

# TECHNICS OF REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM APPLIED IN CLIMATE ACTION PROJECT IN EAST COAST OF PARANA STATE

R. Wodzynski, D. Schmidlin, M. Prestes

SPVS - Society of Research in Wild Life, Gutemberg, 296 Curitiba - PR, Brazil  
E-mail: labsig@spvs.org.br

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## ABSTRACT:

The SPVS, Society of Research in Wild Life executes, among others activities, with partnership of the TNC (The Nature Conservancy) and financing of Texaco, General Motors and American Electric Power (AEP), three projects of Action Against the Global Change, in a 40 year duration. These projects are **The Guaraqueçaba Climate Action Project** (7 thousand hectares), **The Atlantic Rainforest Restoration Project** (10 thousand hectares) and **The Antonina Pilot Reforestation Project** (one thousand hectares). The objectives of the projects are the forest restoration of degraded areas, enrichment of secondary forests, protection of forests (under deforestation risk), conservation of biodiversity, sustainable development and production of carbon credits. These projects are located in the EPA of Guaraqueçaba (Environmental Protection Area), coastal north portion of Parana state in south Brazil. The project activities have been divided in three groups: feasibility study, planning & development and execution phase. The LABSIG, Laboratory of Geographic Information Systems of SPVS, participated in all of these three phases. By the phase of planning & development, the definition of the line base in the work area - EPA of Guaraqueçaba – were launched, with a Multitemporal Study of the land use based on orbital images. The environment compartmentation of the area was executed, with the generation of the geoambiental map as subsidy to the planning of the projects. This work consisted in the delimitation of zones with similar characteristics from the overlapping of the subjects in a GIS (soil, geology, relief, climate, hydrography and hydrogeology). After the definition of the areas, photogrammetrics surveys in scale 1:30,000 and digital orthophotos in scale 1:10,000 have been done. During this phase agrarian surveys still have been made as subsidy to the prospection and acquisition of areas, as well as to the definitive mapping of the projects areas, with perimeters and memorials for agrarian regularization. As orientation to the prospection, the degraded areas were mapped and quantified in the interest regions. In the phase of project execution, detailed environment surveys have been made for the handling of the reserve, as soil, geology and vegetation in scale 1:10,000. The next step, the forest restoration, was defined as a function of priority areas and attendance of matrices and plantation.

## 1. INTRODUCTION

The SPVS – Society of Research in Wild Life, is a non-governmental organization located at Curitiba, State of Paraná, south region of Brazil, acting as a technical-scientific organization founded in 1984. Since march 2001 SPVS has the title OSCIP (Public Interest Civil Society Organization). The NGO from Paraná State, recognized as one of the most important in Brazil, has the mission “work for the conservation of nature through the protection of native areas, by environmental education actions and by development of models aimed to the rational utilization of natural resources”. Its actuation today is focused in the Araucaria Forests and Natural Fields, as well as in the Guaraqueçaba region, north seashore of Paraná State – an area that contain the major contiguous remnant of Brazilian Atlantic Rainforest.



Figure 1: Paraná State location

In order to accomplish its efforts, the institution counts on the support from governmental agencies, NGOs and private enterprises. With this partnership, the SPVS runs after to come attention to achieve investments for the environmental cause as a way to add value to its business, whose work already counts on more than 25 official partners. It's acknowledged by the quality of its work, performed by more than 100 employees - of the technical area (Biology, Forest Engineering, Agronomy, Veterinary Medicine, Geology and

others) and administrative area, as well as field activities assistants acting as park rangers, foremen and reserve administrators.

Among its initiatives are environmental education actions, an effort aimed at maintaining the Red-tailed Amazon (*Amazona brasiliensis*) out of the roll of species threatened with extinction, efforts for recovering and protection of native areas and an awareness campaign to avoid the environment contamination with heavy metals contained in cellular-phone batteries.

From 1991 on SPVS elected as its priority actuation focus the EPA (Environmental Preservation Area) of Guaraqueçaba, on the north seashore of Paraná state. By 1999 the institution realized an important step in order to strengthen its actuation in the region, obtaining financial support to implement three long-term projects. These projects include degraded areas acquisition for the development of forests restoration projects (reforesting with native trees) and, together with the local communities, look for income generation alternatives compatible with nature preservation. These projects also have the purpose of helping in the fight against global warming. Thanks to the photosynthesis process, the growing trees will contribute to remove one of the gases (carbon dioxide) from the atmosphere. The carbon dioxide is the main component that causes the global warming.

These projects are undertaken by SPVS, with partnership of The Nature Conservancy (TNC) and the funders American Electric Power (AEP), General Motors and Texaco. The projects, each one with a 40-year duration, count on 7 thousand hectares in the Serra do Itaquí Natural Reserve, 10 thousand hectares in the Cachoeira Natural Reserve and 1 thousand hectares in the Morro da Mina Natural Reserve.



Figure 2: SPVS projects location: 1 – Morro da Mina Natural Reserve; 2 – Cachoeira Natural Reserve; 3 - Serra do Itaquí Natural Reserve.

## 2. TECHNICS OF REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM APLIED IN CLIMATE ACTION PROJECT IN THE COAST OF PARANÁ STATE

The activities of the projects were grouped in three components: Feasibility Study, Development Planning and Phases of Project Execution.

### 2.1 Feasibility Study

#### 2.1.1 Definition of the area in which the projects are to be elaborated

The project sites were defined based on the potentialness for carbon sequestration and other relevant aspects to the projects that involve conservation actions priority. This work took into account the probable areas available for acquisition.

2.1.1.1 Previous evaluation of the carbon sequestration potentialness – Brazil: for the purpose to evaluate the Brazilian vegetation remnant from 1991 to 1995, a GIS application was developed. Based on the annual increase and decrease of the vegetation, a potentialness index for the carbons sequestration for a specific region was established. Such application, developed in the Evenue language for ArcView 3.2, works with vegetation shape files and generates new shape files based on the results. These information helped in the evaluation and documentation of the execution feasibility of the project in the Guaraqueçaba EPA region.

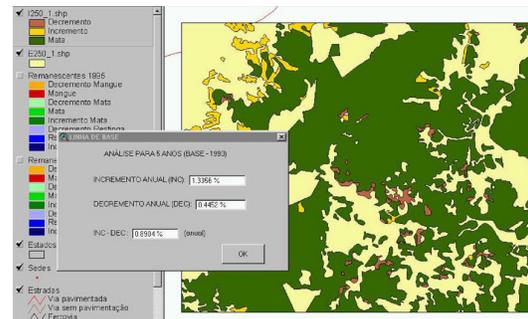


Figure 3: Application for previous evaluation of the potentialness of carbon sequestration.

2.1.1.2 Other aspects to be considered: Besides the vegetation studies, the other aspects observed and defined as characteristic of the priority conservation areas through visual analysis of the orbital images and an institutional knowledge or the Guaraqueçaba EPA region were: Presence of buffalo raising, presence of furnaces for charcoal production (contribution to the deforestation), croplands of banana and ginger (high consumption of pesticides), soil erosion, pasture areas with *Brachiaria sp* (an exotic plant with encroaches areas and is severely aggressive to the environment) and a pretty degraded landscape.



Figure 4: Aerial view of Cachoeira Natural Reserve. In the detail is shown buffaloes and coal furnaces.

## 2.2 Planning and Development

### 2.2.1 Definition of the baseline in the embracement area – EPA of Guaraqueçaba

In order to evaluate a demonstration of the dynamics of the area under study, with and without the existence of the SPVS project, information were collected. Two methods were employed which enabled a comparison and a complementation of the information. The area under study was limited within the EPA of Guaraqueçaba (314,000 hectares). The results of these analysis generate data about the carbon amount to be captured by the project alongside its duration. The two evaluations done are the multitemporal study from the orbital images and another, also based on orbital images, but with additional details that made possible the Shape (Modelling).

2.2.1.1 Multitemporal Study of the land use from the orbital images: Land Use Mapping for the years 1986, 1994 and 1999, based on the Landsat 5 TM satellite images, bands 543, RGB colour composition and 30m spatial resolution. The method used was the supervised digital classification with field gauging of the points considered as critical and originated by samples. The results were cross-referenced and the result was a map with the changing in areas for the period. The hydrographic and road data were also cross-referenced and as a consequence it was noted that the changes occurred mainly alongside the roads and accesses.



Figure 5: Map of Land Use by 1999 (Part of the Multitemporal Study)

2.2.1.2 Shaping – Geomod \*: A land use study for the years 1975, 1986 and 2002 was done by supervised digital interpretation, but in a different way of the multitemporal study already mentioned. Such a mapping has as outcome the vegetation and non-vegetation classes for the shaded and non-shaded areas of the satellite images. The images had a 30m resolution, RGB coloured composition of the bands 4, 3 and 2 from the Landsat TM (1075) satellite and bands 5, 4 and 3 from the Landsat 5 TM (1986) and Landsat ETM 7 satellites (2002).

From the understanding of land use covering changes dynamics it is possible to build mathematic models for scenario generation with a good reliability in the land covering status in simulations for past and future. For the model build-up there were considered variables that maximize or minimize the human-related activities in the environment. These variables were the distances from hydrographic ways, from paved and non-paved roads, sea border, deforestation and from communities, slopes, hipsometry, water sources orientation, soils and hidrografic basins.

For the shape execution it was used the GEOMOD program, an IDRISI module. The program analyses the vegetation data in reference to the two dates and calculates the changes in a linear form. In addition it simulates the vegetation status in the past and in the future based on the use of the interference variable in the deforestation or reforestation.

The characteristics of each region are also considered inside the area under study, as they can influence the analysis in a differentiated maner.

### 2.2.2 Area compartmentation in terms of physical environment – geoambiental map as a subsidy to the projects planning

The zones with similar characteristics were delimited from overlapping of the issues in a GIS ambient (secondary data). The data relating to Soils, Geology, Relief, Climate, Hydrography and Hydrogeology were intersected and, by the use of the characterization rules, the Homogeneous Geoambiental Units were achieved.

### 2.2.3 Projects influence areas

The projects influence areas were defined from the following characteristics:

DAA - direct affected area (ADA – área diretamente afetada) – an area restricted to physical-territorial sites of farms already effectively acquired or even those in the prospection phase. Over these areas the actions for degraded areas recovering due to the forest suppression must be concentrated.

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DIA – direct influence area (AID – área de influência direta) – an area related to DAA and surroundings including the local draining and the spaces among neighbor farms which were not acquired.

IIA – indirect influence area (AII – área de influência indireta) – na area that comprises the main draining basins involved in each project.

MIA – municipal influence area (AIM – área de influência municipal) – an area that corresponds to the bigger surrounding municipalities which border the project area.

#### 2.2.4 Cartographic Base Definition

2.2.4.1 Projection and Cartographic Data System: The project of each Natural Reserve was executed according to the Brazilian Systematic Mapping (Mapeamento Sistemático Brasileiro) model, in Universal Transversa Mercator – UTM and Datum SAD-69. Considering the maps printing, the scale adopted was 1:10,000.

2.2.4.2 Flight and Digital Orthophoto: photogrammetry services were hired using flights with a 1:30,000 scale and generation of digital orthophotos in a 1:10,000 scale.

2.2.4.3 Digital Cartographic Base: Alongside with the orthophotos an hydrography restitution and the digital terrain model (DTM) were hired. Through the digitalization method over orthophoto in CAD software or with the data acquisition with GPS, the main roads and the important sites inside the reserves were drawn, as well as an adaptation of other existing cartographic bases of the region. These data were prepared and inserted into a GIS ambient (Geographic Information System), with insertion of complementary attributes as identification, dimensions and properties. Legends for each mapping issue were also defined.

#### 2.2.5 Prospection and Acquisition of the Areas:

Perimeters Mapping and area description documents: At first all the areas to be acquired as well as their respective owners were identified based on maps furnished by the municipalities and by an agrarian inquiry. From the cartographic base, orthophotos and a GPS survey with more than 50 cm precision, the agrarian information could be completed and checked, with the tabulation of the data related to the limits of the acquired properties aiming at the agrarian regularization. Each perimeter was shown in details in the area description documents and the maps. For the unification of the several perimeters maps area description documents were also being done, according to the Brazilian law requirements.

2.2.5.2 Degraded Areas Quantification: Inside the properties perimeters the deforested areas were identified and quantified. For this purpose a visual interpretation of the photos were done, with the areas being drawn over the orthophoto in a GIS ambient.

### 2.3 Projects Execution Phases

#### 2.3.1 Detailed survey of the physical environment

2.3.1.1 Cartographic information preparation: In order to ensure an adequate development of the work, cartographic information in a 1:10,000 scale in the hard copy and digital forms were supplied to the technical staff responsible for the surveys in Soils, Geology and Vegetation.

2.3.1.2 Support and orientation to the technical staff in each area: aiming at the several surveys being executed in an organized form and with facilities for inserting them into a GIS ambient, the GIS staff in charge of the projects kept a close contact with the field technician, giving them orientation about the working scales, digitalization forms of the data and methodologies for description of the ambients, in such a way that the data common to the GIS objects could be designated to the GIS objects (shapes, points, lines) in a simple and direct way.

2.3.1.3 Survey conclusion: with the raw data sent by the technical staff, the next step was the edition and transformation of these data in polygons by means of the software tools of ArcInfo and ArcView. The attributes describing the polygons and other objects were inserted resulting in final maps in scale 1:10,000 for each one of the surveys.

#### 2.3.2 Forest Restoration

2.3.2.1 Definition of the Priority Areas: With the help of the Forest Restoration technicians in the rules definition phase, it was established, from the cross-referencing of soil, geology and vegetation maps, which would be the priority areas for the forest restoration inside the reserves. Such rules were based on the ambient fragility, defining weights to each soil, geology and vegetation characteristic, which resulted in an environmental fragility map.

2.3.2.2 Matrices Monitoring: Seeds from native trees are collected for the production of trees at nursery, designated for plantation in restoration areas. Each matrix tree is georeferenced with the help of a GPS equipment and then marked at the field. From the development of trees at nursery it is possible to obtain the productivity of each matrix tree considering the origin of the seeds.

2.3.2.3 Forest Restoration Plan – Plantation: Homogeneous areas were defined based on the cross-referencing of vegetation, soils maps and the results of restoration priorities. Information concerning to accesses and slopes also took part of this work. With this crossing, restoration polygons with similar characteristics could be separated. Each of these areas receive different seed species, also with different planting spacing, treatment and maintenance. In addition, the access and slope of terrain information are still the basis for the definition of the trees plantation technique (by hand, with machines, with pole, etc). Each polygon in the GIS receives a number, that become the key between the mapping and the restoration data base. Besides serving as activity manager, the GIS sends additional information to the data base as area in hectares and

perimeters, as well as the Physical Environment data. The data base then uses this information for calculation of the quantity of seedlings that must be produced at the nurseries, helping in this way the definition of better and more detailed production chronograms, as well as to evaluate the productiveness of the works in a time X human resources relationship. The hardprinted maps also collaborate to the understanding of the work by the field technicians. Marks for photographic monitoring are installed for the monitoring of plantation alongside the years. In these points the plantation areas are pictured and the data are stored and related to its geographic position. The carbon stock monitoring will be described below (Item 2.3.6).

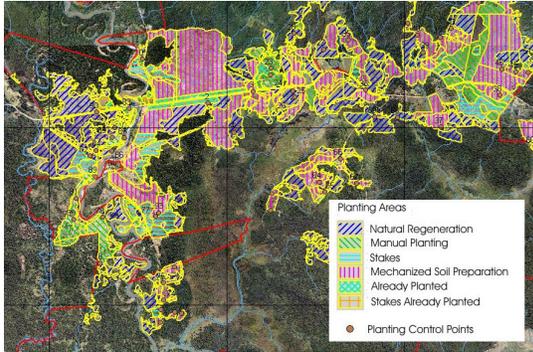


Figure 6: Planting Areas

### 2.3.3 Reserve Handling Plan

2.3.3.1 Subsidy for for the Handling Plan elaboration: Biotic Surveys (flora and fauna) and Zoning: The data from the reserve ecological evaluation research are stored in a GIS ambient, which provides for a better interdisciplinary understanding. The surveys are performed in several areas as fauna, flora, social-economy, birds and archeology and are integrated resulting in a base for the Handling Plan of the reserves. The results are demonstrated in maps with indications for the correct use of each area in the reserve.

2.3.3.2 Planning and management of the inspection (trails): The reserves had their trails and internal accesses mapped using GPS. For the management of localization and rescues points were marked, at the field and in the GIS, at each 200 meters alongside the trails, which allows for any occurrence could be communicated by a radio system and the local identified quickly. With a nomenclature of the type “number of the point/name of the trail” established at the field and at GIS, hardprinted maps help the inspection system. Other information are still stored as trail size, journey time, situation and possibility of access with cars or animals. The park rangers were instructed to collect GPS points and digital photos about hunting, fishing and deforestation occurrences among others. These occurrences are stored according to its geographic position, which can be analysed for obtaining fragility maps of external menaces.

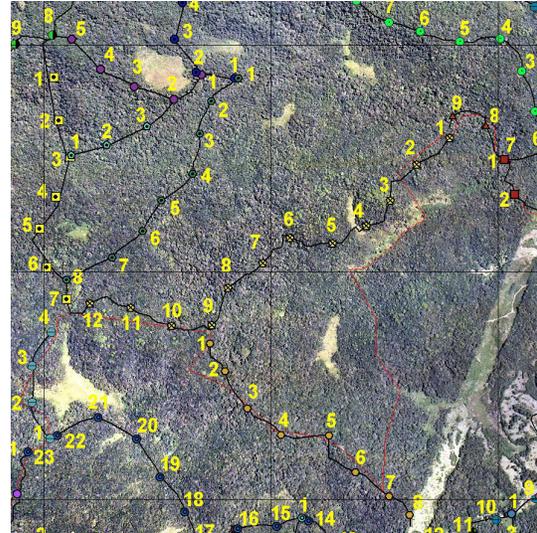


Figure 7: Trails: points at each 200 meters.

### 2.3.4 Carbon Leakage Control

2.3.4.1 Changes in the use of regional land use: The projects foresee an upgrade of the Land Use Map at the EPA of Guaraqueçaba, within a defined frequency between 2 to 5 years until conclusion of the project to allow identification of regional changes of the soil use. These information will be subsidy for evaluation of projects effectiveness, mainly in relation to the activities previously performed inside the reserves and after being interrupted in these areas, could have been moved to surrounding areas.

### 2.3.5 Conservation and Development

The projects maintain this component with objectives as the creation of models of income generation compatible with the natural environment conservation, the environment education and the contribution to reduction of human pressure in the region. For this purpose activities in the communities surrounding the reserves are developed.

2.3.5.1 Characterization of the communities: All the communities in the region of the EPA of Guaraqueçaba were mapped (point) and characterized minimally. Taking into account the distances and ease of access it was defined which communities were considered as direct and indirect surround and in this way which would have its Participative Rural Diagnosis (PRD). The PRD data are prepared and fed to GIS, thus complementing the data from the communities. These informations are analysed and then it is possible to define which communities have priority in the receiving of different activities related to this project component.

2.3.5.2 Environmental education actions: Besides the identification of areas with need of environmental education (item 2.3.5.1), the technicians in charge of these activities make use of GIS in their activities as they can easily demonstrate the objectives and advantages of maintaining the ambients equilibrated. There are also activities in the maps production in a participative way that, besides spreading the

culture of maps utilization, brings about an enhanced understanding concerning to environmental interest issues.

### 2.3.6 Carbon Monitoring

2.3.6.1 Planning of carbon inventory: as a subsidy to the inventory, it were produced detailed cross-references of soils, vegetation and hipsometry. With these data it is possible to plan the instalation of carbon monitoring plots, distributed in the best way and quantity in the diverse ambients and in successive stages of the forest.

2.3.6.2 Georeferencing of pemanent plots: From the data collected at the field and those of the planning, the localizations of the Monitoring Plots are fed to GIS. Those consist of carbon stock sampling places through the measuring of trees diameter. Each plot receives a denomination and is contained in a group. With this identification it is possible to connect the multitemporal data base to each installed plot.

2.3.6.3 Determination of carbon stock: Plots for monitoring are installed not only for the case of forest areas but also for the recovering areas (trees plantation). From the plot's carbon stock analyses averages a projection is done for the total vegetal typology area.

2.3.6.4 Correlativeness between the carbon stock and type of soil, relief, climate and draining: The analysis of carbon stock data by physical environment type complement the studies of carbon biomass in Brazil. The results between the SPVS project areas and the data from other geographic regions are compared.

## 3. CONCLUSIONS

Environment projects normally have limited resources, that come from governmental or private funds, with specific activities and well defined targets. Not always such projects foresee a data organization in a Geographic Information System, although the culture of using GIS in projects is being consolidated year-after-year. It is all dependent on the professionals that prepare the projects that apply for these funds. For the sake of the success in the completion of the tasks it is indispensable to use the GIS and to elaborate projects that involve geoprocessing activities. All the concepts already established as management tools, quickness and precision in the decision-making, possibility to forecasts and premises, ambient for complex relationships and to demonstrate with the proposed facilities and results turn the costs involved with GIS easily justifiable. The SPVS, as a model researcher and elaborator, mantain its own Laboratory for Geographic Information System already for 7 years. All the SPVS projects are attended by this Laboratory, so the institution have understood in practice the effectiveness that can be achievable with GIS use.

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