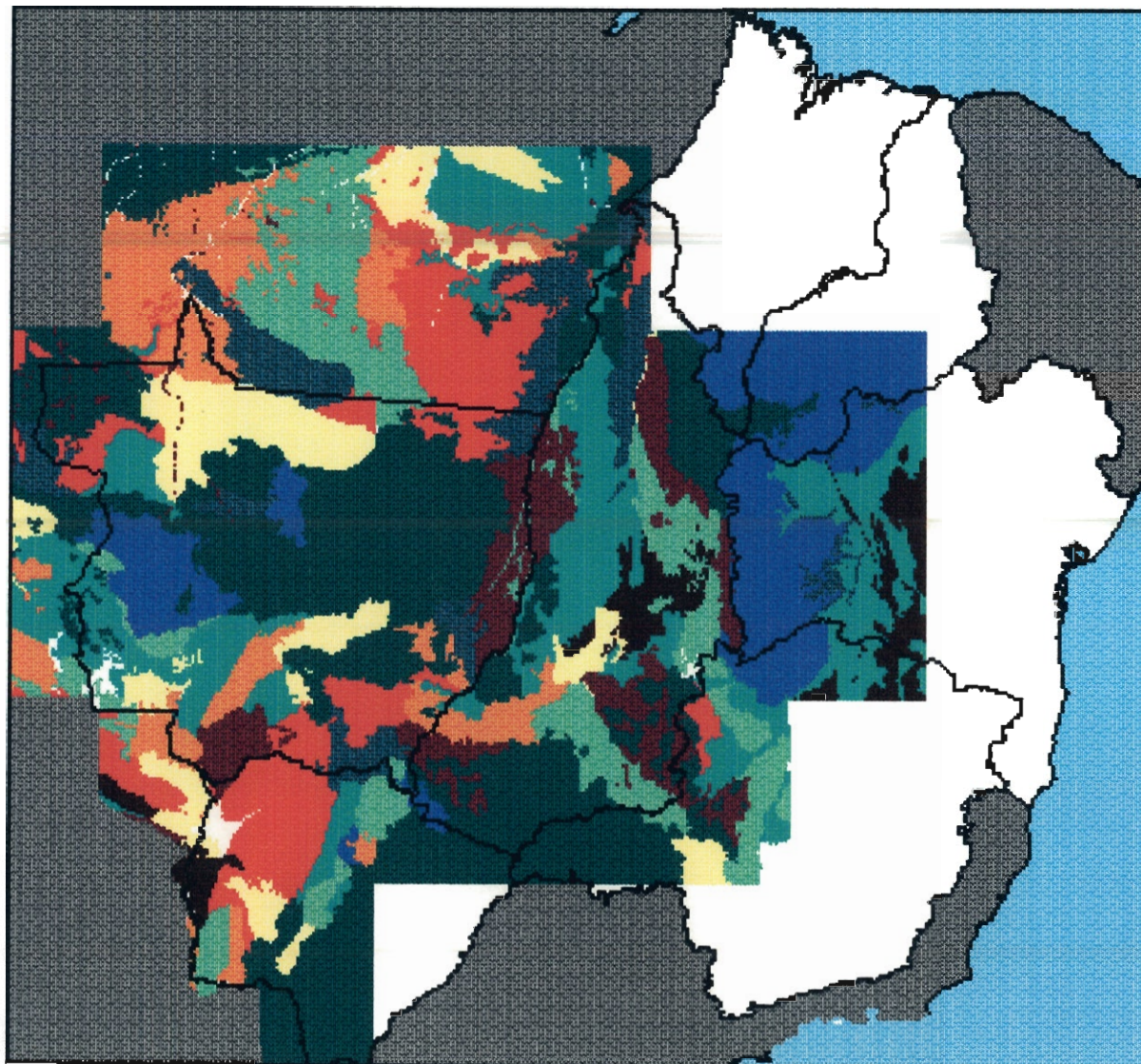
A random sample of 4000 pixels was prepared from the complete image of the window. This sample was then masked to exclude all points falling outside the study area. This was originally the states of Maranhao, Piaui, Bahia, Goias (before division of Tocantins), Minas Gerais, Mato Grosso and Mato Grossos do Sul. We had grave doubts about the compatibility of some census data from Maranhao in 1970 and felt it best to eliminate these data from the study. After consultation with our colleagues from EMBRAPA it was determined to restrict the study to the official boundaries of the cerrados as shown in the CPAC map of incidence of veranicos in January.(CPAC 1991). This reduced the sample points to still a very representative random sample and not to be influenced by environments in which we were not interested. Points falling in legally protected areas were also eliminated.

Restrictions of the land system study of CIAT/EMBRAPA (Cochrane et al 1984) further reduced the sample points for analysis to 1639 points from the original window. This was somewhat of a disappointment because one of the areas of interest fell outside the window of full data. More of this later.

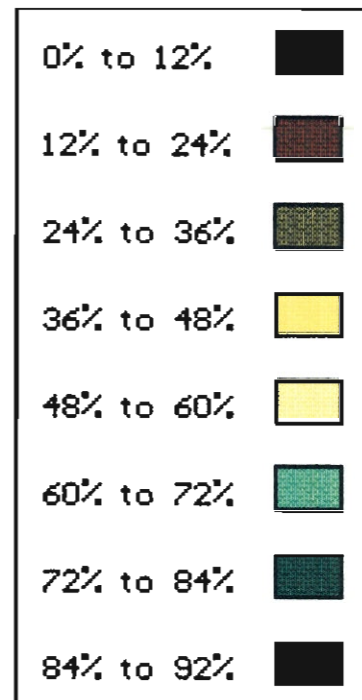
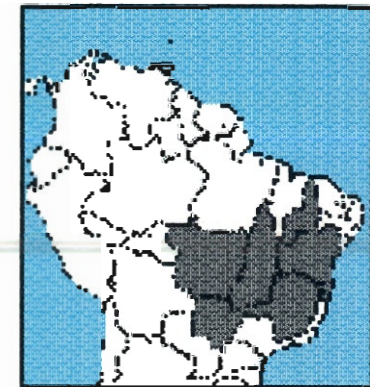
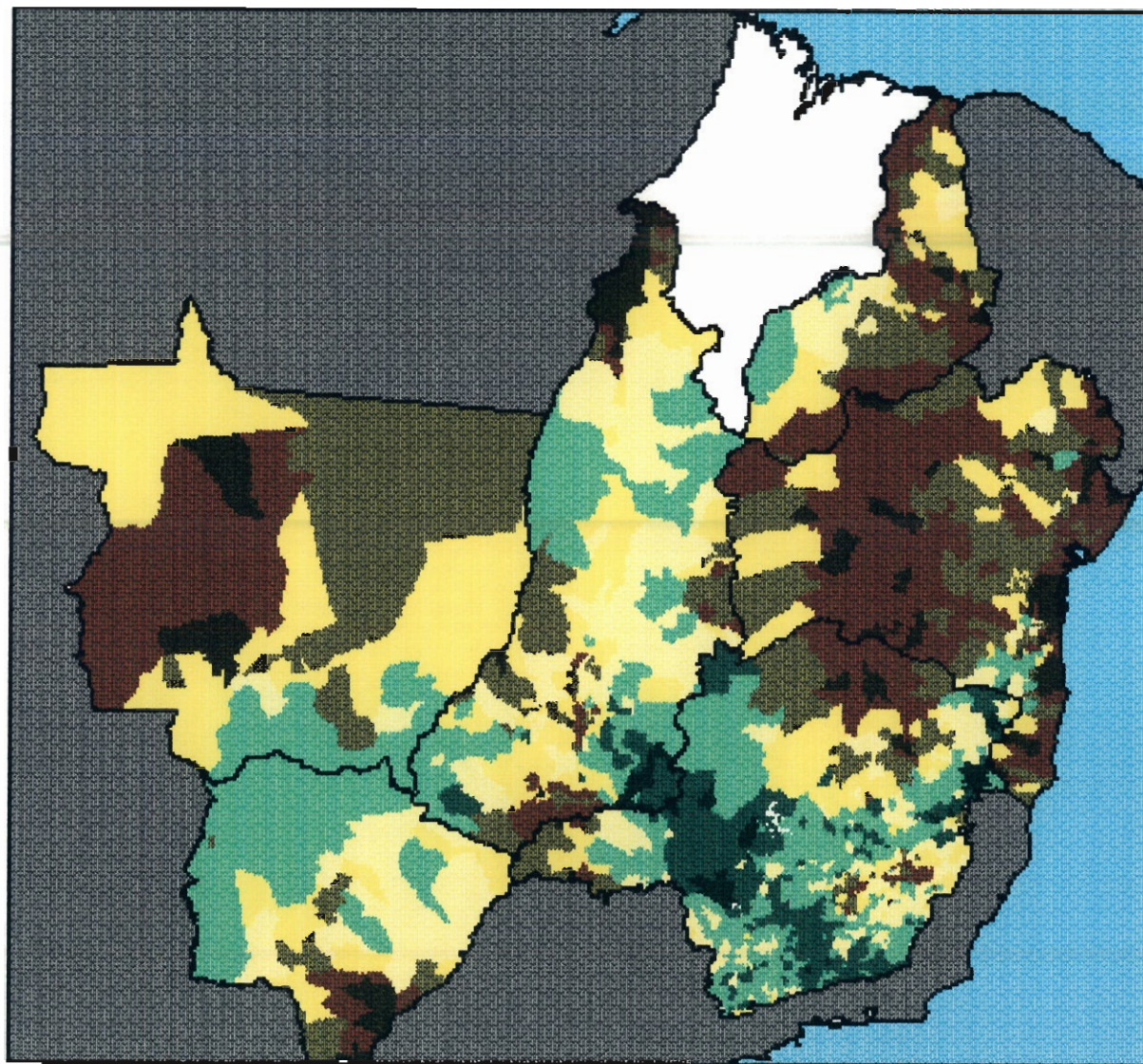
Data from each of the images in the four groups of data type (Climate, terrain, land use, land use trend) were extracted for the sampled pixels.



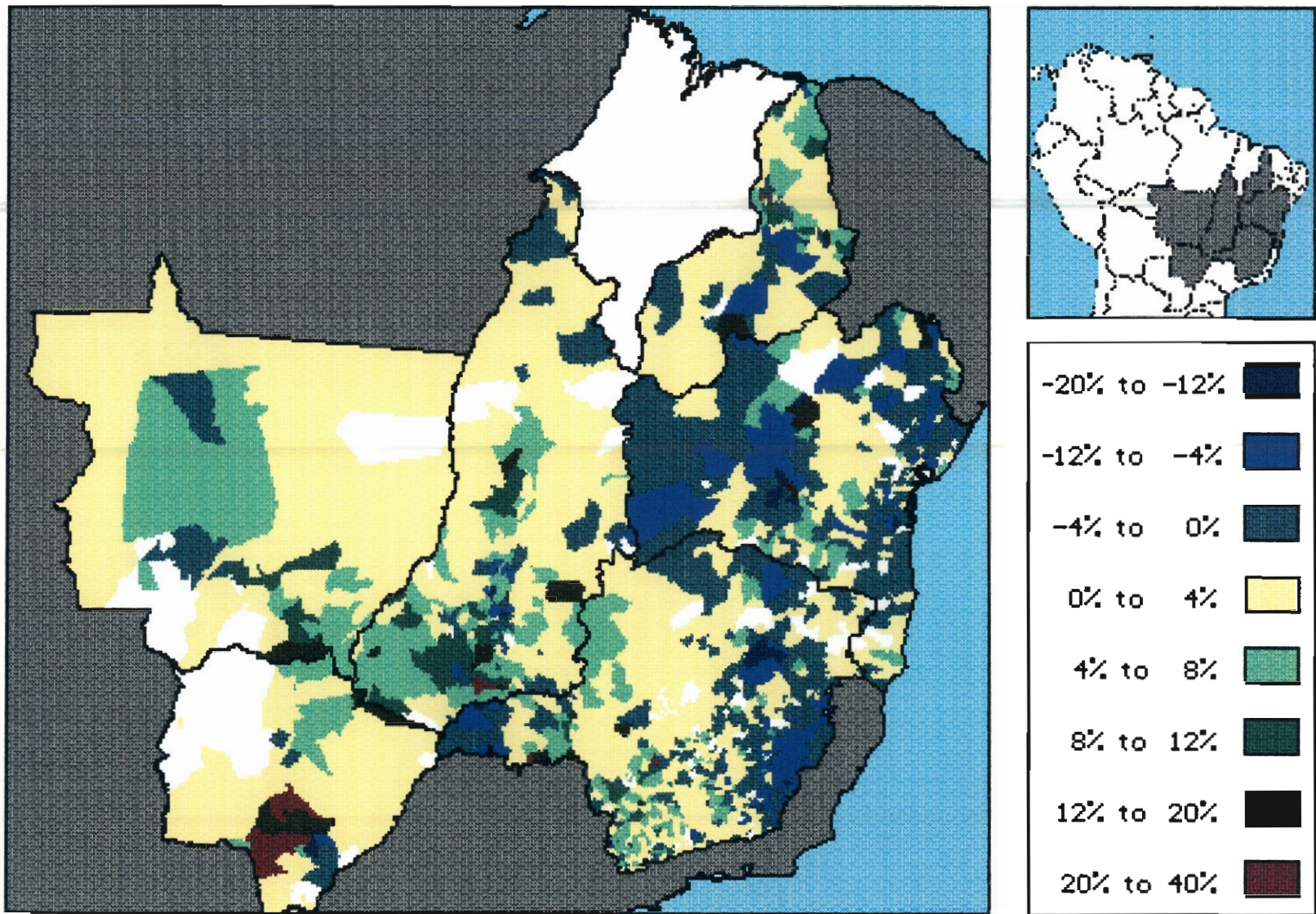
Mean temp. during growing season



Flat potentially cultivable lands (T-planas)



Average percentage natural pastures



Trend in annual crops

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A few examples of the original data images follow.

The first shows the mean growing season temperature as interpolated to the digital elevation model. The second is the percentage of the land area covered by well drained land with slopes less than 8%. Although the image title is 'potentially cultivable' it does not take into account factors other than slope or drainage. The third shows the average percentage of the census area that was occupied by natural pastures during the years 1970-80. The fourth gives the change in the percentage of the census area used for annual crops between 1970 and 1980. Note that the census area also changed between these years.

#### **4. OTHER DATA**

Other images prepared were an updated image of access via all weather roads and an image of legally protected areas, national parks, forest reserves, indigenous reserves etc. The former was rasterized from updated files digitized from the latest Brazilian roadmaps. The latter rasterized from the ongoing database on protected areas maintained in CIAT. (Robison 1992).

#### **5. FACTOR ANALYSIS**

The four declared data groups (although not necessarily known to be independent or orthogonal) were individually subjected to factor analysis using Genstat (1987). A principal components analysis was performed on the standardised variates in each group. The proportion of the variance accounted for by the first three variates in each group was inspected. It usually accounted for from 60 to almost 90 percent of the variance in each case (see Appendix 1).



We decided to use the first three factors in each data class obtained after varimax rotation to give the most simple way of recombining the GIS images of the basic variables. This gave 12 Factor images. The details of the calculation of these images is presented in Appendix 1.

The equations for the standardised factors were used to recombine the original variate GIS images to produce images of the 12 factors. This helped to check the analysis and understand where we were going. It also helped to put some common names on some of the factors. This is useful but not always possible in factor analysis, the geographic representation, as well as the interpretation of the factor equations was enlightening and reassuring.

As seen in Appendix 1, some of the factors can be confusing. However, the first shown here is quite clear, although as is common in factor analysis the signs are arbitrary. It is an overall 'temperature factor' (CLIM1), integrating the four measures put into the analysis.

The second illustration we have denoted a 'topography factor' (LAND2). This appears to be positive for preponderance of flat cultivable lands but of course ignores other factors.

The Development Factor is quite clear, it includes the proportion of the municipio reported in the census among other data. The pattern is intuitively correct for 1970 - 1980. How interesting it would be to produce a time series of this factor for all of Brasil, or even all of Latin America.

The 'Land use trend' factor is much more difficult to interpret. It may stem, in part from differences in methods of taking census. It is not simply a measure of intensification. This could be inferred more clearly from the trend in annual crops as

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shown in the original data. Nevertheless positive values for the Distrito Federal, Paracatu, Uberlandia and around Campo Grande may be indicating this.

## 6. CLUSTER ANALYSIS

The four independent factor groups were weighted following discussions with the collaborators. It was decided, in view of the uncertainty of some of the census data to give extra weight to the more stable climatic and landform data. Thus the set CLIM was given a weighting of 3, LAND a weighting of 2 and MEAN and TREND left with weightings of 1 each. This slightly favoured the climate data over that of landsystem and census in a ratio 3:2:2.

The sample points converted to their weighted factor values were then clustered using the procedure FASTCLUS of SAS. 30 clusters were obtained. The cluster means were then used as input to a further cluster analysis to determine the relationship between them. This was done with GENSTAT and a cluster dendrogram obtained. This assisted in the inspection of the primary clusters and a number were discarded for obvious reasons. In some cases the clusters were spurious due to missing data, in some we could discard them as having no significant savanna vegetation. The poorly drained lands fell into two distinct clusters which were discarded. Some of the remaining clusters were so close in the dendrogram that they were aggregated. The clusters around Barreiras were such a case and two closely similar clusters were combined. In hindsight this may have been a mistake - see CLASS descriptions below.

The result of this analysis and inspection was a set of 18 CLASSES of environment. The separate map at 1:3,000,000 show these classes.

### Choice of 12 Potential CASE Study Areas

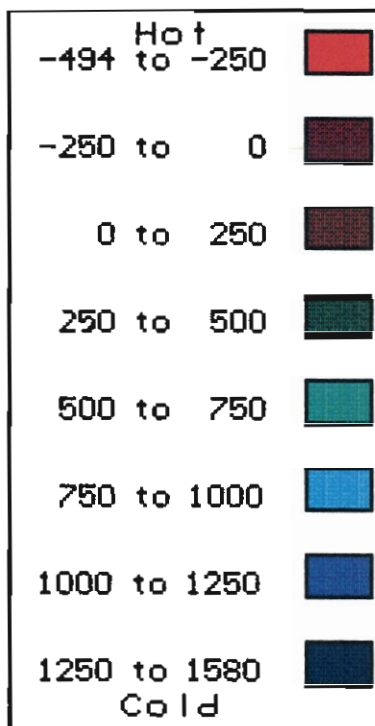
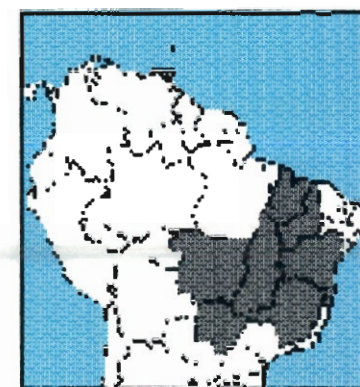
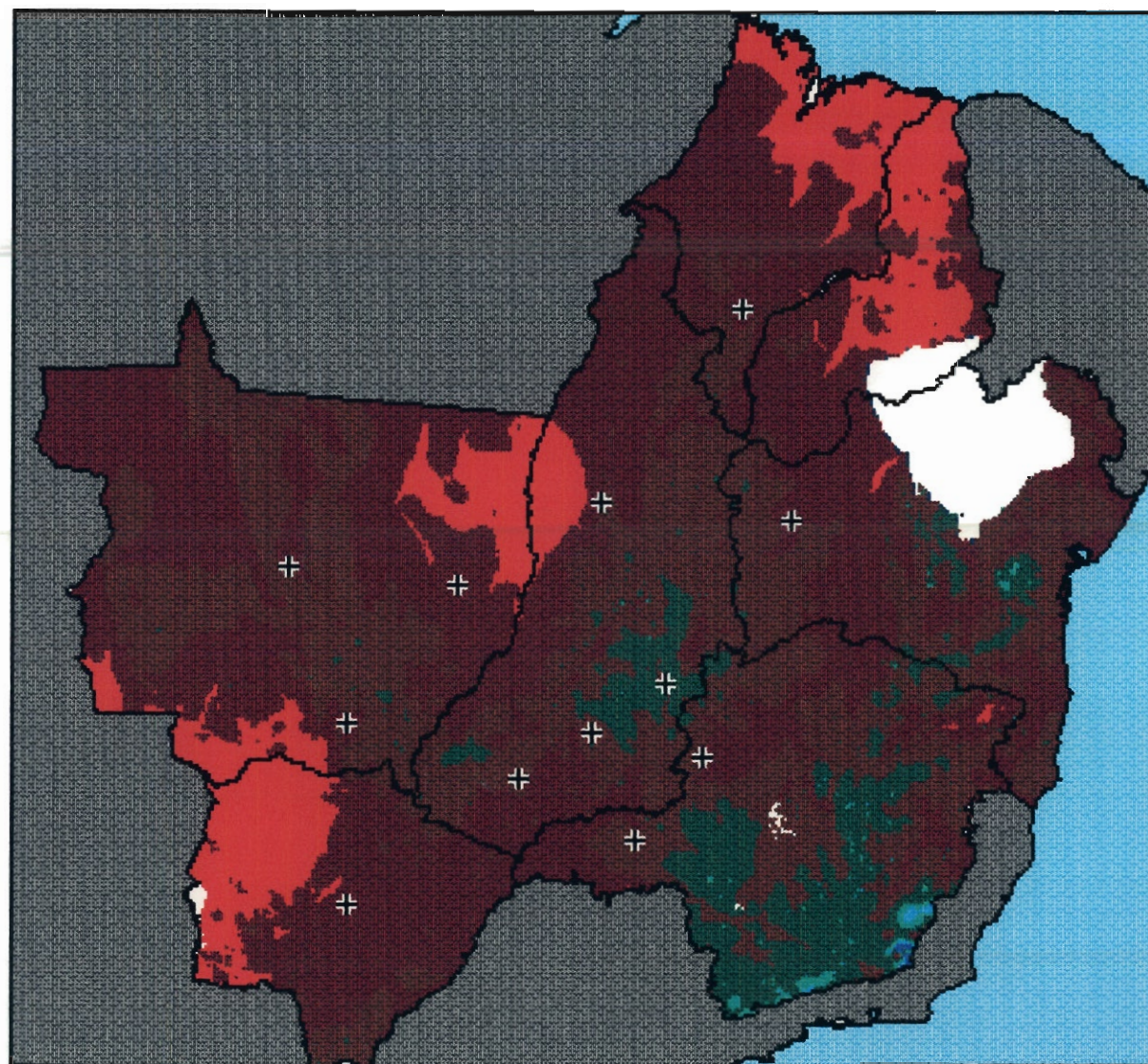
In March 1992 the first phases of the clustering analysis were still under way. Problems with the data, the factor weightings and errors in the algorithms were such that the tentative results and maps presented in the first draft to the meeting of collaborators were wildly erroneous.

However the meeting successfully determined the guidelines for the factor weightings reported above and more importantly designated a series of areas of special interest. Using the basic information available at that time, 12 points were designated as the centroids of potential case study areas. The following map shows their locations.

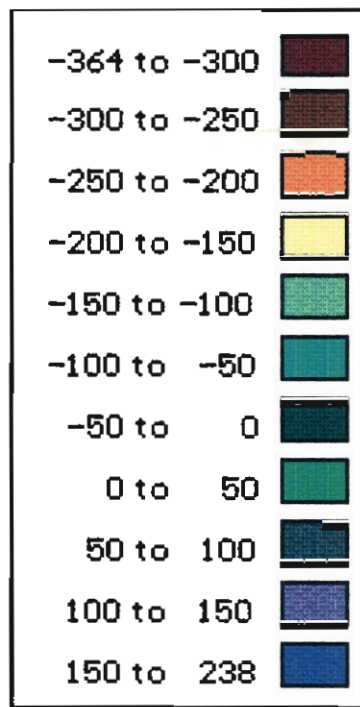
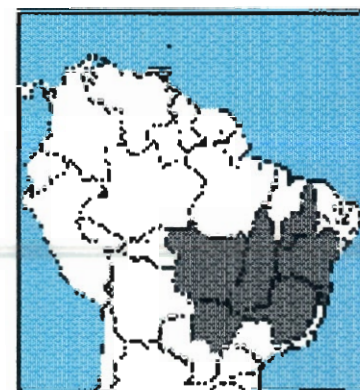
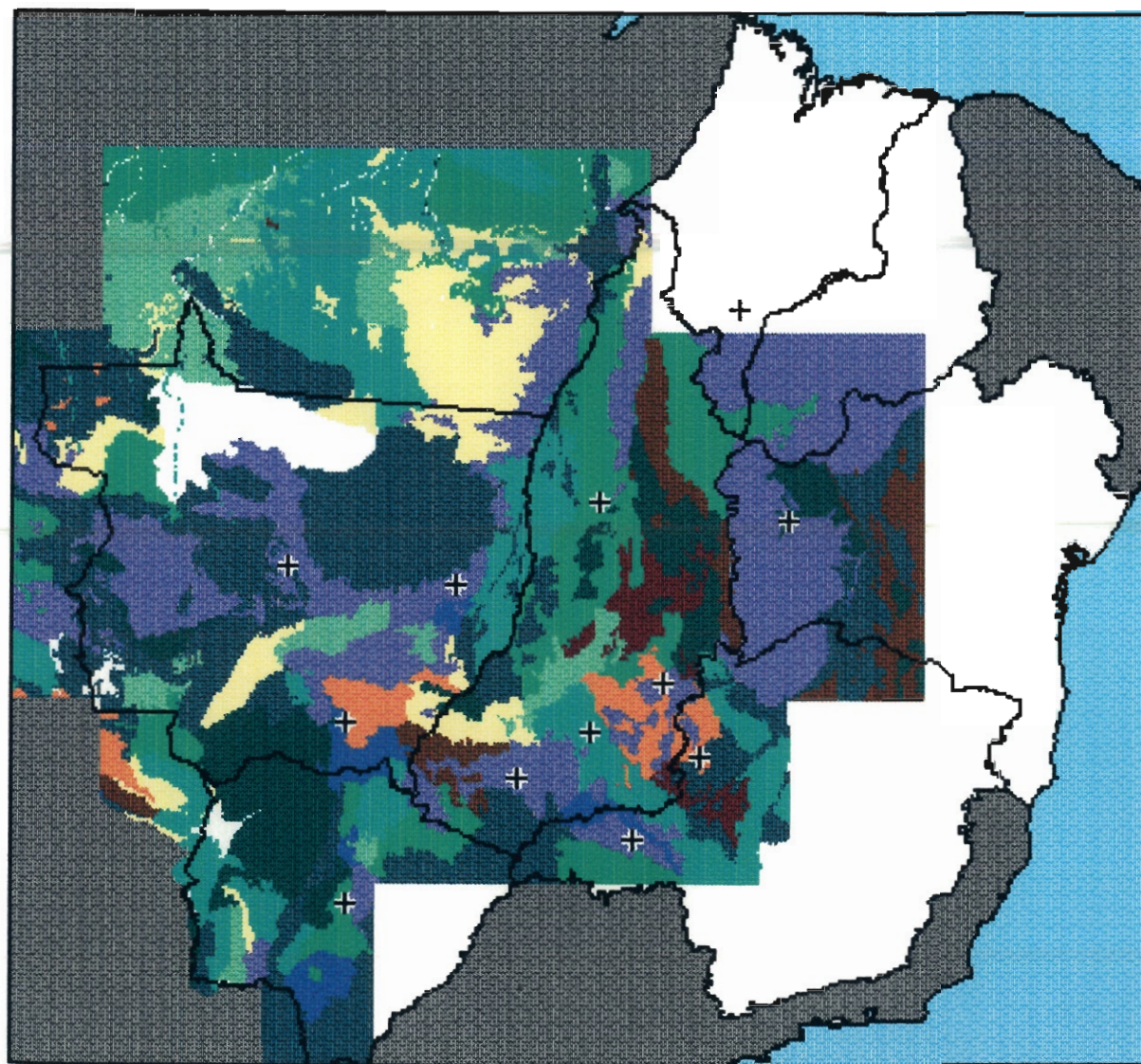
It was decided to circumscribe a circle of 60km radius around each designated point. This rather arbitrary figure is not an estimate of what should be the case study area but stems from two completely pragmatic considerations, the area in the circle is a little over 10,000km<sup>2</sup> and the diameter of the circle approximates that of a Landsat image. Both of these are realistic measures for a successful rapid rural survey of the area and also give a scale which is reasonable for the mounting of a reasonably detailed spatial model in a geographic information system.

This is not to say that the final study area might be much more or much less depending on in depth analyses of the area.

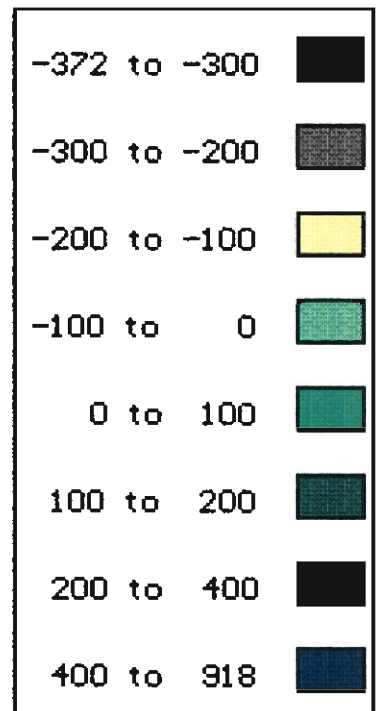
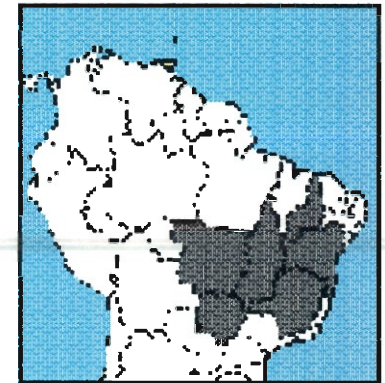
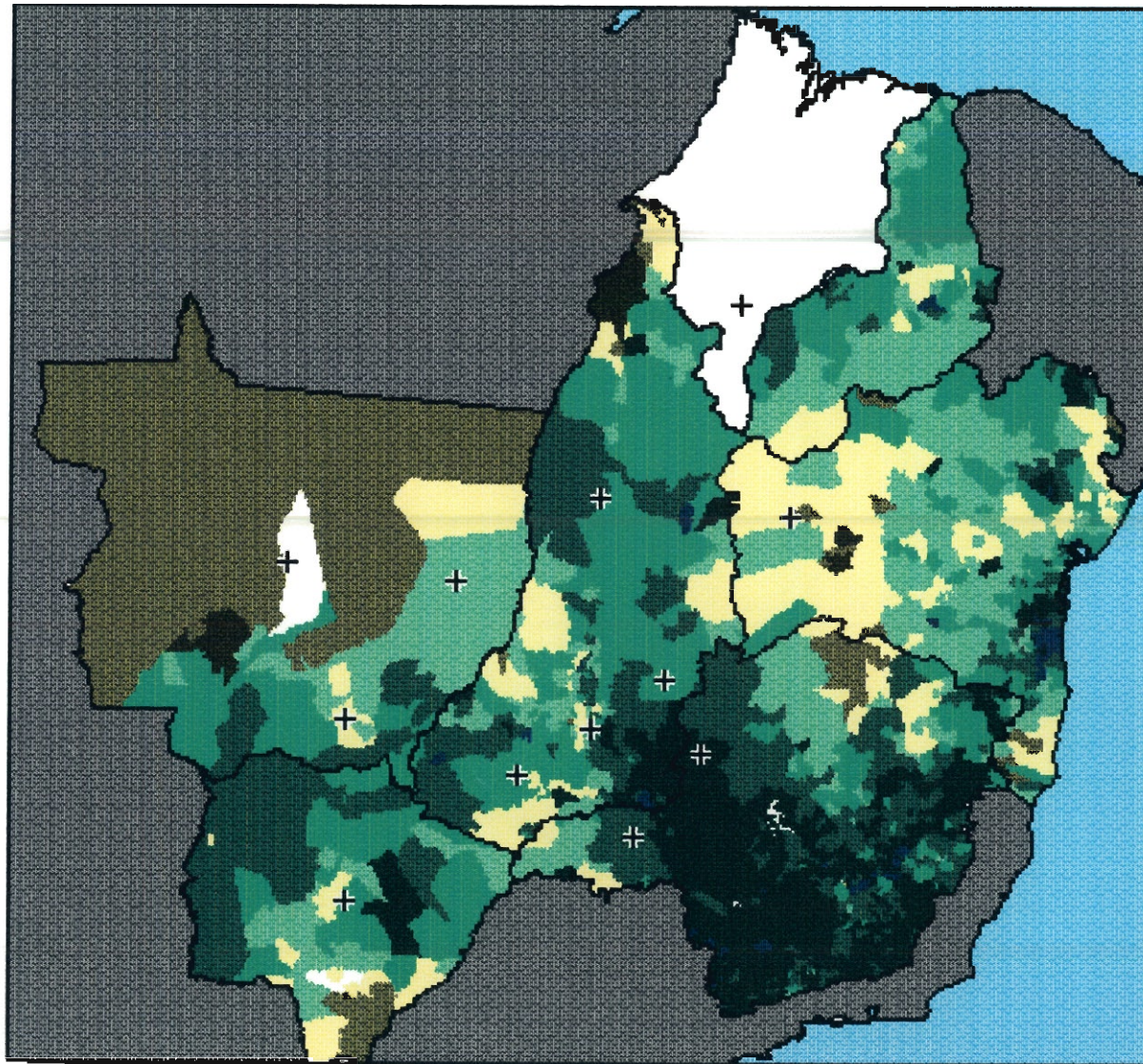
Descriptions of the 12 CASE areas are found in Appendix 2. The data available at CIAT are adequate (but not perfect) for climate, landform, soils and to some extent vegetation. The crop production data are not up to date and therefore little weight is placed on them in the descriptions. We hope that our collaborators in CPAC and CNPAF will be able to supplement the actual landuse and production data at the meeting in Brasilia.



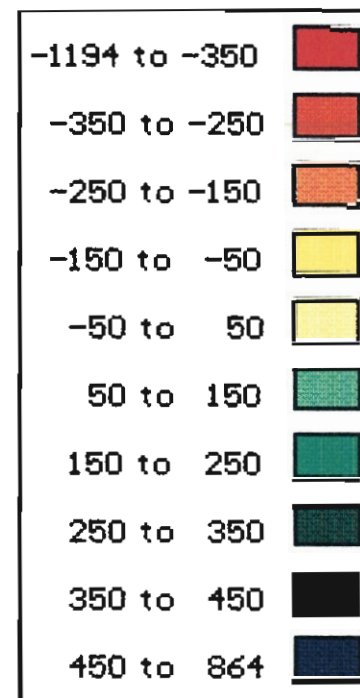
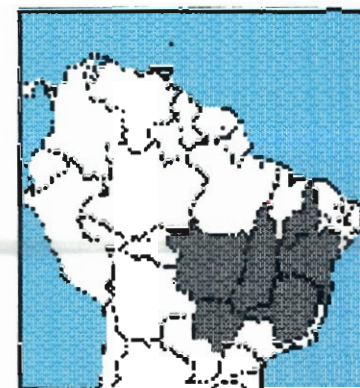
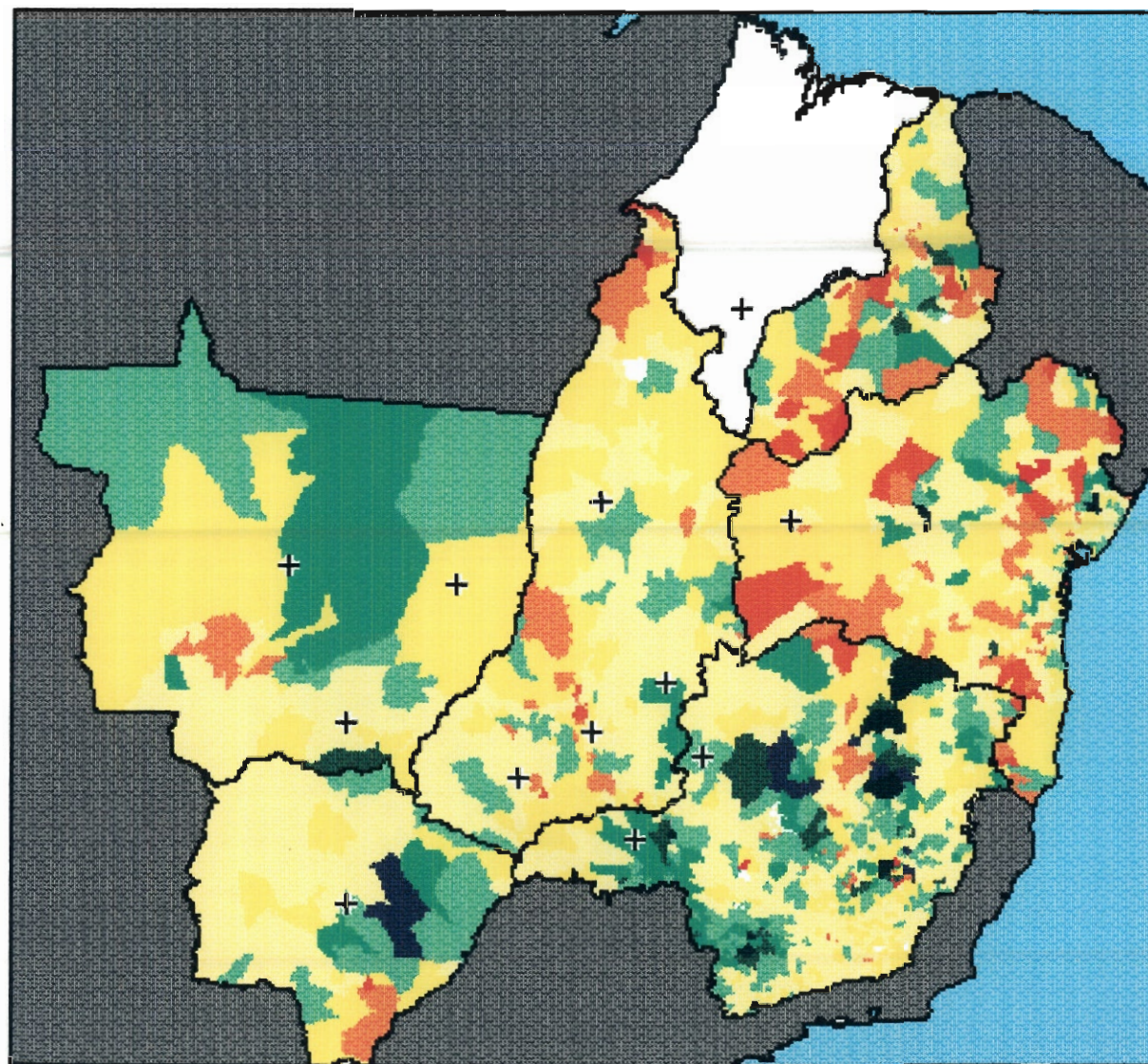
Temperature Factor (Clim1m)



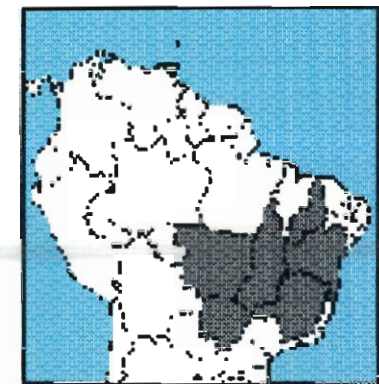
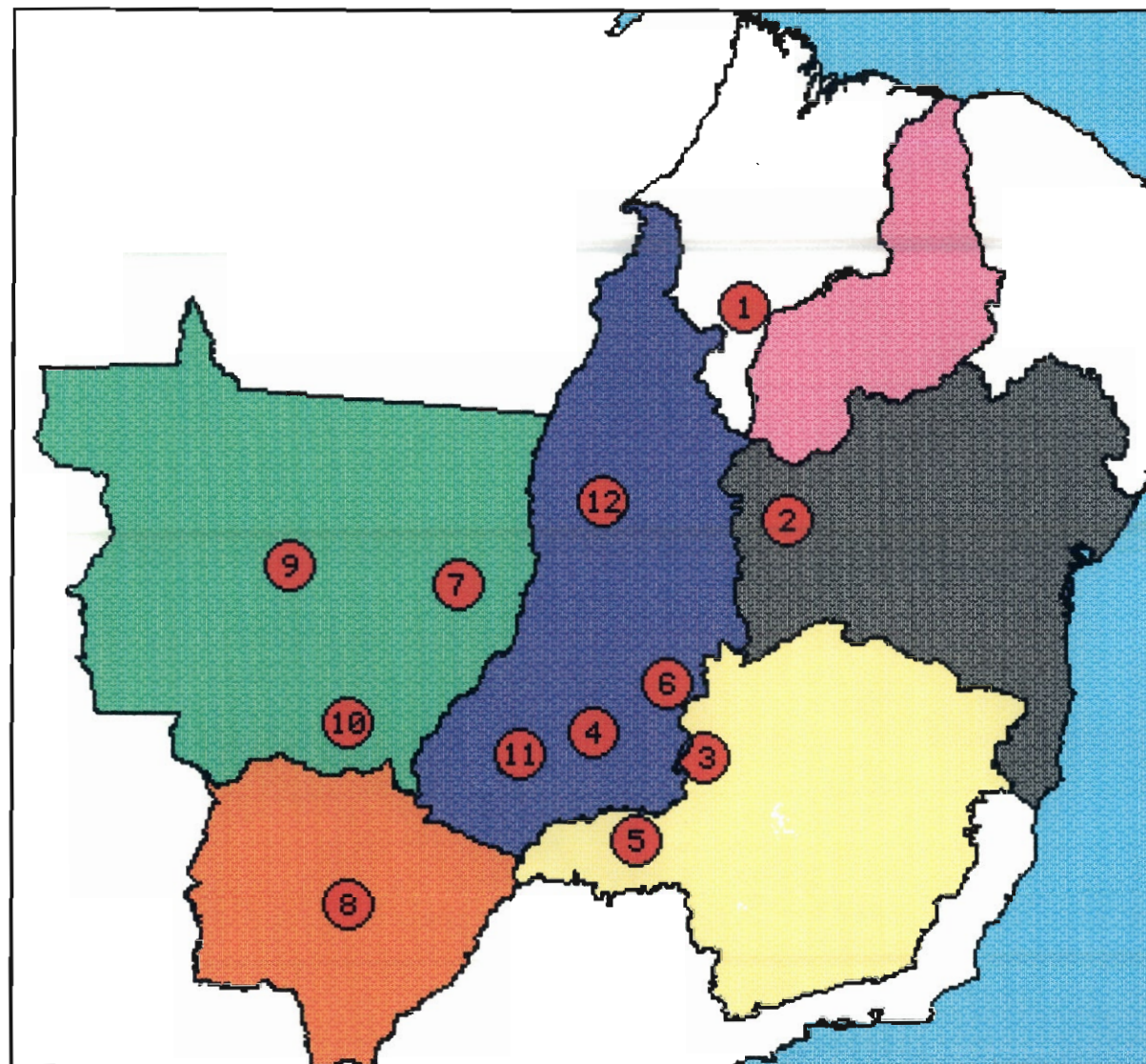
Topography Factor (Land2mcl)



Development Factor (Mean3m)



Land Use Trend (diff2mcl)



- 1 BALSAS
- 2 BARREIRAS
- 3 PARACATU
- 4 GOIANIA
- 5 UBERLANDIA
- 6 PLANALTINA
- 7 CANARANA
- 8 CAMPO GRANDE
- 9 LUCAS RIO VERDE
- 10 RONDONOPOLIS
- 11 RIO VERDE
- 12 GURUPI

SAVANNAS STUDY AREAS



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### Climate Comparison.

The interpolated dataset of long term monthly climatic means is useful in many ways. It has been the practice in CIAT to use this for producing maps of a comparative climate index.

The climate of a given point is defined by the 12 monthly means for rainfall and the 12 monthly means for temperature. These can be compared to each of the pixels in the raster, interpolated data set. The problem of timing of seasons is eliminated by the following strategy.

The 12 data points for each variate are converted into their Fourier coefficients.(Jones 1986). The timing of the growing season throughout the year varies from place to place and is almost always (in the tropics) dependent on the major rainfall pattern. The timing of this pattern is inherent in the first phase angle of the Fourier transform. Eliminate this angle and all points are brought together to a standard time.

The analysis then proceeds, standardise the first phase angle of the rainfall record to zero and use the same angular standardisation on the temperature record. The reference point is now in standard time. For each of the pixels in the comparison set perform the same operation, determining the phase angle from the rainfall record of each pixel. An Euclidean distance measure can then be readily calculated directly from the phase and amplitude coefficients of the transformed rainfall and temperature data, between the reference point and each pixel in turn. This gives two distances, one for rainfall, one for temperature. The distances are standardised by the maxima and minima in the area of comparison and combined as a euclidean distance measure of climate similarity.

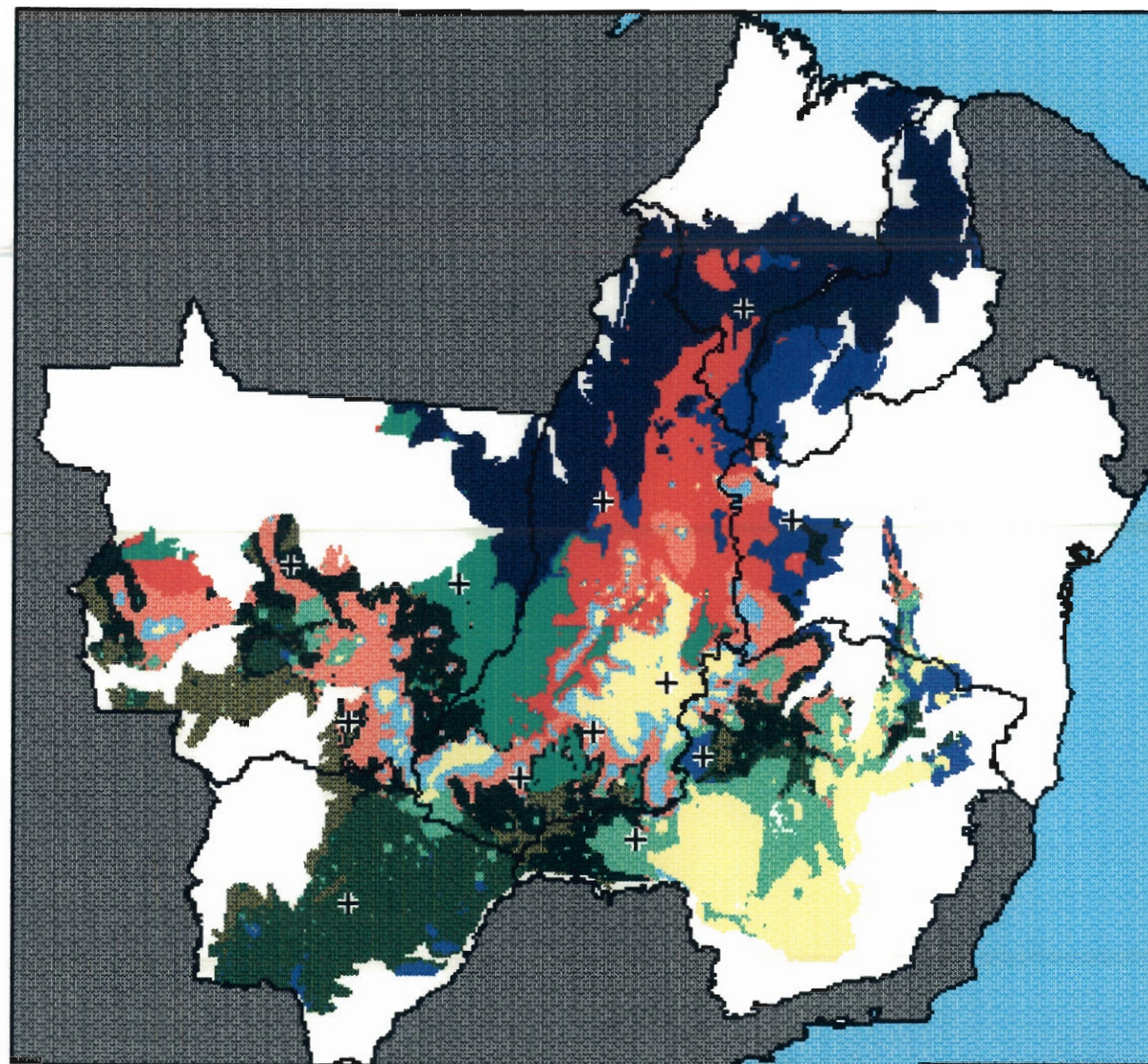
This study is the first attempt at trying to map a number of reference points as to one single map. The comparison indices for each of the 12 CASE points were computed for the whole study area. The twelve files of indices were then read in parallel to determine the CASE having the lowest index for each pixel in the study area. A map was constructed showing the climatic affinity of each pixel to the nearest CASE point in a multi dimensional space of standardised climate data.

The map included in this document is for illustrative purposes only. For better precision see the 1:3,000,000 map plotted separately.

It is possible to rank the 12 CASE areas by their area of climatic influence from this map. However I should like to insert a note of caution. This map shows the areas most like the CASE in question and if no other CASE is at all similar will subsume areas which may be very different. Conversely, if two CASE areas are very similar, the conflict for the ownership of the similarity areas may reduce the influence of both.

We can depict this in a single dimension, let us say - elevation. Fig.1 shows how this can come about. The marginal points capture all the area further from the central points. Although the climate comparison index is constructed in a multidimensional (24) space, it is almost certain that this will happen. It is therefore well to be cautious about the similarity range of Balsas, which may be including all areas hotter than its comparison point. Also Planaltina may be capturing all the cool areas regardless of other factors.

We present this map results as an aid to discussion, but, given the above doubts as to this analysis it might be better to leave consideration of the results to purely visual appraisal, since the absolute areas involved are doubtful. Nevertheless it is instructive to see where, in purely climatic terms, a case study analogue might be looked for.



12 case study areas , climate similarity areas

### Zone of Similarity (Geographic)



Fig. 1. A diagram to show the possible conflict in the climate comparison map. Four comparison points are shown on an elevation profile. The profile is divided between them by allocating the points all the areas closest in elevation. 4 captures all the high ground, 1 all the low ground and 3 is caught in between 2 and 4.

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### Comparison of Cluster classes with Case study areas

Table 1 shows the areas of each Cluster class in the 60 km radius from the case study centroids. Using a lower limit of 10% of the case study area as a cutoff, seven of the 18 classes could be eliminated as being insignificant to the study areas.

Balsas is excluded by this analysis due to lack of landsystem and census data. For the purpose of discussion the data on climate comparison and the description in Appendix II must serve.

Classes 1, 2 and 3 are all drier zones either to the east of the region or around the pantanal in the south west. Classes 5, 6 and 7 are also small dispersed marginal areas, mostly lowland. The main occurrences of Class 5 are to the south of Balsas and north east of Planaltina but small area are widely distributed even though of no great extent. Class 6 is restricted to marginal areas around Cuiaba and Caceres. Class 7 is restricted to areas of very limited access in the valley of the river Araguaia. Class 10 is a moderate to small extent to the south and east of Class 12 which is a major class in Gurupi case area. The main difference from Class 12 is it's steeply acciderited topography.

The map on pages 28 shows the remaining 11 cluster classes. The above seven have been declassified and are shown in the same grey tone as the areas lacking data.

TABLE 1. AREAS OF CLUSTER CLASSES WITHIN 60 KM RADIUS OF CHOSEN CASE STUDY AREAS. KM<sup>2</sup>.

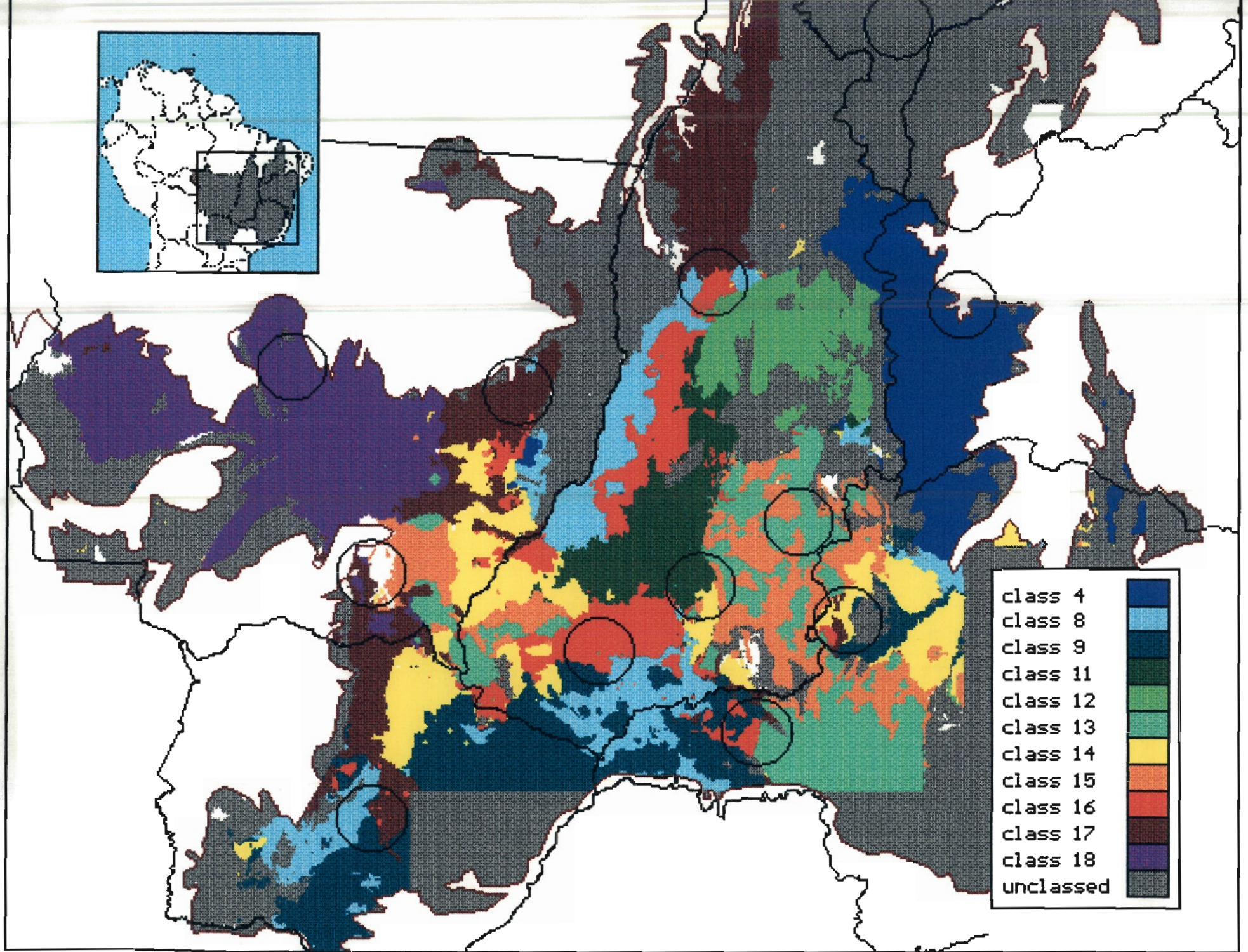
CLUSTER																		
CASE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
BALSAS					136													
BARREIRAS			241	6356														
PLANALTINA					437								7319		3609			
GURUPI							67	2593				1610		40		3491	3510	
CANARANA							1121	241								146	8429	
GOIANIA					184			118			5721		1748	1601	1616	381		
PARACATU		524					315			1243			578	3030	840	694	1362	
UBERLANDIA					816					2738			4304		117	2788	572	
RIO VERDE								1318	1709				26			8279		
CAMPO GRANDE							425	3897	2594							193	4270	
LUCAS RIO VERDE						321												9846
RONDONOPOLIS														171	2262		2288	841

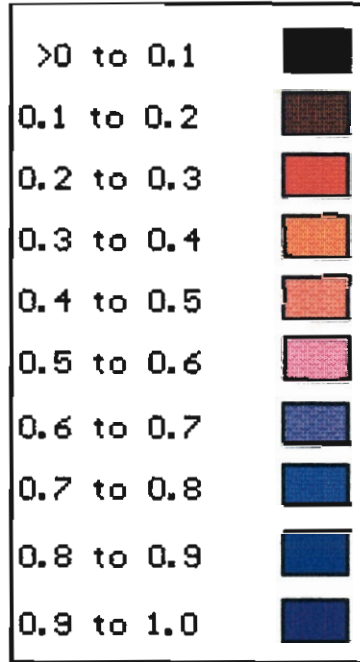
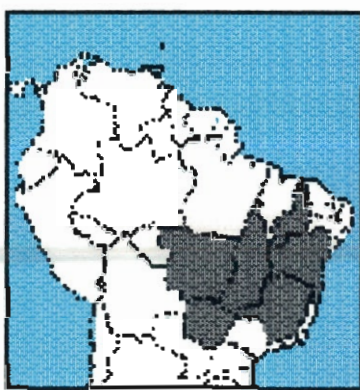
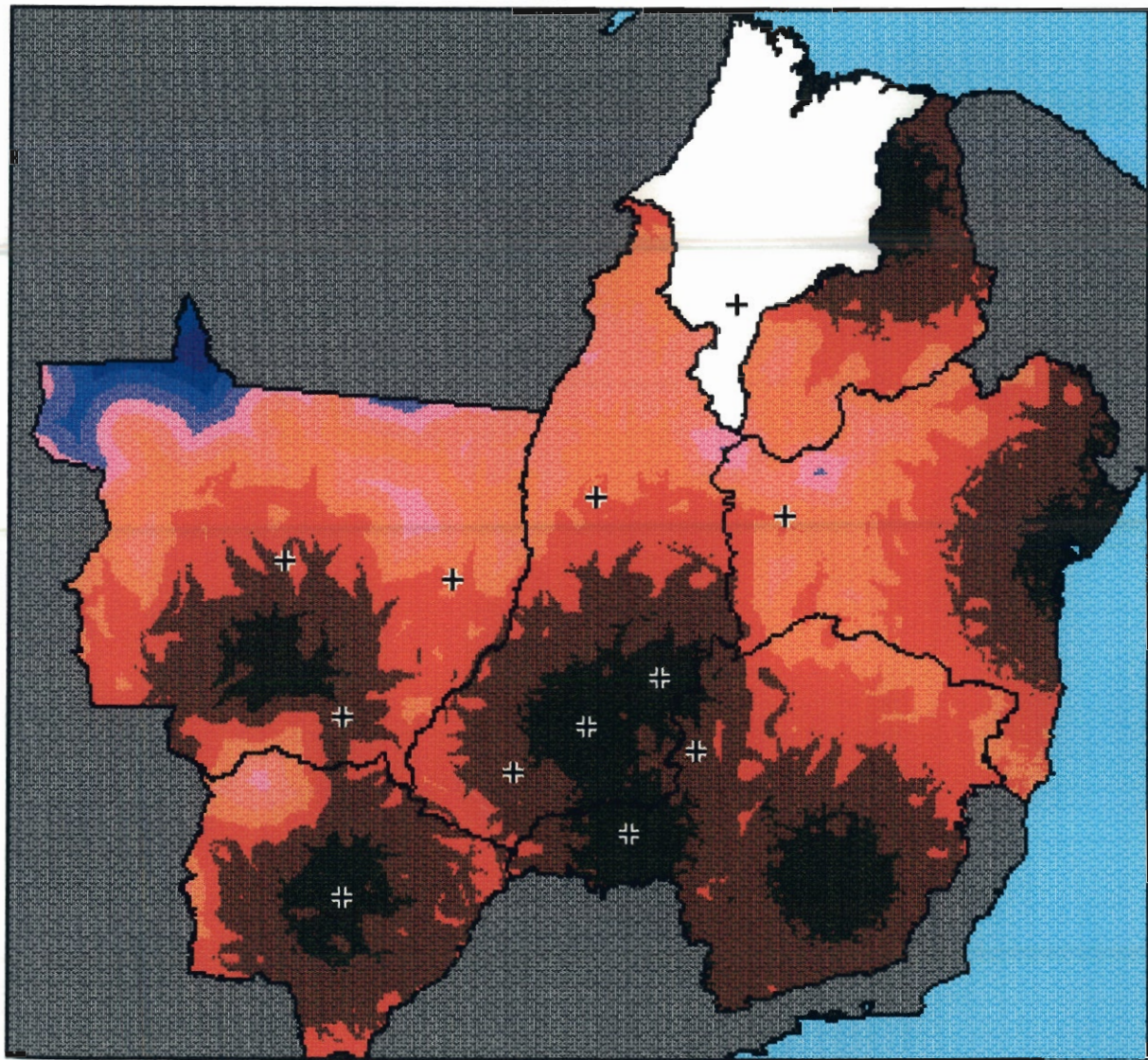


CLASS REJECTED - LESS THAN 10% OF ANY CASE STUDY AREA.



AREAS GREATER THAN 10% ACCEPTED.





Distance to market index



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### Analysis of accessibility to markets

The road, rail and navigable river network was digitized, not just for Brasil, but for the continent. The Brazilian section was updated for this study by incorporating the most recent maps available. These were at various scales between 1:1,000,000 and 1:2,000,000. An image of distance from major city markets was produced using the IDRISI GIS package. The index of distance to a major market was calculated as the sum of the geographic distance to the nearest major market standardized by the maximal distance in the region of interest plus the distance to the nearest route of access (all weather road or railway) standardized by the maximal distance from any of these. In the analysis this weighted the distance of accessible roads to be three times the cost in time as opposed to travel by all weather main roads.

In discussions at CIAT we judged this to be a fair weighting taking into account general latin american experience. This judgement of course could vary from place to place and obvious anomalies occur when areas are periodically cut off by heavy rains.

The map on page 29 shows our analysis of the distance to market index. Obviously a reading of zero is a market centre and the cost increase from thereon out. This index is far too crude to assign a real monetary cost but can serve to give some idea of the remoteness of an area.

TABLE 3. Land system data by Cluster Class (See page 6 for variables).

CLASS	ACID	ALUM	PHOSPH	ROLL	SAVANN	FLAT	DRAIN
4	3.33	0.07	0.00	10.49	0.66	88.18	0.43
8	50.26	15.10	11.27	18.50	35.32	71.93	10.02
9	68.93	0.96	16.99	17.18	37.47	74.28	8.86
11	89.87	24.94	12.55	50.26	72.19	48.68	1.36
12	42.73	11.74	0.00	30.11	80.58	58.18	11.74
13	95.85	87.02	66.34	30.22	95.13	67.18	2.91
14	87.66	30.99	3.87	58.74	83.16	40.55	0.80
15	89.30	61.21	21.13	74.35	86.42	25.28	0.38
16	87.56	74.08	43.47	17.94	88.61	74.67	7.53
17	93.30	71.48	62.69	19.03	91.38	75.01	6.39
18	92.54	53.58	35.54	20.81	79.04	74.59	5.18

TABLE 4. Climate data by Cluster Class (See page 5 for variables)

CLASS	NRAIN (Months)	RMAX (mm)	TDIFF (°C)	TM (°C)	TMEAN (°C)	TX (°C)
4	4.95	255.93	12.43	16.66	22.94	28.82
8	5.28	267.98	12.09	19.06	24.96	30.89
11	5.23	308.20	13.37	16.37	23.09	29.37
12	4.97	290.99	15.16	15.30	23.10	30.66
13	6.24	319.80	11.13	16.18	21.46	26.37
14	5.39	270.66	11.50	18.22	23.82	29.22
15	6.19	303.29	11.08	16.75	22.08	26.95
16	5.16	288.87	12.37	17.47	23.63	29.53
17	6.20	271.40	11.28	19.28	24.80	30.26
18	6.92	244.16	10.41	18.42	23.44	28.55

---

in the clustering.) The growing season is moderate at just over 5 months and temperatures are high. Differences in rainfall distribution are marked, with class 9 having a rather longer season and more moderate rainfall amounts but class 11 having a shorter season with a high peak rainfall month. This coupled with the more sloping topography must make for a higher erosion risk. As there is a higher preponderance of small farmers in this class this risk might be even higher. Incidentally class 11 coincides closely with the area of minimal veranico risk in central west Goias denoted on the CPAC January veranico map. (CPAC 1991)

Class 4 is a puzzle. The area is dry, exceedingly prone to veranico, soils are not highly acid. The topography is not unduly sloping but the soils are sandy. Temperatures are moderate due to the intermediate altitude. Apart from in the south access is extremely poor. The low figure for savanna vegetation in table 4 is because much of this region is classed as Caatinga in the land system study. So far, all this makes good sense. The 1980 census, however, gives the area the highest incidence of farms smaller than 5 ha. and the highest rural population in the study.

This does not coincide with the previous impression of a dry, inaccessible area of very extensive grazing (low cattle numbers, note in table 2). As mentioned before this class was formed by the aggregation of two very similar classes from the dendrogram after the second cluster analysis. While this may have been an error, the area of high population minifundistas must be highly significant to bring the figures up to this tally.

Should a study area be chosen within this class we suggest that a careful, in depth, study of all available data from the whole class area should be made to clarify the reality and the geography of these seemingly disparate results.

Suppose that we were to work, jointly, in two of the suggested areas. Which two of the areas would represent the greatest area of the cerrados? This can be worked out from a combination of table 1 and the actual areas of the cluster classes presented in table 2.

TABLE 5. Areas of the Cerrados study area Classification classes representative of the 12 case study areas.

CASE STUDY	AREA OF MAJOR CLASSES ('000 Km <sup>2</sup> )	No. CLASSES	ORDER
BALSAS	NA	-	-
BARREIRAS	106.6	1	
PLANALTINA	180.7	2	
GURUPI	348.5	4	1
CANARANA	132.3	1	
GOIANIA	326.0	4	4
PARACATU	337.7	3	3
UBERLANDIA	285.8	3	5
RIO VERDE	279.1	3	6
CAMPO GRANDE	336.8	3	2
LUCAS RIO VERDE	153.4	1	
RONDONOPOLIS	215.6	2	

TABLE 6. The number of Cluster classes constituting more than 10% of any pair of case study areas.

	GUR	PAR	CGR	GOI	UBE	RV
GURUPI (GUR)	4	6	5	8	6	5
PARACATU (PAR)		3	4	6	5	5
CAMPO GRANDE (CGR)			3	6	5	4
GOIANIA (GOI)				4	6	7
UBERLANDIA (UBE)					3	4
RIO VERDE (RV)						3

The analysis in table 6 seems to single out Goiania as a particularly good complementary site on numbers of cluster classes covered. The analysis on the area extended is presented in table 7.

TABLE 7. The areas of cluster classes present in two of the chosen study areas relevant to the cerrados region study area.

	GUR	PAR	CGR	GOI	UBE	RV
GURUPI (GUR)	348	534	442	655	540	442
PARACATU (PAR)		338	409	572	510	483
CAMPO GRANDE (CGR)			337	643	489	391
GOIANIA (GOI)				326	514	585
UBERLANDIA (UBE)					286	357
RIO VERDE (RV)						279

The winners in this case are the pairs (Gurupi/Goiania) and (Campo Grande/Goiania).

This is only one of many exercises that we could discuss, but it does illustrate the power of the classification map.

## CONCLUSION

We have set out as best we can some data that are not, as everyone knows, the best available. The point of this exercise was to focus thought and assist in discussion not to come down to hard judgements. We hope that we have done that and for the purpose of discussion the summarized data found in the appendices will suffice. For more up to date knowledge of the agriculture of the areas we must rely on our Brazilian colleagues who have first hand experience.

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LAND1 = -.516 ACIDS - .525 ALUMS - .467 PHOSPHS - .487 SAVANNAS  
 LAND2 = .701 FLATS - .631 ROLLS - .111 SAVANNAS + .296 PHOSPHS  
 LAND3 = .897DRAINS-.312ROLLS-.242FLATS-.136SAVANNAS+.128ACIDS

### FACTORS MEANS

BOSNAS = (BOSNA - 48.45)/37.53  
 PERMS = (BOSPLA + CULPE - 1.797)/6.00  
 CULTES = (CULTE - 11.52)/12.31  
 GANBOS = (GANBO - 23.18)/15.78  
 POPS = (HOMOC + MUJOC - 3.902)/8.05  
 PASNAS = (PASNA - 116.1)/45.78  
 PASPLS = (PASPLA - 37.17)/26.15  
 TIEDESS = (TIEDES - 26.07)/19.47  
 AREASS = (AREAS - 142.9)/37.54

MEAN1 = .542 CULTES + .5 GANBOS + .504 POPS + .295 PASPLS  
 + .155 AREASS - .268 BOSNAS - .13 PASNAS.

MEAN2 = .14 BOSNAS - .206 GANBOS + .478 POPS - .175 PASNAS  
 - .356 PASPLS + .547 TIEDESS - .496 AREASS.

MEAN3 = - .532 BOSNAS + .262 PERMS + .116 POPS + .636 PASNAS  
 - .452 PASPLS + .155 AREASS

### FACTORS DIFF.

BOSNAD = (BOSNA - 5.124)/29.77  
 PERMD = (BOSPLA + CULPE - 2.758)/9.5

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**Appendix 1 (Cont.)****Proportions of variance accounted for by the  
first three factors in each data group**

	<b>PERCENT VARIANCE</b>	<b>CUMULATIVE PERCENT</b>
CLIM1	48.7	48.7
CLIM2	26.7	75.4
CLIM3	13.5	88.9
LAND1	37.3	37.3
LAND2	25.7	63.0
LAND3	16.7	79.7
MEAN1	33.4	33.4
MEAN2	23.8	57.2
MEAN3	14.7	71.9
DIFF1	30.8	30.8
DIFF2	15.4	46.2
DIFF3	14.4	60.6

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The second is our digitized version of the Mapa de Solos do Brasil a 1:5,000,000. The descriptions are taken from the 1:1.000.000 maps but we did not have time to digitize the areas completely. The third is our best estimate of municipal boundaries and roads. This may be much out of date, but we present it so that at least we all of us know where we are talking about.

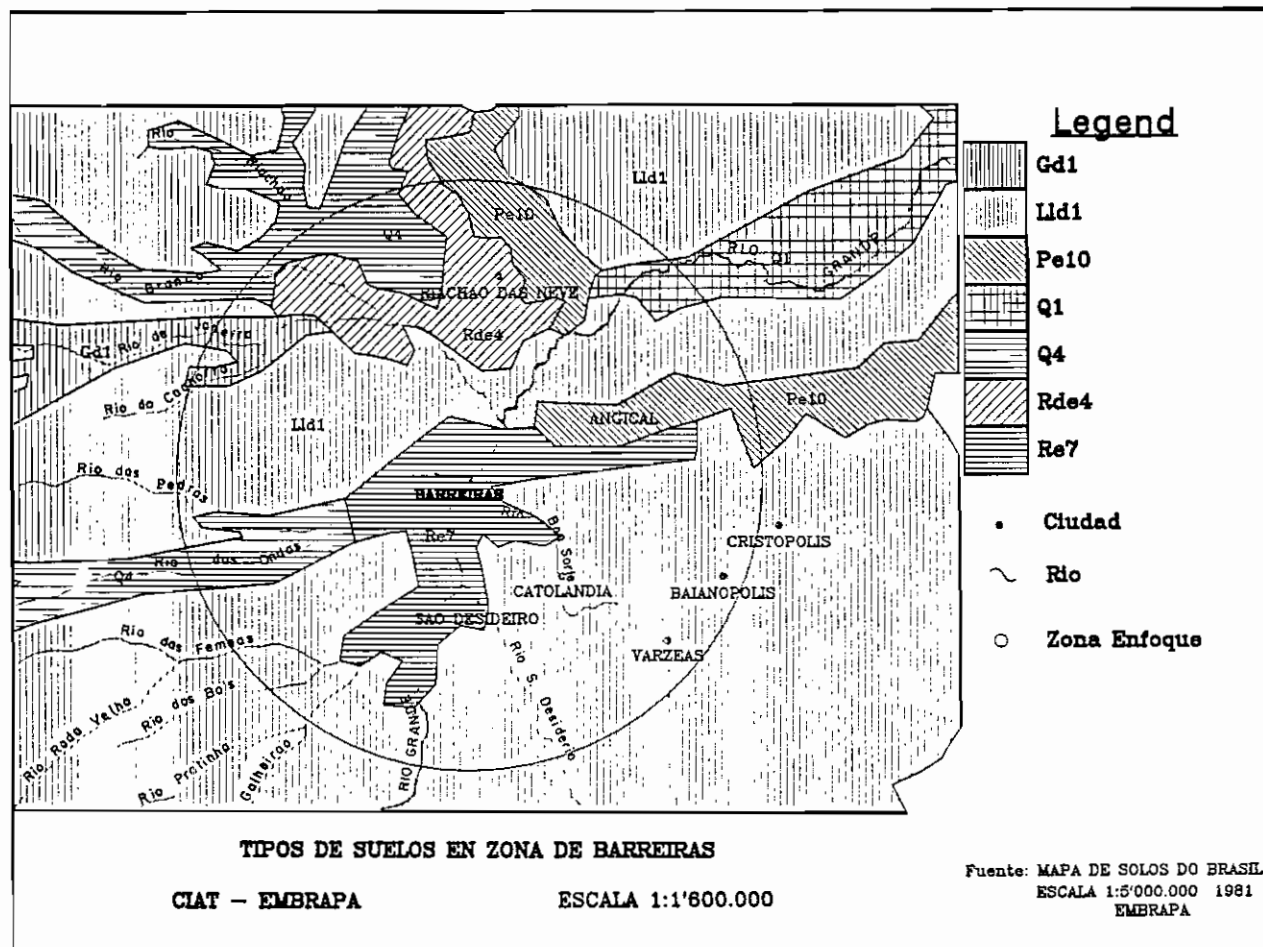
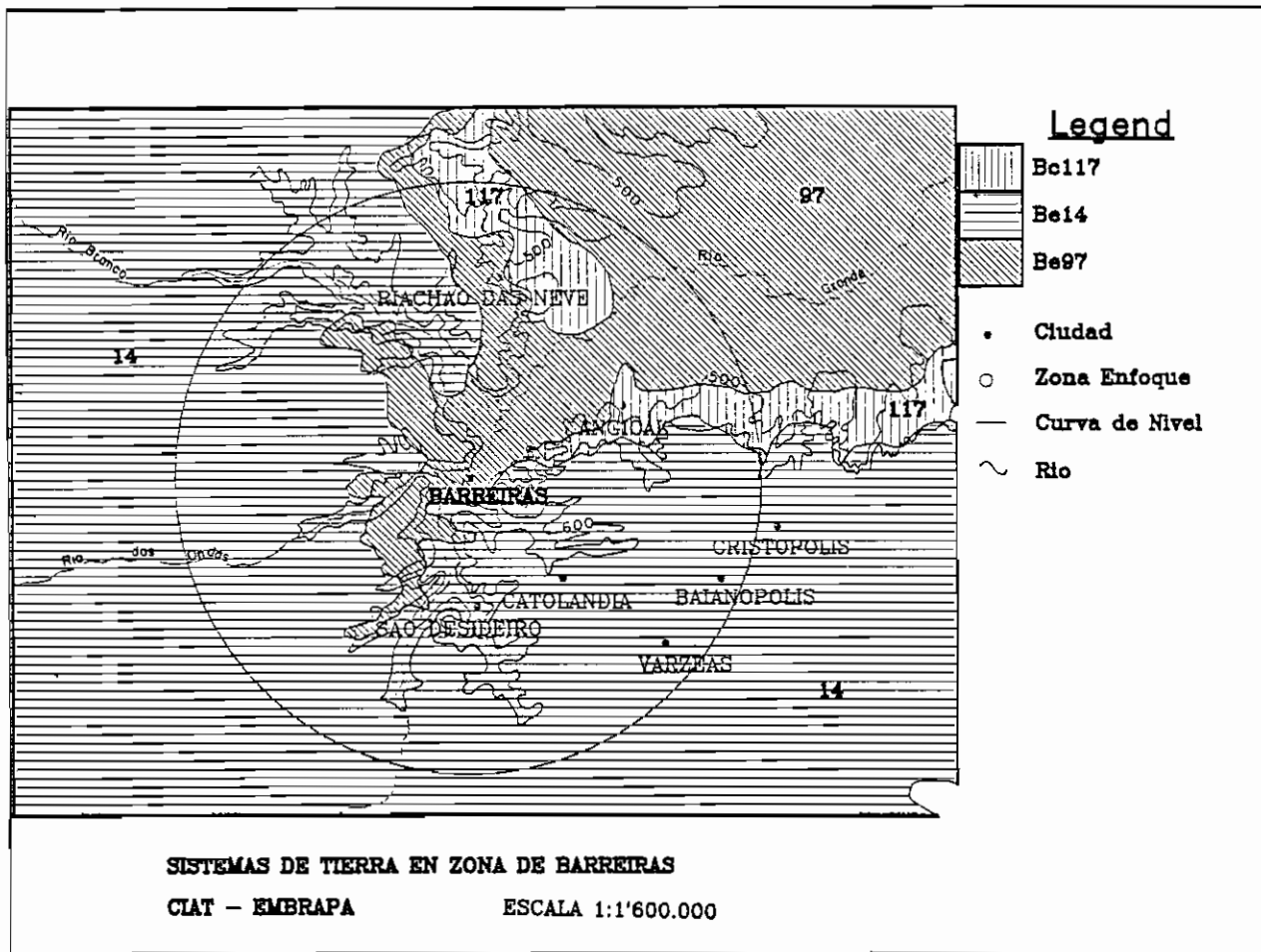


## BALSAS

This area in southern Maranhao has been excluded from the cluster classification for two reasons. First, it was not included in the land system study, this can be remedied now by a detailed description of the soils and terrain. The second reason was doubts about the census data for Maranhao. We had chosen to express the various land uses as a proportion of the censused area. When we found in one municipio in Maranhao in 1970 over 4000 head of cattle in a municipio censused at about 1000ha with 70ha in pastures we realised that the area basis of this census was being strongly biased by some factor, presumably uncertainty over ownership of land or use of land in common. Since this would have confused the analysis in comparison to the other states, we eliminated the data for Maranhao.

Balsas is however an area developing a mechanized agriculture. By 1980 up to 2% of the censused area was under rice and maize in the municipios of Sao Raimundo Das Mangabeiras and Sambaiba. Up to that time no soya was grown. The area is low lying, at 150-400 metres surrounding the valley of the Rio das Balsas. Rainfall is good and reliable at about 1500mm per year with only four really dry months and not a high probability of veranico. The growing season temperature is high at 24.9°C and suited to C<sub>4</sub> plants.

Although there appear to be great differences between the 1:5,000,000 and 1:1,000,000 soil maps in terms of classification, the characteristics of the area are clear on the 1:5,000,000 map. The main areas of cultivation to the north east of Balsas are now classed as latossolo amarelo and podzolic Vermelho-amarelo with smooth to undulating relief and a semideciduous cerrado vegetation often with Babuacu palm. Some plinthite may be found.



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temperature is still rather high at 25°C. Maximum monthly precipitation is not excessive at 190mm but the light textured soils need careful handling to prevent erosion.

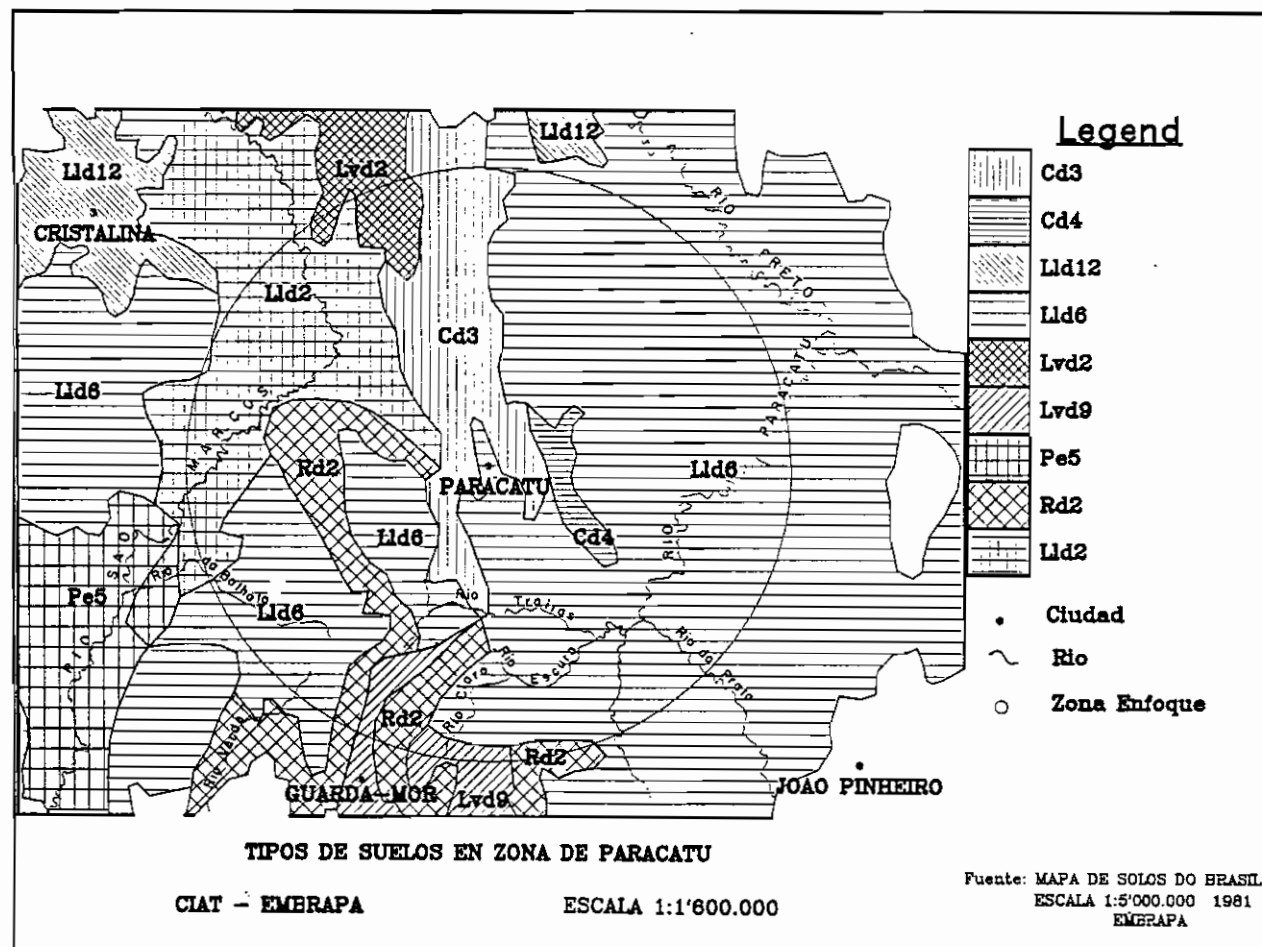
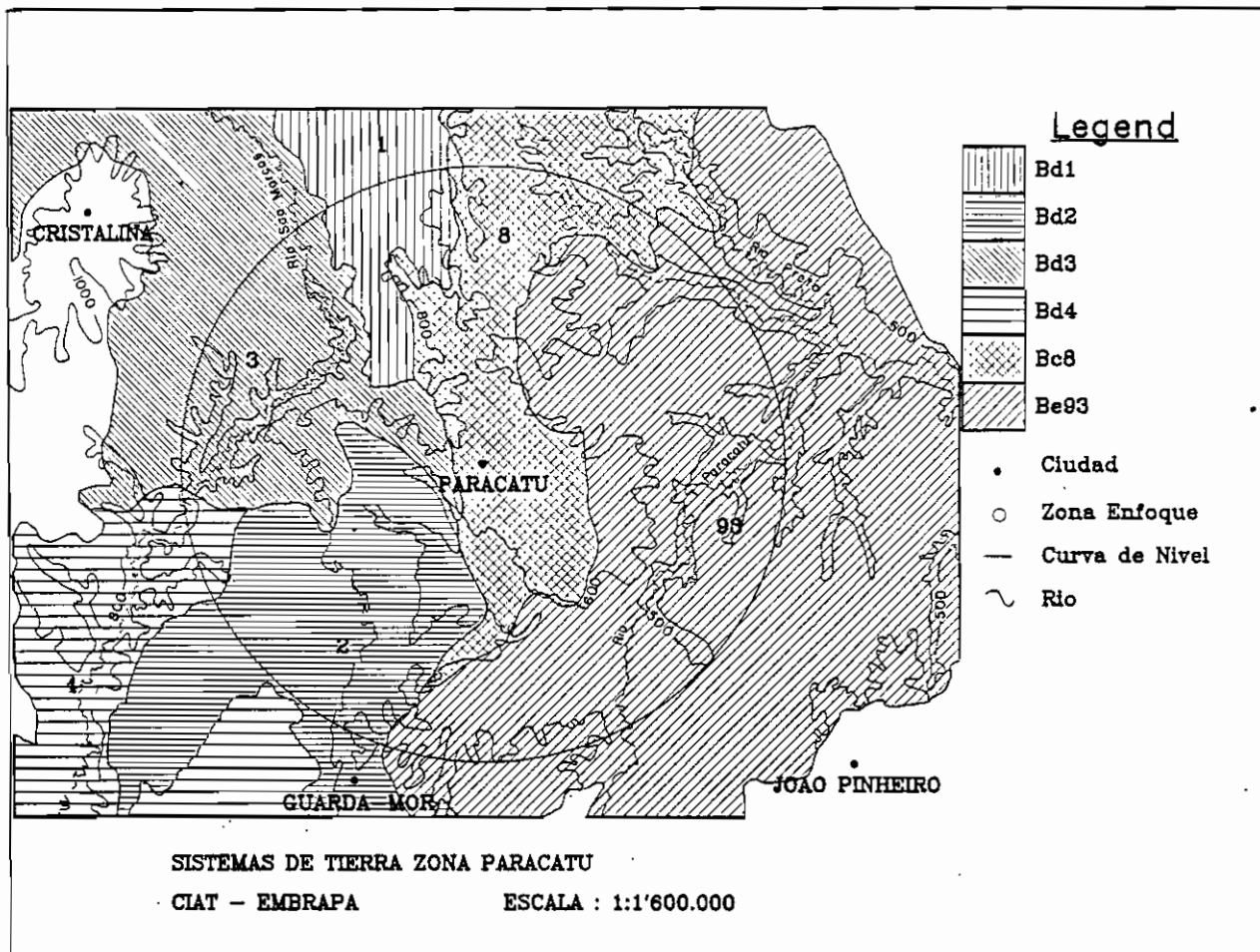
Down stream in the Rio Grande Valley the soil is mainly latosolo vermelho amarelo-distrofico with flat relief and a natural vegetation of deciduous forest. The texture is moderate to loam. To the north and west in the municipios of Riachao das Neves and Angical are quite large extents of eutrophic podzolic vermelho with medium to sandy texture and flat or gently rolling relief. Native vegetation here is also deciduous forest.

Along the rivers, Rio Grande, Rio Riachao, Rio Branco and Rio das Ondas are dystrophic quartzitic sands. These are general flat to low rolling relief and are associated with a variety of hydromorphic soils. The typical vegetation is semideciduous cerrado or vegetation of the varzeas.

The town of Barreiras itself stands on an area dystrophic lithosols, markedly stony with an undulating relief and a natural vegetation of semideciduous cerrado. These soils have been developed on coarse river sediments and include phases of silt and sand.

The main soils of the area are however the latosolo Vermelho distrofico of unit 10 and 11 on the 1:1,000,000 map. LVd 10 coincides with the Cluster class 4 on the 1:3,000,000 map of this study. With a loamy to moderate texture, flat relief and vegetation ranging from semi evergreen to semi deciduous cerrado to campo cerrado these soils form a large extent to the west and south of Barreiras.

Because of the way that the municipal boundaries include some of each of the land types it is almost impossible to interpret the main agricultural activities by



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Rainfall is 1330 mm per year with only three really dry months. However the area is prone to veranicos which have been registered from 10 to 15 times in 20 years for January.

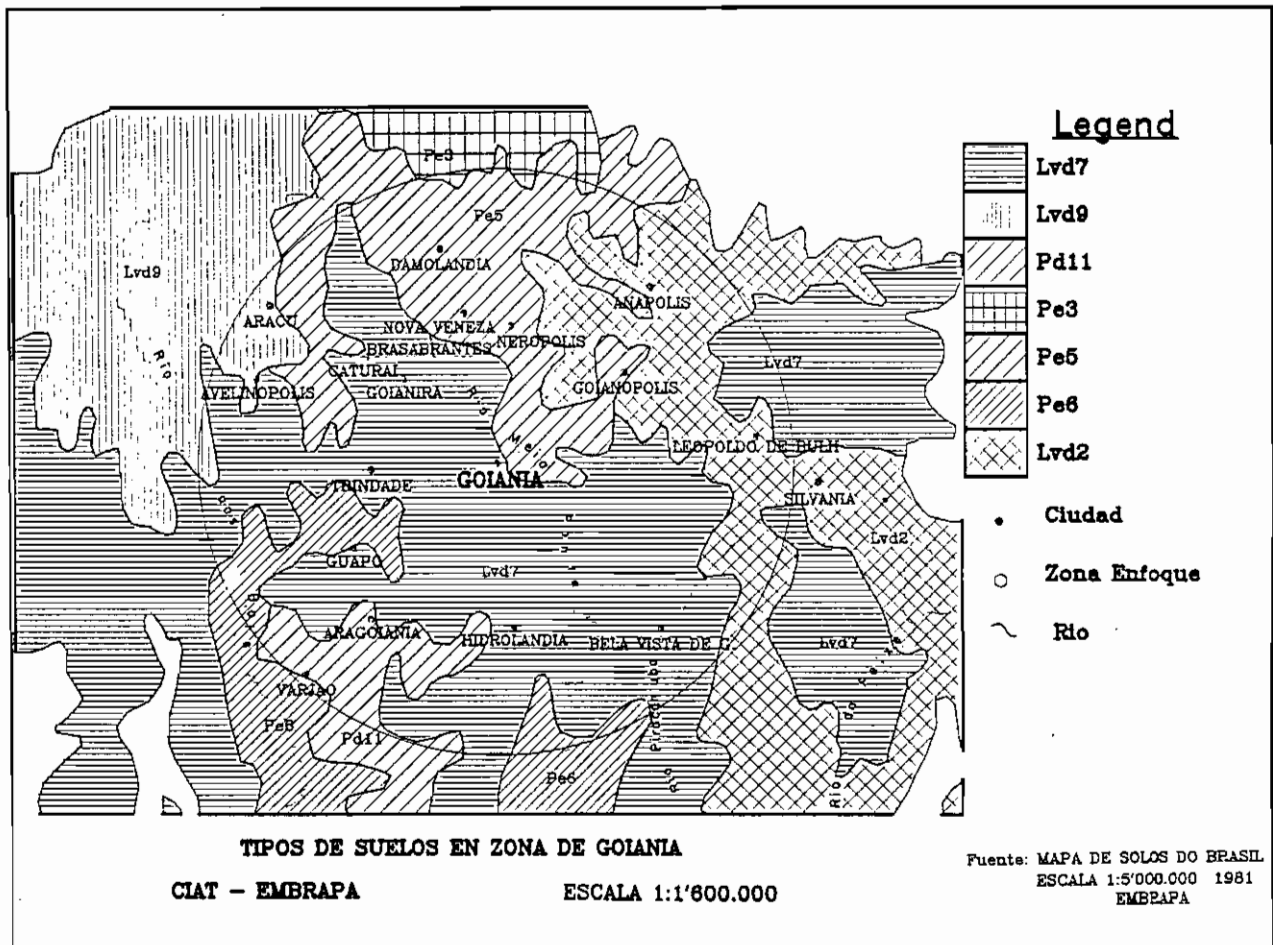
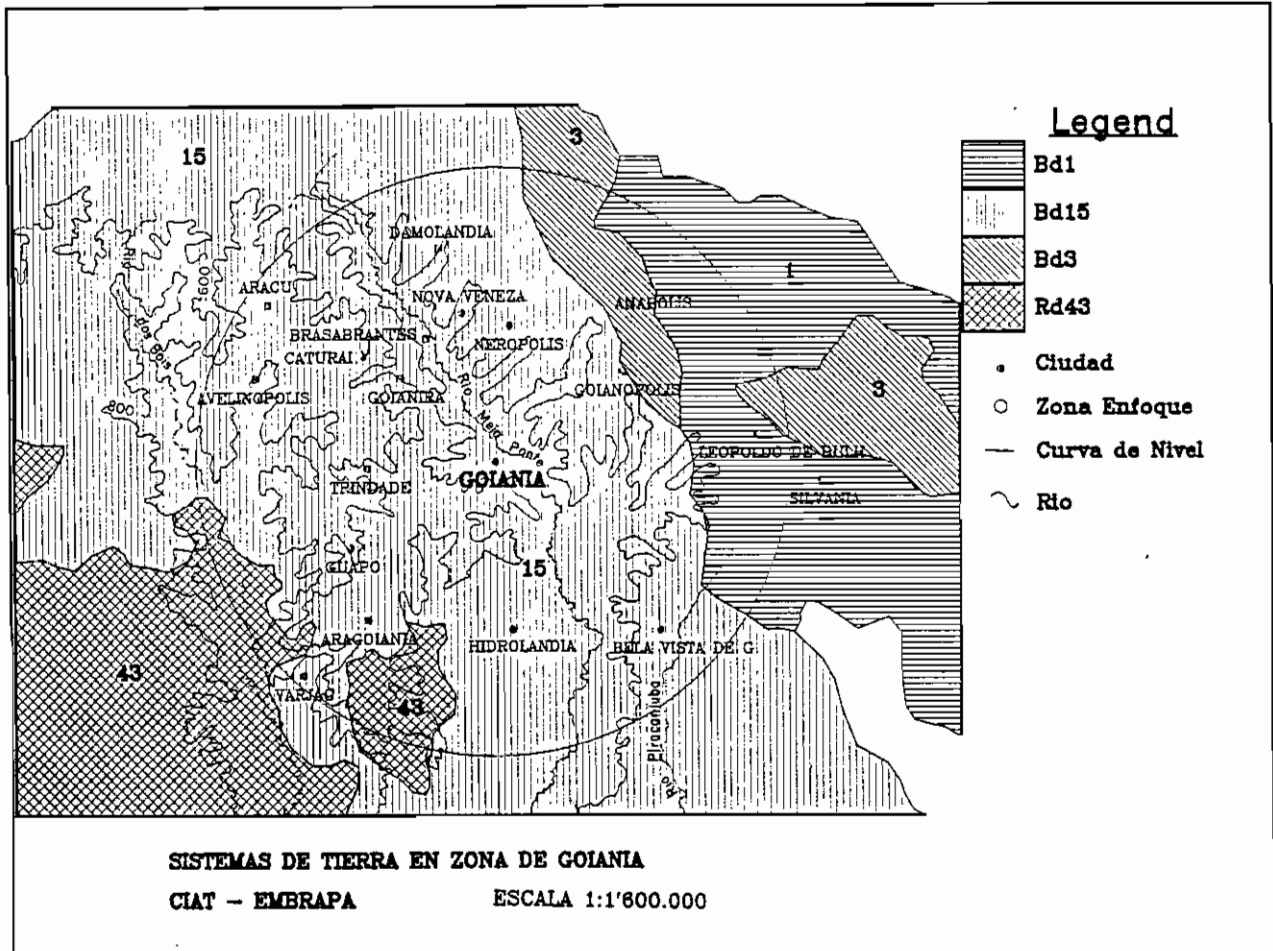
The natural vegetation was campus cerrados and savannas with palms. The area is now quite intensively cultivated. In 1980 although a significant amount of rice was grown, the main crops were beans and maize. Some soyabean had by then started to appear in the area.

The Cluster classes assigned to the region were 9,14 and 17. The major of these, class 14 is common with Goiania. The eastern side of the area was discounted with the clusters including significant amounts of poor drainage.

We do not have the map sheets at 1:1,000,000 for the soils of this area and so must rely on the land system descriptions and the 1:5,000,000 map.

To the north of the zone there is a continuation of the planaltina land system with the characteristic latosolo vermelho distrofico. Land system 8 bisects the area from north to south and is roughly equivalent to the Cambisolo distrofico 3 marked on the 1:5,000,000 map. It is a dissected area of campo cerrado interspersed with gallery forest. Only 25 - 30% of the land is flat and well drained, the rest is sloping or steeply sloping. While the acid cambisols prevail as the main soil type there are better soils on the lower flat lands. These are denoted Ustic fluvents by TTC and latossolo vermelho - amarelo distrofico on the 1:5,000,000 map.

The north west sector of the area consists of the valley of the Rio Sao Marcos. The soils are latosolo vermelho- amarelo distroficos with some cambissolos. Very little of the terrain is flat and a considerable percentage is very steep. The main vegetation is cerrado with some cerradao in the lower areas.



Goiania is an area of relatively old settlement in terms of the history of the cerrados. The property ownership patterns shows an almost consistent mode for numbers of properties by size as between 20 to 50 ha. The mode for area owned is only between 200 to 500 ha which shows a mature as opposed to frontier agricultural development.

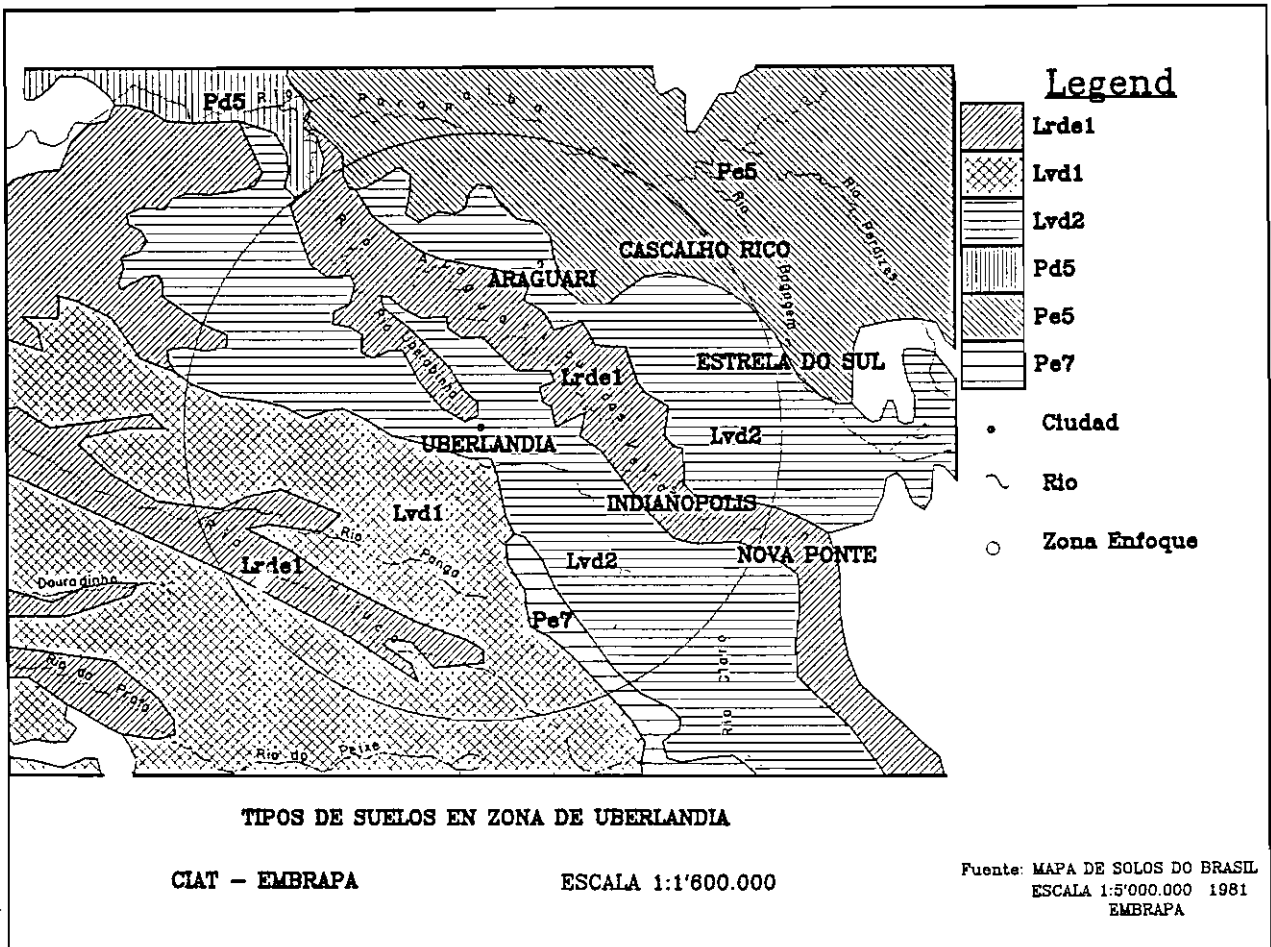
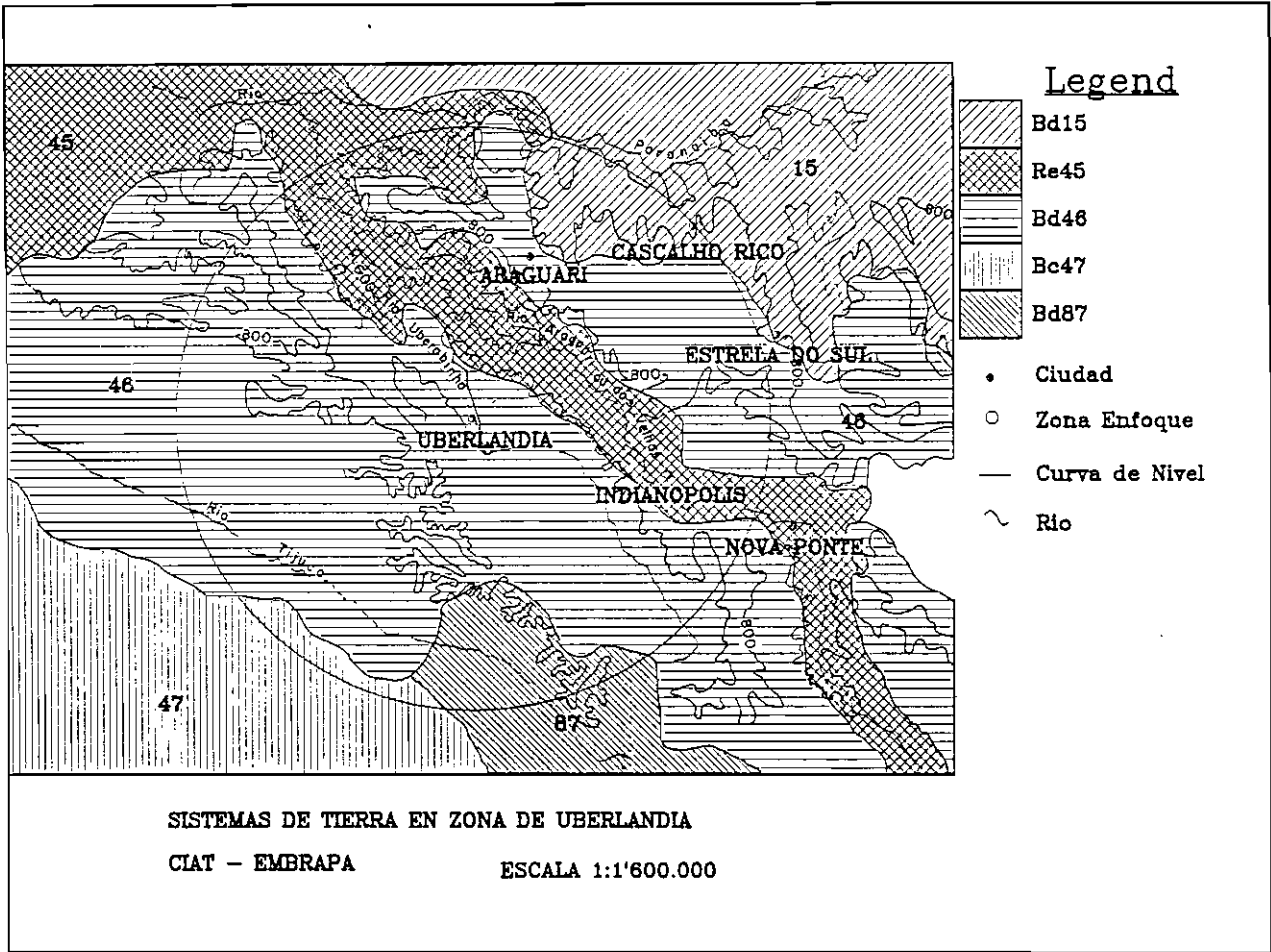
By 1980 the region around Goiania had become a major rice producer. Some municipios had up to 20% of their land under rice. Beans and maize were cultivated widely and soya was starting to make its mark in some areas. We leave the subsequent history to our colleagues in CNPAF who have much better data.

The vegetation was originally dominated by seasonal forest but little remains due to the intensive agricultural use of the land.

The altitude of the area ranges from almost 1000 m in the north and northwest to 600 metres in the lower parts of the rio Dos Bois. Five dry months are expected from May to September with an annual rainfall of about 1500mm. The growing season temperature is about 23°C depending on altitude. The CPAC estimate of veranico frequency is low, less than five occurrences in January per 20 years.

The geography of the soils in the region does not lend itself to simple sectorization, belying the landsystem and soils maps presented as mentioned above. The main soil throughout the region is a Latossolo Vermelho-Escuro Distrofico. Much of this has a flat or gently rolling topography and a clay texture and may be accompanied by Dystrophic Cambisols or even Eutrophic Podsolico Vermelho.

To the north, west and southwest of the area there are significant areas of Podzolico Eutrofico soils. Some of these, notably in the north and north east around Damolandia and Aracu have some properties of Chernozems, medium to clay





textured with some areas of sands. Low lying areas, about 15% of the region, are subject to flooding and have less acid, but hydromorphic soils. The main vegetation is campo cerrado but almost all of the area has been cleared for pasture or crops.

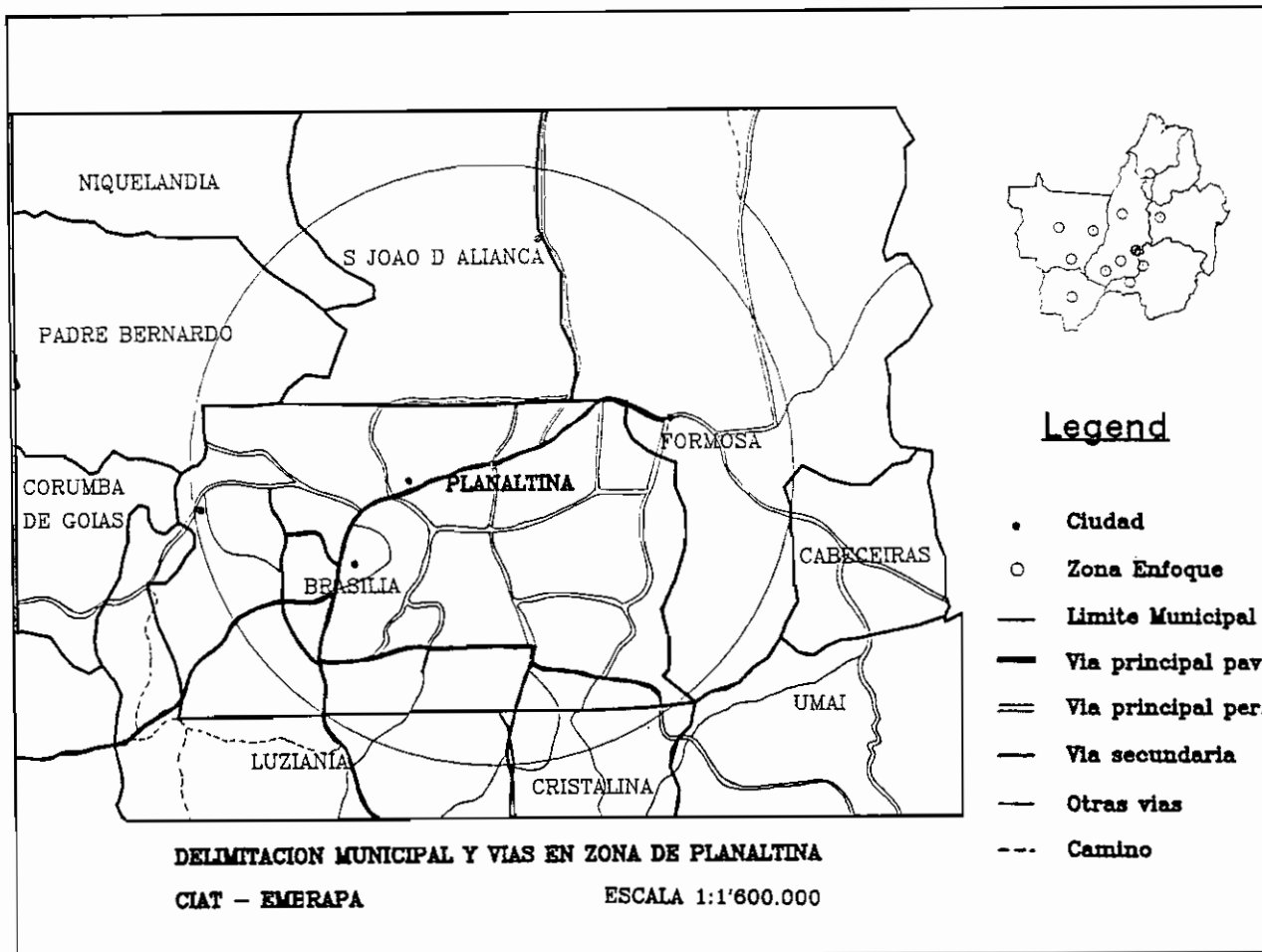
The valley of the river Araguari and the lower valley of the Uberabinha to the north of Uberlandia have a flat to gently rolling topography with less acid soils. These are heavy to very heavy textured latossolo roxo distrofico and eutrofico. The lower reaches of the Araguari are dominated by hydromorphic soils. Vegetation was mainly semideciduous forest with some campo cerrado but almost all has been cleared for pasture and crops.

To the north east in the municipio of Araguari the terrain becomes more broken and a complex of soils is found. Immediately around the town of Araguari the soil is latossolo vermelho-escuro distrofico, medium textured gently rolling relief. Around this is a complex of eutrophic podsolics interspersed with alic cambisols. The vegetation was a mixture of semideciduous forest and campo cerrado depending on soil and topography.

Altitude is between 750 to 800 metres and an annual rainfall of about 1500mm gives a dry season of five and a half to six months. The growing season temperature is 22.6°C.

The area was a strong producer of rice, beans and maize in 1970. By 1980 the production of rice and beans had diminished and considerable areas of soybean were planted.

Modal land holdings are generally between 20 - 500ha by number of holdings and also less than 500ha by total area which indicates a very even distribution of land holding size.



## PLANALTINA

Brasilia and Planaltina occupy an old leached plateau just above 1000m. The landscape is generally flat but there is much variation in microrelief. The area includes various sub regions.

To the north west the landsystem Bd 5 includes a number of terrains. Drained by the Rio Maranhao with its tributaries Arraial Velho and Rio Das Salinas it is immediately a matter of conflict to soil mappers. T.T.Cochrane describes it as broken terrain in two facets, the first is about 60% of the landscape and the second only

The central Brasilia-Planaltina plateau is classed 13 in the cluster analysis. It has an altitude of 900-1000m, just over five dry months running from May to September. The mean growing season temperature is 21.3°C, the lowest of all areas studied. The maximum monthly precipitation is high at 347mm making erosion a definite risk. The risk of veranico is between 5 to 10 per 20 years which although not insignificant is not high for the cerrados area.

Land holdings in Cristalina and Formosa which are marginal to the region are medium sized. The mode in terms of number of establishments is between 200 and 500ha the modal area owned is 2000-5000ha. In other municipios, Luziania, Padre Bernardo, Planaltina and Brasilia the modal establishment is between 20 to 50ha with the majority of the area owned in properties of less than 2000ha.

The main soils of the area are latossolo vermelho-amarelo distrofico. they are moderate textured and mainly flat with occasional slopes greater than 8%. The dominant vegetation is campo cerrado. To the south of the area at the head of the Rio Sete de Setembro there is an area of podzolic vermelho amarelo alico. The landscape is relatively flat and the vegetation more open campo sujo with campo cerrado and some gallery forest.

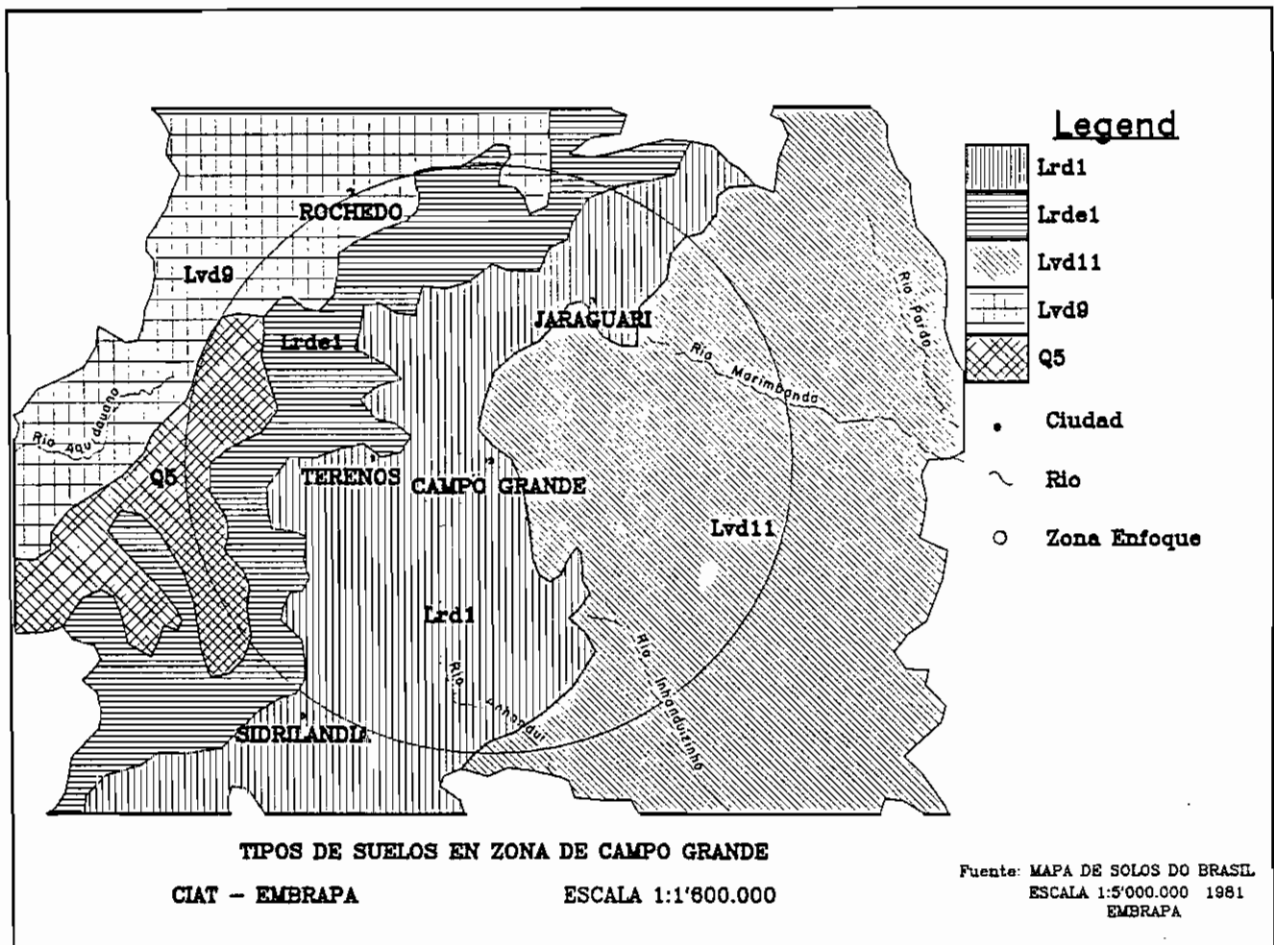
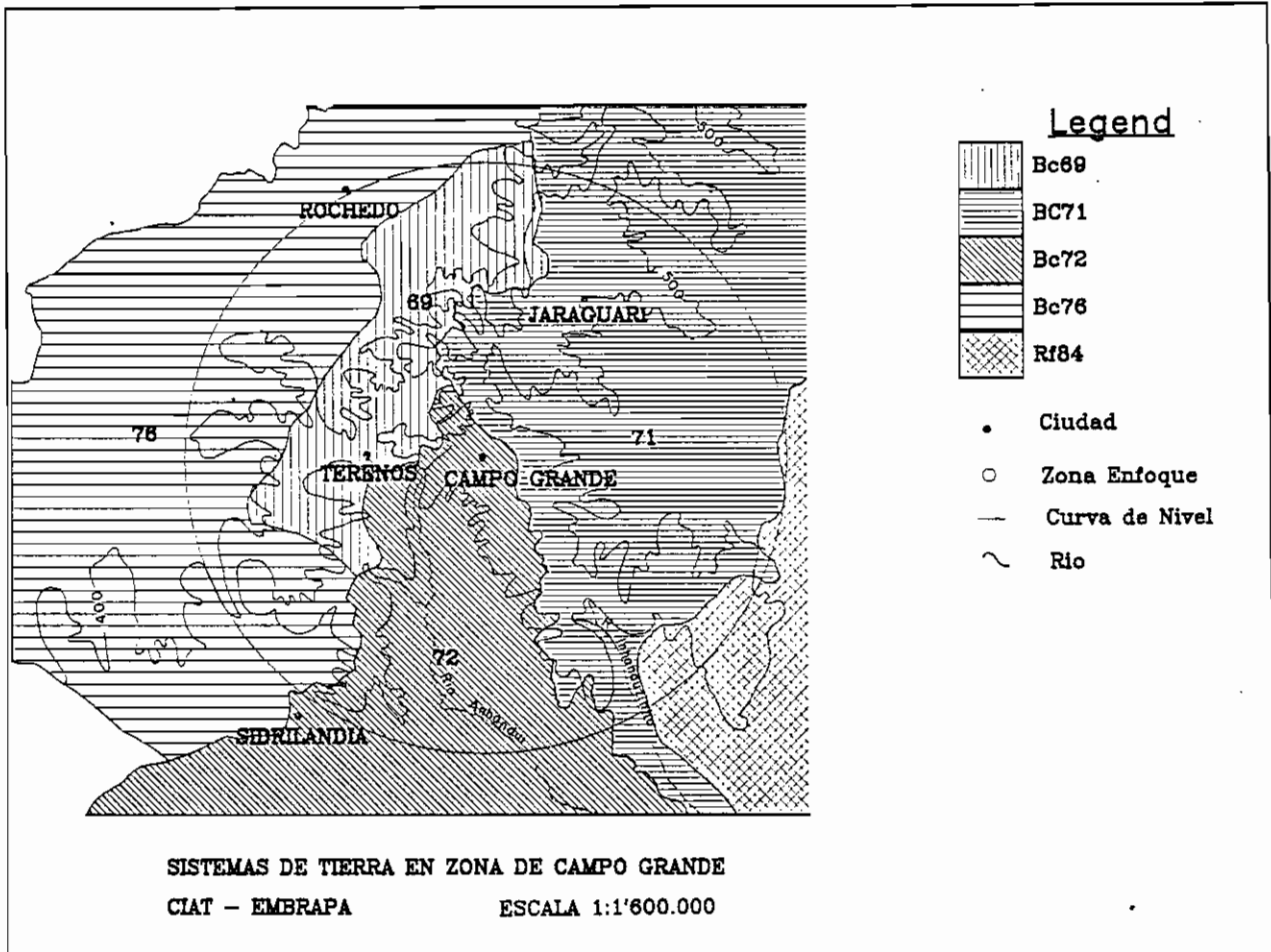
Significant areas of concreted soils exist with broken terrain and steep slopes. Plinthite is present over extensive areas.

The area is relatively low lying with altitudes between 400 to 500 metres. Temperatures are high with a mean growing season temperature of 25.4°C.

Rainfall is plentiful, 1600 mm per year with a five month dry season and little risk of a veranico.

The area is a recently settled area and the land holding shows a tendency for large properties with a modal size between 200 - 500 ha. The majority of the area is however accounted for by holdings of 10,000 to 100,000 ha with at least one of over 1 million hectares.

Few crops were sown in 1970 but by 1980 the production of rice had increased a hundredfold and the area was sowing 168,000 hectares. Beans, maize and soybeans were insignificant compared to this.



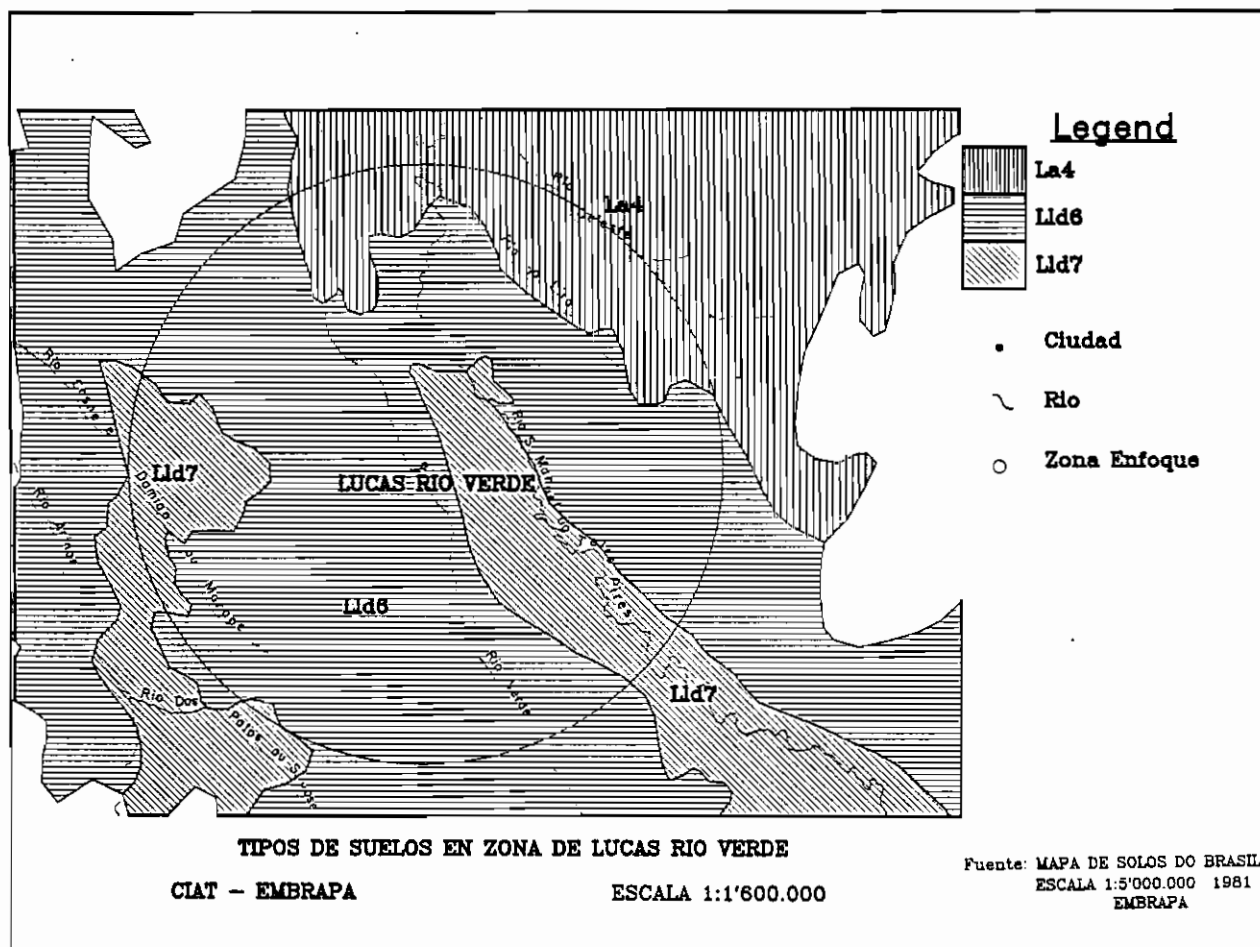
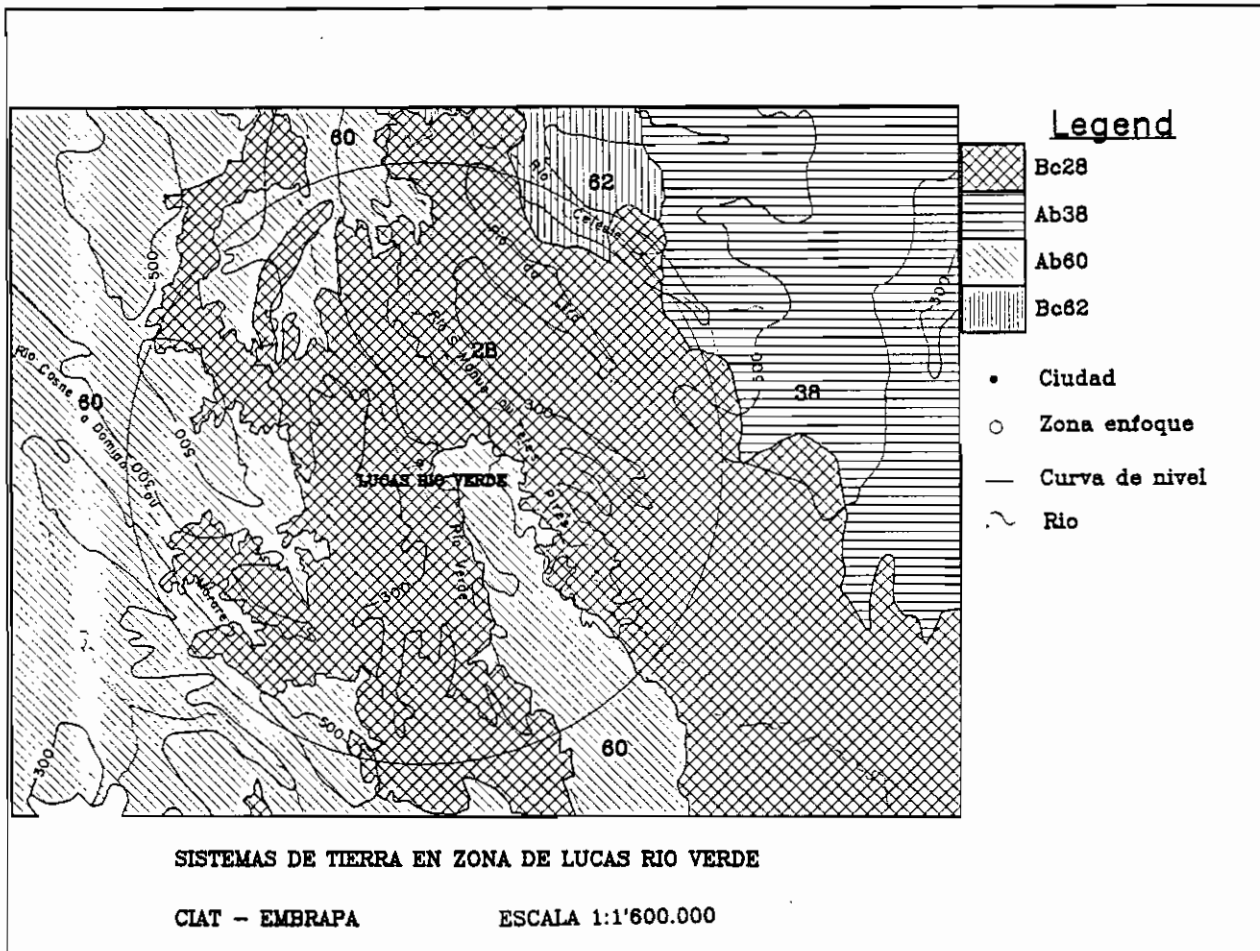
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The central valley is an association of latossolo roxo distrophico and eutrophico with latossolo vermelho-escuro. The former are heavy textured, the latter moderately textured and acid. There are inclusions of hydropomorphic soils and some sands. The latossolo roxos eutroficicos are not deep but cultivable on gently rolling terrain.

The western third of the area is separated by a band of lithosols with steep relief along an escarpment running from south west to north east. The northern part are sands similar to the eastern region. To the south the soils are acid latossolo vermelho escuro with medium texture and flat relief. Large extents of hydromorphic soils exist along the drainage lines. The vegetation here is a mixture of semideciduous forest and campo cerrado.

The area is distinctly inhomogeneous and the land holdings reflect this. The sandy areas of Ribas do Rio Pardo and Rochedo show a modal property size between 500 and 2000 ha with most of the land being held in units of 10,000 up to 100,000 ha. Typical of extensive grazing system for these poor soils. The more arable area of Campo Grande however shows a modal farm size between 20 and 50 ha, although most of the area is held in units of 2000 to 5000 ha. This is borne out by the production figures, at no time from 1970 to 1980 has there been significant production of rice, beans, maize or soyabean from the sandy areas.

In 1970 however Campo Grande, Sidrilandia, Terenos and Jaraguari were major rice producers, produced some beans and maize and some farmers were starting to experiment with soya. By 1980 rice production had doubled in Campo Grande and increased 5 times to 26000 ha in Sidrilandia. The most spectacular change was in the cultivation of soybeans which had reached 8000 ha in Campo Grande and 58500 ha in Sidrilandia.



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by acid quartz sands and extensive poorly drained soils along the river. Relief is undulating and the characteristic vegetation is campo cerrado.

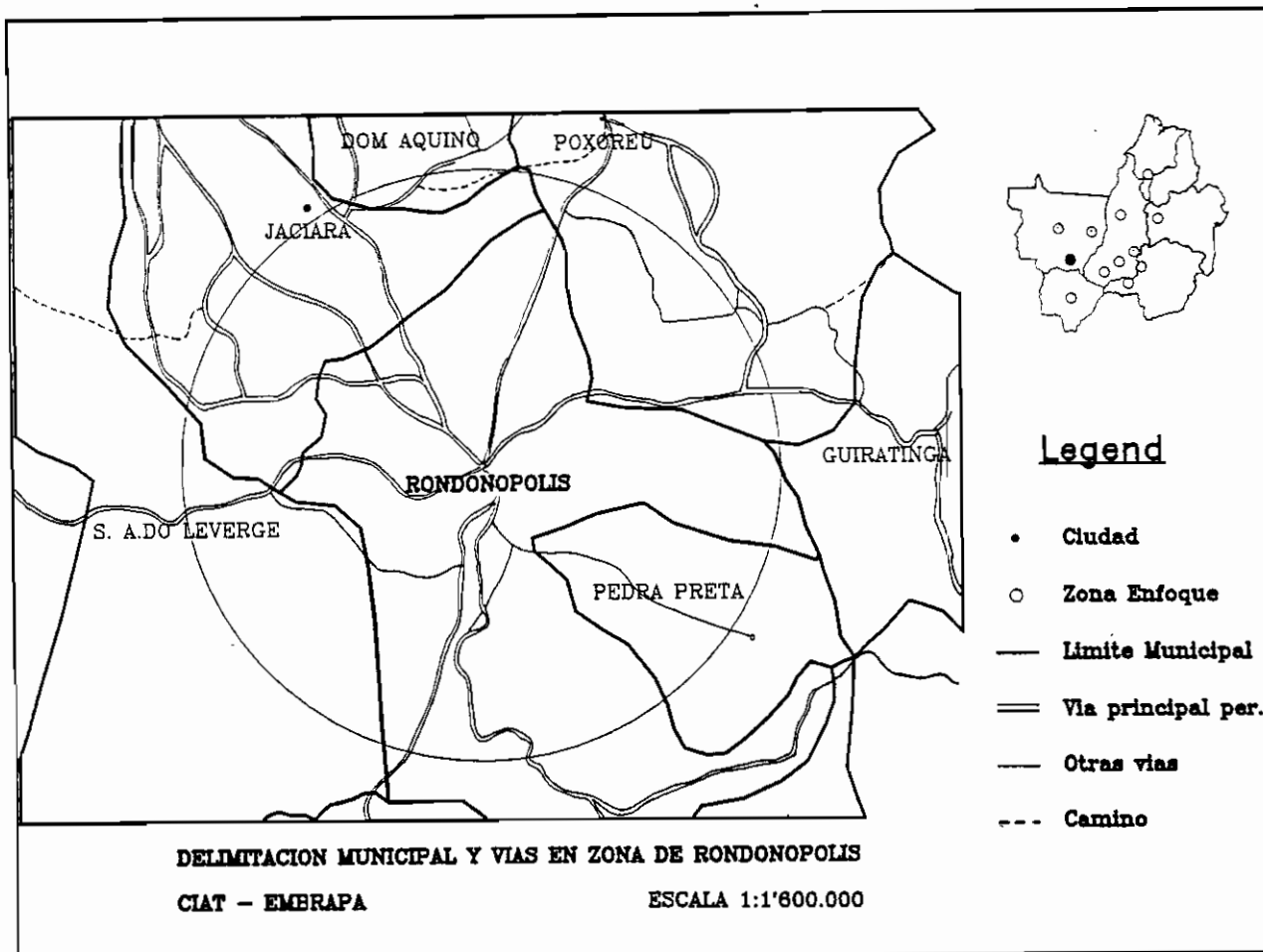
The higher ground between the Rio Teles Pires and the Rio Verde, to the south of Lucas is a uniform area of latossolo Vermelho-amarelo distrofico some heavy textured, but interspersed with some areas of medium texture. The relief is flat to gently undulating and the vegetation is predominantly semi evergreen seasonal forest with some occurrences of cerrado.

The main central part of the area to the north, west and south west of Lucas is a pattern of two basic soil types. On the higher land a heavy clay Latossolo vermelho-amarelo with very flat relief. In the lower areas a similar soil with accumulation of plinthite and inclusions of gleyed soils is found. The vegetation in this region is campo cerrado. To the north west and south west are areas of acid quartz sand soils.

Lucas Rio Verde is probably the most recently settled of all the study areas and hence the reliability of the data is low. In 1970 there was essentially no production of annual crop. By 1980 the area was sowing 131,000 ha of rice and even experimenting with 370 ha of soybeans. In 1980 the modal farm size was between 200 and 500 ha with most of the area in properties from 10,000 to 100,000 hectares with at least one of over 1,000,000 ha. This farm size distribution is not unexpected for a new frontier area where land is cheap and soils poor.

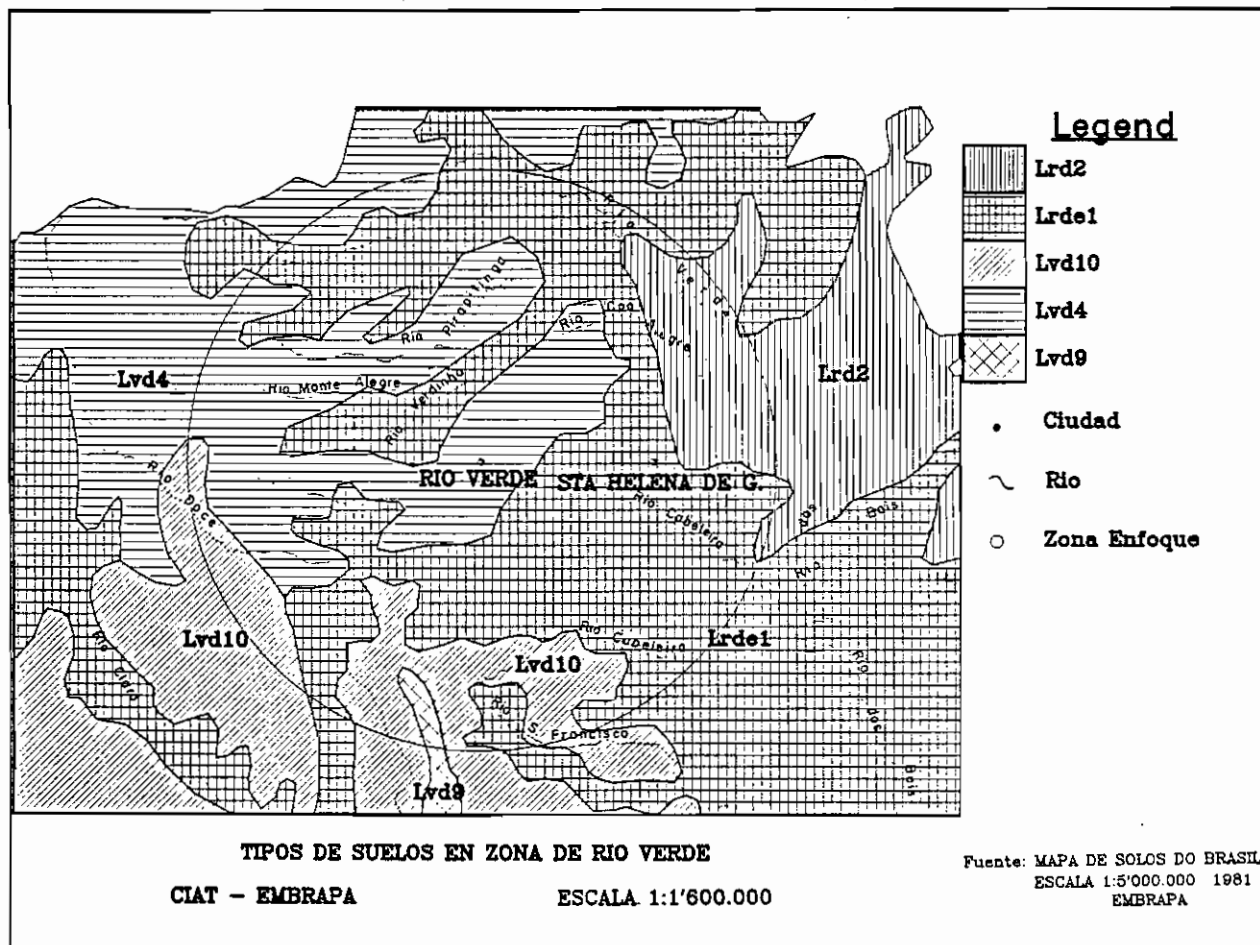
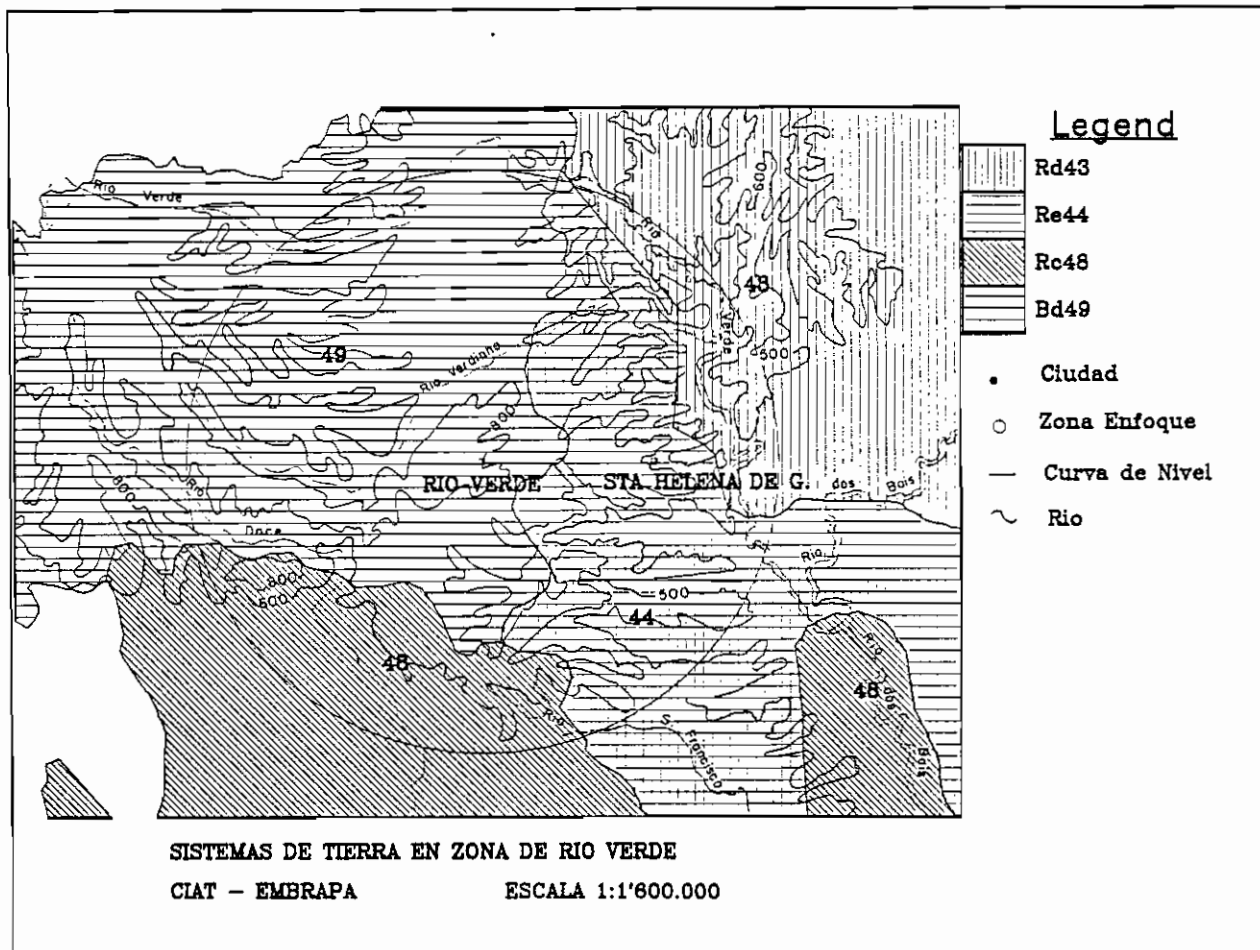
Altitudes are from 400 to 500 metres. Rainfall is about 1500mm well distributed with a five month dry season. Probability of veranicos is very low. Temperatures are high, 25°C during the growing season.





## RONDONOPOLIS

There is a marked discrepancy between the 1:1,000,000 soils map and the two maps shown here. The 1:1,000,000 map lists all of the area north and east of Rondonópolis, roughly that denoted by landsystem Bc34, as podzolicos vermelho-amarelo eutrofos. This is confirmed by the Mapa de Solos da Amazonia Legal 1:2,500,000. 1989. The area is undulating to quite steeply sloping in parts but areas of flat relief are found in the north around Jaciara. Some inclusions of dystrophic soils are found throughout the region and plinthite is quite common. The area is formed from a series of river valleys converging from all directions on Rondonópolis.



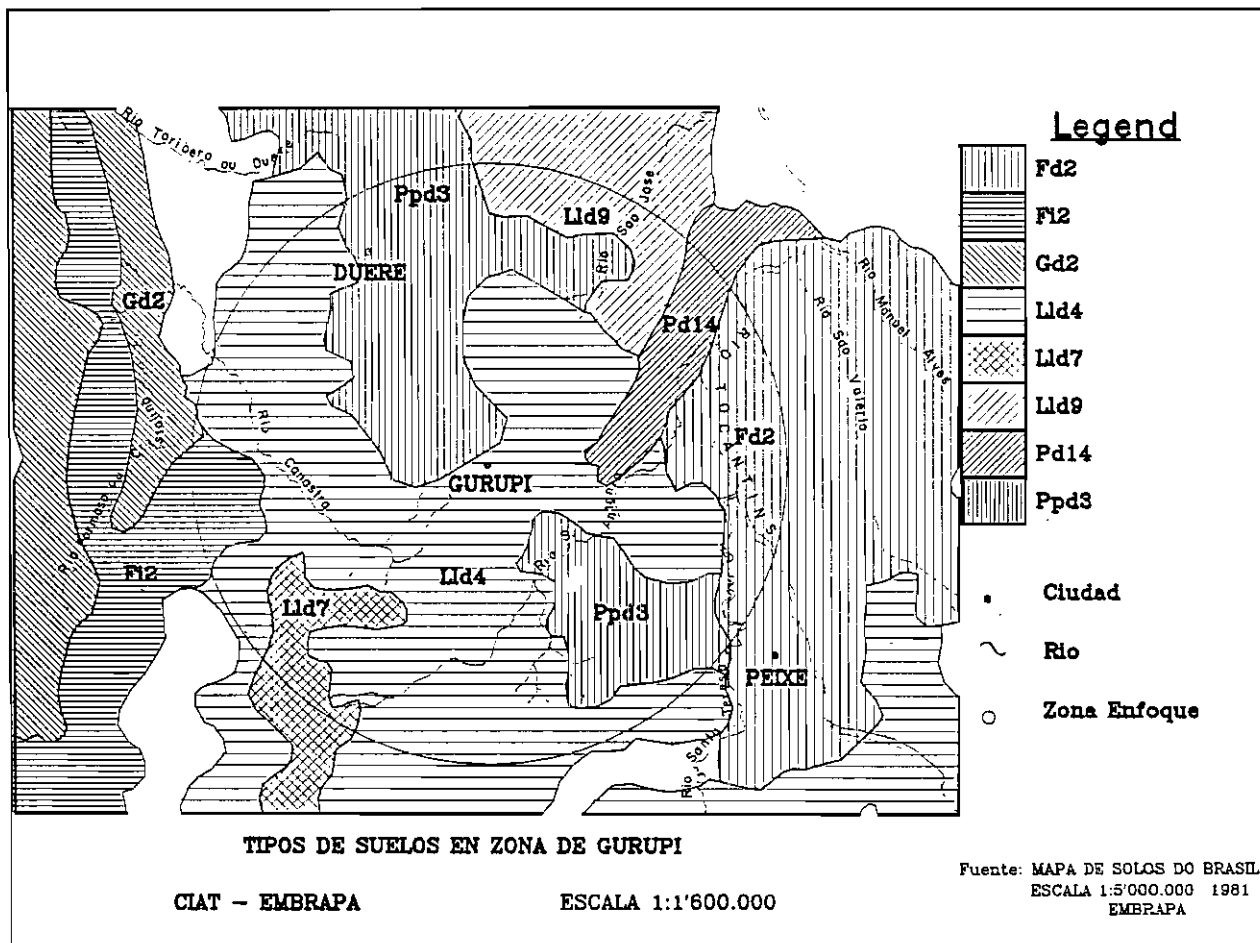
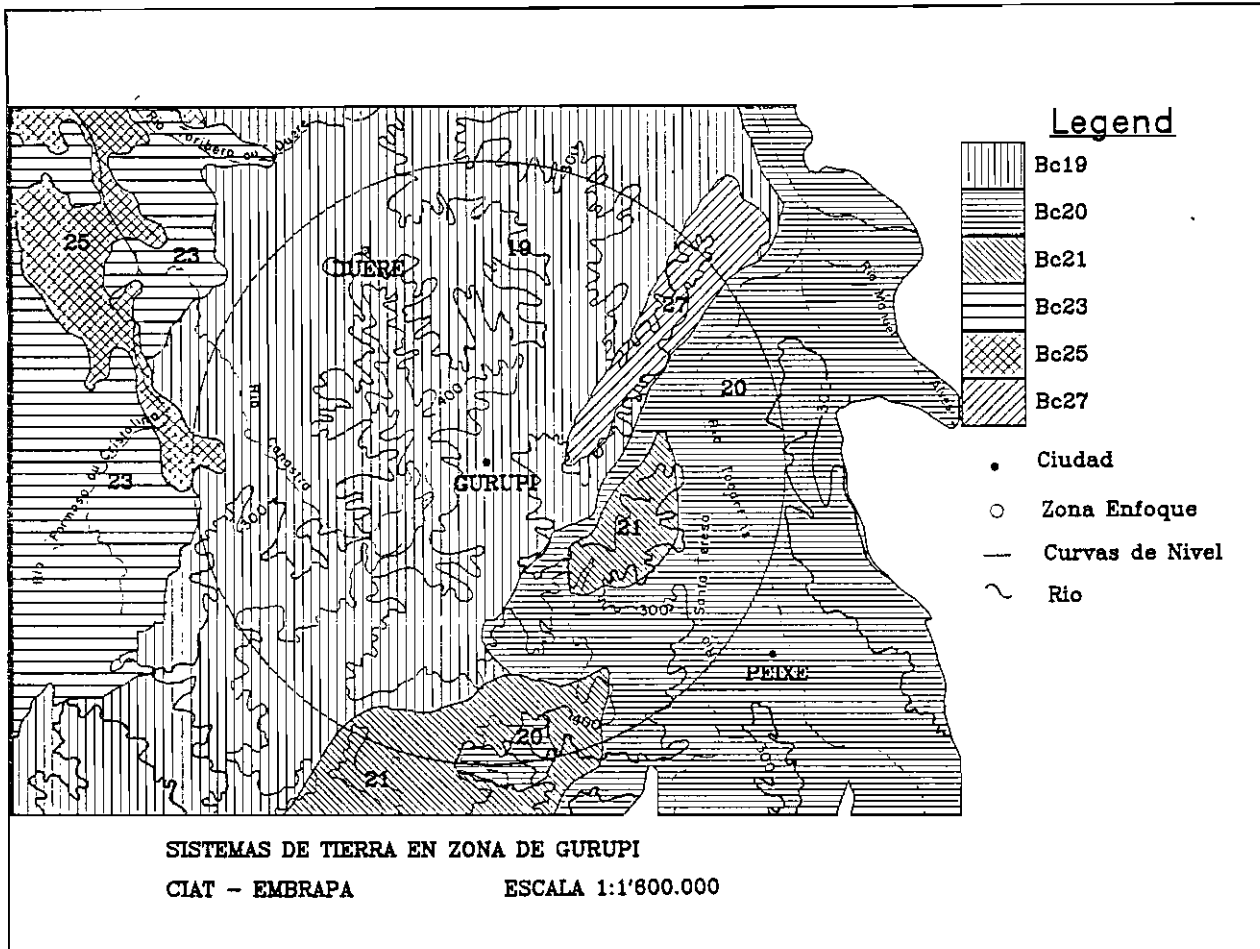
To the east in Santa Helena de Goias the soil is uniformly latossolo roxo distrofico with heavy clay texture. The slopes are more pronounced as the land trends down to the valley of the Rio Dos Bois but are not severe and much flat land is still found. The original vegetation was semideciduous seasonal forest and cerradao but most of this has been cleared for pastures and crops.

Further south in the valleys of the Rio Doce, Cabeleira and S.Francisco the soils are still predominantly latossolo vermelho-amarelo distrofico but textures are medium to sandy with some associated quartz sands, acid and alic. The relief is generally flat but with some slopes, occasionally steep.

The original vegetation was almost all cerrado with some cerradao although little of this remains and induced pastures and annual crops predominate the landscape. Although the soils throughout the area are acid, aluminium toxicity is not generally severe.

The area is an old established agricultural region. In 1970 large extents were already in sown pastures. Rice, beans and maize were major crops and the area is unique among case study areas in already having an established soyabean area at this early date. (over 6000 ha were sown in 1970).

In the years to 1980 the rice crop shows a differential development. The area increased in Rio Verde and Jatai but decreased markedly in Santa Helena de Goias. The bean crop practically disappeared from the area and only a little over 1000 ha was still grown in Jatai. Maize remained an important crop and areas increased markedly in all municipios. Soyabeans increased to some 45,000 ha, in this case not at the expense of maize area and much in excess of the reduction in phaseolus beans.



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The main agricultural soil in the area is widely distributed through Gurupi and Peixe. It is Latossolo vermelho amarelo distrofico with heavy to medium texture, some concretions and gently sloping relief. This is interrupted in the north east by an area of poor acid lithosols with steep slopes and rocky outcrops. The lowland soils around the rivers S. Antonio and Tocantins are dystrophic gleysols of various textures. The main vegetation is cerrado with some campo limpo.

In 1970 few of the municipios had major areas in annual crops. Gurupi was the most developed with some areas under rice, beans and maize (6290, 1646 and 3728 hectares respectively). It also had the largest areas in sown pastures. By 1980 the area under rice had increased in Gurupi and Peixe only. The total reaching about 29,000 ha. The cultivation of beans had almost ceased and maize sowings had been reduced to less than a third. Contrary to areas further south where the reduction in these crops had often been compensated for by large increases in soyabean production, no soyabeans were sown in 1980.

Farm sizes are quite large, the mode lying between 200 and 500 hectares with the majority of the land area in Gurupi and Peixe being occupied by farms of 200 to 1000 ha. The other municipios show a pattern of more extensive use and the majority of the land was farmed in units of 100,000 ha or more.

The altitude of the area ranges from somewhat less than 300 metres to 400 metres to the north west of Gurupi. Rainfall is almost 1700 mm per year with five dry months from May to September. Probability of veranico is moderate reaching almost 50% and increases markedly towards the south east. Mean growing season temperature is 24.8°C.

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- Linacre E.J. 1977. A simple formula for estimating evaporation rates in various climates using temperature data alone. *Agricultural Meteorology*. 18:409- 424.
- Riehl M.1979. *Climate and weather in the tropics*. Academic Press London England. p.67.
- Robison D.M., Barona E., Castaño S.E., Becerra J.H. and Rincón M. 1992. Protected areas in Latin America and their relationship with the Agricultural Frontier. Working Document. Agroecological Studies Unit - CIAT.
- SAS/STAT Users Guide Version 6 Fourth edition. SAS Institute Inc. Cary NC. 1990.
- Carta do Brasil ao milionesimo. Ministerio do Planejamento e Coordenacao Geral. Fundacao IBGE. Instituto Brasileiro de Geografia. International chart of the world on the millionth scale. Brazil 1972.
- Mapa Exploratorio - Reconhecimento de solos margem esquerda. Do Rio Sao Francisco Estado do Bahia. Escala 1:1.000.000. 1973.
- Mapa Exploratorio - Reconhecimento de Solos. Estado de Piauı EMBRAPA/snlcs. 1983. Escala 1:1.000.000. Mapa de Solos, Estado do Piauı. Acompanado por el libro "Levantamento Exploratorio-Reconhecimento de Solos do Estado de Piauı. Volumen 1."
- Mapa Exploratorio - Reconhecimento de solos do Estado do Maranhao. Escala 1:1.000.000. 1986.

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**MAPAS DIGITALIZADOS DE BRASIL PARA EL  
ESTUDIO DE SAVANAS**

Mapa Polivisual Estado Minas Gerais. Politico Regional, Rodoviario esc. Polimapas Editora Ltda. 1978. Escala 1:1.350.000

Mapa Polivisual do Maranhao e Piaui. Politico Escolar, Did. Turist., Rodof. Mapa Político - Turístico - Vial. 1979. Escala 1:1.135.000.

Mapa Rodoviario Estado Mato Grosso do Sul. Polit., Turist. Esc., Polivisual Polimapas Editora Ltda. Tercera Edicion. Sao Paulo Polimapas Editora Ltda. 1979. Escala 1:1.000.000.

Mapa Rodoviario Mato Grosso do Norte. Político, Turístico Escolar, Polivisual. Polimapas Editora Ltda. Segunda Edición. Sao Paulo. Polimapas Editora Ltda. 1979. Escala 1:2.000.000.

Mapa do Estado Goias. Rodoviario e Politico. Geomapas Producciones Cartográficas Ltda. Sao Paulo. Geomapas Producciones Cartograficas Ltda. 1977. Escala 1:1.500.000.

Mapa de Solos do Brasil. EMBRAPA. Empresa Brasileira de Pesquisa Agropecuaria. Servicio Nacional de Levantamento e Conservacao de Solos. Escala 1:5.000.000. 1981.

Mapa do Estado de Bahia. Sociedade Comercial e Representacoes Graficas Ltda. Curitiba. Sociedade Comercial e Representacoes Graficas Ltda. 1976. Escala 1:1.200.000.

## REFERENCIAS BIBLIOGRAFICAS DE LOS CENSOS

Secretaria de Planejamento da Presidencia da Republica Fundacao Instituto Brasileiro de geografia e Estatistica. Censo Aeropecuario Maranhao. VIII Recenseamento Geral. 1970. Volumen III, Tomo V, 1a. parte.

Secretaria de Planejamento da Presidencia da Republica Fundacao Instituto Brasileiro de geografia e Estatistica. Censo Aeropecuario Piaui. VIII Recenseamento Geral. 1970. Volumen III, Tomo VI, 1a. parte.

Secretaria de Planejamento da Presidencia da Republica Fundacao Instituto Brasileiro de geografia e Estatistica. Censo Aeropecuario Bahia. VIII Recenseamento Geral. 1970. Volumen III, Tomo XIII, 1a. parte.

Secretaria de Planejamento da Presidencia da Republica Fundacao Instituto Brasileiro de geografia e Estatistica. Censo Aeropecuario Minas Gerais. VIII Recenseamento Geral. 1970. Volumen III, Tomo XIV, 1a. parte.

Secretaria de Planejamento da Presidencia da Republica Fundacao Instituto Brasileiro de geografia e Estatistica. Censo Aeropecuario Matto Grosso. VIII Recenseamento Geral. 1970. Volumen III, Tomo XXII, 1a. parte.

Secretaria de Planejamento da Presidencia da Republica Fundacao Instituto Brasileiro de geografia e Estatistica. Censo Aeropecuario Goias. VIII Recenseamento Geral. 1970. Volumen III, Tomo XXIII, 1a. parte.



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Secretaria de Planejamento da Presidencia da Republica. Fundacao Instituto Brasileiro de Geografia e Estatistica - IBGE. IX Recenseamento Geral do Brasil - 1980. Volumen 2. Tomo 3. Numero 16. Censo Agropecuario Minas Gerais, Rio de Janeiro Brasil - 1983.

Secretaria de Planejamento da Presidencia da Republica. Fundacao Instituto Brasileiro de Geografia e Estatistica - IBGE. IX Recenseamento Geral do Brasil - 1980. Volumen 2. Tomo 3. No.24. Censo Agropecuario Mato Grosso, Rio de Janeiro, 1983.

Secretaria de Planejamento da Presidencia da Republica. Fundacao Instituto Brasileiro de Geografia e Estatistica - IBGE. IX Recenseamento Geral do Brasil - 1980. Volumen 2. Tomo 3. Numero 23. Censo Agropecuario Mato Grosso do Sul, Rio de Janeiro, 1983.

Secretaria de Planejamento da Presidencia da Republica. Fundacao Instituto Brasileiro de Geografia e Estatistica - IBGE. IX Recenseamento Geral do Brasil - 1980. Volumen 2. Tomo 3. Numero 8. Censo Agropecuario Piaui, Rio de Janeiro, 1983.

Secretaria de Planejamento da Presidencia da Republica. Fundacao Instituto Brasileiro de Geografia e Estatistica - IBGE. IX Recenseamento Geral do Brasil - 1980. Volumen 2. Tomo 3. Numero 15. Censo Agropecuario Bahia, Rio de Janeiro, 1983.

Secretaria de Planejamento da Presidencia da Republica. Fundacao Instituto Brasileiro de Geografia e Estatistica - IBGE. IX Recenseamento Geral do Brasil - 1980. Volumen 2. Tomo 3. Numero 25. Censo Agropecuario Goias, Rio de Janeiro, 1983.