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A Biodiversity Protection Monitoring System Using Remote Sensing and Geographic Information Systems

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1. Introduction

Brazil has great agroecological diversity and also a very dynamic socio-economic land occupation due to its giant size. An efficient and operational system of environmental protection of its biodiversity in protected areas, is an exciting challenge. Remote sensing and geographic information systems can be important tools in this work. The constant evolution of this technology, the number of terrestrial satellite monitoring operations available and the national experience in this field, open new perspectives for environmental policies.

The orbital data may integrate a specific methodology to provide information on the status and dynamics of the biological diversity of strategic protected areas (PA). Partial examples of a system of this nature are already operating in Brazil, such as the orbital monitoring of burned areas in national parks based on satellite images of the series NOAA/AVHRR; the mapping program of deforestation of the Legal Amazon of Brazil (PRODES) based on LANDSAT images; a qualification of preserved areas by remote sensing based on SPOT and LANDSAT images (Projeto Olho Verde, Projeto Rio Demene); the mapping of wildlife habitats by remote sensing (NMA and University of São Paulo (USP) Projects, and others.

This document analyses possible routes to be explored in this context. Here, current information about the main characteristics and the newest information on orbital monitoring systems is presented, followed by a list of possible actions on a specific methodology to provide information on the status and dynamics of the biological diversity of strategic protected areas (PA).

2. Main characteristics of the orbital monitoring system

The fast pace of orbital platforms and sensors' evolution is capable of offering a great amount of environmental data. Three main criteria should be used to evaluate if a certain platform is useful and appropriate to generate the required data providing information on the status and dynamics of the biological diversity of strategic protected areas:

- spatial image resolution
- temporal image resolution
- spectral image resolution

All of the imaging satellites are capable of being compared and examined by these three main criteria to provide information on the status and dynamics of the biological diversity of strategic protected areas.

2.1. Spatial Resolution

The fact that data are taken in a synchronized fashion is the main advantage of using satellite images for monitoring protected areas. The spatial resolution of terrestrial monitoring satellites deals with two concepts: the territorial coverage or extent of each image and the definition or detail of observation capable of being detected in each image. The spatial resolution in the detection capability, is reaching the meter range, allowing a series of applications which were never imagined to be possible before.

Today, the SPOT series is operating with a 10 m spatial resolution in the panchromatic spectrum and the IRS-D of India with 6.5 m. This year, some satellites will be launched with spatial resolution in the range of 1–3 meters. The possibilities of cylindrical stereoscopy by coverage of side views, for example, guarantees the construction of digital elevation models in areas which lack topographical data. This, in turn allows, in the case of temporal monitoring, a regular overlap with large-scaled maps (1:50,000 and 1:20,000). By the year 2000, almost a dozen satellites with spatial resolutions in the range of 1 to 4 meters will be launched, mainly by private companies. A detailed report on this evolution will be presented in chapter 3 of this work.

The second specific methodological interest in satellite images is the wide geographic extension of data collection. This is an especially attractive feature because of the possibility of having a simultaneous view, in a specific moment in time, of the whole extension of a protected area. For example, at a certain specific time, it is possible to inspect a variety of ecosystems in an area, which would otherwise take many hours and even days to inspect using aerial transportation. In many Amazon areas of Brazil, this method of observation would be very expensive and not viable. The simultaneous view of a variety of ecosystems allows informed comparisons about processes such as the photosynthetic activity, the occurrence of hydric deficiencies, nutritional stress, etc. In flooded or potentially flooded areas it is possible to see simultaneously and immediately the water level, vegetation behavior, etc. An area of approximately 34,000 km^2 can be seen with a LANDSAT image and with a SPOT image, approximately 3,500 km^2.

2.2. Temporal Resolution

Temporal resolution refers to the frequency in which the images are obtained for a certain place by an orbital platform. Again, two concepts must be considered, when one wants a specific methodology to provide information on the status and dynamics of the biological diversity of strategic protected areas: first, the spatial resolution of each platform and, second, the group of platforms of interest.

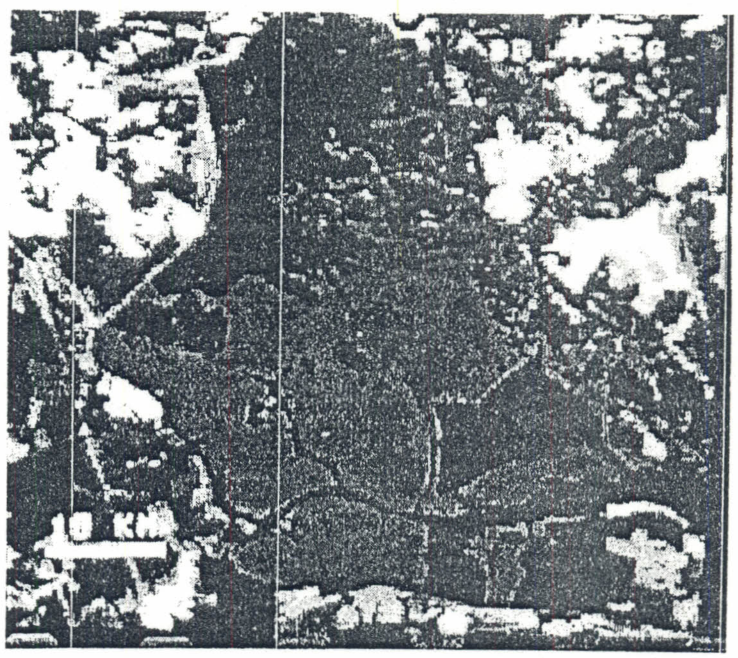
Today, the level of each orbital platform and the frequency in which images are taken can be on the order of hours or days, weeks and months. Certain ecological and environmental processes which are of interest for biodiversity can be observed daily and even, more than once per day thanks to the NOAA/AVHRR data system. Figures 1 and 2 show images of the Emas National Park of Brazil, obtained by NOAA/AVHRR (1) and LANDSAT TM (2), after a fire. On the east part of the park one can still see an active fire.

The spatial resolution of satellites may allow, at a distance and without habitat interference, an efficient monitoring of processes that endanger and change the biodiversity such as the destruction of habitats, fires and burnings, deforestation, floods and droughts etc. This temporal resolution of each platform is magnified by the existence of more than one satellite in

Figure 1. Emas National Park by NOAA/AVHRR Imagery

Source: INPE

Figure 2. Emas National Park by LANDSAT TM Imagery



Source: INPE

each series and by the possibility of combination of many orbital systems. Due to an increase in satellite constellations, the temporal resolution is also increasing. The increasing number of satellites will assure a great repetition rate in taking images from the same place and an almost constant observation can be made over protected areas of interest.

2.3. Spectral Resolution

Except in the case of some Russian platforms, satellites do not take pictures of the terrestrial surface. They generate digital images by the solar light reflectance over the planet or by active systems such as imagery radars. A detailed explanation of the physical aspects of the processes to acquire images will not be discussed here. The fact is that the range of spectral resolution of Earth's observation also has increased significantly and in an operational form in the last two years.

In 1972, the concept of spectral resolution became a reality with the LANDSAT (Land Remote Sensing Satellite) series satellites. LANDSAT 2, 3, 4 and, especially LANDSAT 5 or TM (Thematic Mapper), were a follow up to that. The main objective of LANDSAT 5 was the multi spectral mapping in high resolution of the Earth's surface. This was and is the most used orbital system when mapping the spatial temporal dynamics and all of its applications. The antenna of INPE (National Institute for Space Research), located in Cuiabá, Mato Grosso, Brazil, continuously receives images of the whole territorial system, since the seventies, and this is a huge and unique data collection of the country. In this same imagery strategy, several satellites participate, especially the SPOT satellite which has its images also received in Cuiabá.

Today, satellites provide images within a wide range of radiometric values which include the visible spectrum, the closer infrared, the farther infrared, the ultraviolet and microwaves (radar) in many sizes and polarizations. Several radar satellites are operating with success, especially ERS, JERS and RADARSAT (see description below). They are particularly interesting for monitoring areas where there is a constant presence of clouds.

The atmosphere is totally transparent for radar imagery and images may be acquired constantly and regularly. Radar images are extremely sensitive to any changes in wrinkles of the Earth's surface. Deforested areas, even small ones, may be detected efficiently. The RADARSAT, for example, is capable of covering the whole terrestrial surface, with the flexibility to attend specific requests, depending on the mode of operation of the synthetic aperture radar.

The image spatial resolution, in a refined operation mode, can be very big: 9 meters. What the RADAM (Airborne Radar Mapping of the Amazon) Project took years to execute, through an air transported radar, RADARSAT executes in a matter of days, with a superior spatial resolution. This is one of the most sophisticated and complete systems of radar observation of the planet. Yet the cost of these images is very high. ECOFORCE and NMA has been following up the validation program made in the Amazon region.

The concept of hyperspectral data is being more and more applied in place of multispectral images. The National Aeronautical and Space Administration (NASA), associated with the North American TRW Spacecraft Guide, projected and built the first orbital hyperspectral sensor, the LEWIS, which will be launched in 1997, inside

Small Spacecraft Technology Initiative (SSTI)—Lewis Spacecraft. This satellite has a resolution of 30 m in the visible spectra and 5 m in the panchromatic, it carries three scientific tools for spatial and terrestrial observation, and it has a temporal resolution from three to seven days. The Hyperspectral Imager will observe the Earth in 384 spectral bands, giving an idea of the commercial production of orbital data up to the end of this millennium. New orbital platforms, such as SPOT 4 VEGETATION for example, will be launched in 1998; they will also daily supply data in great amounts and with geometric, geographic and spectral accuracy.

Finally, the number of countries building, launching and operating orbital systems has also been increasing, resulting in a diversification of information sources, reducing image costs and the time for data supply. In the case of Brazil, launching of CBERS, the Chinese-Brazilian Earth Resources Satellite (or *Satélite Sino-Brasileiro de Recursos Terrestres*), is scheduled for 1998 and it should amplify even more this scenario and make its application to Brazil viable, since there was a need for a national satellite. The CBERS program puts together the technical capability and the financial resources of China and Brazil to establish a complete system of remote sensing competitive and compatible with the international needs. The satellite was planned to have a global coverage, amplifying and in addition to the remote systems already in operation. The diversity of sensor tools with different spatial resolutions and frequency of data collection is an exclusive characteristic of the CBERS. Federal institutions such as the Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA), will now be able to start monitoring programs more consistently based on this national satellite.

3. Evolution of orbital monitoring systems

The objective of this chapter is to show the potential of current and future orbital platforms to integrate a specific methodology providing information on the status and dynamics of the biological diversity of strategic protected areas. The main platforms of interest are presented in alphabetical order below. More detailed information about these orbital platforms may be obtained through the Internet in the following URL address:
http://www.nma.embrapa.br/satelite

ADEOS

The Japanese orbital platform ADEOS (Advanced Earth Observing Satellite), launched in 1996, has as its main objective contributing to terrestrial monitoring through environmental data acquisition and in the development of new space technologies of global observation. To the continuous observation of the Earth's surface and its atmosphere, the platform carries sensors such as: radiometric, scatterometric, spectrometric and interferometric, developed by NASDA (Japanese Space Agency), NASA, CNES, and the Environmental Agency of Japan.

ALMAZ

The ALMAZ-2 (Multi-Sensor Satellite System), scheduled to be launched in 1998, will be a complex Russian orbital platform, built by the NPO Machinostroyenia agency. The platform will have a variety of multispectral sensors and synthetic aperture radar (SAR) with 5 m resolution. This will be a follow up to ALMAZ-1, launched in 1991. Its data will be digitally transmitted, processed by Almaz corporation in Houston, Texas and available commercially from Hughes STX Corporation and SPOT Image Corporation. This platform is dedicated to geophysical, agricultural, geological and environmental applications and should supply a great amount of new data of high spatial and temporal resolution (1 to 4 days) simultaneously. This is the result of an international cooperation for the construction of a variety of sensors and of the reception and image distribution system.

ALOS

The satellite ALOS (Advanced Land Observing Satellite), of the NASDA, is scheduled to be launched in 2002 from Tanegashima Space Center and it will have tools such as the AVNIR (Advanced Visible Near-Infrared Radiometer) and a SAR (Synthetic Aperture Radar), along with a sophisticated data collection system (DCS). The ALOS system's first priority is to provide with accurate cartographic problems and with a flexible environmental monitoring directed towards problem solving in Asian and Pacific countries.

CBERS

The CBERS Program (China-Brazil Earth Resources Satellite or *Satélite Sino-Brasileiro de Recursos Terrestres*), gathers the technical and financial resources capability of China and Brazil to establish a complete remote system competitive and compatible with international needs. This satellite was planned for a global coverage, amplifying and adding to other remote sensing systems already in operation. The diversity of sensor tools with different spatial resolution and the frequency of data collection, is an exclusive characteristic of CBERS, which is scheduled to be launched by the end of 1998. NMA and ECOFORCE have been collaborating in the definition of the CBERS preparatory program with INPE.

CLARK

One more series of North American commercial satellites, which have imaging tools of high spatial and spectral resolution. Their images will visualize details in the order of 3 meters in the panchromatic channel and 15 in the multispectral, with temporal resolution of 7 days. The system is being developed by Small Spacecraft Technology Initiative—SSTI, associated with the North American TRW Spacecraft Guide Agency, and it has its first launching scheduled for 1997. Satellites of this nature, totally private, such as ORBVIEW, QuickBird, EarlyBird, GDE, RESOURCE, and SPACE IMAGING, for example, are a milestone in the new phase of high spatial resolution acquisition data, thanks to changes in the policies related to U.S. military information control.

DMSP

The DMSP (Defense Meteorological Satellite Program), started in 1960. Initially, this satellite program was used for defense activities, but its data were also used of weather studies. One of its special characteristics is the ability to generate images with little amount of light, such as reflected moonlight. It allows an excellent detection of cities and nocturnal points of light, such as burned areas. The information access still is very limited and ECOFORCE has been developing some application examples, thanks to data given by the University of Nevada. There is a future possibility that data from this platform may be accessed through antennas of the NOAA type.

EarlyBird

The EarlyBird is a satellite developed by the North American Agency EarthWatch which is scheduled to be launched in 1997. It has high spatial resolution, three meters in the panchromatic and 15 meters in the multispectral. It is capable of generating stereoscope images and it will have an spatial resolution of two to three days. The EarlyBird is dedicated to the monitoring of phenomena that require these high temporal and spatial resolution characteristics simultaneously and will be able to generate images from 9 km^2 to 900 km^2. The time for image delivery, between acquisition and reception by the client, should be just a few hours.

EOS

The EOS program (Earth Observing Systems), will supply a great amount of data for terrestrial studies. The system will include processes to observe global changes and contribute to the knowledge of atmosphere, lithosphere, hydrosphere and biosphere interaction. The system depends on a relatively complex institutional and operational structure which still gives a virtual characteristic to this program.

ERS

The radar series ERS (European Remote Sensing Satellite), was initiated with the launching of ERS-1 in July of 1991, by the European Space Agency—ESA and it continued with the ERS-2. These satellites have many tools (scattermeters, cameras, etc.) and generate a continuous information flux about oceans and immersed lands. One of the interesting features of the ERS is that the atmosphere is transparent to the radar waves, thus eliminating the problem of clouds in obtaining the images. NMA has been working with ERS data in several points of the semi-arid regions of the Northeast area, identifying geological and geomorphological features and correlating these data with the presence of groundwater. Observations on deforestation have also been made.

GDE

A commercial American satellite of high spatial resolution, dedicated to a detailed monitoring of terrestrial resources. It was developed by the GDE Systems (TBD), and its first launching scheduled for 1998.

GOES

GOES series (Geostationary Operational Environmental Satellite), is operated by the National Oceanic and Atmospheric Administration—NOAA. These geoparked satellites are located around 36,000 km above the Earth, in a equatorial geosynchronous orbit. This system of imaging is fundamental to the world's weather studies and it includes two GOES satellites (East and West) and one European METEOSAT satellite (parked over Africa). These advantageous positions allow the visualization of around one third of the Earth. South America and the greater part of the Atlantic Ocean are monitored by GOES-East, responsible for the generation, each fifteen minutes, of weather images, totally available through the Internet by CPTEC of INPE. ECOFORCE uses data of the GOES system daily, serving as a support for detection of burned areas and smoke in certain conditions.

GPS

The GPS (Global Positioning System), is a generic name for a whole constellation of satellites, whose numbers are always increasing. They are used for navigation and for precise measurements of geographic and geodesic localizations. GPS use is becoming very generalized and ample in the research work developed by ECOFORCE. Its data have been integrated with the Geographic Information Systems and they represent an important support for digital cartography, in the localization of ecological sampling points, etc.

IRS

The IRS series (Indian Remote Sensing Satellite), started with the launching of IRS-1A in 1988, followed by IRS-1B (1991). Both had multispectral sensors and resolution of approximately 36 meters and 72 meters. The third satellite generation, IRS-1C launched in 1996, has multispectral and panchromatic sensors, capable of generating images with a spatial resolution of 20 meters and 6 meters, respectively. India has had success in the development, launching and operation of its remote sensing satellites. These satellites lack tape recorders on board and also a reception antenna in South America, making it difficult to use the data of these platforms. The incorporation of tape recorders on board and the adoption of a more aggressive commercial political attitude should soon increase the availability of images from these platforms for Brazil.

JERS

The Japanese satellite JERS (Japanese Earth Resource Satellite), launched in 1992 by the National Space Development Agency of Japan, was an important investment of that country in environmental monitoring of the planet, followed immediately by the ADEOS platform. The JERS satellite has radar of synthetic aperture and an optical sensor, capable of observing the terrestrial surface in its totality and with an excellent resolution. NMA has been working with images from JERS in the Northern bank of the Amazon river mapping ecosystems that have strong hydrological dynamics (flooding and low damp ground), and focusing on certain kinds of vegetation ("igapós," open fields of low damp ground, low damp grounds, "lavrados," etc.). In São Paulo, JERS images are being tested by NMA in land use and for soil humidity monitoring. Courses are being organized in collaboration with INPE.

LANDSAT

The LANDSAT series (Land Remote Sensing Satellite), started in 1972 with the launching of ERTS-1 satellite. Next, LANDSAT 2, 3, 4 and the LANDSAT 5 or TM (Thematic Mapper) were also launched. Since there was a failure in launching LANDSAT 6 in 1993, the only satellite of the series that is still working is the LANDSAT 5, operational since 1984, beyond its planned time of operation and also with problems on the quality of generated images, which are more and more degraded. The main objective of LANDSAT 5 was the multi spectral mapping in high resolution of the Earth's surface. This was and is the orbital system most used by far by ECOFORCE in the mapping of land use spatial temporal dynamics and all of its applications. The INPE antenna in Cuiabá continuously receives images of the entire national territory, since the seventies, and this constitutes a huge and unique data information collection about the country.

LEWIS

The National Aeronautical and Space Administration (NASA), associated with the North American TRW Spacecraft Guide, projected and built the first hyperspectral orbital sensor, with its launching scheduled for 1997, on board the Small Spacecraft Technology Initiative (SSTI)—Lewis Spacecraft. This satellite carries three scientific tools for spatial and terrestrial observation and has 30 meters resolution in the visible spectrum and 5 meters in the panchromatic. The temporal resolution is from three to seven days. The Hyperspectral Imager will observe the Earth in 384 spectral bands, giving an idea of future trends in commercial production of orbital data until the end of this millennium.

NOAA

The NOAA series (National Oceanic Atmospheric Administration), started in 1970, followed up with the launching of more than a dozen satellites and a variety of operational tools (probes and image makers). After NOAA-13 was out of use, ECOFORCE continued using data from NOAA-12 and of NOAA-14, both launched in 1994. This satellite series generates daily global observations of the weather patterns and environmental conditions, in the form of quantitative data. Today, in NMA, this information is the base for monitoring studies of burned areas, of a follow up on the photosynthetic activity, of a detailed weather forecast, of agroclimatic zonings, of studies of landscape thermic behavior, of droughts and flood mapping, etc.

ORBVIEW

The ORBVIEW series is produced jointly by Orbital Sciences Corporation - OSC and National Aeronautical and Space Administration—NASA. The three satellites: MicroLab-1, launched in 1995; ORBVIEW-2 scheduled to be launched in 1998 and the ORBVIEW-3 scheduled to be launched in 2000, have different characteristics of imaging bands and resolutions, even if a high resolution (a meter) is a constant characteristic. The future ORBVIEW-3, for example, will generate images of high spatial resolution in real time, thanks to a new innovative system of image distribution directly to the interested clients.

POLDER

This is the first initiative of French-Japanese cooperation in spatial projects, the release of the POLDER (Polarization and Directionality of the Earth's Reflectance) tool on board the platform Advanced Earth Observing Satellite (ADEOS), in 1996, from Tanegashima Space Center. POLDER has a camera which has a bidimensional sensor, large field view and spectral and polarized filters. This is a platform for scientific purposes in which the atmosphere properties shall contribute to improving image correction models in other platforms. ECOFORCE is participating in platform data validation in two areas of the Brazilian Amazon, focusing on issues of ozone in the stratosphere.

QuickBird

The QuickBird is a satellite developed by the North American agency EarthWatch which will be launched in 1998. This satellite will have a high spatial resolution of less than a meter in the panchromatic and around three meters in the multispectral, it will be capable of generating stereoscopic images and it will have a spatial resolution of two to three days. The QuickBird will follow the EarlyBird, and it will be dedicated to the monitoring of phenomena that require the simultaneous characteristics of high temporal and spatial resolution. It will be able to generate images from 484 km^2 up to 40, 500 km^2. The deadline for image delivery, between acquisition and reception by the client, should be only a few hours.

RADARSAT

The RADARSAT (Synthetic Aperture Radar), developed by Canada, to monitor environmental changes and natural resources characteristics, was launched in 1995. Planned to have a life of five years, the RADARSAT is capable of covering the whole terrestrial surface, with flexibility to answer specific requests, depending on the operation mode of the synthetic aperture radar. The spatial image resolution, in a smooth operation mode, can be very big: 9 meters. This is one of the most sophisticated and complete radar observation systems of the planet. The image cost is very high and ECOFORCE has been watching the validation program conducted in the Amazon region.

RESOURCE

RESOURCE 21, which will be launched in 1998, will be an American commercial satellite with a medium spatial resolution, to offer multispectral coverage of the Earth's surface.

SCD-1

The SCD-1 (Data Collection Satellite), totally built in Brazil by INPE, was launched in 1993. This is the first satellite of the Brazilian Complete Space Mission (MECB) that foresees the development and construction of three others, the SCD-2 (already finished) and two other satellite of remote sensing (SSR-1 e SSR-2) for observation of terrestrial resources. The SCD-1, receives and retransmits information of the Data Collection Platforms (PCDs), installed in remote regions of the country. It has the capability to get signals of 500 PCDs simultaneously, the SCD-1 retransmit this information to the Terrestrial Station in Cuiabá, to be processed at the Mission Centers of the National Space Research Institute—INPE, in Cachoeira Paulista and São Paulo, and distribute it to users.

SIR-C

SIR-C is part of a series of initiatives linked to radar satellites, started in 1978 with SEASAT, and followed by SIR-A in 1981, with Germany's Microwave Remote Sensing Experiment in 1983 and with SIR-B in 1984. The SIR-C/X-SAR (Spaceborne Imaging Radar SIR-C/X-SAR band Synthetic Aperture Radar) was an imaging radar system launched on board the American Space Shuttle in 1994. It consists of a radar antenna and associated hardware. The images generated by this instrument helped scientists in the understanding of processes that affect the terrestrial environment, such as Amazon deforestation and desertification in the Southern Sahara. In Brazil, INPE participated actively in programs that have pilot areas in the Northeast and in the Brazilian Amazon region. NMA has had the opportunity to receive and use images of some places of interest in the Amazon.

SPACE IMAGING

Commercial Remote Sensing Systems, is a commercial American satellite to be launched in 1997. It will have sensors in the visible spectra, in the near infrared and in the panchromatic. This satellite is dedicated to studies that need a high spatial resolution, on the order of two meters.

SPIN

The SPIN will be starting a series of Russian-American satellites of high spatial resolution, dedicated to the detailed monitoring of terrestrial resources and developed by private companies. The SPIN system will use Russian cameras of the kind KVR-1000, with resolution of 2 to 3 meters, used on the COSMOS satellite series, which had regular launching since 1987. Each mission will, as an example of the COSMOS series, last around two months collecting data covering approximately 50% of the Earth's surface. The available images, similar to aerial photographs, are generated under the COSMOS program. They have around 34 x 57 km and are distributed by Intermountain Digital Imaging, L.C. and by Russian Satellite Imagery, which also distributes images generated by the Russian camera TK-350 (10 meters of resolution).

SPOT

The SPOT series (*Satellite pour l'Observation de la Terre*), started with the French-European SPOT 1, in 1986 under the responsibility of the *Centre National d'Etudes Spatiales*—CNES of France. The series continued with the launching of SPOT-2 after a good working period became disabled. The series will continue with the launching of SPOT-4 satellite scheduled for the first semester of 1998 and in the future SPOT-5. The SPOT series opened up the possibility of tridimensional images thanks to its lateral view, of up to 27 grades (cylindrical stereoscopic), and also made a mark of a great spatial resolution in the panchromatic: 10 meters. NMA and ECOFORCE have been frequently using this platform in studies of biodiversity on densely occupied areas or in studies that require a great spatial resolution in the results.

SPOT VEGETATION

The sensor VEGETATION will be part of the platform SPOT-4 and will be launched in the first semester of 1998, under the responsibility of the CNES of France. VEGETATION is relatively analogous to the NOAA/AVHRR system. The technical characteristics of VEGETATION are the following: stable terrain resolution through daily coverage above 35° latitude and every 5 days between 35° N and S; internal pixel greater than 350 meters; overlap of several days with accuracy greater than 500 meters; a possible simultaneous acquisition of HRVIR SPOT; an absolute radiometric calibration better than 5%; pre-processing homogeneous centralized and a permanent quality of the product and the possibility of local reception to be substituted by a L-band in the AVHRR reception stations. NMA and ECOFORCE participate with a project on the SPOT VEGETATION preparatory program.

SSR

The SSR (Satellites of Remote Sensing) of the National Space Research Institute—INPE, are part of the Brazilian Complete Space Mission (MECB), scheduled to be launched in the year 2000. The SSR will range of 2,200 km and a high temporal resolution. Due to its positioning, 5° N e 15° S, it will allow tropical forests, especially the Brazilian Amazon region, to be in constant observation. Some technical aspects of the platform are still in a definition phase, as well as the participation of countries in the equatorial zone that have an interest in the development of the platform. The high frequency of data collection of images of the same region will allow a variety of applications and the improvement in the study of natural resources, weather, and environmental impact detection.

5. Structure and organization of orbital monitoring system of PA

In a first phase a Geographic Information System would be assembled having information on all of the PA of interest. Each PA would be a project. The information plan of each project would be:

- geographic delimitation of the protected area
- delimitation of surrounding and external areas of interest
- topography
- terrain numerical model
- declivities
- expositions
- geology
- geomorphology
- hydrographic network
- hydrographic basins
- vegetation
- roads and highways
- infrastructure and agricultural situation
- nature and vegetation status of the PA and surroundings

- land use in the PA and surroundings
- eventual mapping of the spatial temporal dynamics of land use based on remote sensing and aerial photos
- identification of ecological communities and main areas of biological interest
- evaluation and preliminary mapping of direct and indirect impacts on biodiversity
- others

Several orbital systems can supply the needed data to implement this first project phase, in case complete cartographic information is not available. A first analysis of the situation of each unit will be made. Examples of this nature have been done by NMA in forest remains, counties and conservation units. They aim to contribute to management plans and they may be seen at NMA's home page. A classification of situations (by biome, unit type or other criteria) and processes could be concluded.

In a second phase, in each protected area, a reflection involving researchers, inhabitants, neighbors, inspectors, project managers, park directors, and others would be organized by the IBAMA Directorate of Ecosystems—DIREC.

It should define (through a series of successive approximations) a hierarchy of factors, phenomena and processes that endanger biodiversity in each case. Social and technical perception would be faced. The DIREC technical team, supported by specialists, would define the physical, biological and socio-economic evidence capable of being monitoring orbitally in the case of each process, phenomenon or unit. This definition details the required spatial and temporal accuracy, as well as qualitative and parametric aspects, field equipment for validation, periods and experiment duration, etc.

In a third phase, a pilot test would be conducted on orbital data and on remote sensing as an additional instrument in the monitoring of evidence on the status of biodiversity in some protected areas.

Representative differentiated units would be chosen (regarding ecosystem, surroundings, area size, facility or difficulty of access, available infrastructure, type of unit, etc.). The operational costs and the system efficiency for each subject or phenomenon (burned areas, deforestation, invasions, wood cutting, agricultural expansion, pollution. . .) should be evaluated in each concrete situation.

In a fourth phase, integration of results and the obtained methods should be defined using these tools in the designed and implemented system to contribute to biodiversity preservation in protected areas (objectives, goals, partner identification, instruments, organizational proposal, costs, etc.). The validation and incorporation of data from new orbital platforms could also be incorporated in system planning.

6. Conclusions

Achieving an efficient and operational system of environmental protection of biodiversity in protected areas is possible in Brazil. Remote sensing and geographic information system can be important tools in this field. The constant evolution of this technology, the number of terrestrial satellite monitoring platform available and the national experience in this field, open new perspectives for environmental politics.

The orbital data may integrate a specific methodology to provide better information on the status and dynamics of the biological diversity of strategic protected areas.

are already operating in Brazil by institutions or organization such as INPE, IBAMA, NMA, SMA, ECOFORCE, SOS Mata Atlântica, etc. This document analyses possible routes to be explored in this context. Here current information about the main characteristics and the newest information on the orbital monitoring system and, finally a list of possible actions of a specific methodology are presented.

The proposed system could be operationalized at the national level in the relatively low compared to traditional systems of remote information acquisition. The diversity of orbital platforms and sensors allows adjustment of activities to be monitored. This adjustment can be made by biome, unit type, data, accessability, etc. Data collection at repetitive periods can guarantee constant and efficient monitoring of dynamic subjects. Finally, launching of the Brazilian satellite CBERS, in 1998, should open very special conditions (in costs and in operational status) for a project of this nature.