WRITINGS OF THE DIALOGUE

DIÁLOGO FLORESTAL
THE BRAZILIAN FORESTS DIALOGUE

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SUSTAINABLE FOREST MOSAICS

INTEGRATED BIODIVERSITY MONITORING AND FOREST RESTORATION GUIDELINES


Christine Dragisic

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TO PRODUCE ECONOMICALLY IMPORTANT FIBERS AND NATURAL RESOURCES IN TROPICAL REGIONS AND SAFEGUARD THE LIVELIHOODS OF COMMUNITIES, WHILE PROTECTING ECOSYSTEMS, IS A COMPLEX AND CHALLENGING TASK.

Miriam Prochnow

FOREWORD

To produce economically important fibers and natural resources in tropical regions and safeguard the livelihoods of communities, while protecting ecosystems, is a complex and challenging task. In the Atlantic Forest, the **Sustainable Forest Mosaics Initiative** (Iniciativa Mosaicos Florestais Sustentáveis-IMFS in Portuguese) brings together companies, civil society organizations and research institutions, in order to establish a collaborative and innovative model of production, conservation and income generation.

This innovative initiative incorporates three different action scales: local/regional, national and global. At the local/regional level, the IMFS operates in a region with the highest concentration of forest-based productive activities and one of the most biodiverse areas in the world. It is in this territory, which includes the contiguous extreme southern Bahia and northern Espírito Santo that the participants develop and investigate methodologies, procedures and practices to create models for the improvement of sustainable forest management and production, expansion of ecosystem services and income generation in local communities. At the national level, the IMFS disseminates its experiences, acquired knowledge and practices, through a close partnership with the Brazilian Forests Dialogue, which since 2005 has maintained a privileged communication and cooperation channel between environmentalists and forestry companies.

At the global level, the combined efforts of the Center for Environmental Leadership in Business, Conservation International, and Kimberly-Clark, undertake disseminating the sustainable models and practices designed and tested in Brazil among the network of forest companies that supply Kimberly-Clark. Conservation International and Kimberly-Clark also seek closer relations with The Forests Dialogue, an international initiative that inspired the Brazilian Forests Dialogue, striving to deploy their forums and platforms for comprehensive dissemination and discussion of the results at the national level. The publication **Writings of the Dialogue** on IMFS is a natural outcome of the complementary contributions of these two initiatives.

The outcome of Brazilian Forests Dialogue and IMFS is the proneness to dialogue and the belief that it is possible to identify shared views between stakeholders' apparently contrasting objectives and ideas. As in the Brazilian Forests Dialogue, the issues broached by IMFS are strategically and scientifically discussed and analyzed, without any partiality or predisposition.

Two volumes of **Writings of the Dialogue** on the experiences of IMFS were planned. This is the first one, which introduces the advances and innovations in two of the themes identified as priorities by the participants of the initiative: biodiversity monitoring guidelines and forest restoration activities.

From a scientific perspective on the landscape and forest mosaics, the IMFS supports the outlook of building large-scale results, hence positively impacting a large enough area to benefit a wide range of species and ecosystems, contributing to the sustainability of an economically important activity in the region and country, and engaging the local society within the scope of environmental services and income generation. This publication addresses aspects such as habitat proportion, size distribution of forest remnants, isolation, connectivity and edge effects from the landscape ecology approach, in order to maximize the biodiversity potential at different scales.

We hope that reading and consulting this publication will help to improve current knowledge of conservation areas, sustainable forest production and landscape ecology, associated with the reality and potentials of the local communities.

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WHAT IS SUSTAINABLE FOREST MOSAICS INITIATIVE

Forests are essential ecosystems to maintain the ecological balance and to provide essential environmental services, upon which society's quality of life and means of production depends on. Homogeneous tree plantations, or forest plantations, are the most efficient ways to produce wood for various uses and fibers for pulp and paper production.

Due to a number of reasons, including the restrictions established by the Brazilian Forestry Code and those defined by the mechanized planting and harvesting system adopted by most forestry companies in the country, large tracts of land are currently occupied by a forest mosaic that combines fragments and corridors of native forests and forest plantations. Vast areas, located in the states of Bahia, Espírito Santo, Minas Gerais, São Paulo, Paraná and Santa Catarina – which concentrate most of the Brazilian forest production – include a continuous forest cover in the form of native forest mosaics, in different development stages, and also forest plantations, particularly *Eucalyptus* and *Pinus* in different life cycle stages.

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THE ATLANTIC FOREST IS VITAL TO MAINTAIN NUMEROUS ECOSYSTEMS SERVICES.

This landscape, interspersed with native forest fragments and tree plantations is a forest mosaic that, as a whole, ensures boundaries and the production of environmental services, soil protection, landscape ecological permeability and job and income generation opportunities. Such gains, however, come with drawbacks and challenges. Among these we can highlight those resulting from the concentration of land ownership, the risks of economic monoculture in major areas (a single species, based on clonal genetic reproduction, cultivated to produce a single product, mainly for foreign markets) and the intensive interference in the forest landscape caused by the successive and increasingly shorter planting and harvesting cycles.

If on the one hand the importance of pulp and derivatives for economic, social and cultural development of human societies is quite evident, on the other hand the need to expand the adoption of advanced sustainable practices throughout its chain is increasingly pressing. To innovate, validate and adopt sustainability principles and practices is the responsibility of all stakeholders involved in the various links of this chain, from forestry to consumers, extending across different processing industries and wholesalers and retailers up to the end consumers.

It was based on these premises and on their responsibility to disseminate sustainable production practices among their suppliers that the North American Company Kimberly-Clark, which is the largest pulp buyer worldwide, accepted the proposal made by the Center for Environmental Leadership in Business (CELB) of

Christine Drasigic

THE CONSTRUCTION OF FOREST MOSAICS UNDERGOES LANDSCAPE PLANNING.

Conservation International, to join a global initiative, with the following objectives:

- Identify, build and validate sustainable forest mosaic models in different cellulose production regions.
- Develop planning and communication tools and exchange of experience that enables to conciliate land use planning, forest management, biodiversity conservation and the protection of environmental services.
- Disseminate these successful models to all pulp suppliers.

To fully accomplish this alliance between the world's largest pulp buyers and one of the most prestigious conservation organizations in the world, it involved other strategic partners. For the local operation scale – where the tools for integrated planning and sustainable management were designed and validated – we had the Bio-Atlântica Institute and the companies Fibria, Veracel and Suzano. At the national level, the Brazilian Forests Dialogue was identified as the most efficient platform to disseminate these practices among the other companies operating in the country, in the Atlantic Forest as well as in other forest biomes, through their regional forums. Therefore, it also relied on the strategic work of Conservation International and on the partnership with The Nature Conservancy.

CHAPTER 1

THE CONCEPT OF FOREST MOSAICS

The sustainable forest mosaics concept recognizes the multiple roles tropical forests have in different parts of the world. Tropical forests are vitally important for global climate, helping to mitigate climate change by absorbing and storing CO_2 and also oxygen generation. Forests protect water sources, prevent soil erosion and degradation, perform water and nutrients cycling, provide forest products and serve as habitat for the majority of known species. The tropical forest areas are also home to vast high-performance forest plantations, providing much of the increasing world demand for paper, personal use products and low-cost wood products.

The sustainable forest mosaics concept views the forest landscape as a "puzzle" of different land uses, working at a landscape scale to plan productive activities while protecting forest ecosystems and the environmental services they provide.

The sustainable forest mosaics fit the "puzzle pieces" – such as nature reserves and protected areas, plantations, agricultural production areas, infrastructure and settlements – to create a landscape that simultaneously meets several needs. To achieve this goal, the stakeholders involved assess a wide landscape and raise the following questions: what areas are the most suitable for forest plantations, for agriculture or livestock? What areas need to be protected to preserve our water resources? What sites are important for carbon storage? What habitat is critical for the species we depend upon?

Once these questions are answered, those involved will work together to plan how the different land uses can fit into in the forest landscape in a sustainable way. After meticulously examining all the conceivable land uses, the next step is to ensure that the demands for food, fiber, fuel, ecosystem services and biodiversity protection are all met. It is by carefully planning productive land use and conservation within the landscape that the mosaic strategy helps insure the optimal conservation and potential income-generation for the economic activities carried out.

Christine Drasigic

THE LANDSCAPE MUST BE ANALYZED IN ORDER TO OBTAIN THE FOREST RESTORATION NEEDS.

THE SUSTAINABLE FOREST MOSAICS CONCEPT RECOGNIZES THE MULTIPLE ROLES TROPICAL FORESTS HAVE IN DIFFERENT PARTS OF THE WORLD

Christine Drasigic

THE BALANCE BETWEEN THE VARIOUS LAND USES ALSO ENSURES THE CHALLENGING ENVIRONMENTAL BALANCE.

CHAPTER 2

FROM THEORY TO PRACTICE: PLANNING AND IMPLEMENTING SUSTAINABLE FOREST MOSAICS IN THE CENTRAL ATLANTIC FOREST BIODIVERSITY CORRIDOR

The Atlantic Forest is widely recognized as one of the planet's most biodiverse biomes and also one of the most endangered. Thus, it is considered by scientists as one of the most relevant hotspots[1] to be protected. When the first Europeans settled along the Brazilian coast, the Atlantic Forest took up more than 1.3 million km^2. Currently, less than 16% of its original area remains with its native forest cover. Besides the massive loss of habitat and biodiversity, the Atlantic Forest has reached an advanced stage of fragmentation, in which less than 7% of the remaining forests exist in fragments larger than 100 hectares.

Similar to what occurs at a planetary scale, the remaining forests and biodiversity are not evenly distributed along the Atlantic Forest. Some regions concentrate most of the remaining forests and also the endemic species – in other words – which only occur at that location. The Central Atlantic Forest Biodiversity Corridor (CCMA in its Portuguese acronym) is one such region and is therefore treated as a "hotspot within a hotspot". That is, at the Atlantic Forest scale, CCMA is deemed as one of the highest priority regions to implement conservation and forest restoration actions.

Covering the regions of southern Bahia and all of the state of Espírito Santo, CCMA covers about 213,000 km^2, and includes marine (37%) and terrestrial (63%) areas, extending for over 1,200 km along the Atlantic coast of these two states. The terrestrial portion is composed of more than 95% of privately owned lands, with the remainder occupied by federal, state and municipal conservation areas, as well as indigenous lands and reservations.

1 *Hotspot* conservation is a term coined by Norman Myers and collaborators to define the biomes that form a wide variety of species (high biodiversity), with a considerable part that is exclusive to that biome (endemic). Moreover, these are strongly threatened biomes, in which more than 70% of the native vegetation cover has been eliminated or suffers from human disturbance that drastically alter its environmental function and balance.

If it is possible to emphasize the total area covered by CCMA as a hotspot within the hotspot in the Atlantic Forest, it is equally possible to demonstrate its middle third, defined by the territory inserted between the rivers Jequitinhonha (north) and Doce (south) as a key area for conservation strategies and recovery within CCMA. This region, which covers 49 municipalities in Bahia and Espírito Santo and that is equivalent to almost half the total land area of CCMA, concentrates not only the most significant forest fragments of this corridor, but also the entire northeast region of Brazil, both in terms of size as well as diversity and endemism.

On land, the landscape relief known as coastal plains (plateaus interspersed with valleys in forms of "U" and "V") favors conciliating the agricultural and forestry production (along the flat areas) and the protection of the valleys through which streams and rivers flow. In the marine part, this CCMA stretch is composed of the Abrolhos Bank, a region known for harboring the coral reefs complex that has the greatest biodiversity in the South Atlantic Ocean.

The importance of this part of CCMA can be understood by the attention that four of the eight strictly protected public areas and a Private Natural Heritage Reserve received from UNESCO. Recognized as World Natural Heritage Sites, these areas, along with other protected areas of the territory, represent the main habitat for countless biodiversity species in the Atlantic Forest, many of them classified under some degree of threat and some with their distribution restricted to the biome or to the region.

Called the "Mesopotamia of Biodiversity" by the partners of the Sustainable Forest Mosaics Initiative (IMFS in Portuguese), as it is delimited by two rivers that form relevant ecological barriers, this region also concentrates the forest plantations and the manufacturing plants of three of Brazil's largest pulp mills. Fibria, Suzano and

Thadeu Melo

THE SUCCESSFUL IMPLEMENTATION OF ENVIRONMENTAL PROJECTS DEPENDS ON THE INVOLVEMENT OF THE VARIOUS STAKEHOLDERS.

THE ATLANTIC FOREST IS WIDELY RECOGNIZED AS ONE OF THE PLANET'S MOST BIODIVERSE BIOMES AND ALSO ONE OF THE MOST ENDANGERED. THUS, IT IS CONSIDERED BY SCIENTISTS AS ONE OF THE MOST RELEVANT HOTSPOTS TO BE PROTECTED

Veracel account for over 12,000 km^2, between plantations (approximately 60% of the total) and natural areas in different protection or recovery stages. This means that the decisions of these three companies directly affect more than one fifth of the entire "Mesopotamia" region.

Considering this situation and despite the negative aspects that may result from the concentration of land ownership, particularly from the socio-economic standpoint, the strategic need to influence this decision making process becomes quite evident, in order to improve the environmental and territorial management procedures of the companies.

As this concerns areas that integrate the landscape with public conservation areas and indigenous territories – as well as forest fragments considered "anchors[2]" for protection and recovery actions – the management decisions implemented in the areas owned by these companies are even more sensitive, as they directly and indirectly affect a great portion of the remaining natural ecosystems.

Before the activities that IMFS began in 2007, there was little cooperation, information exchange and integration of activities among the three companies in the areas of biodiversity monitoring, planning and management of private protected areas and forest restoration to create the ecological corridors. This scenario, though it did not in essence represent a risk to the protection of regional natural heritage – as long as each company individually

2 Anchor areas for conservation and forest restoration is a name coined by C. Holvorcem and colleagues (*Natureza & Conservação*, v. 9, p. 225-231, 2011) to designate forest fragments with or without legal protection status, selected through a set of criteria involving landscape metrics (fragment area and its importance for the maintenance of landscape connectivity). Conservation and forest restoration actions within and around anchor-areas have, in principle, higher success probability and greater impact on biodiversity than similar actions in the vicinity of small fragments and/or isolated from other fragments.

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MEETING OF BAHIA'S SOUTH AND EXTREME SOUTH FOREST FORUM.

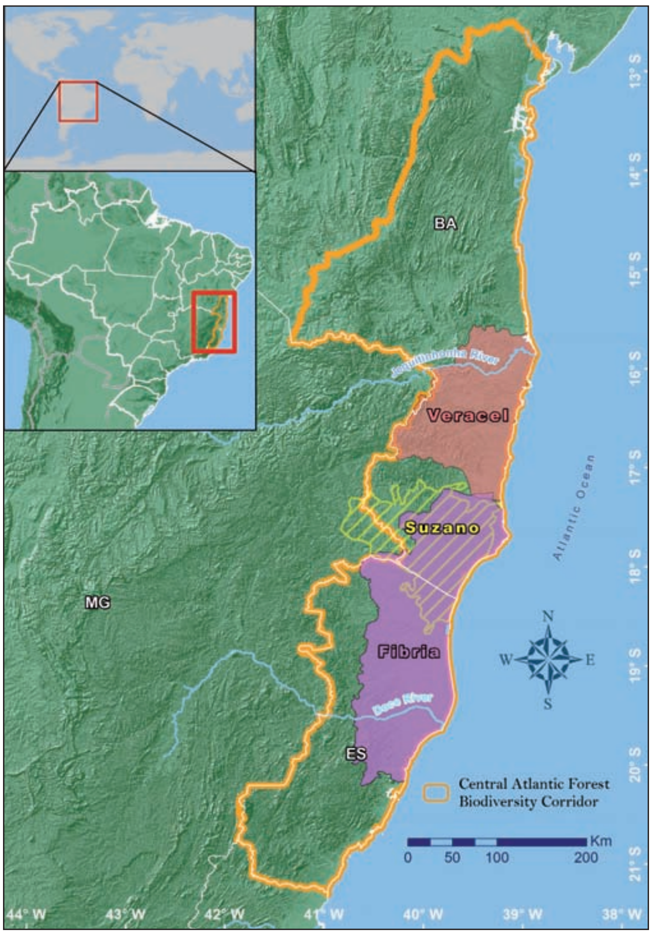
Christine Drasigic

PARTICIPANTS OF THE SUSTAINABLE FOREST MOSAICS INITIATIVE IN A PLANNING MEETING.

adopted conservation practices – did not favor attaining scale and efficiency economies that could be obtained with greater proactive integration and cooperation.

Despite the strong cooperation that already prevailed between the three companies in the areas of production and forest management, there were integration gaps in the planning and implementing of protection actions for natural areas, flora and fauna monitoring and forest restoration guidelines. The best examples of this lack of integration were provided by the fauna and flora databases, built by each company with data input, without the likelihood or strategy to consolidate this information and analyze it together in the landscape scale; the different methodologies each company adopted to collect such information, hence preventing their integration; and also the different vegetation classification, with each company using a different name and definition for areas with the same natural vegetation and attributes.

Figure 1
AREA OF OPERATION OF FORESTRY COMPANIES



With this perception, shared by the technicians and executives of the three companies and the three participating organizations, the action priorities of IMFS were approved. As a key priority, the construction of a common protocol was defined to classify the landscape areas, to monitor biodiversity, the forest restoration actions and to monitor and control invasive species.

Over the past four years, the technicians of the participating companies and organizations, with the support of renowned experts in biodiversity and landscape ecology, held several workshops and meetings, focusing on the pre-existing data to then conduct new analysis – always validated by each company – to set new guidelines for the companies' natural forest management.

With scientific accuracy and the companies' commitment to implement the strategies, we now have a set of shared guidelines and procedures that over the coming years will enable building one of the most important biological and spatial databases of the Atlantic Forest. This information, which will be collected, stored, processed and analyzed according to a set of common variables and criteria, will make possible the integration of processes, of decision making and execution of actions in favor of the regional biodiversity.

In summary, IMFS seeks to integrate the three companies' planning and implementation strategies of land use and conservation activities. It also seeks to insert conservation elements in the forest programs (incentives, loans and technical assistance to support private forestry carried out by other landowners). Based on the actions that have already been implemented by companies and organizations, constantly discussed and refined within the scope of the Forest Forum for the South and Extreme South of Bahia (regional forum of the Brazilian Forests Dialogue), IMFS has the goal of increasing the effectiveness of conservation and biodiversity efforts in the forest mosaics that combine remaining native and planted forests.

CHAPTER 3

BIODIVERSITY MONITORING GUIDELINES

WHY MONITOR BIODIVERSITY?

As in most tropical forests, the rich biodiversity of the Atlantic Forest faces critical threats due to human activities, particularly those that involve the destruction or degradation of natural habitats for economic activities such as agricultural livestock farming and timber/wood extraction.

In the "Mesopotamia of Biodiversity", after five centuries of human occupation and after the intensification of natural resources exploitation within the last forty years of the 20th century, only 11% of the original forest covers remains, unevenly distributed in thousands of forest fragments of different sizes and shapes. Since the mid 1980s, the three companies that comprise IMFS have become the largest landowners in the region, raising concerns about the impact their activities have on the biodiversity of the remaining fragments.

IN THE "MESOPOTAMIA OF BIODIVERSITY", AFTER FIVE CENTURIES OF HUMAN OCCUPATION AND AFTER THE INTENSIFICATION OF NATURAL RESOURCES EXPLOITATION WITHIN THE LAST FORTY YEARS OF THE 20TH CENTURY, ONLY 11% OF THE ORIGINAL FOREST COVERS REMAINS, UNEVENLY DISTRIBUTED IN THOUSANDS OF FOREST FRAGMENTS OF DIFFERENT SIZES AND SHAPES

For many years, the three companies have maintained biodiversity monitoring programs. However, the data thus far obtained could not be cross referenced, since the monitoring and analysis methodologies widely differed from company to company. In addition, the sites selected and used for data collection up to now did not cover representatively the different vegetation types, the different topographic reliefs in the region and the different ecological communities determined by geographical barriers.

Thus, although considerable financial resources have been invested by the companies in their individual monitoring programs, they did not have global overview of how their activities could be affecting the region's biodiversity, at the landscape scale.

In order to overcome this limitation, the participants of IMFS decided to join their talents and knowledge to enable integrating the monitoring efforts undertaken by the companies using a unified methodology, based on well established scientific principles. The main target of this integration is to evaluate if and how the land-use changes affect biodiversity in the region's forest fragments, in order to support decisions and actions that prevent or mitigate such impacts.

Through an integrated network of monitoring stations distributed over an area of more than 6 million hectares, this new unified monitoring program will be able to detect biodiversity changes over time. Such a biodiversity monitoring effort at this scale is an unprecedented initiative across the Atlantic Forest, as well as in most *hotspots* around the planet.

WHAT WILL BE MONITORED?

Monitoring the biodiversity of a region as far-reaching as this one represents extensive, complex and costly operational undertakings, also requiring careful planning to optimize the use of financial and human resources available for its implementation, in order to extract the greatest possible useful information. Among the various aspects to consider in the planning phase, special care is required in choosing the biodiversity indicators to be monitored, which will decisively influence defining the collection and analysis data protocols to be followed during the monitoring. It is important to take into account that the monitoring data to be obtained at different times will only be comparable among its variables if the indicators collected at various times are always the same, and if the collection methodology does not vary over time.

Each biodiversity indicator captures a particular aspect of one of the three components of what was designated as biodiversity: composition, structure and function[3]. The composition indicators are determined by the identification of the elements, such as the number of species in a given area or the number of landscape habitat fragments. Structure indicators exhibit standards, such as the abundance ratios of the different species within a community, the degree of similarity in the compositions of different communities of species, the degree of fragmentation of a habitat type or the connectivity in the different forest fragments. Finally, function indicators reflect ecological and evolutionary processes such as predation, colonization, extinction, invasion by exotic species, population fluctuations, decreased vegetation cover or land-use changes.

Furthermore, each indicator reflects the composition, structure or function of a specific level of biological organization. For example, the degree of fragmentation of a forest habitat is a structural indicator at the landscape level, while species richness is a compositional indicator at the community level. Gene flow is a functional indicator at the genes level and the age structure of a population is a structural indicator at the population level.

Thus, to proficiently monitor how biodiversity behaves over time and how it responds to human actions, ideally, it would be necessary to choose compositional, structural and functional indicators at various biological organization levels. At the community level, it is not enough to produce annual lists of species in a given area (compositional indicator), it is also important to assess how the abundance distribution of the various species in the community (structural indicator) changes over time (e.g., do the dominant species remain the same?), and if the community is being invaded by exotic species (functional indicator). At the population level, it is not enough to count the individuals of a given endangered species (compositional indicator); it is important to understand how the individuals in the population are spatially distributed (structural indicator), and if there is a metapopulation[4] dynamics in the area being monitored (functional indicator), with individuals migrating between different forest fragments.

By applying the aforementioned principles and considerations to the biodiversity monitoring in the "Mesopotamia of Biodiversity", it was decided to only monitor at the levels of communities and populations. The decision to not carry out monitoring at the landscape level was based on the fact that this work is already being carried out by other institutions – namely the SOS Mata Atlântica Foundation, INPE (National Institute for Space Research), the Ministry of Environment and some companies in the pulp and cellulose sector. Monitoring at a genetic level was considered unfeasible due to its high cost and the lack of sufficient knowledge in the scientific literature in order to prepare a monitoring proposal at this level and that can meet the overall objective of the monitoring program proposed.

At the community level, the main biodiversity indicators to be monitored will be determined by bird sampling in this region. Comparative studies between various groups of animals and plants suggest that the monitoring of biodiversity indicators related to birds are the most cost-effective among the groups studied. Moreover, the three companies that comprise IMFS have accumulated considerable experience in monitoring birds throughout their specific monitoring programs.

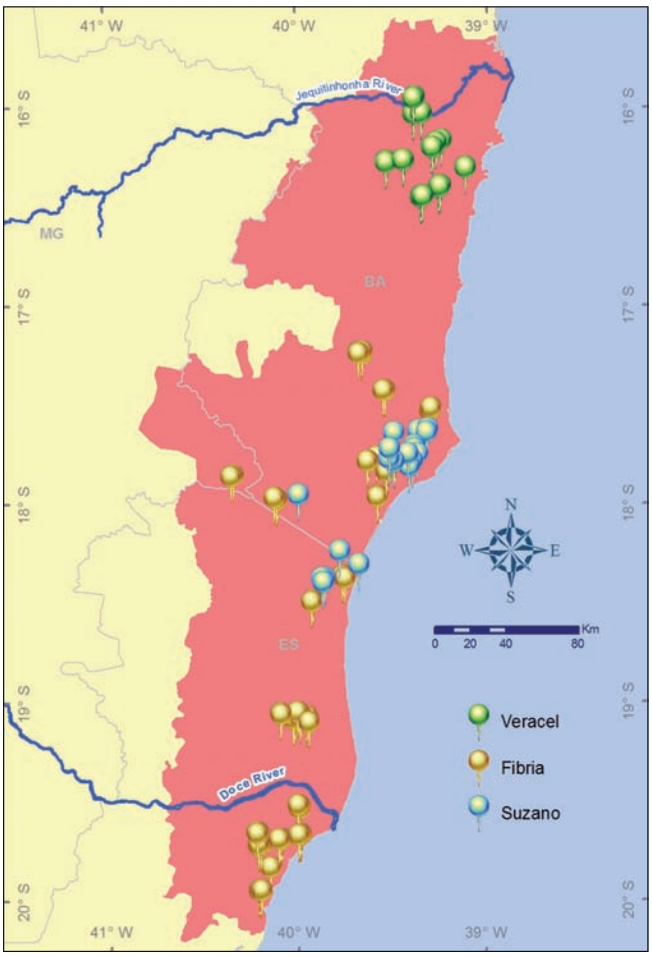
3 Here we follow the hierarchical approach of biodiversity indicators proposed by R.F. Noss in 1990 the article "Indicators for monitoring biodiversity: a hierarchical approach" (*Conservation Biology*, vol. 4, p. 355-364).

4 A metapopulation is a population formed by sub-populations or local populations. In other words, it is a spatially structured population. For example, when several local populations occupy different habitat patches, the sum of these constitutes a metapopulation, with the connection between local populations accomplished by migration. Currently, metapopulation dynamics has been widely used in conservation studies of rare species, to assess the diversity evolution and to assess gene flow, in addition to biological control works.

In addition to the bird group, biodiversity indicators of plants and medium and large mammals will also be monitored, which are also cost-effective for monitoring purposes and for the companies, which also have good previous experience.

It is expected that biodiversity monitoring will enable to characterize the communities of birds, medium and large sized mammals and also plants, hence producing lists of species at each monitoring station, including endangered, endemic, rare, exotic and invasive species. It is also expected to be able to assess the changes over time in the structure of communities and in the ecological processes, as for example, pollination and seed dispersal by birds and mammals, biomass accumulation by vegetation etc.

Figure 2
SAMPLING STATIONS OF THE COMPANIES



At the population level, one or more endangered species will be monitored in the monitoring area, using indicators such as population density and parameters that describe the population structure and demographic processes occurring within them. The endangered species to be monitored will be determined after the first monitoring results at the community level are obtained.

ENVIRONMENTAL AREAS AND SAMPLING DESIGN

Once the groups of organisms to be monitored are defined, the places where the monitoring stations are to be set up must be chosen. In a landscape where the topography, vegetation and species composition are spatially uniform, a grid of evenly spaced stations would be perfectly suitable. However, the “Mesopotamia of Biodiversity” landscape is far from being uniform in these three aspects. There is a considerable altitude variation between the coastline and the mountains along the western boundary of the region. These differences in altitude, along with the differences in climate, soil and other factors, produce different vegetation types in different parts of the region.

Another point to consider is that forest fragments at different elevations and terrain types may undergo very different pressures caused by human activities and also respond differently to these pressures. Thus, fragments on steep and high terrains tend to suffer less from deforestation, when compared with fragments in flat and low regions.

Therefore, a clear and unbiased view of biodiversity changes in the region covered by the monitoring stations will only be possible if we choose monitoring stations at locations that represent all the types of vegetation and topographies in the region. It could also be relevant to establish stations along similar types of vegetation and topographies on opposite sides of the geographic barriers represented by the Jequitinhonha and Doce Rivers, which delimit the “Mesopotamia” to the north and south, respectively.

When trying to select biodiversity monitoring stations following the aforementioned guidelines, there is a drawback: how to define “vegetation types”? There are different classifications for the types of vegetation found in the Atlantic Forest, based on physiognomic, floristic and ecological criteria.

The vegetation classification in the Atlantic Forest is complicated on account of the significant vegetation characteristic variations, determined by altitude and climate variations. These variations are not abrupt – therefore there is no specific way or a better way to classify the types of vegetation in the Atlantic Forest. Besides the official vegetation categorization, proposed by IBGE, each of the three companies used their own categorization, rendering difficult to exchange information of the regional vegetation among the companies, as well as between them and other organizations and researchers working in the same region.

It was then decided to build and adopt a common categorization to classify the vegetation in the region. The work of constructing and field validating this categorization within the IMFS started in 2008, which considered both the official categorization proposed by IBGE, as well as the differences and similarities between the categorization used by the three companies.

In 2010, a common categorization was proposed by consensus. It will serve to guide the technicians of the forestry companies to simplify and standardize the nomenclature of vegetation classes in their vegetation cover mapping.

Table 1 shows the criteria adopted for delineating the landscape units to select the monitoring areas were the different types of "vegetation formation" are located, which are related to the original vegetation and altitude.

After subdividing the area into different formation types, the four "geomorphological areas" found in the region were added to the analysis, classified according to Table 2.

Then, a new variable defined by the "geographical barriers" represented by the Doce and Jequitinhonha rivers was added to the analysis, which subdivided the area covered by the analysis into three regions: to the north of the Jequitinhonha river, between the Doce and Jequitinhonha rivers ("Mesopotamia of Biodiversity") and to the south of the Doce River.

The cross referencing of the classifications obtained for Vegetation Formations (Figure 3), Geomorphological Areas (Figure 4) and Geographical Barriers (Figure 5) resulted in the definition and delimitation of 14 Environmental Areas (EA), which represent the environments with different species compositions in the area in question and that were the basis for choosing the monitoring target-fragments. The use of GIS tools was vitally impor-

Table 1

THE PROPOSED UNIFIED CATEGORIZATION

LAND USE	TIPOLOGIA	FORMAÇÃO (MAPA DE RELEVO)
NATURAL AREAS	DENSE OMBROPHILOUS FOREST	ALLUVIAL
		LOWLANDS
		SUBMONTANE
		MONTANE
	OPEN OMBROPHILOUS FOREST	ALLUVIAL
		LOW LANDS
		SUBMONTANE
		MONTANE
	RESTINGA	HERBACEOUS
		SHRUBBY
		ARBOREOUS
	MANGROVE	
	MUÇUNUNGA / CAMPINARANA*	
	ALLUVIAL COMMUNITIES	
	RUPESTRINE GRASSLANDS	

Adapted from IBGE, 1992; Lowlands: altitude of up to 50 m; Submontane: between 50 m and 500 m, Montana: between 500 and 1500 m (vegetation formations by altitude, according to IBGE).

* Campinarana is the technical term adopted by the official Brazilian classification (IBGE) to denote the "muçununga" type vegetation formation. Although the official map of IBGE does not indicate the presence of "campinaranas" in southern Bahia, we must consider the similarity of vegetation and floristic types of the muçunungas of the "Mesopotamia", as well as the same type of soil (Hydromorphic Spodosol - before hydromorphic podzol - and quartz sand), with campinaranas in the Rio Negro basin.

Table 2
GEOMORPHOLOGICAL AREAS IN THE REGION ANALYZED

CLASS	DESCRIPTION
1	BARREIRAS
2	DEPÓSITOS LITORÂNEOS
3	GRANITÓIDES
4	PARAÍBA DO SUL

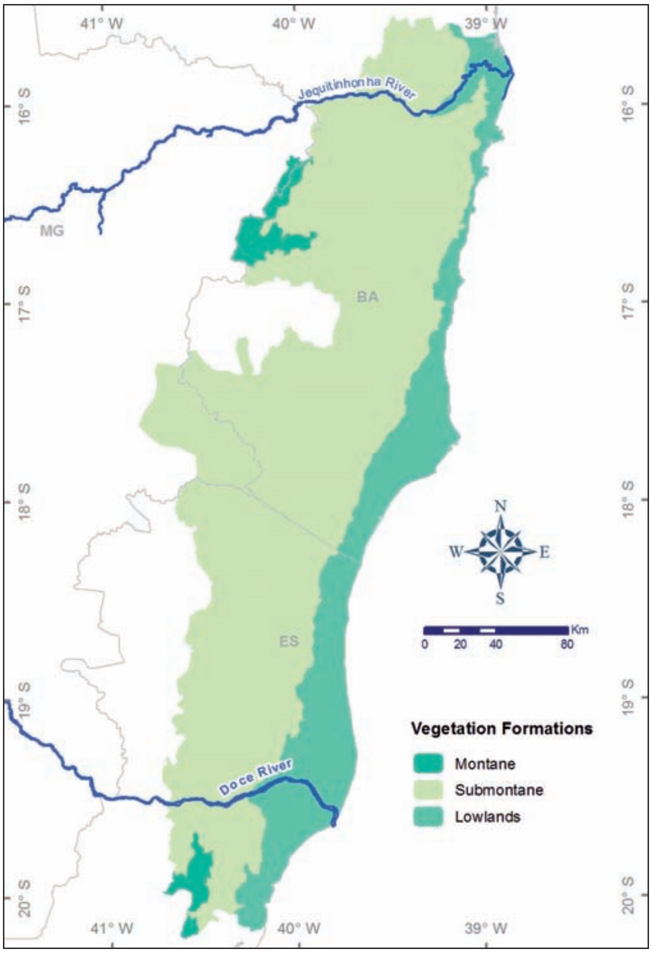
tant for the analysis and generation of the EA map (Figure 6), which allowed a better understanding of the peculiarities of the environments and the complexity of the territory as a whole.

FOREST FRAGMENTS TO BE MONITORED

One forest fragment was selected in each EA to implement the monitoring stations. The fragments chosen are distributed in order to address the existing biodiversity in the region, to sample most of the local species richness. Thus, the monitoring will initially be implemented in all EAs where the companies directly act, hence seeking to represent all the delimited environmental areas.

To select the locations of the monitoring stations only those areas included in the properties of the companies were analyzed, as the goal is to ensure maximum coverage monitoring on the territorial assets currently available. Four criteria were considered to select the forest fragments that will accommodate the monitoring stations: (i) the fragment area should be over 200 hectares; (ii) the vegetation in this fragment must be representative of the respective EA; (iii) a fragment should not be in transition zones between different EAs; (iv) the fragment should be considered a High Conservation Value Area (HCVA), a High Conservation Value Forest (HCVF) and/or an anchor area for conservation or recovery (see Note 2). In those EAs where more than one fragment was identified, meeting the aforementioned criteria, additional criteria were considered, such as

Figure 3
VEGETATION FORMATIONS IN THE REGION ANALYZED, ACCORDING TO TOPOGRAPHY AND CLIMATE



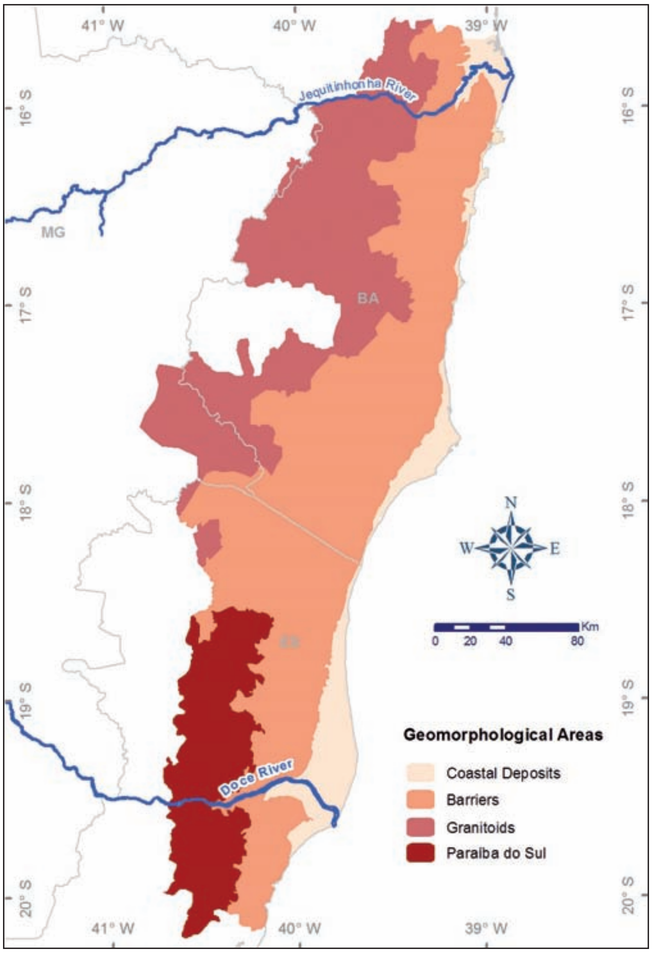
Adapted from IBGE, 1992

pre-existing monitoring activities in one of them, easy access or not or, as a last resort, the owner company.

However, of the EAs defined in the analysis, four did not have fragments that met the four selection criteria presented above, as can be seen in Figure 6. For this reason, only 10 of the 14 EAs will be addressed in the first phase of the monitoring program.

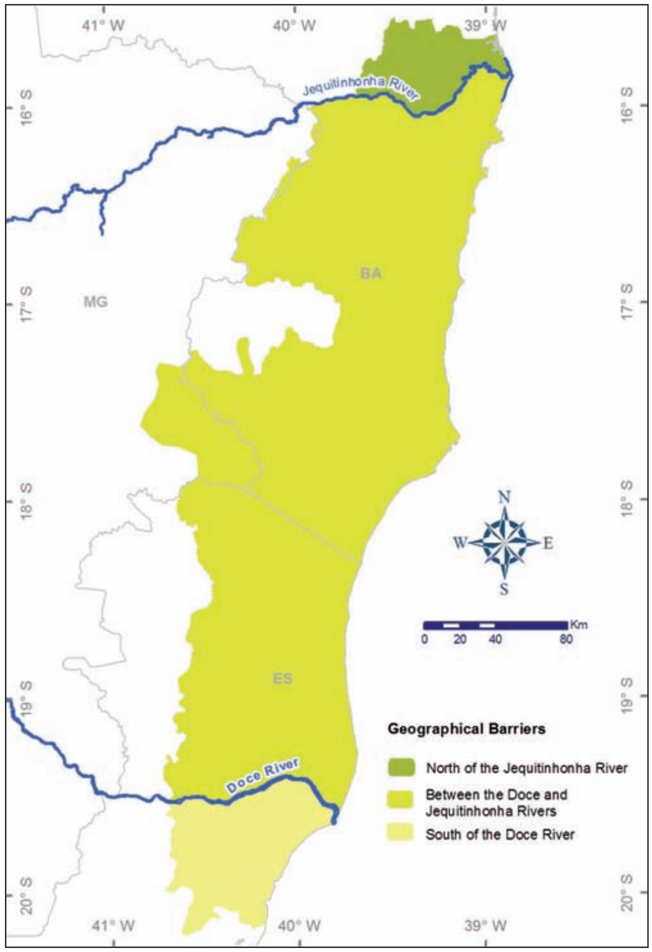
Figure 7 shows the location of the fragments in which monitoring stations will be installed, with additional information given in Table 3.

Figure 4
GEOMORPHOLOGICAL AREAS IN THE REGION ANALYZED



Source: CPRM, 2002.

Figure 5
GEOGRAPHICAL BARRIERS IN THE REGION ANALYZED



IT IS EXPECTED THAT BIODIVERSITY MONITORING WILL ENABLE TO CHARACTERIZE THE COMMUNITIES OF BIRDS, MEDIUM AND LARGE SIZED MAMMALS AND ALSO PLANTS, HENCE PRODUCING LISTS OF SPECIES AT EACH MONITORING STATION, INCLUDING ENDANGERED, ENDEMIC, RARE, EXOTIC AND INVASIVE SPECIES.

Figure 6
ENVIRONMENTAL AREAS PROPOSED FOR THE REGION ANALYZED

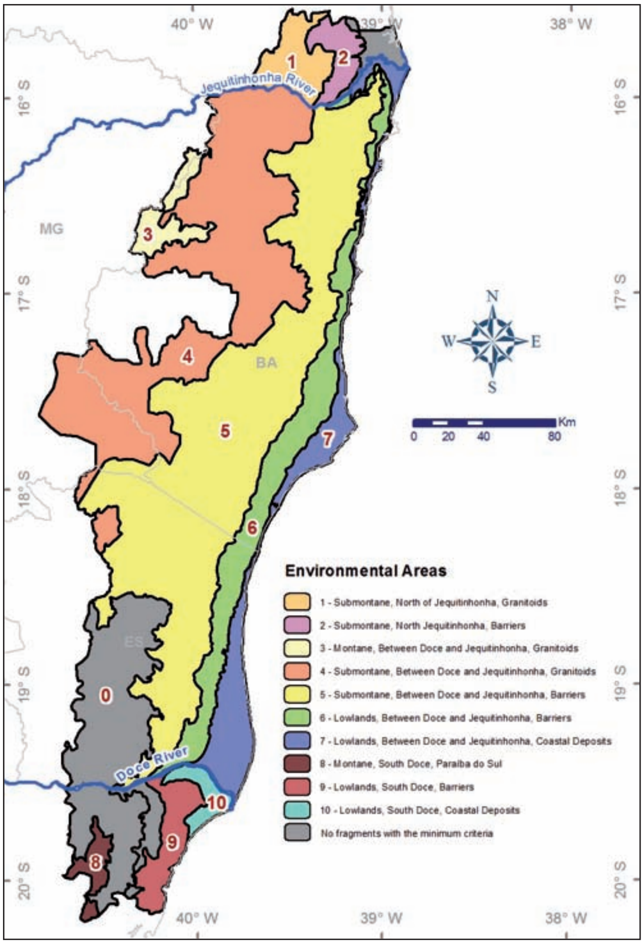
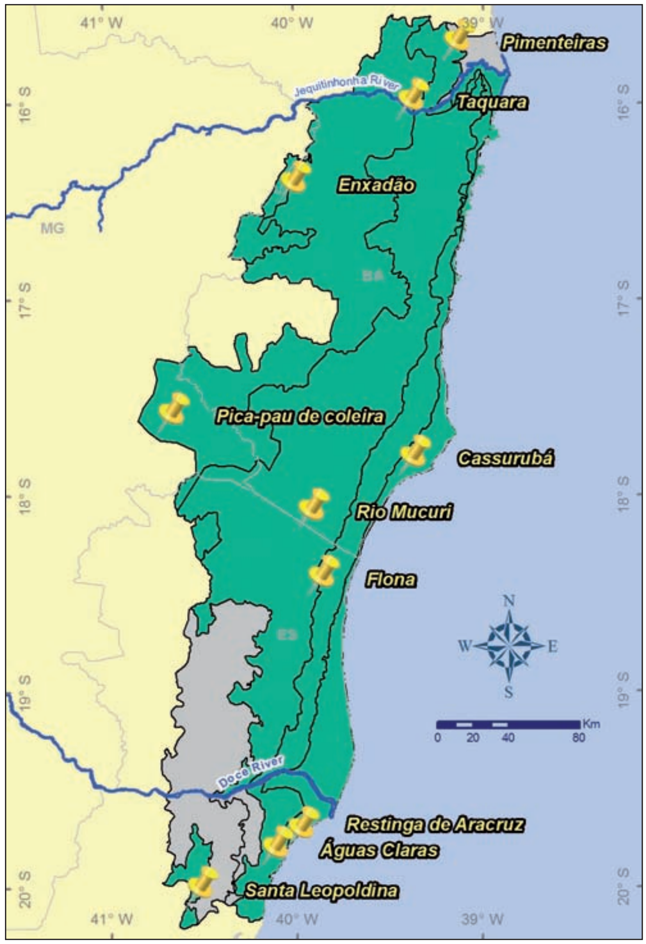


Figure 7
LOCATION OF THE TARGET FRAGMENTS FOR THE MONITORING PROGRAM



IN THIS PROCESS, THE EXPERIENCE ACCUMULATED OVER THE PAST SIX YEARS WITH THE BRAZILIAN FORESTS DIALOGUE WAS PROPITIOUS AND DECISIVE. ALWAYS RELYING ON THE POSSIBILITY OF RECONCILING INTERESTS, WITHOUT AT ANY MOMENT DISREGARDING THE SCIENTIFIC RIGOR, WE REACHED WHAT WE CAN CALL THE LEAST COMMON DENOMINATOR

Table 3
FRAGMENTS CHOSEN TO IMPLEMENT THE MONITORING STATIONS OF IMFS

TARGET FRAGMENTS	ENVIRON-MENTAL AREA	AREA (HA)	COMPANY	PREDOMINANT VEGETAL TYPOLOGY	AAVC/ FAVC	RPPN	ENDAN-GERED, RARE OR ENDEMIC SPECIES
TAQUARA	1	2.022,2	VERACEL	DENSE OMBROPHILOUS FOREST	YES	NO	YES
PIMENTEIRAS	2	8.166,6	VERACEL	DENSE OMBROPHILOUS FOREST	-	NO	-
ENXADÃO	3	3.656,5	VERACEL	DENSE OMBROPHILOUS FOREST	-	NO	-
RIO MUCURI	4	2.159,7	SUZANO	DENSE OMBROPHILOUS FOREST	YES	NO	YES
FLONA	5	274,3	SUZANO	DENSE OMBROPHILOUS FOREST	YES	NO	YES
PICA-PAU DE COLEIRA	6	787,8	SUZANO	SEASONAL SEMIDECIDUOUS FOREST	YES	NO	YES
CASSURUBÁ	7	2.148,9	SUZANO	MUÇUNUNGA / DENSE OMBROPHILOUS FOREST	YES	NO	YES
SANTA LEOPOLDINA	8	208,7	FIBRIA	DENSE OMBROPHILOUS FOREST	-	NO	YES
ÁGUAS CLARAS	9	238,1	FIBRIA	DENSE OMBROPHILOUS FOREST	-	NO	YES
RESTINGA DE ARACRUZ	10	329,2	FIBRIA	RESTINGA FOREST	-	YES	YES

GUIDELINES AND MINIMUM STANDARDS FOR BIODIVERSITY MONITORING

The data collection protocol was built over the past three years, with the recommendations of experts in the different priority groups and in accordance with the strategies and commitments of each of the companies. It should be emphasized that this represents the minimum monitoring requirements, defined by consensus among the representatives of the participating companies and institutions.

Reaching a consensus with regards to defining what the undertaking or the minimum parameter should be was not always a simple task. Meeting the scientific robustness requirements of the monitoring, while considering the companies' operational limitations – taking into account that this activity is not directly part of its core business – called for much negotiation and validation. In this process, the experience accumulated over the past six years with the Brazilian Forests Dialogue was propitious and decisive. Always relying on the possibility of reconciling interests, without at any moment disregarding the scientific rigor, we reached what we can call the least common denominator.

The sampling effort and the number of variables to be collected and/or observed at each of the monitoring stations, set forth below for the three taxonomic groups (birds, mammals and plants), do not represent in any way, a maximum limit to the efforts that each of the companies, in partnership or alone, can implement. On the contrary, it represents the least common effort that all companies commit to implement, in order to render possible the integration and compatibility of the databases and their processing and analyzing at the regional scale as a whole and not only within each particular company.

As for the number of monitoring stations, for example, installing one station at each Environmental Area where at least one target fragment was identified represents

THE MONITORING OF MAMMALS WILL BE CONDUCTED USING CAMERA TRAPS AND THROUGH THE OBSERVATION OF FOOTPRINTS.

the minimum monitoring effort. Nothing prevents, and is even desirable, that a company that has more than one fragment within one Environmental Area that meets the environmental conditions indicated, implements more monitoring stations, hence increasing the sampling effort in that area. The same goes for the number of data collection hours, the number of plots at each station and the time interval between one collection and another, which may be even less than what defined here.

Moreover, as already mentioned in a previous section, the implementation of this monitoring program, even if only with the minimum standards indicated herein, will represent the largest integrated biodiversity monitoring effort in progress in the Atlantic Forest. This is a novel initiative in the pulp and paper companies in Brazil and worldwide. Consequently, IMFS fulfills its role to establish and adopt best practices for companies in that sector, which can and should be replicated in other regions where economic forestry is an important activity, both economically and environmentally.

BIRDS

Due to the complexity of the biodiversity standards of birds in tropical forests, two sampling methods will be used in order to obtain statistically consistent data.

In the "point census" method, a series of sampling points will be defined in each fragment, and an experienced observer will record and identify, at the species level, visible or audible individuals at each sampling point, in 20-minute observation periods. Field studies in Hawaii and in forests in Brazil's southeastern region indicate that in 20 minutes of observation, at least 90% of species can be detected at the site. The bird census observations will take place between half an hour and two hours after sunrise, to cover in a standardized manner the birds' highest activity time.

The distribution of the sampling points within a forest fragment will take into account the bird fauna differences in between the interior part and the edge of the fragment, with the latter more exposed to wind and sunlight. Thus, each fragment will be divided into two parts: 50 m from the border line (forest edge habitat), and a "center" that consists of the remaining fragment (forest interior habitat).

In each of these two parts at least three fixed sampling points will be set up, demarcated by stakes whose coordinates will be registered using a GPS receiver. This minimum number of points will estimate the variability of the results of the census at different points within or at the edge of the fragment. Another important consideration is that to avoid counting the same individuals more than

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THE MONITORING OF BIRDS IS ONE OF THE COMPONENTS USED TO EVALUATE THE STATE OF BIODIVERSITY CONSERVATION.

once, the census points cannot be too close together. To avoid these problems, a distance of 200 meters between sampling points is considered adequate.

Some fragments may contain forest areas in different stages of ecological succession, where the birds can be significantly different. To ensure that the bird sampling is representative of such changes within the same fragment, at least three sampling points at the edge and three points within each succession stage will be used, to represent at least 20% of the total area of the fragment.

The second method to be adopted to monitor the bird fauna will be "ornithological nets". To capture birds, this method uses the nets vertically laid out, which are supported by stakes, with its positions registered by a GPS receiver. Each net will be placed from sunrise to noon, in one or two mornings in each data collection area. A longer permanence of the nets is not productive, since experience shows that the birds "learn" to avoid the nets set up.

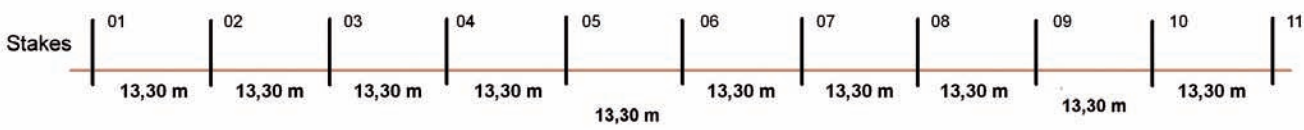
The nets will be inspected periodically during the sampling period, and the captured birds removed from the net as soon as they are seen. Next, the species will be identified, banded and the biological and biometric collection data performed. Fecal samples or regurgitated seeds may also be collected, when possible, to obtain information on dietary habits and seed dispersal of the different species.

For the endangered, rare or endemic species, collecting blood for more elaborate genetic analysis is advisable. After completing the data collection and the banding procedure, the birds are released.

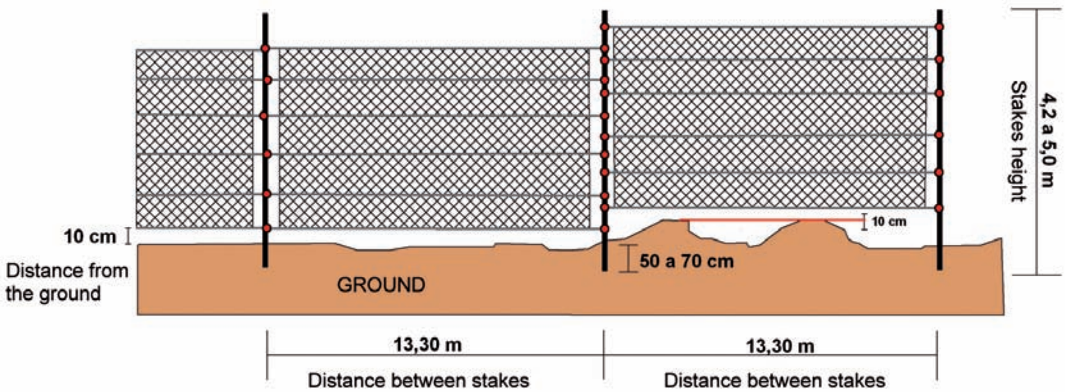
5 This is a simplified description, since in practice the fragments have a complex and asymmetrical shapes and therefore have no a "center".

Figure 8

SCHEME OF A NET LINE INDICATING THE DISTANCE BETWEEN THE SUCCESSIVE STAKES



NET LAY OUT ALONG A LINE ON A TERRAIN WITH IRREGULARITIES



The layout of the nets within each forest fragment also requires special planning. Each net, 12 meters long and about 4.5 meters in height, will be laid out linearly, in rows with a total of 10 nets (figure 8), of which five nets are 36 mm mesh and five nets are 61 mm mesh, to enable sampling birds of different sizes. In each fragment, a line of nets will be placed on the forest edge habitat and another in the forest interior habitat of the fragment.

In the case of fragments containing more than one succession stage, two rows (one at the edge and one in the center) will be laid out in each succession stage to cover at least 20% of the fragment area. The stakes to support the nets in each line will be placed at least 15 days prior to the beginning of the field work to ensure that disturbance to the birds by the activities and noise from installing the stakes have ceased before the beginning of the data collection. A similar caution will be taken in the demarcation and preparation of sampling points of the bird census.

The data collection campaigns for the bird fauna must also take into account the main phenomena related to seasonal variation, which directly affect the bird community in the region. The breeding season of birds in the "Mesopotamia of Biodiversity" usually occurs between August and February, more or less coinciding with the rainy season (October to April). Moreover, the region receives a significant flow of migratory birds from other regions of Brazil and South America, as well as from the northern hemisphere. In order to capture these two dynamic processes (reproduction and migration), two yearly sampling bird periods were chosen: from the second half of March until the end of April and from the second half of September until the end of October.

Observations conducted in a non-systematic manner, including incidental records of birds that are not part of the systematic campaigns, will also be recorded, in order to supplement the lists of species in each forest fragment.

MEDIUM AND LARGE-SIZED MAMMALS

For monitoring medium and large-sized mammals, the methodology to be used includes the use of camera traps. At each monitoring station, traps will be set up adjacent to the points defined for the monitoring of birds, with the same coverage sample.

When preparing the ornithological net lines (15 days before the bird campaign), the camera traps will also be set up. The traps must be programmed to remain active for 15 consecutive days, and then collected by the bird sampling team during their observation activities.

Each monitoring station will be sampled twice a year, during a 15-day period. Non-systematic observations of animals, including footprints, will be conducted as complementary methods, producing qualitative data, hence contributing to the compilation of lists of species in each fragment.

PLANTS

Although there is no standardized methodology for monitoring vegetation, there is some consensus indicating that it is efficient and beneficial to use permanent monitoring plots, in which the vegetation is monitored for long periods (years or decades). The periodic sampling of permanent plots allows observing and recording the changes in forest structure, through changes in the composition of species, mortality rates, recruitment and growth rates and biomass accumulation. The permanent plots also provide information on species replacement patterns over time, and enable to make predictions about the future composition of the forest.

The sizes and number of permanent plots vary widely from project to project. In some cases, a small number of large portions are used (e.g., 10 acres in each area), with the implicit assumption that each large plot samples the vegetation variation in the region of interest. However, this assumption may not always be precise, and the sampling results of a small number of large plots may introduce a bias in the statistical results.

Alternatively, a large number of small plots may be sampled. In this case, each plot samples a smaller portion of the habitat to be monitored, and most likely not representative of the habitat as a whole. However, it is expected that this shortcoming is compensated by the presence of a large number of plots, located in different parts of the habitat, which should sample the existing vegetation variation over a larger area, thereby reducing the likelihood that peculiarities of certain parts of the habitat introduce misguided trends in the statistical results.

To monitor the vegetation within the IMFS, it was decided to use a relatively large number (40) of "smaller" plots (10 m x 10 m or 0.01 ha, Figure 9), covering a total fixed area of 0.4 ha per fragment to be monitored.

In each of these plots, all the trees or shrubs with circumference at breast height (CAP) greater than or equal to 15

PERMANENT PLOTS WILL BE IMPLEMENTED
TO SURVEY THE FLORA.

cm will be identified and measured, following a protocol recommended for the Atlantic Forest in the scientific literature[6]. The exact point of the trunk where the first diameter measurement will be marked with acrylic paint, so that subsequent measurements are performed in the same place. Well-defined rules will be applied to measure individuals with sloping or branched trunks, or located on a slope. Each individual will be tagged with an aluminum plate fixed with a galvanized nail that has a serial identification number. The distribution of the marked individuals within the plot will be registered using a sketch, in order to facilitate their location in subsequent visits.

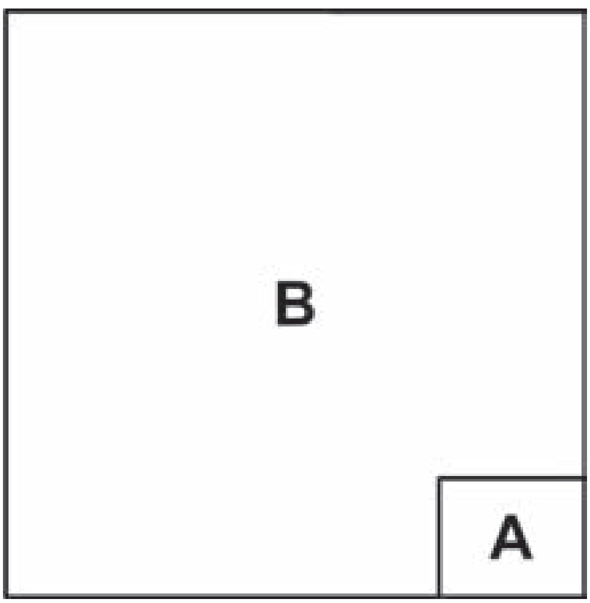
Each plot of 10 m x 10 m will contain a sub-plot of 2 m x 2.5 m (Figure 9), in which all the shrubs and saplings (individuals with CAP less than 15 cm, including young trees and shrubs) will be identified and counted. Shrubs and small trees (trees with more than 1 meter in height and CAP less than 15 cm) will be tagged with an aluminum plate fixed using a piece of aluminum wire. The herbaceous plants in these sub-plots will be identified and the abundance and cover of each species will be visually estimated. The precise location of each plot will be recorded using a GPS receiver.

Besides identifying the plant species in these monitoring plots, the codes indicating the health and quality state of the trees will also be registered (e.g., "dead", "rotten", "broken", "forked below 1.3 m" etc.).

The layout of the permanent plots within each fragment will follow the logic similar to that employed in the layout of the birds and mammals sampling points. Half of the 40 plots will be placed in the forest edge habitat and the other half in the forest interior habitat of the fragment. If the fragment contains more than one stage of succession, the plots will be distributed so as to sample all the stages that cover more than 20% of the fragment.

Figure 9

DIAGRAM OF PERMANENT PLOTS FOR VEGETATION MONITORING. A = SUB-PLOT OF 2 M X 2.5 M; B = PLOT OF 10 M X 10 M



6 For details, see the chapter In Felfili, J. M.; Eisenlohr, P. V.; Melo, M. M. R. F.; Andrade, L. A.; Mra-Neto, J. A. A. (eds). *Fitossociologia no Brasil*: métodos e estudos de casos. Vol. 1.Viçosa, MG. Ed. UFV. p.174-212.

DATA ANALYSIS

One of the goals of the monitoring program proposed by IMFS is to evaluate the long-term evolution of the biodiversity indicators in the regions where the production chain of the forest companies operate. The first task is to estimate the actual species richness (number) of a given group, based on the data collected at each monitoring period. This species richness is not simply the number of species actually recorded during the field sampling. The natural communities, especially in tropical forests, contain many rare species, with a low probability of recording each one in a limited sampling period. Thus, the actual number of species in one area is usually larger than the number actually recorded. If the sampling effort is sufficient, the actual number of species can be estimated with the available data, using a variety of methods proposed in the literature and implemented in various softwares available on the Internet. The same process can be applied to other diversity indices, seeking to remove the finite size effects of the samples used.

Once the diversity indices are estimated at each sampling period, the IMFS participants will detect possible variation rates over time, including long-term trends that can predict the future state of the communities monitored. This type of analysis (called "time series analysis") has to

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DATA ANALYSIS WILL BE UNDERTAKEN BY MULTIDISCIPLINARY TEAMS.

be performed carefully, taking into account the total monitoring duration already carried out, the sample distribution within the interval of time already sampled (which must be nearly uniform, as recommended in the statistical literature) and the uncertainty in the estimated values of the diversity indices. If such precautions are not taken, there is the risk of producing ill-founded extrapolations, which may indicate inexistent trends.

The evolution of the diversity indices over time does not provide a complete view of the changes undergone by the communities monitored. For example, the bird community may be becoming richer in species in a disturbed environment, with the replacement of the initial species for others that are more resistant to disturbance. This species replacement process cannot be described only by the diversity indices. To evidence this, the abundance rates of different species can be analyzed, and then adjusted to known models, which describe different community "stereotypes". For example, one of these models describes a community where only one species is numerically dominant, while another model describes a community where many species have comparable abundances.

It is also possible to calculate "similarity indices" for the abundances of different species in the community in the first sampling period and in each one of the subsequent sampling periods. If the similarity index decreases over time, the ratios of the different species in the community are probably deviating from the initial rates, possibly due to the introduction of new species and/or loss of other species.

The data sampling proposed for bird monitoring will estimate the population size and densities of the various species. For the mammals, the proposed method has limitations to estimate population size for most species, except for animals with natural individual imprints, such as some felines, including jaguars (*Panthera onca*), ocelots (*Leopardus pardalis*) and small felines (*Leopardus wiedii* and *L. tigrinus*), all with potential distribution for the area to be monitored. For these species their population densities may be estimated using statistical capture-mark-recapture models, tracking the population size variation over time.

INFORMATION MANAGEMENT

A monitoring program is geared to potentially produce a large amount of data that should be well organized to enable efficient access and processing. Therefore, it is imperative to initially set up an information system in a computerized database.

To achieve the biodiversity monitoring objectives proposed by IMFS, which require completing the efforts in cooperation and the integrated and synergic decision making among the companies, with the collaboration of the conservation organizations and academic and scientific institutions, it is indispensable to use a common platform for recording, storing, updating, processing and sharing the data generated by the monitoring program.

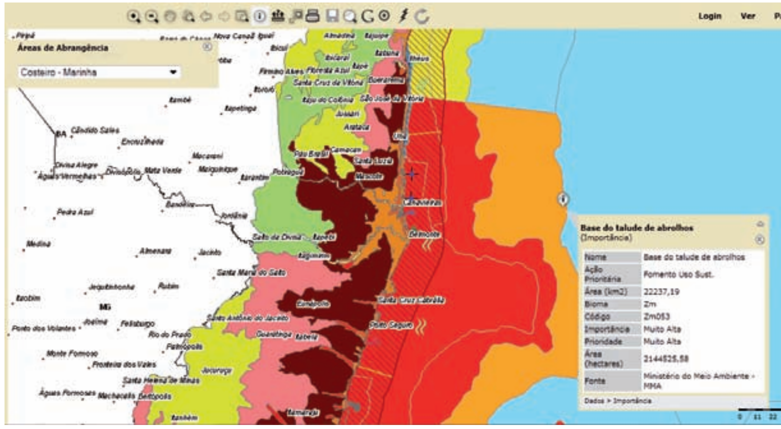
There are some database models and software specifically built to store and process information related to biological diversity. For camera traps data, for example, a relevant and easy to use software was developed by Mathias Tobler, of the Botanical Research Institute of Texas.

An interesting Brazilian contribution in this niche is the platform of the Environmental Information System of the Biota (SINBIOTA), developed to integrate information generated by researchers linked to the Biota Program/ Fapesp and input them to a quality digital cartographic base. Developed by the Reference Center on Environmental Information (CRIA, in Portuguese), with the support from academics and researchers in partnership with other institutions, this system, which is a world reference on the subject, stores a vast catalog of flora and fauna species, thus relevantly contributing to numerous surveys conducted in Brazil, thereby promoting the dissemination of information on the biodiversity of the state of São Paulo for the scientific community, the decision makers, policy makers and environmental educators.

The planning of the information storing system cannot be neglected. There needs to be a well-established field data

Figure 10

CONSULTATION EXAMPLE OF DIFFERENT INTEGRATED DATA ON THE GEOATLÂNTICA PLATFORM



collection protocol, with fast storage and standard electronic spreadsheets, centralized information on a server with scheduled *backup* and also with broad access to the IMFS participants and the scientific community.

The program's monitoring data from IMFS will probably be stored and processed through the platform Geo-Atlântica , an integrated system of georeferenced information developed and administered by the BioAtlântica Institute. The GeoAtlântica, launched in July 2009 with support from Petrobras, Conservation International and The Nature Conservancy, is a web platform that provides a vast georeferenced and integrated database, which serves as a consultation, planning, management and decision making support tool.

In addition to storing, updating and sharing information from the monitoring program, the technicians of the companies and the organizations involved can use and consult this information, in an integrated manner, with the data collection already available on the GeoAtlântica platform. This will enable a better understanding of the territory and greater decision making efficiency regarding the landscape ecology and biodiversity conservation.

7 www.geoatlantica.org.br

CHAPTER 4

FOREST RESTORATION GUIDELINES

FOREST RESTORATION CONTEXT IN THE CENTRAL ATLANTIC FOREST BIODIVERSITY CORRIDOR

In addition to the immense challenge of protecting the remaining Atlantic Forest, the high fragmentation rate, which keeps much of the forest patches isolated from each other, points to the need for investment in forest restoration, namely in critical areas that need to restore connectivity at the landscape scale.

Several forest restoration initiatives have been implemented along the Central Atlantic Forest Biodiversity Corridor (CCMA, in Portuguese). However, many efforts and investments are still needed to significantly expand the connectivity between forest fragments and to improve the working capacity of the institutions in the region. Landowners, community groups, civil society organizations and companies, and in particular the pulp and paper sector, have coordinated efforts to restore the most critical places, both in terms of landscape connectivity as well as the provision of environmental services.

LANDOWNERS, COMMUNITY GROUPS, CIVIL SOCIETY ORGANIZATIONS AND COMPANIES, AND IN PARTICULAR THE PULP AND PAPER SECTOR, HAVE COORDINATED EFFORTS TO RESTORE THE MOST CRITICAL PLACES, BOTH IN TERMS OF LANDSCAPE CONNECTIVITY AS WELL AS THE PROVISION OF ENVIRONMENTAL SERVICES

It is estimated that over 60% of the land not intended to forest plantations, and owned by the three companies participating in the IMFS, are fully deforested or with some degree of degradation. In at least half the cases the impacts on these areas – prior to their acquisition by the companies – were so intense that some type of intervention will be needed to permit, induce or at least foster their forest restoration.

Although the three companies are among the main players for the recovery of the Atlantic Forest in CCMA, IMFS's work group identified several opportunities to increase the efficiency and effectiveness of these initiatives. By using analysis with more precise and scientifically based criteria to choose the areas to be restored, up to using more robust indicators to assess the restoration results, several planning and monitoring tools could be developed and adopted in order to enhance the forest restoration initiatives carried out by companies.

As in the monitoring biodiversity actions, there was also very little cooperation between the companies in the forest restoration programs. For the same reasons as those given for the biodiversity case – to extend the effective scale of the results of these activities and optimize the investments and technological resources applied – formulating common guidelines for forest restoration was perceived as a priority.

The proximity of the companies' properties in the regional landscape reinforces the opportunity to integrate the planning, implementation and monitoring activities of forest restoration. Within this context, the need to adopt a common methodology of analysis was pointed out in order to identify the areas that will serve as reference for the creation of ecological corridors, and in some cases going beyond the property boundaries of different companies. Called "anchor areas" (see footnote 2), these priority areas were defined from the cross-referencing of different landscape metrics, using a methodology developed by the teams of the BioAtlântica Institute (IBio) and the

Laboratory of Landscape Ecology and Conservation at the University of São Paulo (LEPaC/USP).

First applied in the "Mesopotamia of Biodiversity" by IMFS, this methodology has already been validated in other strategic areas for forest restoration activities, such as in the Muriqui`s Ecological Corridor in Rio de Janeiro.

Following the premises of the Pact for the Restoration of the Atlantic Forest (see box), which all institutions participating in IMFS are part of, the planning and implementation of corporate programs for forest cover restoration will not only ensure the environmental regulation of rural properties, but also the protection of environmental services and the creation of work and income opportunities for local residents.

The survey conducted by the Pact in the "Mesopotamia of Biodiversity"[8] region (Figure 11) revealed the existence of 651,015 hectares with restoration potential in areas located on the banks of streams, rivers and springs, and in low agricultural suitability areas. To this result, however, more detailed analysis will be added, with higher spatial resolution, and seeking to define the priorities between different areas.

PACT FOR THE RESTORATION OF THE ATLANTIC FOREST

PACTO
PELA RESTAURAÇÃO DA
MATA ATLANTICA

In order to reverse the present degradation situation and to restore part of the forest cover in the Atlantic Forest, in April 2009 the Pact for the Restoration of the Atlantic Forest was launched. With over 200 members, including civil society organizations, companies, research centers and government agencies, the Pact's main objective is to integrate efforts to restore the Atlantic Forest at a large scale and with quality, while promoting biodiversity conservation, jobs and income generation, legal adequacy of agricultural activities and the provision of environmental services key to economic development and also the well being of more than 120 million people.

Christine Drasigic

Thadeu Melo

FIELD SURVEY TO ASSESS THE FOREST RESTORATION PROJECT.

THE INVOLVEMENT OF REFORESTATION ASSOCIATIONS IS ESSENTIAL FOR RESTORATION ACTIONS.

Always seeking to use the practical experiences and the methodologies adopted by the participating institutions, IMFS provided the opportunity to conduct more specific analysis to define and prioritize the areas to be restored by each company. By integrating the information generated by the private sector with the latest knowledge from academia and conservation organizations, the initiative offers another methodological procedure that can be replicated in other forest regions around the world, in which forest mosaics are formed between tree plantations and native remnants.

HITTING THE TARGET: HOW TO PRIORITIZE FOREST RESTORATION AREAS

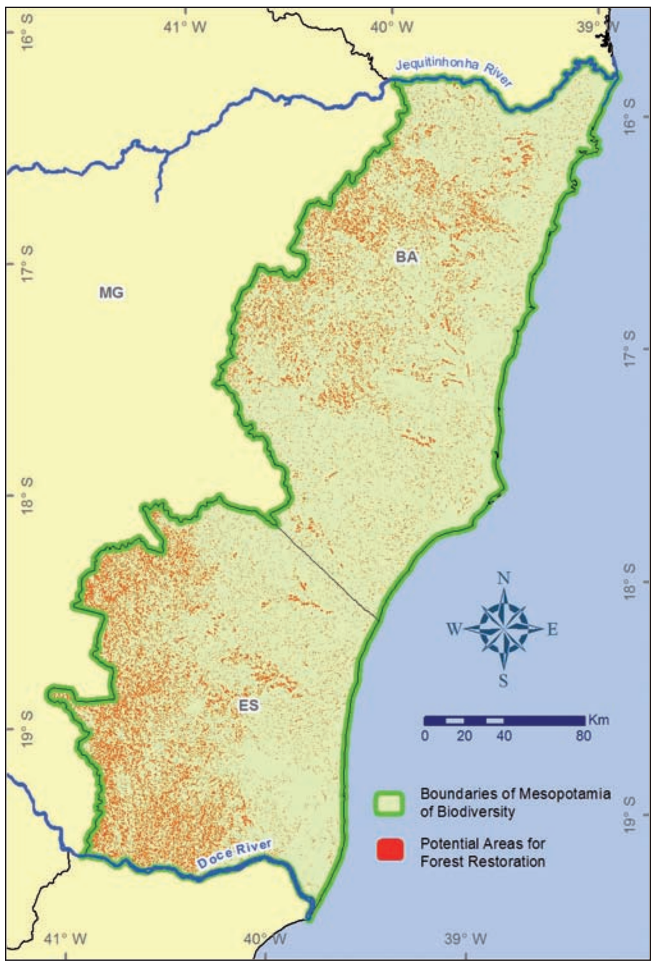
The last two decades have seen an increase in research on the effects of habitat fragmentation, which gave a better understanding of how degradation factors operate and affect the persistence of biodiversity in the landscape. These studies showed that the level of fragmentation of natural ecosystems, when combined with other degradation effects (hunting, fires, extraction, agricultural activities in the vicinity of the fragments and etc.) causes profound biodiversity changes, leading to an irreversible decline of fauna and flora species.

When planning forest restoration activities in a region, it is very important to optimize the use of available resources – that will always be limited – in order to generate the greatest possible benefits to the natural ecosystems. The restoration actions need to be concentrated in carefully chosen locations, where a positive impact, as large as possible, is expected to restore the connections needed to maintain the gene flow and to promote biodiversity maintenance.

In order to define a methodology that could actually implement this principle, IBio and LEPaC/USP have worked closely together from 2009 to 2011, to develop the methodology to define the anchor areas for conservation and restoration, enabling to choose the locations where the restoration and conservation actions will have the greatest positive impact on the landscape and biodiversity structure.

After experimenting with different landscape analysis techniques, a methodology based on the mathematical theory of the graphs was adopted, which selects the forest fragments that meet two basic conditions: (1) they are the largest forest fragments in the landscape, and (2) they are the most important fragments to maintain the

Figure 11
POTENTIAL AREAS FOR FOREST RESTORATION IN THE MESOPOTAMIA OF BIODIVERSITY



Source: Pact for the Restoration of the Atlantic Forest.

8 "Mesopotamia Biodiversity" is the nickname created by the staff at the BioAtlântica Institute, used within the scope of IMFS, to label the territory delimited to the north by the Jequitinhonha River, to the south by the Doce River, to the east by the Atlantic Ocean and to the west by the ridge lines of the water basins of two rivers (or by the border between the states of Bahia and Espirito Santo with Minas Gerais, depending on the scale of operation). It comprises 21 municipalities in Bahia's Extreme South and 28 municipalities in the north and northwest of Espírito Santo.

connectivity between the various fragments of the forest landscape (the importance of the different fragments is defined here based on indexes from the theory of graphs).

Thus, the anchor areas are important sources of organisms that can move between different forest fragments of the landscape. Through its various connections with neighboring fragments, it has "paths" through which they can exchange organisms with other fragments, increasing the gene flow between the different populations in the landscape.

It is recommended that the degree of protection in the anchor areas is increased through conservation actions (as for example, creating new protected areas) and also that smaller fragments are restored in their neighborhood, to form "bridges" between other fragments. By investing in restoration in carefully defined locations, ecological corridors that connect anchor areas to other fragments in their surroundings can be achieved, in some cases with modest forest restoration efforts.

The cooperation between IBio and LEPaC/USP was strengthened by a partnership with another reference laboratory at the University of São Paulo. The Laboratory of Ecology and Forest Restoration (LERF/USP), one of the institutions that heads the studies conducted by Pact, joined their expertise to apply the anchor areas methodology by developing guidelines for selecting and prioritizing the areas to be restored by the pulp and paper companies operating in the "Mesopotamia of Biodiversity".

This methodology uses the anchor area concept, discussed earlier, and proposes more refined criteria for prioritizing restoration actions in Permanent Preservation Areas (PPA), Legal Reserve (LR) and other types of areas. Below the steps of this procedure are briefly described:

(a) Each company created and provided digital files with the following information:

- ✓ Boundaries of PPA (river borders and areas more than 45º of inclination).
- ✓ Boundaries of LR already registered (at least 20% of the land in each rural property must be set aside to protect and/or restore the native vegetation).
- ✓ Delimitation of Areas of High Conservation Value (AHCV).
- ✓ Other natural vegetation fragments and abandoned areas.

(b) The aforementioned polygons were overlapped to the anchor areas map generated by the IBio-LEPaC to identify fragments that can form areas of connected vegetation.

(c) Based on information obtained in (a) and on the analysis results (b), the PPA and LR to be restored in the areas of each company were identified. For restoring each area the "landscape metrics" were calculated, hence enabling to quantify the connectivity gain resulting from its restoration and the effort needed for such gain.

(d) The analysis results (c) were given to the companies, along with the criteria suggested for the prioritization of areas to be restored based on the calculated metrics.

(e) A The companies may adjust the prioritization criteria suggested in (d), taking into account their own strategies, interests, opportunities, legal constraints and particular situations in order to obtain a final prioritization of the areas to be restored, thereby improving their forest restoration activities.

It should be noted that all of the PPA in the companies' properties must eventually be restored, even if the technology used only allows natural regeneration (when there are seed sources near and the impacts undergone by the area prior to its purchase was not very intense). The methodology described above can be used to prioritize restoration actions based on landscape parameters at a regional scale, in order to improve the configuration and expansion of the ecological connectivity of the landscape.

EXAMPLES OF RESULTS OBTAINED WITH THE PROPOSED METHODOLOGY

Some initial experiments were conducted to test the application of the guidelines developed by IMFS in concrete situations, involving areas of the participating companies.

Figure 12
DETAIL OF A PORTION OF THE LAND USE MAP PROVIDED BY FIBRIA

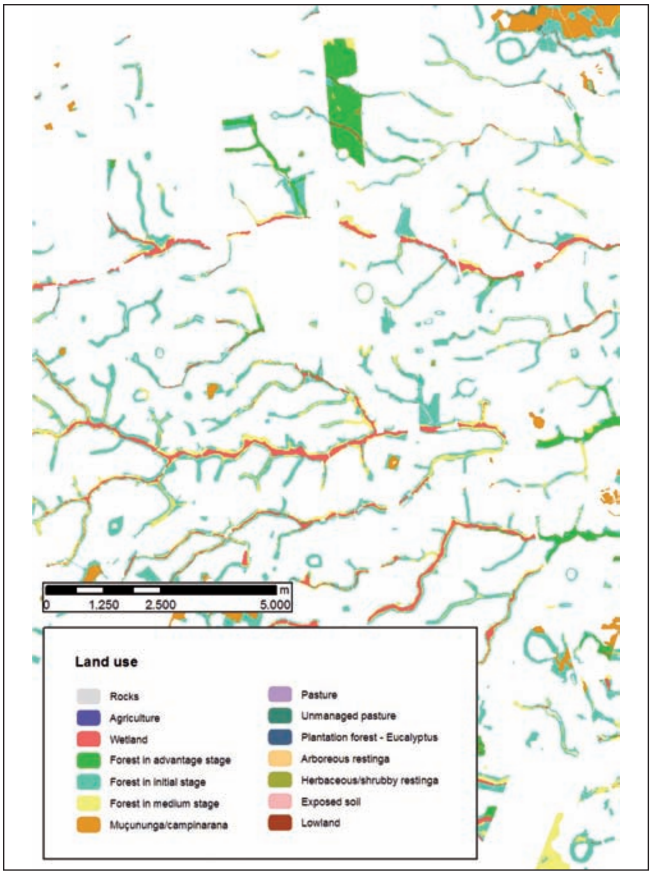
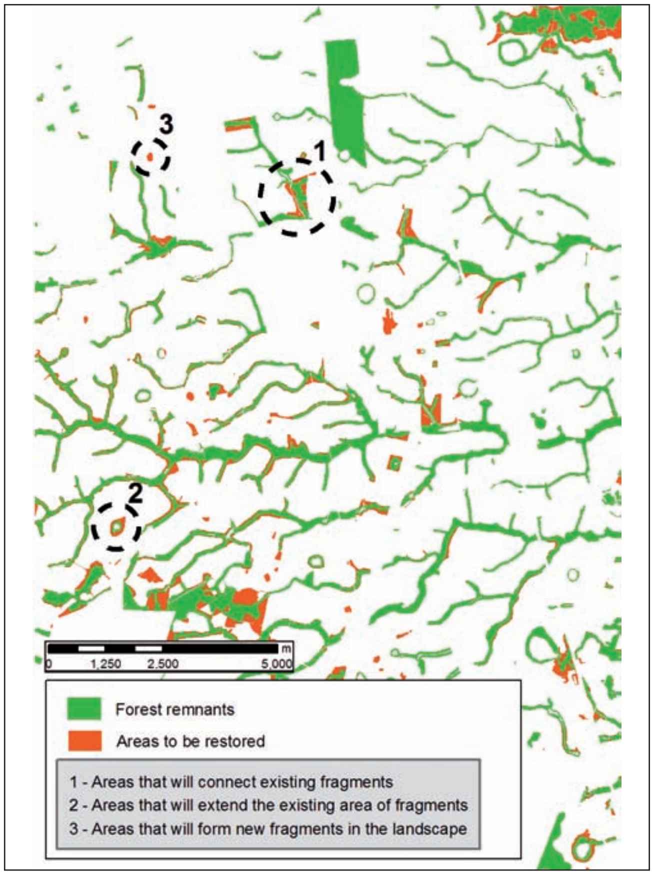


Figure 13
IDENTIFICATION OF REMAINING NATURAL VEGETATION AREAS AND AREAS TO BE RESTORED IN THE LANDSCAPE



These tests also served to improve the original versions to prioritize the proposed guidelines.

For the task performed in the areas belonging to Fibria, the company provided a file containing the classes of land cover (Figure 12), which was simplified to only two classes (Figure 13): (i) natural vegetation areas, which included all the areas of remnant vegetation, from the floodplain areas to the woody vegetation areas in early and advanced stages of succession; (ii) areas to be restored, which included the LR areas as well as the PPA areas.

Initially, the areas of each forest fragment and of each region to be restored were calculated. Next, a scenario representing the landscape after completing the restoration process was simulated (Figure 14). For this, all areas to be restored were classified as vegetation and the area of each vegetation fragment was calculated after the forest restoration.

Thus, it was possible to determine the initial area of each vegetation fragment before the restoration, as well as to identify the areas that after the restoration connected more existing vegetation fragments.

After performing these analyses, the criteria to prioritize the areas to restore were established, so that the actions are initiated by the areas that will connect more vegetation fragments when the restoration is complete, and so that the greatest restoration benefits are achieved in

Figure 14

SIMULATION OF THE LANDSCAPE AFTER COMPLETING RESTORATION

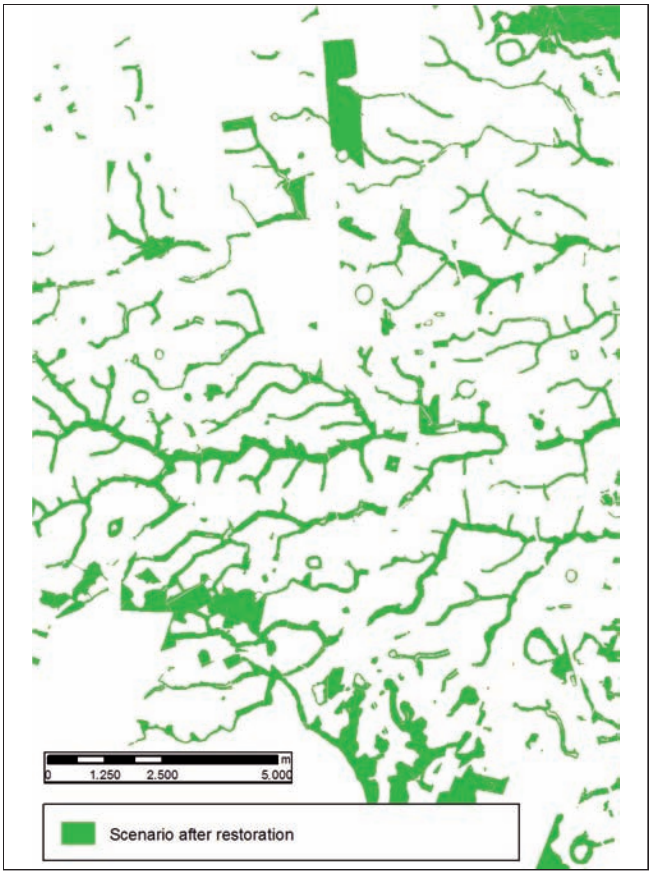
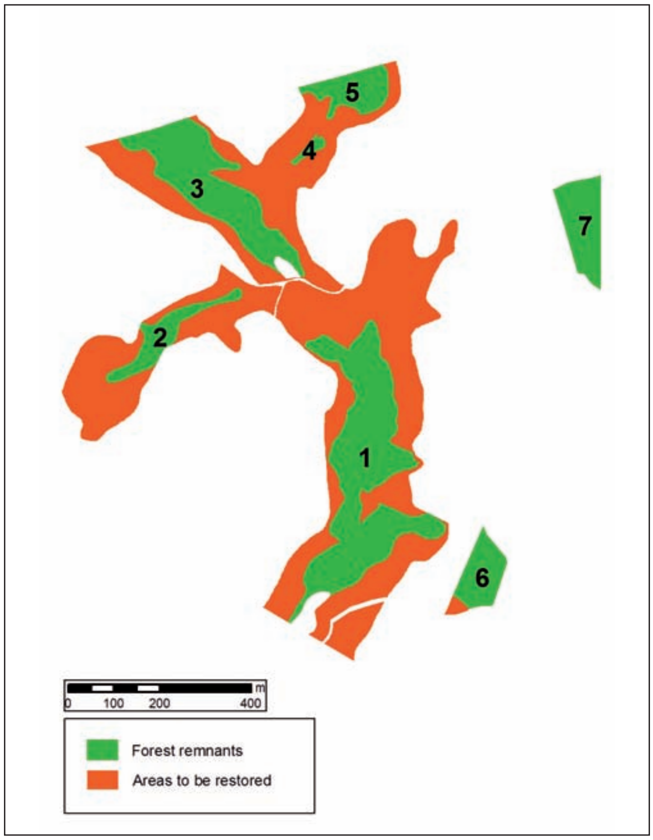


Figure 15

REPRESENTATION OF AN AREA THAT WILL CONNECT THE FRAGMENTS OF NATURAL VEGETATION FROM 1 TO 5 AFTER THE RESTORATION PROCESS IS COMPLETED



the first phases of the projects. The connectivity measure used to prioritize the restoration areas was the area volume added to the largest fragment, after the restoration, which was called "connected area gain", whose definition is illustrated in Figure 15.

This figure shows the vegetation fragments currently existing on the landscape (fragments 1-7) and the areas that will be restored. After restoration, fragments 1 to 5 will be connected, hence forming a larger fragment. We can consider that the vegetation area currently existing on the landscape that was connected is equivalent to the sum of areas of fragments 1 to 5.

To determine what was the connected area gain when compared to the initial situation (before restoration), we subtract from the last area connected the area of the largest fragment originally existing (fragment 1), in other words, the connected area gain is the sum of the areas of the fragments 2 to 5.

Another important variable to prioritize restoration areas is the ratio of the connected area gain and the area to restore. It would be desirable to restore the high values areas of this ratio to maximize the gain per connectivity of restored hectare. This ratio was also calculated for each fragment in the post-restoration scenario.

Figure 16
THREE TARGET AREAS (SEE TEXT) INDICATED BY BLUE CONTOURS

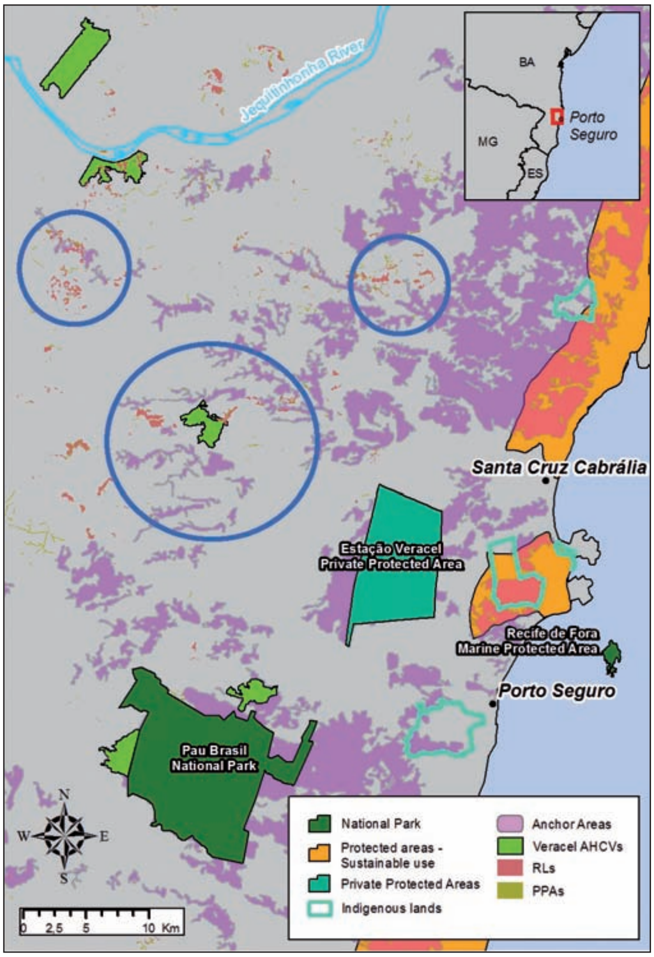
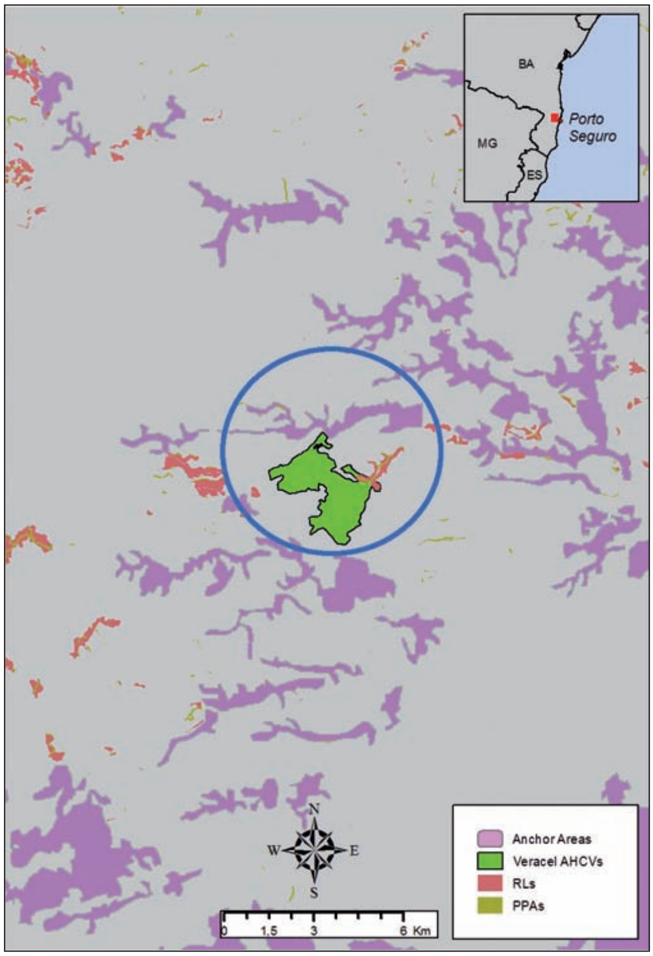


Figure 17
DETAIL OF THE MAP IN FIGURE 16, SHOWING ONE OF THE TARGET AREAS



The fragments whose area to restore was less than 10 hectares were excluded from the analysis, given that, from the operational point of view, it may not be feasible or efficient to restore many areas of few hectares. This left 428 fragments, which were prioritized by the connected area gain ratio and the area to restore, in descending order. Considering the 10 fragments with higher values of this ratio, the total area to be restored is of 302 hectares, with a total gain of connected area of 546 hectares and a total area of 1,667 connected hectares.

The same 428 fragments analyzed above were prioritized by the connected area gain, in descending order. With this analysis, considering the 10 fragments with the largest connected area gains, the total area to be restored is of 722 hectares and a total area of 2,723 connected hectares.

In another joint analysis with Veracel's GIS team, a map with the company's LR and PPA was superimposed on a map of anchor areas for restoration. Three target areas containing LR and PPA with high forest cover deficit were chosen, which are now largely covered by grazing lands near anchor areas (Figure 16). For one of these target areas (Figure 17), it was estimated that restoring 41 hectares in a LR and 17 hectares in a PPA could form a solid continuous forest of 900 hectares.

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