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16. Summary/Notes

The area under study is located between coordinates 52° - 52°30' W and 22°- 22°30' S. This region, formerly covered by a tropical forest, was deforested in the early 40's for coffee plantation and cattle raising, which caused intense gully-erosion problems. The main objective of this study is to develop a method to analyze the relationship between land-use and soil erosion, using remote sensing techniques. First, visual interpretations of aerial photographs (scale 1:25.000), MSS-LANDSAT imagery (scale 1:250,000), as well as automatic interpretation of Computer Compatible Tapes (CCTs) by IMAGE-100 system were carried out. From visual interpretation the following data were obtained: land-use and cover types, slope classes, ravine frequency and a texture sketch map. During field work, soil samples were collected for texture and X-ray analysis. The texture sketch map indicates that the areas with higher slope angles have a higher susceptibility to the development of gullies. Also, the over-carriage of pastureland, together with very friable lithologies (mainly sandstone) occuring in that area, seem to be the main factors influencing the catastrophic extension of ravines in the study area.

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Remote sensing data applied to the evaluation of soil erosion caused by land use: Ribeirão Anhumas basin area; a case study.

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RÉSUMÉ

L'aire étudiée se situe entre les coordonnés 52^0 - $52^0 30'$ W et 22^0 - $22^0 30'$. Cette région, autrefois couverte par une fôret tropicale, fût défrichée pendant les années 40,pour donner lieu à des plantations de café et des pâturages, ce qui a causé des ravines en grandes extensions. L'objectif principal de cette étude est le développement d'une méthode pour l'analyse des relations entre l'utilisation du terrain et l'érosion du sol, à l'aide de techniques de télédetection. Initialement furent realisés des interpretations visuelles de photographies aériennes (échelle 1:25.000), d'images du MSS-LANDSAT (échelle 1:250.000) et l'interpretation automatique de "computer compatible tapes" (CCT). D'après l'interpretation visuelle, les données suivantes furent obtenues: types d'utilisation du terrain et couverture végétale; classes des versants, fréquence des ravines et un croquis des textures. Pendant le travail sur le terrain, des échantillons de sol furent collectés pour l'analyse de texture et pour l'analyse par rayons X. Le croquis des textures indique

que les régions avec des angles d'inclinaison de versants plus elevés ont une susceptibilité pour le développement des ravines. Ainsi le surpâturage, alié à des lithologies très friables (surtout grês) qui occurent içi, semblent être les facteurs qui influent le plus sur l'extension catastrophique des ravines.

ABSTRACT

The area under study is located between coordinates 52^0-$52^0 30$'W and 22^0-$22^0 30$' S. This region, formerly covered by a tropical forest, was deforested in the early 40's for coffee plantation and cattle raising, which caused intense gully-erosion problems. The main objective of this study is to develop a method to analyze the relationship between land-use and soil erosion, using remote sensing techniques. First, visual interpretations of aerial photographs (scale 1:25.000), MSS-LANDSAT imagery (scale 1:250.000), as well as automatic interpretation of Computer Compatible Tapes (CCTs) by IMAGE-100 system were carried out. From visual interpretation the following data were obtained: land-use and cover types, slope classes, ravine frequency and a texture sketch map. During field work, soil samples were collected for texture and X-ray analysis. The texture sketch map indicates that the areas with higher slope angles have a higher susceptibility to the development of gullies.Also, the over-carriage of pastureland, together with very friable lithologies (mainly sandstone) occuring in that area, seem to be the main factors influencing the catastrophic extension of ravines in the study area.

INTRODUCTION

The main objective of this paper is to show the preliminary results of a methodology which is being developed to study the relationship between land-use and soil erosion problems in the Ribeirão Anhumas basin area (SW São Paulo State Brazil), using data from aerial photographs and LANDSAT system (Fig.1). This study area is under intensive erosion processes with huge gullies and rills (Suarez, 1975).

A river basin was chosen as a study unit, because it constitutes a geomorphological system where there are interactions between forms and processes (Gregory & Walling, 1973). Studies of erosion processes have been carried out using aerial photographs and LANDSAT imagery by Ray (1960) and Morrison & Cooley (1973), respectively.

METHODOLOGY

Description of the study area

The area drained by Ribeirão Anhumas (approximately 750 Km^2) is built up lithologically by sandstones from Bauru and Caiuá formations, Upper Cretaceous (Almeida, 1956 and Suarez, 1975). These formations are often capped by Cenozoic sediments (Suarez, 1975). The relief of the basin area is made up by low hills with gentle slopes and large drainage divides. Altitudes vary between 400 and 250m, from the upper to the lower river course. The tropical continental climate in the study area has a dry season from April to September, with an annual average rainfall around 1.000 mm. According to Köppens's classification, the study area belongs to climate type CWA; the warmest month (January) has a mean temperature around 26°C and the coldest month (June) has a mean temperature over 18°C.. The predominant soil type in the area is the dark red, latosol, sandy phase (Serviço Nacional de Pesquisas Agronômicas, 1960).

Methodological procedures

The following materials were used for this study: topographic maps of scale 1:50.000; panchromatic aerial photographs taken in 1972 of scale 1:25.000; MSS-LANDSAT imagery; path/row number - 220/27 on June, 28, 1973, channel 5 and 7, scale 1:250.000, and LANDSAT computer compatible tapes (CCTs). A grid of 2 x 2 cm was overlaid on the topographic map which divided the basin area into 880 sampling units; each unit corresponds to an area of 1 Km^2. Twenty percent of the sampling frame (176 units) were selected by lottery sampling. The selected sampling units were then analyzed on aerial photographs using criteria recommended by Buringh (1960); Ray (1960) and Bergsma (1974). Information such as the frequency and extension of ravines, slope classes, land-use and soil cover types were obtained. During field work, soil samples were collected from 17 representative units at the middle segment of slopes, and submitted to textural analysis. Declivity values were calculated from topographic maps. Using these data, graphics were made correlating ravine frequency with the following parameters: declivity, the ratio of fine sand/rough sand, land-use, soil cover types and hydrographic density. Data from LANDSAT computer compatible tapes were analyzed by the multispectral image analyser (system IMAGE-100). The classification programmes available for this system were used according to the User's Manual (General Electric, 1975). The programmes for spatial feature extraction developed by Dutra & Mascarenhas (1980) and MAXVER (Velasco et al.,1978) were also used for LANDSAT imagery texture analysis.

PRELIMINARY RESULTS

Table 1 shows the standardized data obtained from aerial photographs for the 17 samples considered.

These data allowed an multivariate analysis after Koch & Link (1971). The multiple correlation coefficient obtained was $R^2y\ x_1x_2x_3 = 45.1$. Even though some of the sample correlation coefficients are low, the R^2 value shows that these variables, together , were responsible for 45.1% of the y variation, indicating that they have a certain participation in the erosion process in the area studied.

In Fig.1, it can be observed that those points where hydrographic density is low, the frequency of ravines is also low, suggesting a probable correlation with the drainage network. The correlation coefficient between these 2 variables was 0.502.

The correlation coefficient between ravine frequency and thin sand/rough sand ratio (Fig.2) was very low (0.117). Most points analyzed are located within a narrow band of textural variation, indicating a great homogeneity of material. The variable declivity (Decl.) here is not the main factor responsible for gully erosion frequency (Fr.). This is shown by a low correlation coefficient between Fr. and Decl. (0.411) and the dispersed distribution of samples in Fig.3. Other important variables in the erosion process such as: rain intensity, soil erodibility, slope length, lapse time of human occupation, considered by Wischmeier, 1977;

Toy, 1977 and Meyer & Kramer,1969, were not yet included. On the other hand, the number of sampled units analyzed up to the present moment is not sufficient for an observation of linear distribution.

RESULTS OF THE AUTOMATIC ANALYSIS

The print-out of texture classes (Fig.4) was obtained by the Multispectral Image Analyser (system IMAGE-100) using LANDSAT computer compatible tapes (CCTs). Five classes were grouped and compared with topographic profiles, declivity data, hydrographic density and ravine frequency. The preliminary analysis from this print-out shows that unit V corresponds to areas with higher susceptibility to accelerated erosion processes, as well as to areas with intense erosion at drainage divides. This class is characterized by a higher thematic variation than the other classes. Classes II and IV present an intermediate texture between classes I and V. Class III corresponds to areas with a dense vegetation cover, and was easily distinguished from the other classes. This indicates that class III is not a response of texture variation from the imagery. The textural classification presented here is yet a preliminary result. New procedures are being tested to get a better classification of image texture.

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Fig. 1. Correlation between ravine frequency and hydrographic density.

Fig. 2. Correlation between ravine frequency and thin sand/rough sand ratio.

Fig. 3. Correlation between ravine frequency and declivity.

Fig. 4. Print-out of texture classes.

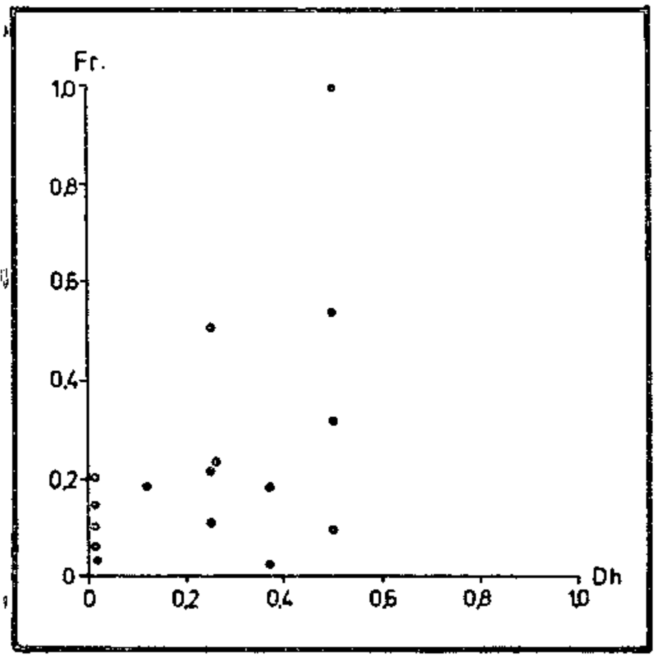

Fr.
1,0
0,8
0,6
0,4
0,2
0
Dh
0
0,2
0,4
0,6
0,8
1,0

Fig.1

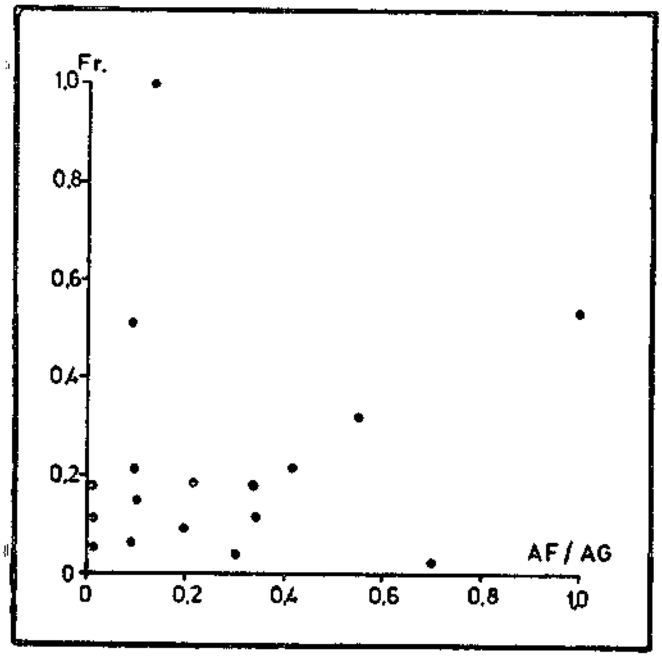

Fr.
1,0
0,8
0,6
0,4
0,2
0
AF / AG
0
0,2
0,4
0,6
0,8
1,0

Fig.2

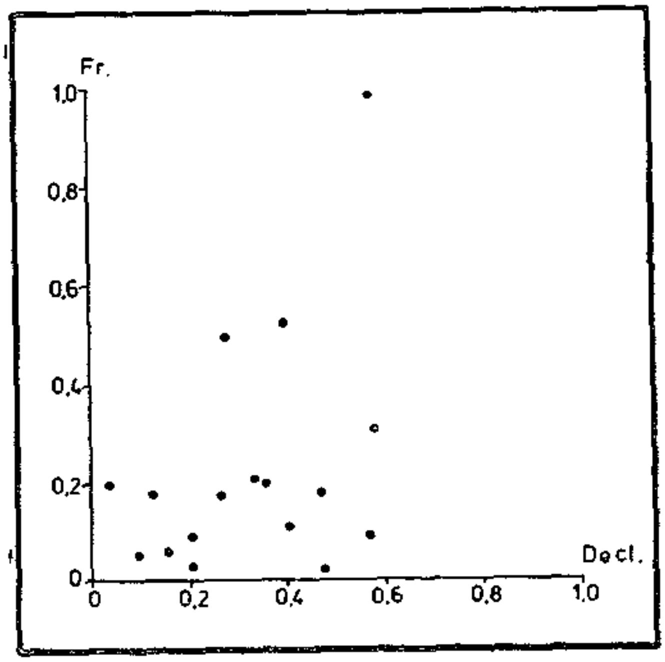
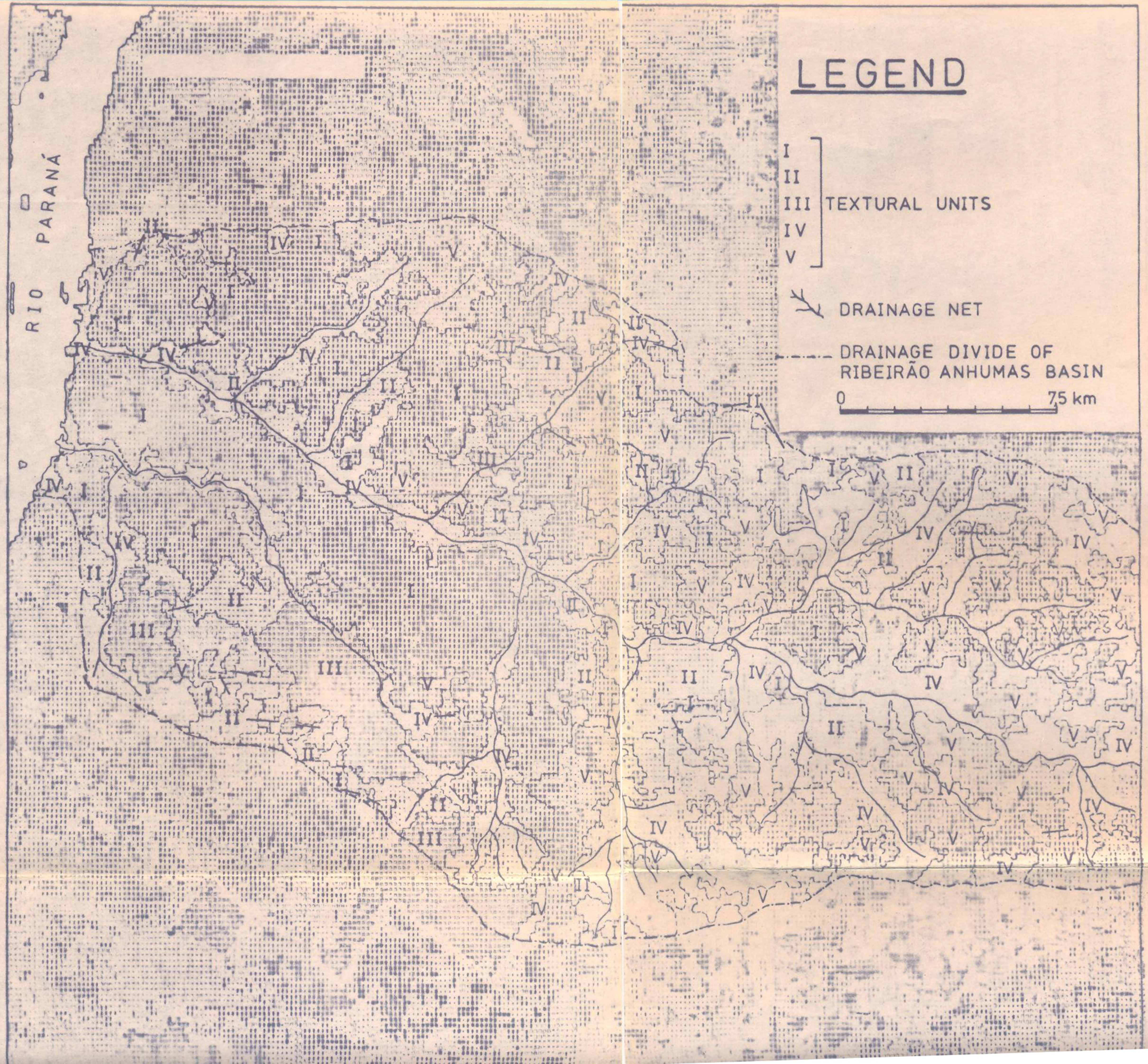


Fig.3

Table 1 - Standardized data for frequency of ravines (Fr.); average declivity of the slopes (Decl.); thin sand/rough sand ratio (AF/AG) and hydrographic density (Dh.)

Nº of samples / Variable	653	567	397	468	538	540	541	475	655	716	453	251	200	333	190	134	32
Fr. (Y)	0,22	0,54	1,00	0,32	0,04	0,10	0,03	0,12	0,19	0,19	0,51	0,22	0,19	0,06	0,07	0,10	0,21
Decl. (X_1)	0,33	0,39	0,57	0,57	0,20	0,56	0,47	0,40	0,46	0,26	0,27	0,34	0,12	0,09	0,15	0,20	0,03
AF/AG (X_2)	0,42	1,00	0,14	0,55	0,30	0,20	0,70	0,34	0,22	0,34	0,09	0,10	0,00	0,01	0,09	0,02	0,09
Dh (X_3)	0,25	0,50	0,50	0,50	0,00	0,50	0,37	0,25	0,37	0,12	0,25	0,25	0,00	0,00	0,00	0,00	0,00


LEGEND
I
II
III TEXTURAL UNITS
IV
V
DRAINAGE NET
DRAINAGE DIVIDE OF
RIBEIRÃO ANHUMAS BASIN
0
75 km
RIO PARANÁ