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Farm Land Use Classification for the Planning of Planting of *Eucalyptus Spp.* at Mato Grosso do Sul of Brazil Using Remote Sensing and Geographic Information System[1*]

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브라질 Mato Grosso do Sul 주에서의 유칼리나무 植栽計劃을 위한 農場土地利用區分에 관한 研究[1*]

- 遠隔探査技術과 地理情報시스템(GIS)의 適用 -

禹鍾春[2] · Ricardo Campos Nobrega[3] · Jose Imana-Encinas[3]

ABSTRACT

This paper analyzed vegetation and land use classification, slope and permanent preservation and legal reserves on the farm Jangada and Jamaica-Mato Grosso do Sul, Brazil, using satellite image for assisting the planning of planting *Eucalyptus spp.* This part of the State of Mato Grosso do Sul represents an important geopolitcal area, since it is located on the borders of Bolivia and Paraguay. Also exportation of goods can be achieved through hydrovias extending to Buenos Aires, Argentina-through the Paraguay River. Also there are road and railroad connection which link the soutreastern part of Brazil to the Andean countries. The vegetation map from sheet SF 21-Campo Grande of the RADAMBRASIL Project was used as the basis for the preliminary interpretation of coverage, and complemented by a visit of the field. After the initial interpretation of the image, definition of classes of use and land occupation were made, and files of spectral signatures were created. On the farms Jamaica and Jangada Open Arboreal Savanna and Grass Savanna are the predominant physiognomies occuping 68% of total area. In spite of the results being satisfactory at the present moment, the development of this project should be revised and adjusted based on the evaluations already made, including a greater detailing of environmental components, principally with respect to soil and topography.

Key words : Farm land use classification, remote sensing, GIS

要 約

본 연구는 브라질의 서부에 있는 Mato Grosso do Sul 주의 Jangada 농장과 Jamaica 농장에 유칼리나무 植栽計劃을 원활히 추진하기 위해 인공위성사진을 이용하여 植生分類 및 土地利用區分, 傾斜度 및 永久自然保存地域 등을 분석한 결과이다. Mato Grosso do Sul 주의 서쪽에 위치하는 이 지역은 볼리비아와 파라과이의 국경근처에 있기 때문에 地政學的으로 매우 중요하다. 또한 물품수출이 파라과이강을 통해서 아르헨티나의 수도인 부에노스아이레스 까지 도달될 수 있고 브라질의 남동지역과 안데스산맥에 연한 국가들을 연결하는 國道와 鐵道가 존재한다. 농장의 山林 被服地域의 일차해석을 위한 기

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초로서 Radambrasil프로젝트 SF-21 Campo Grande로부터 얻은 식생지도가 사용되었고, 그 이후에 現場調査가 수행되었다. 최초의 이미지해석이 이루어진 후에 사용급과 토지점유에 대한 개념정의가 이루어 졌으며 스펙트럼분류가 행해졌다. Jangada 농장과 Jamaica 농장에 있어서 산림지역 Savanna와 초원지역 Savanna가 전체 총면적의 68% 정도를 차지하고 있다. 현재로서 만족한 연구결과에도 불구하고 이미 이루어진 評價結果에 기초하여 프로젝트 발전을 위한 修正과 補完이 요구된다. 특히 土壤과 地形을 포함해서 환경인가에 대한 상세한 분석이 병행되어야 할 것이다.

INTRODUCTION

The application of remote sensing and geographic information systems(GIS) in the forest sector increases every year. It is important to have, aside from their use as "automizers of cartographic routines, a plan to put into practice the relevant potential of remote sensing and geoprocessing as a support for management of forest resources.

Remote sensing is the science and art involved with the gathering of data about the earth's surface without reference. The image obtained is a model of target features described through the use of spectral reflectance. The availability of multispectral scanner along with a multitude of quantitative computer-aided analysis techniques for processing such data, has created a tremendous increases in the array of data, analysis procedures, and results that can be obtained using remote sensing capabilities.

Cornett(1994) comment about the "black hole" created between data and knowledge, and define GIS as an information management tool that has profound potential for bridging that "black hole" and transformig data in usable information for scientists and decision makers.

Recent and very developments in GIS technology, and the interrelationships between remote sensing and GIS, have created additional dimensions of complexity as well as opportunities to use various data source and analysis techniques to provide the information needed by the resource managers. "···The identification, measurement, and inventory of the earth resources is a considerable task, the technology of remote sensing does offer mankind the potential to produce a broadly consistent data base, at spatial, spectral, and temporal resolution, that is useful for resource managers"(Colwell 1993, p.1). Given many advantages using satellite image, forest management is one of the most possible areas to advance the technique to classify the relevant resources(Lee and Kim, 1998).

The objective of this work is to produce maps of the cover and land use, slope, areas of permanent preservation and legal reserves on the farm Jangada and Jamaica with the aim of assisting in the planning of planting of *Eucalyptus* spp.. As a complement to this process, we hope to show some of the possibilities and available resources of Remote Sensing and Geographic Information Systems(GIS) as applied to silviculture.

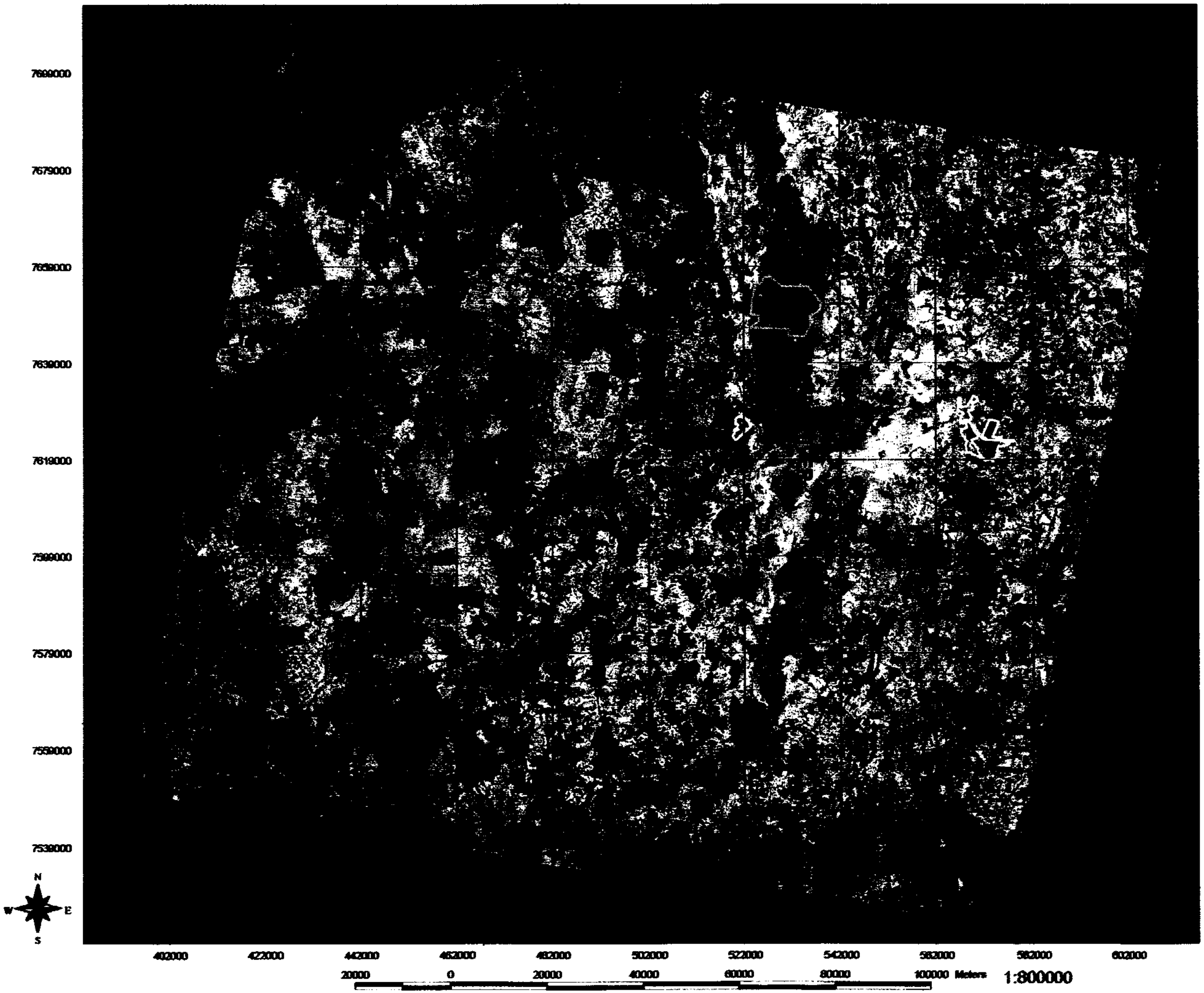
METHODOLOGY

Starting with maps furnished by the owners, the farms were localized on maps produced by the Directory of the Geographic Service, in the scale of 1 : 100000. These maps also served as reference for the image obtained from Landsat. The satellite image that covers the regions was identified from the list of orbital points furnished from the Institute for Spatial Research INPE.

The satellite Landsat5-TM collects data in seven bands, with three in the visible spectrum and one thermal. In function of the objective of this study and the characteristics of these bands-bands numbers 3, 4 and 5-were chosen.

The stages of treatment, correction and classification of the images were done using the software ENVI 3.0. The phases of editing the classification, selection, quantification and localization of the areas of reserves, protection and use as well as production of the layouts(maps) were done with the software ArcView and Arc/Info.

MATO GROSSO DO SUL - BRAZIL



TABOQUINHA FARM
NEW HOPE FARM
JAMAICA AND JANGADA FARM
HARMONIA FARM

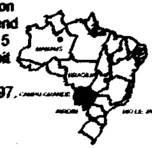
LOCALIZATION AND CHARACTERIZATION

This part of the State of Mato Grosso do Sul represents an important geopolitcal area, since it is located on the borders of Bolivia and Paraguay, and is the main road and rail access from Brazil to the Andean region. It is integrated to the exportation corridors of the States of São Paulo and Paraná, by land, towards the Atlantic Ocean. Also exportation of goods can be achieved through hydrovias extending to Buenos Aires, Argentina through the Paraguay River. Also there are road and railroad connections which link the southeastern part of Brazil to the Andean countries, though the roads BR 163 and BR 262 and the Northeastern Railroad of Brazil (Estrada de Ferro Noroeste do Brasil), which interlink with the Pan-Ameriacn highway in the Pacific region.

The geomorphological aspects, linked with the presence of relatively fertile soils, and the presence of a relatively good climate and the existence of a good access, create favorable conditions for forestry.

Vertical Datum: Imbituba - Santa Catarina
Horizontal Datum : Córrego Alegre - Minas Gerais
Projection: UTM
Origin: equator and 57 W. GR.
constant addition : 10.000 Km and 500 Km.

*Color composition with bands 4, 5 end 3 of Landsat TM 5 images, in its orbit point 226/076, made in Feb. 1997.



1. Acquisition and Generation of the Catographic Base

The basic documentation used were images from the satellite Landsat5TM in its orbital point 226/075 on February 2nd, 1997, using data from bands 3, 4, and 5. The methodology used in this study was as follows : (1)The files of these images on CD-ROM were acquired from the National Institute for Spatial Research-INPE. The images were furnished in DAT format, which required a transforamtion to TIFF. This transformation was necessary for the images to be read by the software ENVI. The software used for this transformation was L2TIFF(furnished by INPE). (2)The initial processing of the bands 3, 4, and 5 from the satellite Landsat TM5 was done with the software ENVI and consisted of atmospheric correction, geographic correction and image improvement : (a)*Atmospheric correction* is used to eliminate the effects of suspended particulate material and gases in the atmosphere on the attenuation and scattering of the incident and reflected radiation from the area of interest on the land surface. Clean bodies of water were chosen for determination of the digital values(black-body technique) since clean water absorbs almost all of the incident radiation, and thus has a value near zero (0) in all bands(Meneses, 1995). (b)*Geographic correction* consists of the identification of the X-Y coordinates that represent the same position on both the cartographic maps and the satellite images. To identify the sites we used a fifth degree polynomial equation and the cubic-convolution method, which is the method most indicated for large areas(Eastman, 1996), since it uses the weighted values of the 16 pixels which surround the point on the satellite image, corresponding to the localization grid of the pixel(Meneses, 1995). We assumed as a constant datum the cartographic sheet Brazil Corrego Alegre MG and Mercator's Transversal Projection-UTM 21, obtaining an accumulated mean error(RMS) of 9.88 m for a total of 191 points. North American cartographers consider an acceptable error to be, at most, half of the size of the pixel used as a base(in the case of Landsat, the size of the pixel is 30m). (c)*Image improvement*: the exclusive purpose is to improve or highlight the visual characteristics of the entire image, or specific portions, for posterior visual interpretation. The method used was *Improvement by linear amplification of contrast*. This is a first order function, which transforms each value of the digital image into a new brilliance values for each pixel of the original image. The coefficient "b" of the equation defines the offset, which modifies the original histogram while the coefficient "a"(slope of the line) has the effect of increasing the original histogram(Meneses, 1995).

$$Y = f(x) = ax + b$$

which is expressed as

$$VB_s = [(255/M_{ax} - M_{in})\ (VB_e - M_{in})],\ \text{where,}$$

VB_s = final brilliance value
M_{ax} = maximum brillance value
VB_e = initial brillance value
M_{in} = minimum brilliance value.

After the initial processing a colored composition was produced with the bands 4(red), 5(green) and 3(blue)(RGB 453). In this composition Jangada and Jamaica farms were located and a subset were created.

After production of the color composition topographic curves were included with the software TOSCA/IDRISI and the digitalization of the road network, hydrographic channels and perimeters with the software ArcView.

2. Interpretation, Classification and Maps

The vegetation map from sheet SF 21 Campo Grande of the RADAMBRASIL Project was used as the basis for the preliminary interpretation of coverage, using the colored composition to define the classes of cover and land use.

After the initial interpretation of the image, definition of classes of use and land occupation were made, and files of spectral signatures were created for each class(Regions of Interest ROI). The method of maximum similarity(highest probabilities) was chosen for classification of the images. In this method the distribution of the reflectance values in an area are described using a probability function, based on Bayesian statistics. This classification evaluates the probability that a pixel pertains to certain category and then classifies the pixel into the category that has the largest probability of containing the pixel(Meneses, 1995).

3. Field Visits

Image interpretation requires that field verification be done to be able to adjust patterns and actualize usage, due to the delay between obtention of the images and production of the maps. In this study, a field survey was done to identify and characterize the phytophysiognomies. The principal objective of the field visits was to establish a comparative base for interpretation of the images and visual classification and principally realize adjustments and corrections on the preliminary maps.

The visits to the farms occurred on February 11^{th} and 12^{th}, 1998, using ground observations and overflights. For comparison of the phytophysiognomies described in the laboratory we used a GPS Magellan and aerial photographs taken with a Nikon N4004s, with a AF Nikkor 35 - 79 objective for 35㎜ film and a Sony Handycam 8㎜. The points visited were plotted on the maps.

LOCALIZATION AND CHARACTERIZATION OF THE STUDY AREA

With respect of geology, geomorphology, pedology and potential land used, data were compiled based on dados furnished by the Project RADAMBRASIL.

The farms Jamaica and Jangada are situated in the coordinates UTM 21-(Datum Crrego Alegre MG) : latitude 7.622.000 and longitude 571.000 They are part of the State of Mato Grosso do Sul MS, municipality of Jardim. The farms Jamaica and Jangada are contiguous, and together cover a total of 5301 h. Both have low relief and their altitudes vary between 240 and 320m.

The climate is transitional between the hot tropical of the Cerrado of the Central West region of Brazil, with two well marked seasons, to the subtropical without a dry season of the forested regions of the south of Brazil. Maximum temperatures can reach 40℃ in the hottest months and the mean low temperature for the coolest months (June/July) is almost always over 14℃(Brasil, 1982).

Rainfall is generally well distributed over the whole year. The months with the highest rainfall are November, December and January, and the months with the lowest rainfall are June, July and August. The mean annual precipitation is between 1300 to 1700㎜, varying 15 to 20% between years(Brasil, 1982).

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The geomorphological aspects, linked with the presence of relatively fertile soils, and the presence of a relatively good climate and the existence of a good access, create favorable conditions for forestry.

1. Geomorphology

Within the Geomorphological Unit of the Depression of the Paraguay River, which is considerd to be very complex in function of the diversity of topography, morphology and soils, occur the alluvial plains that constitute the Pantanal of Mato Grosso. The Depression of the Paraguay River is identified as na erosive surface(pedeplain), eventually covered by recent deposits, surrounding all of the Pantanal region(Ferreira, 1969).

The Depression of the Paraguay River originated after the Cretaceous Period, when the highland areas were subjected to a sinking through submeridially fractured blocks(Brasil, 1982). The subsidence was so great that the Atlantic Ocean invaded the interior of the continent during the Miocene, forming a gulf in the south of Paraguay, and probably giving rise to the delta of the Paraguay River. There are vestiges of marine flora and fauna in the fossil record.

This subsidence, in conjunction with the easily erodable pyllites and the sandy paleozoic sediments, permitted the rapid evolution of the basin of the Paraguay River, making possible all of the drainage of the basin of Paran(Brasil, 1982), where previously higher ground was encountered. The relief of the Depression of Paraguay was made in the lower layers of the sedimentary basin of Paran in the underlying paleozoic sediments. This fact, by itself, is indicative of the fact that the upper layers of the basin were removed, which indicates that the opening of the Depression was done by erosion(Brasil, 1982).

The notion of hydrographic basin is linked to geomorphology, that qualitatively classifies hydrographic basins in structures, either erosive or accumulalting. These divisions refer to the genesis of the form of the basin.

Within the Geomorphological Unit of the Depression of the Paraguay River, relief is considered to be conserved, that is erosion acts with low intensity, so that the forms in the basin are conserved or only light dissected. These forms reflect the erosion surface that resulted from the removal of the cretaceous sediments. Thus, it should be considered to be a post-cretaceous surface.

Brasil(1982) groups the conserved relief following the form of dissection, into three categories : a sharp forms relief with a continuous sharp top, with different levels and generally separated by valleys in "V" ; c convex forms relief with the tops having a convex shape, with different levels and separated by valleys with flat plains or in "V" and ; t table forms relief with flattened tops, with different levels, and separated by wide flat-bottomed valleys. The dominant forms on the Jangada and Jamaica farms are table forms, with relief type t, slightly plained and with maximum interfluvial difference less than 250m and little deepening of the drainage channels, being separated by valleys with flat bottoms and with flattened tops, with the size of the inferfluvial areas ranging from 750 to 1750m and little deepening and separated by valleys with a flat plain. An index of dissection can be made using a table which includes the intensity of deepening of the drainage system and the size of the dissection forms.

The post-cretaceous erosive phase that removed the sandstones did not do so equally over the whole area. In certain sites the removal of these sediments was complete, leaving bare rock. In other areas, erosion removed only the upper layers, leaving the basal conglomerates(Photo 3). In these sites, human actions are putting at risk the precarious equilibrium of the area.

The type of model of dissection is particularly important for conservation of land and water. In this model there is a medium level dissection, not offering much risk in terms of erosion, but requiring some care to avoid erosion, such as the maintenance of the vegetative cover on the plateaus and along the water bodies, with the objective to reduce superficial runoff and lixiviation of the soil.

2. Pedology

1) Soils

The inherent conditions of the soil are functions of a series of physical, chemical and morphological characteristics present in the soil profile. Naturally the individual consideration of all these factors is only possible and comprehensable after research where it is desirable to control the majority of the variables. Following the level of the studies, the scale of the maps used and published, it is necessary to make generalizations to compatibilize the information with the necessity of the users of the final product and to the technical-economic availabilities

According to the methodology adopted in the RADAMBRASIL Project, the following characteristics are considered to be satisfactory : salinity and alkalinity, drainage, texture and structure of the B horizon, cation exchange capacity, effective depth, texture and structure of the superficial horizon and organic matter.

Each of the pedological units is analyzed according to these characteristics, giving values que vary from 1 to 10 according to the degree of adequacy for plant growth normal for the species, in this case *Eucalyptus* sp.. Thus, the weight for ideal condition is equal to 10 and for totally adverse is equal to 0. With these values, the geometric mean for the site is calculated and used to define the inherent degree of restriction for the soil at the site(Brasil, 1982).

The criteria adopted and mean weights of the respective class intervals are found in the methodology of the RADAMBRASIL Project.

According to the soil map produced by the RADAMBRASIL Project, in the scale of 1 : 1,000,000, three types of soils are found on these farms.

2) Aluminum rich dark red Latosol-LEa8

These are mineral soils, not hydromorphic, identified by the presence of a latossolic B horizon, with levels of hematite(Fe2O3) between 9 and 18% for a clayey texture and the relation aluminum/hematite(Al2/Fe2O3) less than 3.14 for medium texture soils.

The soils are deep, with good drainage, very porous and permeable, in an advanced stage of weathering and predominance clay minerals of the type 1 : 1(proportion of anions of the clay particles and absorption of cations from the soil) and sesquioxides in the composition of the colloidal fraction, with a very low cation exchange capacity(Buckman, 1976), less than 13mEq/100g of clay after correction for carbon and a low stock of nutrients available for absorption.

The A,B, and C horizons can be seen have little differentiation between the subhorizons, generally with diffuse transitions but, occasionally gradual. The color of the matrix is 2.5YR and 10R, with 5YR occurring with a lower frequency. The increase in clay between the A and B horizons is small, giving a low textural relation.

They have excellent physical properties and favorable topography for mechanization because of their position on low or slightly ondulating relief, however their low natural fertility(dystrophic soils) and elevated aluminum content require, respectively fertilization and lime to supply the mineral deficiency and to annul the noxious effects of aluminum.

3) Aluminum rich red-yellow Podzol-PVa4

There are mineral soils, not hydromorphic, deep or very deep and well drained, in which there is the presence of a textural B horizon resulting from the process of illuviation(concentration) of clays, verified by the presence of waxyness and significant textural relationship between the A and Bt horizons, which are the fundamental characters for classification of this soil, aside from the base saturation being less than 50%(dystrophic soils) and aluminum concentration higher than 50%. The A horizon is moderate, on top of the textural B horizon, with a predominance of clay minerals type 1 : 1, which give the clays their characteristic low activity. Gravel may be present in some cases.

These soils originated in the decompositon of rocks from the Aquidauana Formation, principally sandstones. They occur over several kinds of relief, from flat to ondulated and to best use their potentialities they require fertilization to correct their naturally low fertility, in the dystrophic soils, and also the aluminum rich soils require lime to minimize the toxic effect of the aluminum.

4) Hydromorphic Eutrophic Solodic Laterite-HLSe1

These soils have a sequence of horizons A, Bt and C, and are saturated with sodium, with values between 6 to 15%. The have clays of high activity and abrupt change in texture, texture medium sandy and base saturation higher than 50%.

Since this concentration of sodium is prejudicial to the development of the majority of plants, they require for better use, which is not as savanna for natural pasture, irrigation and drainage for removal of sodium.

3. Vegetation

On the farms Jamaica and Jangada Open Arboreal Savanna and Grass Savanna are the predominant physiognomies. These farms were historically used for rangeland for cattle production, which was confirmed by analysis of the satellite images : some areas classified as exposed soil, representing areas which were being prepared for pasture, as related by the foreman at the time of the images. On the field visit, it was possible to observe a well developed pasture, one year later(Photo 1).

After analysis of the satellite image and supervised classification, the following types of vegetation could be distinguished.

1) Dense Arboreal Savanna(Cerrado)

This physiognomy is characterized by groups of xeromorphic tree species with thin, tortuous stems, with thick, rough bark and profuse branching, also with coriaceous and perennial leaves. The height of these species is relatively low, and their spatial distribution is relatively uniform, with their canopies occasionally being in contact with each other, impeding direct penetration of sunlight to the soil surface. Some woody species are deciduous in the winter, leaving the soil surface covered with a layer of dry organic material, whose decomposition is intensified with the beginning of the rainy season. The upper canopy, with a mean height of around 10m, is composed of ecotypes which are characteristic of the Cerrado with a low percentage of species from other formations. The shrub layer is poorly differentiated from the upper canopy. The grass layer is sparse and basically composed of grasses, in the form of tufts, sedges and several other families(Brasil, 1982)(Photo 2).

The floristic composition of this formation is

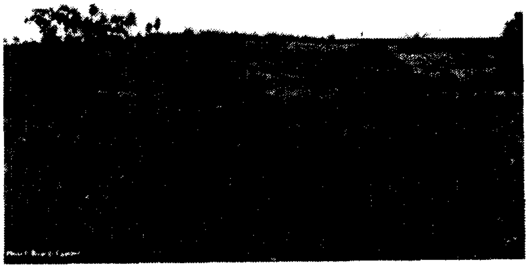

Photo 1. Grassland

Photo 2. Dense arborial savanna

Photo 3. Open arborial savanna

very heterogeneous, characterized by : *Bowdichia virgilioides*(sucupira-preta), *Magonia pubescens* (tingui), *Astronuium graveolens*(gonalo-alves), *Qualea grandiflora*(pau-terra-folha-larga), *Qualea parviflora*(pau-terra-folha-mida), *Piptadenia* espcie (angicos), *Pterodon pubescens*(sucupira-amarela), *Hymenaea stigonocarpa*(jatob-do-campo), *Platymenia reticulata*(vinhtico-do-campo) e *Terminalia argentea*(capito-do-campo)(Brasil, 1982).

2) Open Arboreal Savanna(Campo Cerrado)

This is an open physiognomy, composed of small species with thin, tortuous stems, sparsely distributed in a continuous grass layer. There are occasional stunted woody individuals and acaulescent palms. This savanna formation is exclusive to the lixiviated sandstones with a floristic composition similar to that of the Dense Arboreal Savanna, however its structure is much lower and open(Photo 3).

The phanerophytes with the highest dominance in this formation are the species : *Qualea grandiflora*(pau-terra-folha-larga), *Qualea parviflora* (pauterra-folha-mida), *Kielmeyeracoriacea*(pausanto), *Tabebuia caraiba*(ip-caraba), *annona coriacea*(araticum-do-campo), *Luehea paniculata* (aoita-cavalo), *Dimorphandra mollis*(faveiro-do-campo), *Strypnodendron* spp(barbatimo), entre outras(Brasil, 1982).

3) Grass Savanna(Campo Limpo)

This is also a lowphysiognomy, formed by a grass layer, interspersed with a few small woody species and acaulescent palms. There are no phanerophytes(Photo 4), except in the strips of gallery forest that rarely occur on the streams encountered in this formation(Brasil, 1982).

The most common species are grasses, sedges and low legumes.

4) Gallery Forests

These are forests which have a particular hydrological regime. They occur as narrow strips of woody vegetation which accompany streams and also surround the lakes in natural savannas or man-made savannas and in arid regions(Photo 5). The limiting factor in these sites is the higher or lower avalability of water in the ground water table, which is a function of the bodies of water which these forests surround.

The relative independence from precipitation permits the gallery forest their penetration along streams and rivers, in regions that are situated beyond the limit of rainfall normally seen for forest formations(Lamprecht, 1990).

The expression "gallery forest" is also used in a larger sense to designate the forests localized near the margins of rivers in areas with xerophytic or hydrophytic deciduous forests. In all cases, they can be distinguished from the normal forests of the region by their greater growth, higher percent of cover, larger amount of wood and internal structure, and the higher proportion of evergreen species(Lamprecht, 1990).

4. Exposed soil

Normally as the result of human actions soils could be exposed. The sites on the farms with this physiognomy are the result of preparation of soil for planting and hill tops where erosive process has started. This site(Photo 6) can be considered to be a degraded area, in function of the loss of its properties and productive capacity, thus being a target for recuperation.

5. Hydrography

The principal rivers present on the Jangada and Jamaica farms are the Rio da Prata(affluent of the Rio Miranda on its left bank), the Rio Verde(affluent of the Rio da Prata on its right bank) and the Cambarace Stream(affluent of the Rio Verde on its right bank), all of these compose the basin of the Rio Miranda.

The rivers Miranda present a dendritic drainage pattern and is one of the principal rivers of the State of Mato Grosso, belonging to the Paraguai

Photo 4. Grass savanna

Photo 5. Gallery forest

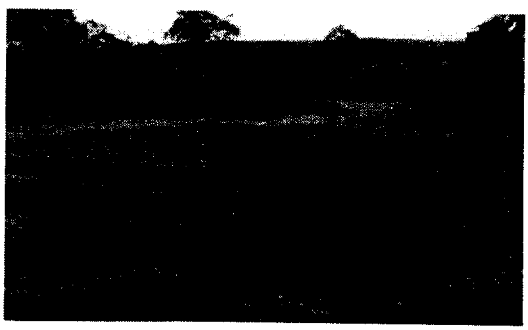

Photo 6. Exposed soil

River Basin.

6. Potential land use

The mapping of the potential land use consists of the delimitation of geographic areas with homogeneous characteristics, from the potential productive point of view. This is, in synthesis, the mapping of the interaction between soils-relief-climate-vegetation.

It is important to establish the difference between the natural potential of an area and its respective economic potential.

Natural potential is the intrinsic capacity to produce or not. It becomes recognized, as in the case of the present work, through surveys which include the delimitation of different areas with different potential productivity, overlaid on maps in the appropriate scale. These maps are accompanied by their respective summaries, in which the systematic criteria and methods that were applied are explained, along with the definition of each cartographic symbol used(Brasil, 1982).

This is basically determined by the slope and presence of protected areas. The soil is the last selection factor and will indicate appropriate sites.

Economic potential is the capacity to generate well-being or riches. Its determination involves, aside from the natural potential, question of infrastructure, technology and market.

1) Relief

Relief is considered an important variable in the definition of the use of renewable natural resources because, in fact, if constitutes the most important physical base of modern technology which covers a sequence of intensification where it is only possible to obtain the maximum of each when its precedents are well applied.

In truth, relief is not only the difference in height between two points, Its connotation includes, aside from relative elevation, form, inclination of the slope and length. Also, since complex forms are more frequent than simple forms, the general pattern must also be included with the elements of identification.

GENERATION OF THE MAPS

1. Vegetation and Soil Use

The classification of the vegetation was initially done on the satellite images followed the terminology adopted by RADAMBRASIL, and considered the following physiognomies : Dense Arboreal Savanna and Gallery Forest, which in this work were grouped and called forests ; Open Arboreal Savanna, Grass Savanna and Exposed Soil. A preliminary map was elaborated which was later compared and actualized after the field visits. The generation of the polygons of the classes of soil use permitted the quantification of the areas.

The next step was the comparison of the actual situation, referring to the forests, with the zones for permanent preservation and established legal reserves(Law-004771 of Sept. 15^{th}, 1965 in articles 2 and 3 of the Brazilian Forest Code. The sum of the areas of legal reserve and permanent preservation should be, at least, 20% of the entire area of the farm.

2. Slope and Relief

The digitalization of the contour curves was done starting with maps produced by the Directory of Geograpahic Services DSG, on the scale of 1 : 100000, using the software TOSCI/IDRISI. The next step was the transformation of this vectorial file into raster format. This permitted the generation of a model of elevation and slope with the software Arc/View.

DISCUSSION

The implementation of a Geographical Information System(GIS) permits an overview of the area being studied, a detailing of the relevant aspects and quantification and qualification of the mapped information which allows satisfaction at various levels of organization, be they operational, managerial or strategic(Ferrari, 1996).

The influence of GIS in administration of firms can be manifested in diverse forms : reduction of operational costs, better support for decision making, improvement in the image of the company, etc.. An organization, which is in the implantation phase of a GIS should consider all of the possible uses and their benefits and then priorize those which are most adequate for local conditions. There is no one solution for all situations.

The different types of influence of GIS in the organization should be considered, not only at the planning stage, but also during all of the process of establishing and evaluation of the project. Each organization should determine the types of use and benefits that are viable and priorities for the local conditions and from this point establish specific goals for the project. These goals should be used as parameters in the choice of implementation strategies and as indicators of success.

The operations at the *Operational Level* are those of every day. In general they are volumous and teedy. Their automation has the potential to produce and economy of resources such as time and money. The expected benefit should be *operational efficiency*. A GIS may be used as support for the basic processes of administration of a farm, or operational tasks, such as :

- maintenance of the base map in a digital format
- use of the digital map as support for the project and execution of engineering projects
- maintenance of forest inventories
- management of the infrastructure network, digital maintenance of data, support for operations of routine maintenance of networks(planning of tasks, generation of maps and schemes), emergency support, etc.

The activities at the *Managerial level* are in general decisions of technical nature. For example, decisions as to the allocation of resources, for example, which plot should receive more fertilization? The basic objective of informatization of managerial tasks is to facilitate better decisions.

The information provided by GIS when utilized at the managerial level is, by nature, reduced and many times multidisciplinary : zoning, localization of equipment, services and networks of infrastructure, maps or a combination of this information. The objective here is *organizational efficiency*, which means improving the administration so as to contribute to the objectives of the farm.

Geographical Information Systems can be used as tools for spatial or locational analysis, modeling and simulation, etc. Applications of this nature include :

- subsidizing the elaboration of policies for use and occupation of the soil
- planning and management of equipment and services, rental of new equipment, evaluation of the transport and collection systems
- environmental monitoring, etc.

Operations at a *Strategic level* are those which directly contribute to the fulfilling of the fundamental objectives of the organization through its commercial strategy. The commercial strategy of the farm should, for example, involve :

- increasing client satisfaction
- improving the image of the farm with the clients, potential clients, suppliers and other commercial partners and potential commercial
- increasing the participation of the farm into new market segments or increasing the participation of the farm in markets already being exploited, etc.

CONCLUSIONS

The use of the satellite image, GPS, field visit, aerial and ground photographs were necessary tools for the realization of this project of mapping of the coverage and usage of the soil on these farms.

In spite of the results being satisfactory at the present moment, the development of this project should be revised and adjusted based on the evaluations already made, including a greater detailing of environmental components, principally with respect to soil and topography.

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