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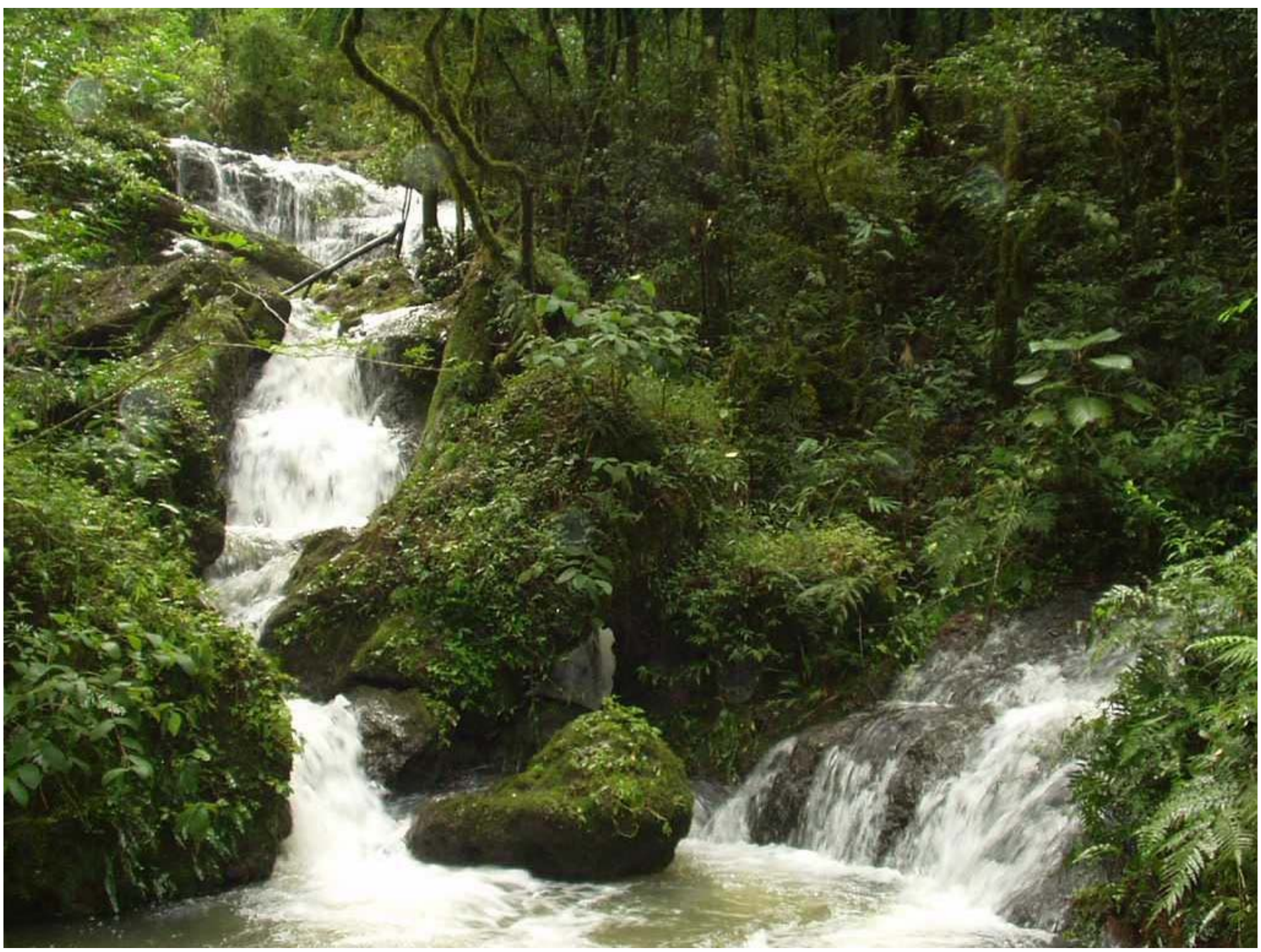
A BIODIVERSITY VISION FOR THE UPPER PARANÁ ATLANTIC FOREST ECOREGION

DESIGNING A BIODIVERSITY CONSERVATION LANDSCAPE AND SETTING PRIORITIES FOR CONSERVATION ACTION



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This Vision for the Conservation of the
Biodiversity of the Upper Paraná Atlantic Forest Ecoregion
(also known as the Interior Atlantic Forest, the Mata Atlântica do Interior,
the Selva Paranaense, Bosque Atlántico del Interior)
is dedicated to all of the many institutions and individuals
who have contributed their efforts and resources to developing it,
and who are orienting their conservation programs to achieve it,
with the hope that together we can make it a reality — if not within our own lifetimes, then
within the lifetimes of our children.

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VISION STATEMENT

To limit further species extinctions and
to maintain critical environmental services
by taking immediate actions
to ensure the long-term viability
of representative biodiversity
of the Atlantic Forest.

EXECUTIVE SUMMARY

Ecoregion Conservation

In recent years the conservation community has been promoting the design and implementation of biodiversity conservation actions at larger scales. WWF has embraced this approach, focusing conservation planning and action on ecoregions — relatively large units of land or water that contain a distinct assemblage of natural communities that share a large majority of species, dynamics, and environmental conditions. Since most ecological and evolutionary processes that sustain biodiversity occur at these larger scales, WWF has determined that ecoregions are the best units to design and implement biodiversity conservation actions.

One of the key elements needed to implement ecoregion conservation is a ***Biodiversity Vision***. A Biodiversity Vision is a planning tool, usually in the form of a document like this, aimed at guiding biodiversity conservation activities in the ecoregion. A Biodiversity Vision sets a number of biodiversity conservation goals based on widely-accepted principles of conservation biology, and identifies critical areas to be either conserved, managed, or restored in order to meet those goals. These areas are identified through a science-based process that relies on the best available biodiversity data and socioeconomic information. Through this process, we developed a Biodiversity Conservation Landscape that is represented in a map illustrating how the ecoregion would look in 50-100 years if we are successful in conserving biodiversity. This Biodiversity Conservation Landscape is a central piece of the Biodiversity Vision, and its representation in a map helps to focus conservation activities on those areas and to set specific targets that would render the best results for biodiversity conservation.

The Upper Paraná Atlantic Forest—a critically endangered ecoregion

In a worldwide ranking based on a comparative analysis of biodiversity data, WWF has identified the Global 200—the most outstanding ecoregions representing the full range of the Earth's diverse terrestrial, freshwater, and marine habitats. The Atlantic Forests, a Global 200 ecoregion, is actually a complex of 15 terrestrial ecoregions[1] that span the Atlantic coast of Brazil, extending westward into eastern Paraguay and northeastern Argentina. The Atlantic Forests are among the most endangered rainforests on earth, with only 7.4% of their original forest cover remaining, and this is in a highly fragmented landscape. They have been ranked as one of the most biologically diverse forests of the world. The southwestern portion of the Atlantic Forest constitutes the Upper Paraná Atlantic Forest ecoregion and is the focus of this Biodiversity Vision.

The original[2] area of the Upper Paraná Atlantic Forest ecoregion is the largest (471,204 km^2) of the 15 ecoregions of the Atlantic Forests Ecoregion Complex, extending from the western slopes of the Serra do Mar in Brazil to eastern Paraguay and the Misiones Province in Argentina. All this area was originally covered by a continuous subtropical semi-deciduous forest

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[1] The Atlantic Forests Global 200 Ecoregion is actually not one Ecoregion but a set of 15 terrestrial ecoregions characterized by tropical or subtropical forests. These 15 ecoregions form continuous tropical and subtropical forests that share a common biogeographic history and have many species in common, and for this reason WWF has considered them together as one Global 200 ecoregion.

[2] Original (or originally) refers to the time when the area was mostly covered by pristine native forest vegetation. That time roughly corresponds to the late 15th and early 16th centuries, coinciding with the arrival of the first European immigrants and the beginning of the rapid process of transformation of the forest into agricultural land. Prior to this time, native people likely impacted the ecoregion as a whole to a relatively small or medium degree.

with a high diversity of plant species that formed different forest communities[3]. This ecoregion has the largest remaining forest blocks, still containing the original set of large vertebrates, including top predators such as harpy eagles, crested eagles, jaguars, pumas, and ocelots, and large herbivores, such as tapirs, two species of brocket deer, and two species of peccaries. While these blocks represent an important conservation opportunity, they present the special challenge of crossing the borders of three countries with different cultures and different languages, a complex socio-economic and cultural diversity, and have experienced recent economic and social crises. More than 25 million people live in this ecoregion, 18.6 million in urban areas and 6.4 million in rural areas. Government decision making in the ecoregion is complex as well, with policies of importance to the Atlantic Forest developed and implemented by three federal governments, 18 provincial/state/department governments, and by 1,572 county governments (called municipalities in these countries).

The largest threat to biodiversity in the Upper Paraná Atlantic Forest ecoregion is the extreme degree of forest fragmentation and degradation, where the main proximate cause is the expansion of agriculture, both large- and small-scale. Other causes include squatting by landless people, the construction of infrastructure (dams, roads, etc.), illegal hunting of wildlife, and unsustainable exploitation of the native forest. Despite the high degree of forest fragmentation, there are still good opportunities for the conservation of the remaining large forest fragments in the ecoregion. By protecting these large areas we will be able to conserve the ecological processes that sustain biological diversity.

Setting biodiversity conservation goals

We have set four basic goals for this *Biodiversity Vision* to achieve conservation results in the Upper Paraná Atlantic Forest ecoregion. The four goals are based on conservation biology principles, and include:

1. The conservation of blocks of natural forest large enough to be **resilient** to short-term and long-term environmental changes
2. The maintenance of **viable populations** of all native species in their natural patterns of abundance and distribution, and with the genetic diversity necessary to meet environmental challenges
3. The maintenance of **healthy ecological processes** and selective factors such as disturbance regimes, hydrological processes, nutrient cycles, and biotic interactions, including predation
4. The **representation** of all native biological communities and seral stages across their natural range of variation within a Biodiversity Conservation Landscape.

Crafting the Vision

Underlying the Biodiversity Vision is a series of complex analyses aimed at designing a Biodiversity Conservation Landscape that will accomplish the conservation goals described above. During the past three years, WWF has led a tri-national participatory process involving more than 30 local organizations representing multiple sectors and disciplines. Many of these

[3] Individual plant communities of the Upper Paraná Atlantic Forest ecoregion are characterized by different soil types and the dominant tree species. In the Upper Paraná Atlantic Forest, some of the typical communities include: palmito (*Euterpe edulis*) and palo rosa (*Aspidosperma polyneuron*) forests, bamboo forests (four species of bamboo are common in the ecoregion and are the dominant species in some areas), laurel forests (several species of trees within the genus *Nectandra* and *Ocotea* are common in this forest type). However, no detailed vegetation map exists for the entire ecoregion and there is not complete agreement on the nomenclature used for the different forest communities.

organizations[4] provided information and data critical to produce this Biodiversity Vision for the time frame and geographic scale necessary to conserve the Upper Paraná Atlantic Forest Ecoregion's biodiversity.

For the analyses we used various overlays of maps representing the distribution of the different biological and socio-economic variables. A Geographic Information System provided a critical tool for conducting the analyses and visually describing different layers of information in various maps. Three separate but interdependent analyses were critical to arrive at the final Biodiversity Conservation Landscape:

The first step involved the **identification of individual landscape units**[5]. Given the lack of complete or sufficient biological information available to define and map all ecological communities, we used climatic, altitude, and topographic information as proxies for developing a biological model. Using these three layers of information, we identified 18 separate landscape units.

The second step involved the identification of native forest fragments with the highest potential for achieving conservation goals. For this **fragmentation analysis,** we used a map of forest fragments obtained from satellite images. We ranked forest fragments according to a Fragment Importance Index developed to indicate the relative contribution of forest fragments to biodiversity conservation. The index was based on four variables: fragment size, fragment size after excluding a buffer zone[6] of 500 m (an indirect measure of edge effects, see Box 4), distance to nearest fragment, and altitudinal range within the forest fragment.

The third step was a **threats and opportunities analysis**, where the objective was to map areas that represent critical threats and important opportunities for biodiversity conservation. Land use information provided a critical basis for assessing conservation opportunities and threats. The threat variables used in our analysis included: distance to cities, agriculture, cattle raising, and rural population density. Opportunity variables that were used included: the distance from a strictly protected area, the proximity to a river (assuming that rivers in this ecoregion constitute potential biological corridors), and zones of planned conservation. Variables were weighted according to their relative impact on biodiversity conservation.

We analyzed the current status of forest cover and representation of the different landscape units within the protected area system using the landscape units map in combination with the forest fragments map and the protected areas map. This gave us an idea of how well represented each landscape unit was in the actual landscape, and guided decisions on how to improve representation of those underrepresented landscape units in the final Biodiversity Conservation Landscape. Combining the fragment importance index map with the threats and opportunities map, we constructed a biodiversity conservation potential map that illustrates where the areas with the highest biodiversity conservation potential are located in the ecoregion. Using

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[4] See Acknowledgements.

[5] A landscape unit is a parcel of land of any size that is fairly uniform in certain characteristics (e.g., soil type, vegetation, land use, etc.) and differs from other such portions of land. In this particular analysis, we identified different landscape units based on abiotic characteristics (altitude, topography, rainfall, and seasonality) considered to be important determinants of biodiversity distribution. See Landscape Units Analysis in Chapter 4 for details on how we identified landscape units.

[6] The term buffer zone is used in this document with two different meanings. Sometimes, as is used here and in GIS analyses, a buffer zone is an area of arbitrary size that surrounds any focal area: a city, a forest fragment, or an ecoregion. In other cases, we will use the term buffer zone as it is typically used in conservation biology: a transitional area that ameliorates the negative effects of human impacts on surroundings of a natural ecosystem, usually a strictly protected area.

this biodiversity conservation potential map as the basic layer of information, we defined a ***Biodiversity Conservation Landscape***. Expert opinions and socio-political viability of certain decisions where also taken into account when outlining the Biodiversity Conservation Landscape. This process is summarized in Fig. 32.

Refining the final Biodiversity Conservation Landscape, involved a series of logical analyses and decisions that we explain in a simplified manner here. First, using the biodiversity conservation potential map as a guide, we identified large native forest blocks (>10,000 ha) to constitute Core Areas (see definition below). These are the forest fragments that may sustain the whole life cycle of a jaguar, which we used as our umbrella species[7]. Next we identified Main Corridors to connect Core Areas. Lastly, smaller areas of relatively high conservation value, surrounded by secondary corridors, were included to increase representation of landscape units and associated biodiversity within the final design of a biodiversity conservation landscape.

Our Vision in a map

Our Biodiversity Vision is a Biodiversity Conservation Landscape that spans the three countries, with adequate space for wildlife set aside from human activities to ensure that critical biodiversity conservation goals are met. The implementation of this Vision will depend on the participation of many sectors and the coordination of activities across the borders of the three countries.

The resulting Biodiversity Conservation Landscape is composed of **three main types of areas:**

The **Core Areas** are the blocks of well-preserved native forest large enough to be resilient to threats that cause biodiversity loss. These are the most biologically important and strategic zones for conservation, either public or private. Each Core Area should be managed to maintain an area of continuous native forest large enough for the life cycle of wide ranging species such as jaguars and white-lipped peccaries. Core Areas should be managed under strict protection and human activities should be reduced to a minimum. Core Areas should be connected to other Core Areas through a network of corridors to meet our biodiversity conservation goals.

The **Biological Corridors** are relatively narrow areas of native forest, either natural or restored, that connect large forest patches, either Core Areas or Sustainable Use Areas. The Biological Corridors would allow the movement of the wildlife and sufficient genetic interchange among Core Areas to maintain viable populations.

The **Sustainable Use Areas** are large areas that function as buffers and connections surrounding the Core Areas, other critical conservation areas under strict protection, and the biological corridors. They maintain healthy ecological processes and environmental services in combination with environmentally friendly economic activities.

We have also identified areas that are important for the development of river basin management and conservation programs as well as areas where we need to develop finer-scale land use planning to appropriately create and implement critical Biological Corridors.

Figure 36 depicts the resulting Biodiversity Conservation Landscape. Due to the lack of opportunities for biodiversity conservation and the lack of forest fragments with sufficient

[7] Umbrella species are those with very large area requirements. These species can be used as target species for conservation planning under the assumption that if we are able to preserve viable populations of them, we will preserve enough habitat for many other species with smaller area requirements. For a critical review of the umbrella species concept see Noss et al. 1997.

conservation value, some landscape units are not represented in the final Biodiversity Conservation Landscape. However, this Biodiversity Conservation Landscape will ensure the conservation of large and resilient blocks of native forests, where viable populations of umbrella species and healthy ecological processes, including predation by top predators, will be sustained. Both the Biodiversity Conservation Landscape and the Biodiversity Vision will continue to be refined over time as additional studies are undertaken and new information becomes available.

From Vision to Action – implementing an Ecoregion Action Plan

The implementation of this Biodiversity Conservation Landscape will require a series of actions at different time and spatial scales. Since no one organization can achieve results at this scale, actions must be coordinated among governmental and non-governmental organizations of many sectors. Achieving this Vision will require governments to incorporate the principles, ideas, and designs into their regional development programs and policies. Maintaining intact forest in the Core Areas will require improved implementation of existing protected areas, both public and private, and new protected areas must also be established. The connections among Core Areas can most easily be secured through the establishment of forest corridors crossing landscapes of multiple use zones that provide services valuable for the human population. Design of these corridors and multiple use zones will require fine-scale land use planning. It is critical to include the participation of stakeholders[8] to develop their support for implementation. New environmentally-friendly and economically-viable production alternatives, as well as incentives for the protection of forest on private land (both large and small holdings), must also be developed. Perverse incentives that contribute to forest conversion must be eliminated. Large-scale education campaigns will be essential to increase public understanding of the value of protected forests and thus generate public support and involvement in conservation—including enforcement of existing forest laws and development of new, improved public policies where necessary. Capacity building is also essential for landowners, both public and private, to become effective stewards of forested areas. To implement many of these activities will require new basic and applied research in areas such as restoration of native forest communities, economic and biological sustainability of alternative land uses, needs assessments for communication and education efforts, land use planning, and economic mechanisms to sustain conservation.

With this Biodiversity Vision as a guide, WWF and local partners need to transform short-term actions already underway to an ***Ecoregion Action Plan*** that lays out targets over the short-term (1-5 years) and medium-term (10-15 years). This Plan should clearly identify threat mitigation strategies, and focus on clear targets for conservation achievement as well as on the roles of partner institutions, long-term financing possibilities, structures for effective governance, communication and campaign activities, and capacity building. These clear targets are essential to guiding, focusing, and monitoring progress. Together with this inspiring Vision, the clear targets and transparent reporting of achievements are necessary to build the commitment and ownership by partners for continued and active engagement. Embedded in the crafting of an Ecoregion Action Plan is the need for flexibility. As more information is collected and actions are monitored, the Plan can be easily updated and allow for sound judgment when a change of course or tactic is necessary. In addition to helping the ecoregion action programs organize their strategic efforts in an ecoregion, the Plan has other benefits. The Ecoregion Action Plan can help openly articulate the biodiversity agenda, and can help leaders recognize the importance of this

[8] Stakeholder—any person, group, or institution that affects or is affected by (either positively or negatively) a particular issue or outcome.

agenda among other national and international priorities. It is clear that appropriate institutional development of partners is necessary to strengthen advocacy on a variety of levels. Since Brazil, Argentina, and Paraguay are all (to varying degrees) recently emerging democracies, this capacity building overlaps significantly with the development of active participation in government and taking an active role as citizens.

Implementation may take place at levels below the ecoregional scale, or outside the ecoregion, depending on the issue involved. A threats analysis is an essential filter for determining at what scale and timeframe we should act. All conservation activities must be conceived and implemented in relation to the social and political realities in which they take place. In the Upper Paraná Atlantic Forest ecoregion, these realities are different in each of the three countries and even in different regions of the same country. Most of the actions will be implemented on a national or regional level within each country. However, strategic planning, monitoring of the threats and conservation results, and resulting adjustments must be conducted at an ecoregional scale.

CHAPTER 1

Ecoregion Conservation and the Biodiversity Vision

Conservation efforts around the world have been traditionally restricted to small areas and focused on local activities that take place in short time frames (1-5 years), such as the creation of a protected area or the implementation of a buffer zone. These activities are the basis of biodiversity conservation. However, to preserve biodiversity over the long term, we need to focus our efforts at much larger spatial and temporal scales, those at which most ecological and evolutionary processes that maintain biodiversity occur. This task requires analysis and planning at the level of landscape or larger spatial scales. Ecoregions are the best units of analysis for planning at large spatial scales (Box 1), even though many actions will be implemented locally.

BOX 1
What is an ecoregion?

An ecoregion is a relatively large unit of land or water that contains a distinct assemblage of natural communities sharing a large majority of species, dynamics, and environmental conditions. A terrestrial ecoregion is characterized by a dominant vegetation type, which although not universally present in the region, is widely distributed and gives unifying character to it. Because the dominant plant species provide most of the physical structure of terrestrial ecosystems, communities of animals also tend to have a unity or characteristic expression throughout the region.

Ecoregions are more suitable units for conservation planning because they:

1. Correspond to the major driving ecological and evolutionary processes that create and maintain biodiversity;
2. Address the maintenance of populations of the species that need the largest areas, an element of biodiversity that cannot be accommodated at the site scale;
3. Encompass a logical set of biogeographically related communities for representation analysis; and
4. Enable us to determine the best places to invest conservation efforts and to better understand the role that specific projects can and should play in conservation of biodiversity over the long term.

Analysis and planning at the ecoregional scale provide the best basis for establishing conservation priorities. "Act locally, but think globally" is a useful motto because although we invariably have to act locally, without thinking more broadly at global or regional scales, we lack a context (biological, social and economic) for specific local actions that will produce long-term conservation benefits.

From: Dinerstein et al. 2000. A Workbook for developing biological assessments and developing Biodiversity Visions for ecoregion conservation. Part I: Terrestrial Ecosystems. WWF- Conservation Science Program.

This is why WWF has focused its attention on critical ecoregions, the Global 200 (WWF 2000, Figure 1). These constitute a set of ecoregions selected among all terrestrial, marine, and freshwater habitats around the world through a science-based ranking effort. To identify the most outstanding examples, this ranking is based on a comparative analysis of biodiversity data throughout the world, using the ecoregions as the units of analysis. The Global 200 includes representations of all major habitat types in each major biogeographic unit. The objective of this ranking is to prioritize conservation actions throughout the world (Olson & Dinerstein 1998, Olson et al. 2000, 2001). WWF and partners are thus shifting from site-based projects to planning and action at the scale of ecoregions, in an approach called Ecoregion Conservation (ERC). Ecoregion Conservation allows us to achieve conservation goals that cannot be attained at other scales of planning and action (BOX 2). Similar approaches are taken by most other major environmental organizations throughout the world, including The Nature Conservancy, Conservation International, and others (Bright & Mattoon 2001).

BOX 2

Minimum conservation targets to achieve the goals of ecoregion conservation (ERC)

The term biodiversity describes the full expression of life on the planet, from genes to species, to ecological interactions, to whole ecosystems. The ERC approach is designed to address the conservation requirements of the full experience of biodiversity; and thus the fundamental goals of biodiversity conservation help shape the overarching Vision for an ecoregion. In order to be rigorous and effective in ERC, we should focus conservation activities on five specific biodiversity targets:

Distinct communities, habitats, and species assemblages (distinct units of biodiversity)
A primary conservation target is the representation of distinct biogeographic subregions, habitats, communities, and assemblages of species. Representation of specific assemblages may also be appropriate. The particular combination of units to be represented in each ecoregion strategy will vary depending on: a) the distinguishing features of each ecoregion, and b) the availability and quality of information on patterns of biodiversity. We should strive to represent and conserve habitats as well as the full diversity of species in each ecoregion.

Large expanses of intact habitat and intact biotas
Empirical studies demonstrate that large areas of intact natural habitat are best for conserving the full range of species, habitats, and natural processes. However, intact ecosystems and biotas are increasingly rare around the world. In particular, top predators and larger vertebrates are disappearing rapidly in most ecoregions as human activities convert and fragment natural habitats and exterminate populations of vulnerable species via overexploitation.

Keystone ecosystems, habitats, species, or phenomena
At ecoregional scales, certain kinds of habitat may exert a powerful influence on biodiversity in surrounding habitats and across the whole ecosystems. Their persistence and intact ecological functioning may be critical for many species and ecological processes in neighboring areas.

Large-scale ecological phenomena
The conservation of distinctive large-scale ecological processes, such as hemispheric-scale animal migrations, requires a combination of site-specific, regional, and policy-level efforts applied over vast continental areas or widely disjunct regions. Habitats or sites that may not be particularly distinctive (e.g., characterized by high richness or endemism) or intact may still act as critical habitat for migratory species. Conservation of such phenomena must be linked with ecoregion-level activities and coordinated among different ecoregions.

Species of special concern
Some species that are heavily hunted, depleted in numbers, or highly specialized in their habitat requirements run the risk of falling through the cracks of ERC, a process which gives greater weight to representation than single-species conservation efforts. However, in many ecoregions, targeted efforts to restore populations of sensitive species and their habitats are central to ERC because they serve as focal species for planning.

From: Dinerstein et al. 2000. A Workbook for developing biological assessments and developing Biodiversity Visions fore ecoregion conservation. Part I: Terrestrial Ecosystems. WWF- Conservation Science Program.

Planning and action at the ecoregional scale and for the long term are essential to achieve conservation results and to link human development opportunities to the maintenance of biological diversity. A cornerstone of ERC is a Biodiversity Vision (Box 3). A Biodiversity Vision is an analysis of patterns of biological diversity and threats and opportunities for conservation at the ecoregional level that serves as a blueprint for conservation action - a design of what the ecoregion's biodiversity will need to survive over the long term. A Biodiversity Vision is thus a planning tool, usually in the form of a document like this, aimed at guiding biodiversity conservation activities in the ecoregion. A Biodiversity Vision sets a number of biodiversity conservation goals, based on basic and widely accepted principles of conservation biology, and identifies critical areas to be conserved, managed or restored in order to meet those goals. These areas are identified through a science-based process that relies on the best available biodiversity data and socioeconomic information. Through this process we develop a Biodiversity Conservation Landscape, represented in a map, that shows how the ecoregion will look in 50-100 years if we are successful at conserving its biodiversity and ecological processes. This Biodiversity Conservation Landscape is a central piece of the Biodiversity Vision, and its representation in a map helps to focus conservation activities on those areas of the ecoregion that will render the best results for biodiversity conservation. A Biodiversity Vision also identifies clear conservation targets and serves as a tool to prioritize conservation actions in the ecoregion.

BOX 3

The Biodiversity Vision as a tool for implementing Ecoregion Conservation

The cornerstone of ERC is a Biodiversity Vision that goes far beyond the current configuration of protected sites and management practices. To conserve the full range of biodiversity in most terrestrial ecoregions over the long term, conservation areas will need to be much larger and more numerous than what currently exists on the map today. In addition to putting more natural habitat under protection, other related conservation activities – more sustainable use of natural resources, protection of watersheds, establishment of strong NGOs, supportive legislation, environmental education – need to be greatly expanded in scope and effort. Thus, in every ecoregion, we ask from a conservation perspective, "What should the ecoregion look like in 10, 20, and 50 years hence?" This creation of a Biodiversity Vision highlights our commitment to the restoration of biologically valuable but degraded landscapes, strong legislation and enforcement programs that protect native biodiversity, and the nurturing of an ecoregion-wide conservation movement.

All of these actions take time to develop. Thus, the Biodiversity Vision requires us to plan conservation activities over larger spatial and longer temporal scales than in the past. Conservationists are challenged to define what success looks like in the context of conserving an ecoregion´s biodiversity in order to create a Vision. This picture of success depends greatly on the biological assessment as it gets refined. Too often, we confine our efforts to protecting isolated sites rather than developing a more far-reaching strategy for successful conservation at an ecoregion scale.

Without the Biodiversity Visions, ERC is only an incremental improvement over existing approaches. The creation of a Vision, as well as the implementation of an ecoregion conservation strategy, depends on the active involvement of many, in particular: host governments, experts of many disciplines, local conservation groups, development organizations, and citizens of countries within an ecoregion. WWF´s role will vary in each ecoregion, and throughout the life of an ecoregion conservation initiative. ERC highlights the conservation of ecological processes, important evolutionary phenomena, higher order diversity (generic and family), and rare habitat types as well as the more traditional taxonomic indicators of priority-setting - species richness and endemism.

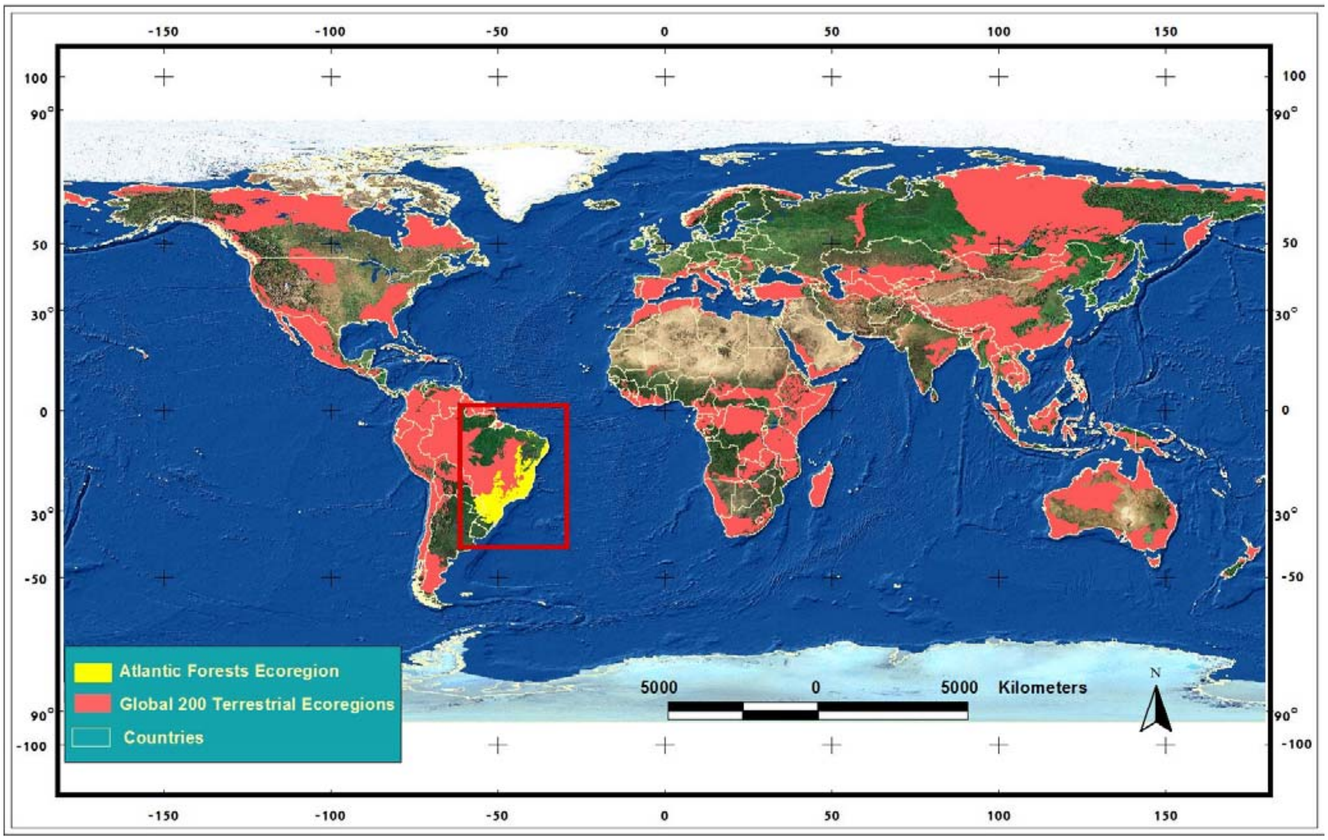
In ERC biological analysis, we highlight intact or near-intact large vertebrate assemblages as vital conservation targets because of their increasing rarity worldwide. Target areas and landscapes that support or, with moderate restoration efforts, could support assemblages of megafauna such as top predators, megaherbivores, and keystone species are identified. Top predators, such as jaguars, mountain lions, wolves, lions, tigers, and snow leopards, help to control native herbivore populations. Megaherbivores, such as elephants, giraffes, hippos, and rhinoceroses, influence habitat structure through their trampling, browsing, and grazing. Keystone species, such as sea otters, fig trees, or keystone herbivores such as beavers, bison, deer, and prairie dogs – are species whose removal or decline in an ecoregion would have a disproportionate negative effect on the persistence of other species. We also highlight the critical importance of less conspicuous invertebrates and diminutive vascular plants – the taxonomic units most numerous in species in any terrestrial ecoregion.

Finally, a smaller goal of ERC is to reduce overarching threats to biodiversity that operate over multiple areas within the ecoregion (and sometimes outside of an ecoregion) rather than on a site-by-site basis.

From: Dinerstein et al. 2000. A Workbook for developing biological assessments and developing Biodiversity Visions for ecoregion conservation. Part I: Terrestrial Ecosystems. WWF-Conservation Science Program.

WWF cannot work simultaneously in all of the more than 200 ecoregions within the Global 200, and so has selected a subset of ecoregions on which to currently focus its efforts as an international network. The Atlantic Forests of South America is one of these focal ecoregions. This document presents a Biodiversity Vision for one of the ecoregions of the Atlantic Forests Ecoregion Complex, the Upper Paraná Atlantic Forest. It also provides a technical description of the analyses undertaken to arrive at this ambitious Vision. The Biodiversity Vision is aimed at laying the foundation for long-term (50 to 100 years) biodiversity conservation in the Upper Paraná Atlantic Forest. It is meant to capture the major elements of biodiversity and serves as a fresh organizing concept from which to frame actions, projects, trade-offs, threats, opportunities, partners, and stakeholders. The Vision highlights areas in which special attention should be paid to factors such as land- and resource-use planning, watershed management, and social and economic development.

Figure 1. The Global 200 Terrestrial Ecoregions



CHAPTER 2

The Upper Paraná Atlantic Forest Ecoregion

The Atlantic Forests Ecoregion Complex

The Atlantic Forests Global 200 Ecoregion Complex of Brazil, Paraguay, and Argentina (hereafter referred to as the Atlantic Forest), is composed of 15 ecoregions, and is among the most endangered tropical rainforests in the world, with just 7.4 percent of its original 1,713,535 square kilometers of forest cover intact. The Atlantic Forest extends from a tropical latitude in the states of Ceará and Río Grande do Norte on the northeast coast of Brazil, to a highly seasonal subtropical latitude in the southern state of Río Grande do Sul in Brazil. It extends from the Atlantic Ocean westward to the interior over Brazil's coastal mountain range to the watershed of the Paraná River in eastern Paraguay and to Misiones Province of Argentina (Figure 2).

The biodiversity of the Atlantic Forest is not evenly distributed since different combinations of temperature, altitude, soils, rainfall, and distance to the ocean along its range have created conditions for unique groups of species to evolve in localized areas. The forest retractions and expansions of the geologically recent Pleistocene period may have contributed to the creation of new species and have shaped the actual distribution of the species of the Atlantic Forest (Prance 1982 in Tabarelli et al. 1999). To design a conservation strategy that would ensure the long-term survival of a representative sample of the complex biodiversity of the Atlantic Forest, WWF scientists and partners have divided the Atlantic Forest into 15 ecoregions for analysis to identify biological goals and long-term conservation strategies to achieve them (Figure 3).

In spite of its highly fragmented condition (Figure 4), the Atlantic Forest remains one of Earth’s most biologically diverse ecosystems, containing about 7% of the world´s species (Quintela 1990 in Cullen et al. 2001). One of the world´s highest diversity of woody plant species per hectare has been recorded in the Atlantic Forest, in the State of Bahia, with 450 species of trees (>10 cm dbh) per ha. Not only its biodiversity characterizes the Atlantic Forest, but its high level of endemic species (those found nowhere else on earth) is astonishing and makes this ecoregion complex a high priority for conservation. Forty percent (8,000 species – 2.7% of all plants on the planet) of the Atlantic Forest’s 20,000 plant species are endemic. Forty-two percent (567 species – 2.1% of the Earth’s terrestrial vertebrates) of the Atlantic Forest’s 1,361 terrestrial vertebrates are also endemic (Myers et al. 2000). Over 52% of the Atlantic Forest’s tree species, 74% of its bromeliad species, 80% of the primate species, and 92% of its amphibians are endemic (Mittermeier et al. 2001, Quintela 1990 in Valladares-Padua et al. 2002). Many of these species are now threatened with extinction. Of all the species recognized as endangered in Brazil, nearly three-quarters live in the Atlantic Forest (Bright & Mattoon 2001). It is not a surprise that the eight Brazilian species considered extinct in recent times were all endemic to the Atlantic Forest (Mittermeier et al. 1999).

The Atlantic Forests Ecoregion Complex has also been identified as a Biodiversity Hotspot, first by Myers (1988, 1990) and then by Conservation International as one of its 25 Hotspots (Mittermeier et al. 1998, Myers et al. 2000). The Hotspots approach focuses on threatened areas of species endemism. BirdLife International has mapped every bird species with a restricted range of less than 50,000 square kilometers with Endemic Bird Areas significantly overlapping a large part of the Atlantic Forests Global 200 Ecoregion Complex (WWF 2000).

In addition to containing some of the world's rarest species, what remains of the Atlantic Forest is directly associated with the quality of life of the human population. Forests are vital to watershed protection, prevention of soil erosion, and to maintaining environmental conditions necessary for the existence of cities and rural areas. In Brazil alone, the Atlantic Forest is the water reservoir for almost three-quarters of Brazil´s population. A large fraction of the electricity produced in Brazil, Paraguay, and Argentina, is produced in the rivers of the Atlantic Forest and especially in the Upper Paraná ecoregion, where two of the largest hydroelectric dams in the world are located (Itaipú and Yaciretá).

A long history of human occupation of the region is testified by the stone tools of approximately 11,000 years ago that have been found in the Atlantic Forest. When the Spaniards and Portuguese arrived in the region in the early 1500s, they found groups of people, mostly Guaraní, with an economy based on small farming, hunting, and gathering. These native people, living at low to medium densities, had at most moderate effects on the environment. However, with the arrival of the Europeans in the 16th century, a dramatic transformation of the environment began to take place in the Atlantic Forest (Dean 1995, Jacobsen in press).

As the first part of Brazil to be colonized by the Portuguese in the early 1500s, the Atlantic Forest has developed into the population hub of the country. In the 17th and 18th centuries, sugar cane, cattle raising, and uncontrolled logging for the exploitation of wood from a few tree species were the main economic activities that began to transform the Atlantic Forest into pastures and monocultures. In the 19th century, coffee plantations became increasingly common in the southern and central portions of the Atlantic Forest. In the 20th century industrial activities, especially steel production, started to consume increasing quantities of fuel-wood (Dean 1995, Bright and Mattoon 2001). Eucalyptus and other exotic monoculture forest plantations (for timber, pulp, firewood, charcoal, and other wood products) replaced huge expanses of Atlantic Forest. In more recent times, and especially in the south, soybean, wheat, corn, and other annual monocultures have definitely transformed what was a vast continuous forest into a highly fragmented landscape where small fragments of forest survive amidst a matrix of monocultures, cattle pastures, roads, and cities. Similar consequences of forest destruction occurred in all the Atlantic Forest´s Brazilian states, despite differences in the main economic activities and the timing of forest destruction. In the state of São Paulo, for example, large landowners began to exploit the forest very early in the history of Brazil, and most of the land is in the hand of a few people (Cullen et al. 2001). In the state of Santa Catarina, the destruction of the forest mostly began in the 20th century and most landowners possess small parcels (Hodge et al. 1997). Nowadays, three-quarters of Brazil's population of 170 million lives in the Atlantic Forest and eighty percent of Brazil's GNP, the world's eighth largest economy, is produced in this region.

In contrast, the isolation from human population centers of the Argentine and Paraguayan portions of the ecoregion has allowed the preservation of the largest piece of Atlantic Forest. The occupation of the ecoregion in Paraguay and Argentina began later, and until the beginning of the 20th century, most of the Atlantic Forest in these countries was still covered by native forest. In the last few decades, large expanses of Atlantic Forests were clearcut in Paraguay for the development of large-scale soybean plantations and small-scale agriculture. In Argentina, the colonization and development of the country began in the pampas, with one of the richest soils in the world, far from the forest. The Atlantic Forest of Misiones Province in Argentina was exploited relatively late in the history of the country, mainly for timber and yerba mate (an endemic plant used for tea).

The habitat destruction and fragmentation of the Atlantic Forest coupled with the high levels of species endemism make conservation action particularly urgent.

The Upper Paraná Atlantic Forest Ecoregion

Natural history of the Upper Paraná Atlantic Forest

The original[9] forest of the Upper Paraná Atlantic Forest ecoregion covered the largest area (471,204 km^2) of all the ecoregions of the Atlantic Forests Ecoregion Complex, extending from the western slopes of the Serra do Mar in Brazil to eastern Paraguay and the Province of Misiones of Argentina (Figure 5). In the north, the Upper Paraná ecoregion borders the Cerrado Woodlands and Savannas Global 200 Ecoregion. The vegetation of the Cerrado is very distinct and its physiognomy differs from that of the Atlantic Forest. The Cerrado is a mosaic of forest communities, with slow growing tree species adapted to seasonal rains and the presence of fires and savannas. The riverine forests of the Cerrado, however, contain species typical of the Atlantic Forest. In the west, the Upper Paraná Atlantic Forest meets the Pantanal and the Humid Chaco, a large floodplain characterized by gallery forests, savannas, flooded grasslands, and deciduous chaco forests in the non-flooded areas. In the south, the Upper Paraná Atlantic Forest borders an area of grasslands. Finally to the east, it intermingles with the Araucaria Forests, another of the ecoregions in the Atlantic Forest Ecoregion Complex. The boundary with the Araucaria Forests ecoregion is not clearly delineated; it is sometimes difficult to define where one ecoregion begins, and where another ends. Both ecoregions have been sometimes classified as only one. With the exception of a few species that characterize the Araucaria Forests ecoregion — such as two conifers, the dominant Brazilian pine or monkey puzzle tree (*Araucaria angustifolia)* and *Podocarpus* sp., and a set of species associated with them such as the tit-spinetail (*Leptasthenura setaria)*—many species are shared between both ecoregions.

The predominant vegetation of the Upper Paraná ecoregion is a semi-deciduous sub-tropical forest. Variations in the local environment and type of soil allow for the occurrence of other plant communities—gallery forests, bamboo forests, palmito (*Euterpe edulis*) forests, and araucaria forests. Most of the remaining forests have been exploited for timber, and some are second growth forests recovering from deforestation. Forest fragments are thus composed of both primary and secondary forests at different stages of succession.

The Upper Paraná ecoregion is situated in the southern portion of the Brazilian Plateau. The topography of the ecoregion ranges from relatively flat areas with deep soils near the Paraná and other main rivers at altitudes of between 150-250 m above sea level (asl), to a relatively flat plateau at altitudes of between 550-800 m asl. The areas located between the main rivers and the plateau, at altitudes of between 300-600 m asl have relatively steep slopes and are dramatically

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9 See footnote 2

exposed to soil erosion when the forest cover is removed (Ligier 2000). Above 700-900 m asl, the Upper Paraná ecoregion gives way to the Araucaria ecoregion in the east and to the Cerrado in the north.

The soils of the ecoregion are relatively nutrient rich. The usually deep red soils near the main rivers become less deep and more rocky at higher altitudes. There is high variation in soil types, varying in texture, chemical composition, and acidity (Ligier 2000, Fernández et al. 2000).

The ecoregion has a subtropical climate. Mean annual temperature ranges from 16-22 ºC with a relatively high annual variation. In the southern portions of the ecoregion, frost is common during the winter months (June-August), especially at high altitudes. Rainfall in the ecoregion ranges from 1,000-2,200 mm per year, usually with less rain in the northern part of the ecoregion than in the south. Rains are not uniformly distributed during the year, and in some portions of the ecoregion there are up to five dry months, usually during the winter. Increased rains during El Niño years produce large inter-annual variations in rainfall.

Rainfall and the strong seasonality in temperature and light determine a seasonal pattern of primary productivity of the forest (Placci et al. 1994, Di Bitetti unpublished). In the Upper Paraná Atlantic Forest there is strong seasonality in the availability of food for folivorous, frugivorous, and insectivorous species. New leaves, fruits and insects are more abundant during the spring months of September to December (Placci et al. 1994, Di Bitetti & Janson 2001).

The natural characteristics of the region form an extremely rich habitat harboring countless species of plants and animals, among them the spectacular large cats—the jaguar (*Panthera onca*), puma (*Felis concolor*), and ocelot (*Felis pardalis*) (Crawshaw 1995). Other common mammals include the tapir (*Tapirus terrestris*), three species of brocket deer (*Mazama americana*, *Mazama nana*, and *Mazama gouazoubira*), two species of peccaries (*Tayassu pecari* and *Tayassu tajacu*), coati (*Nasua nasua*), and four species of monkeys (*Cebus apella nigritus*, *Alouatta caraya*, *Alouatta fusca fusca*, and *Leontopithecus chrysopygus*). About 500 species of birds are found here, including five species of toucans (*Ramphastos toco*, *Ramphastos dicolorus*, *Pteroglossus castanotis*, *Baillonius bailloni*, and *Selenidera maculirostris*). Reptiles and amphibians also show high diversity, and include caimans, turtles, boas and other snakes (including several endemic species within the genus *Bothrops*, such as *Bothrops jararacusu*), lizards and spectacular amphibians, such as the toad *Bufo crucifer*, and the frogs *Osteocephalus langsdorffi, Hyla faber* and *Phyllomedusa iheringi*. Some animals are considered endangered or threatened, such as the giant river otter (*Pteronura brasiliensis*), the black lion tamarin (*Leontopithecus chrysopygus*), the black-fronted piping guan (*Aburria jacutinga*), the solitary tinamou (*Tinamus solitarius*), the Brazilian merganser (*Mergus octosetaceus*), the vinaceous breasted parrot (*Amazona vinacea*), the bare-throated bellbird (*Procnias nudicollis*), and the harpy eagle (*Harpia harpyja*). Some species, like the jaguar, the harpy eagle, the giant river otter and the white-lipped peccary, require large expanses of continuous forest to guarantee their long-term survival—which represents a big challenge for their conservation in a fragmented landscape. Some species of the Upper Paraná Atlantic Forest ecoregion have very restricted distributions and constitute local endemism, such as the black lion tamarin, restricted to a small area in the western part of the state of São Paulo, Brazil (Cullen et. al. 2001), and the Urugua-í frog (*Crossodactylus schmidti*), endemic to a small portion of Misiones (Chebez & Casañas 2000).

Levels of alpha and beta biodiversity [10]are quite high in the ecoregion, although there are very few places that have been intensively surveyed. For example, in the San Rafael Managed

[10] *Beta biodiversity* is defined as the turnover of species within a range or along environmental gradients such as elevation. It contrasts with *alpha biodiversity* which is the number of species at a given site.

Resource Reserve in Paraguay, 378 species of birds have been recorded but it is estimated that between 400 and 450 species are actually present in the area (Clay et al. 2000). The areas of Iguaçú National Park in Brazil and Iguazú National Park in Argentina are among the best-studied sites in the ecoregion, with four hundred and sixty species of birds (Saibene et al. 1993) and more than 250 species of trees recorded in these protected areas. Between 53 and 73 species of trees (>10cm dbh) per ha have been recorded in study plots within the Iguazú National Park (Placci & Giorgis 1994, S. Holz pers. com.). Eighty-five species of orchids have been recorded just in the Iguazú National Park, which represents about 1/3 of the species known for all of Argentina (Johnson 2001). Over 3,000 vascular plant species have been recorded for Misiones, representing about 1/3 of the total vascular flora from Argentina (Zuloaga et al. 2000, Giraudo et al. in press).

The Upper Paraná Atlantic Forest plays an important role in the conservation of watersheds, ensuring the water quantity and quality essential for the conservation of the Upper Paraná Rivers and Streams, a Global 200 freshwater ecoregion (Figure 6). With a remarkably diverse fauna, including over 300 species of fish, in addition to diverse aquatic vertebrates and invertebrates, the Upper Paraná Rivers and Streams ecoregion has a high degree of endemism of freshwater species (Olson et al. 2000).

The Upper Paraná Atlantic Forest ecoregion is located over a large portion of the largest groundwater reservoir in the world — the Guaraní Aquifer. This aquifer extends over a total of 1.2 million square kilometers from the central-west region of Brazil, through Paraguay to southeastern and southern Brazil, northeastern Argentina and central-western Uruguay (Facetti and Stichler 1995). The current volume of freshwater reserves stored is around 40,000 km^3. Its depth varies from almost zero in Brazil to more than 1,000m in Argentina (Fili et al. 1998). Despite a large surface water reserve, the drinking water supply in this heavily populated region is increasingly dependent on this groundwater. Future problems may occur if exploitation does not take place in a sustainable manner or if the waters become polluted. Due to its significant average depth, the Guaraní Aquifer is still relatively unaffected by surface pollution (The World Bank, 1997). However, the rapid development of agriculture in the region, especially in Brazil where the aquifer is nearer to the surface, has the potential to pollute this valuable water resource. This is a very clear example of the need for conservation planning and action at the ecoregional scale.

Demography and political divisions

There are significant differences in the demography and number of political units constituting the Upper Paraná Atlantic Forest ecoregion in each of the three countries. The original area of the Upper Paraná Forest in Brazil today has a total human population of 25,053,461. Of that total 18.6 million are classified as urban, and 6.4 million as rural. This area extends into seven Brazilian states (Rio Grande do Sul, Santa Catarina, Paraná, São Paulo, Minas Gerais, Mato Grosso do Sul, and Goias) and is divided into 1,374 municipalities. In Paraguay the original area of the Upper Paraná Atlantic Forest ecoregion has a population of 2.5 million almost equally divided between urban (1.24 million) and rural (1.23 million). The area is divided into 10 departments (Alto Parana, Amambay, Caaguazu, Caazapa, Concepcion, Canindeyu, Itapua, Guaira, Paraguary, San Pedro) which are subdivided into 123 municipalities. In Argentina, the original area of the Upper Paraná Atlantic Forest includes only one province –Misiones - that has a total population of 788, 000, of which 500,000 are urban and 288,000 are rural. The province is divided into 75 municipalities. Having emerged from dictatorship governments in recent years, all three countries are in a process of decentralization transferring more power from central governments to the municipalities, particularly in issues of land use. Brazil is the most advanced in this decentralization process followed by Argentina. Paraguay's government continues to be the most centralized. Municipal governments will require significant capacity building to carry out new responsibilities.

The main causes of fragmentation and degradation of the Upper Paraná Atlantic Forest

Land use

Mainly due to agricultural expansion westward in Brazil (coffee in the late 19th century and in the past 50 years for wheat, soybeans, sugar cane, and oranges), the Upper Paraná Atlantic Forest has been reduced to only 7.8% of its original extent. In Brazil, only 2.7% (771,276 ha) of the original Upper Paraná Atlantic Forest remains, including the Iguaçu National Park, the Morro do Diabo State Park, the Turvo State Park and a few smaller forest fragments—and virtually none outside of protected areas.

Relative isolation from human population centers in Argentine and Paraguayan portions of the ecoregion has allowed the preservation of the largest area of remaining Upper Paraná Atlantic Forest in those two countries. Approximately 1,123,000 ha (about half of the original forest area of the ecoregion in that country) remain in Argentina, forming a contiguous corridor covering a large part of the province of Misiones. Most of the remaining forest lies within what is known as the Green Corridor, an area of conservation and sustainable use of over 1,100,000 ha created by Misiones provincial law (García Fernández 2002, Cinto & Bertolini in press). Although Paraguay retains a large area (1,152,332 ha) of Upper Paraná Atlantic Forest, it is only 13.4% of the original area in that country. Paraguay has one of the highest deforestation rates of any country in Latin America, and recent deforestation there has fragmented the remaining forest (Altstatt et al. 2003) (Figure 7).

We have identified that fragmentation, isolation, and degradation of the forest fragments constitute the main threats to biodiversity conservation in the ecoregion. These processes have occurred at different intensities in different parts of the ecoregion. We will discuss later (Chapter 3) the consequences of the process of forest fragmentation and degradation on biodiversity conservation. Here, we will focus our discussion on the main causes of forest fragmentation and degradation.

Agricultural expansion has been identified as the major underlying cause of the process of fragmentation of the forest in the Upper Paraná ecoregion. The main economic activities driving this process of native forest conversion include annual crops (soybeans, sugar cane, corn, wheat, cotton, tobacco), and perennial crops (coffee, yerba mate, tea, and pine and eucalyptus forest plantations). Cattle ranching is also an important economic activity in the ecoregion that usually requires the conversion of the native forest into grasslands for grazing. The importance of these economic activities differs regionally within the ecoregion, mainly due to the different histories and development patterns of the three countries (Laclau 1994, Holz & Placci in press). For example, soybean plantations are very important in the southern Brazilian states and in eastern Paraguay, but not in the Misiones Province of Argentina. Illegal marihuana plantations are restricted to the northern part of the Paraguayan portion of the ecoregion. In Misiones, monoculture forest plantations, mainly of pine, constitute the main economic activity in the province, and these plantations are concentrated near the Paraná River. Tobacco plantations are concentrated in the state of Santa Catarina, in Brazil (Hodge et al. 1997), and in the eastern portions of Misiones. Thus, to address the causes of forest fragmentation and degradation, different actions need to take place in different parts of the ecoregion.

While large-scale agriculture clearly has negative impacts on biodiversity, subsistence agriculture also contributes to the fragmentation and degradation of the forest in a number of ways. First, for many small producers, agriculture is economically unsustainable because they lack access to markets or other economic incentives available to large producers. As a result of the unsustainability of the production system, small producers eventually abandon their land and often sell it to large landowners or companies. These lands are then incorporated into highly intensive and large-scale production systems (Laclau 1994, Colcombet & Noseda 2000).

Second, land occupation and settlement of landless poor in areas of forest remnants is contributing to the conversion of the last forest remnants into land dedicated to small-scale and unsustainable agriculture. In this case, landless people illegally occupy private or state-owned properties, usually temporarily, to produce a few annual crops. With no other alternatives, the landless people seeking small parcels of land for subsistence agriculture are sometimes forced to illegally occupy the last forest remnants located in areas not suitable for agriculture, where soils are unproductive or are on steep slopes (Hodge et al. 1997, Cullen et al. 2001, Chebez & Hilgert in press). Cullen et al. (2001) describe the situation for the state of São Paulo: "Land concentration, land speculation, and landlessness are the main causes of imprudent land use in areas where traces of Atlantic Forest remain. Poor people who have been denied land and livelihood are being used as objects of unfair negotiations and forced into these forests fragments in ever increasing numbers, often encouraged by the state government. This land tenure system results in the exploitation of forest remnants and threatens the remaining habitats."

The causes of environmental degradation of the ecoregion are associated with historical and present situations of social inequalities (Laclau 1994). This can be clearly seen when one looks at the unequal pattern of land tenure that is generally similar across the three countries. In Misiones, 93% of the producers have properties of <100 ha, which represents only 1/3 of the productive land. The rest of the productive activities occur in large properties that occupy the other 2/3 of the productive land. The tendency for concentration of land in the hands of a few owners, and the majority of the people owning small parcels, has increased in the last decade (Colcombet & Noseda 2000). In Paraguay, the situation is similar, 82% of the rural properties have less than 20 ha while only 1% have more than 1,000 ha. However, that one percent represents 77% of the cultivated area (SEPA 2000). A similar pattern occurs in the southern states of Brazil (Laclau 1994, Cullen et al. 2001, Figure 8).

Infrastructure

There are several dams in the ecoregion whose effect has been not only to flood large extensions of native forest, but also to impose new barriers that increase the fragmentation of the forest and reduce the dispersal capacity of flora and fauna that live on opposite sides of the newly-formed reservoir (Fahey & Langhammer in press). There are plans for the construction of several new dams in the ecoregion whose negative effects would likely be similar to those that have been already built (FVSA 1996, Bertonatti & Corcuera 2000, Fahey & Langhammer in press).

Roads constitute an important cause of native forest fragmentation and degradation, not only for their direct effect (edge effect, fragmentation and isolation of populations, and road kills) but also because they facilitate the process of colonization and invasion of lands to obtain squatters' rights (Chebez & Hilgert in press). There are almost no areas in the ecoregion without road access. Soil erosion along poorly-designed and poorly-maintained dirt roads is also a cause of concern.

There are plans to develop major engineering work such as dredging and channelization in the Paraná-Paraguay waterway (Hidrovía), enhancing the transportation of goods from the heart of South America to the Atlantic Ocean, and vice-versa. Such plans have the potential of seriously affecting the natural resources of the region (Huszar et al. 1999). This large channel and navigation infrastructure, if implemented, will have a large indirect impact on biodiversity because it will create economic incentives for the expansion of large-scale agriculture and conversion of the last forest remnants in the ecoregion.

<u>Unsustainable exploitation of the native forest</u>

The unsustainable exploitation of the native forest through "conventional" or "traditional" logging has also degraded the forest remnants. Native forest exploitation has traditionally been conducted in a predatory and unsustainable manner (see Rice et al. 2001). It is well documented that conventional logging has severe impacts on biodiversity (Putz et al. 2000). In the Upper Paraná conventional logging of native forest has, as its most direct effect, the impoverishment of the forest and changes in forest structure and soil composition. It may also increase the dominance of some tree species and may reduce the natural regeneration of the forest (Mac Donagh et al. 2001).

Originally, only a few species of native trees (e.g., four in Misiones) were harvested for timber, but as these species became scarce, the number of species exploited has increased. Between 20 and 40 species are now harvested regularly (Laclau 1994). Native forests that have been exploited usually suffer a process of invasion by native bamboo species that fill the gaps and apparently preclude the natural regeneration of the forest. It is known that different bird communities are associated with forests in different successional stages; second growth forests contain more edge species and have lost primary forest species in relation to primary forests (Protomastro 2001). However, little is known about changes in species compositions in relation to different types and degrees of primary forest exploitation (see Mac Donagh et al. 2001). One of the main impediments to reversing this trend of unsustainable exploitation and consequent degradation of the forests is that there is insufficient scientific information on forest composition and structure, forest dynamics, and on the best ways to responsibly manage the forests.

There are laws that protect the native forest cover in all three countries and require management plans for native forest exploitation. However, these plans or laws are insufficient or are not effectively enforced. The situation of native forest exploitation is different in the three countries.

In Argentina the native forest is exploited only outside strictly protected areas. The Misiones provincial authority (Dirección de Bosques) requires a management plan to exploit the native forest, but these plans generally do not ensure the sustainable use of the forests because they are usually clearly non-sustainable and/or they are not well implemented as a result of lack law enforcement. Also, anecdotal evidence suggests that there is likely an important fraction of the timber that is illegally extracted and marketed.

In Paraguay, the native forest is effectively protected in some reserves or in areas of difficult accessibility (e.g., Cordillera San Rafael). However, most fragments of native forest are suffering a process of unsustainable, and in most cases illegal, exploitation, including forests within implemented national parks. Most of the illegally harvested wood is transported to the Brazilian markets, facilitated by the lack of controls, widespread corruption among public officials responsible for law enforcement, and the existence of several roads on the terrestrial border with Brazil.

In Brazil, the situation is very different due to the almost complete absence of remaining large primary forest remnants with valuable wood outside strictly protected areas. Most forest fragments outside these protected areas are small patches of secondary forests. Although prohibited by Brazil's Forest Code, most privately-owned riparian forests have been clearcut. A

1990 Brazilian Presidential decree also prohibits any cutting of primary and secondary Atlantic Forest.

São Paulo, in Brazil, is the main market for the wood irresponsibly exploited in Paraguay and Argentina. Buenos Aires also receives an important portion of the timber extracted in Misiones. Local markets play only a minor role in the consumption of wood from this ecoregion.

Besides the extraction of timber for construction or furniture, the remaining patches of forest are under heavy pressure for the extraction of fuel wood. For example, in the state of Santa Catarina, Brazil, there are no oil or gas pipelines to supply energy. Fuel wood or charcoal (produced locally) is used by the majority of the rural people for heating, cooking, and drying food. The production of tobacco, one of the main products in Santa Catarina, requires large amounts of fuel wood that is obtained locally in the secondary forest remnants (Hodge et al. 1997). In Misiones, yerba mate is also dried with fuel wood obtained from secondary forests, which is becoming a scarce resource for yerba mate producers (S. Holz pers. com.).

Unsustainable hunting

Hunting of most native species is prohibited by law in all three countries, with the exception of a few species for which hunting is allowed and regulated. Indigenous people in all three countries have the legal right to hunt in a traditional manner. However, illegal hunting is widespread across the Upper Paraná ecoregion. Native forests are impoverished as a consequence of a drastic reduction of populations and local extinction of hunted species (Cullen et al. 2000, 2001), suffering the "empty forest syndrome" (Bennett et al. 2002). It is difficult to control illegal hunting in the three countries, as most government agencies lack the technical and financial resources to enforce the law (for Misiones see Cinto & Bertolini in press), and hunting has deep cultural (and in some cases economic) roots (Giraudo & Abramson 1998).

Different sectors of the population conduct different types of hunting. In the three countries, there is a strong cultural tradition of hunting that is practiced during spare time, usually on weekends. Sport hunting is practiced by people living in cities who have financial means. Rural people who live near the forests hunt not only for sport or cultural reasons, but because they may need to obtain meat. The same is true for the lowly paid employees of logging companies who complement their diet with bush-meat they hunt during the weekend in logging areas where they are employed. Rural residents also hunt animals they consider pests, usually because of damage they may cause to domestic animals. For example, jaguars, pumas, and other carnivores are hunted because they may attack livestock (Schiaffino 2000, Pereira Leite Pitman 2002). Snakes are exterminated because a few species represent a danger for humans and domestic animals.

There is also some well-organized illegal hunting to supply bush-meat to local markets, such as in Brazil where there are restaurants that offer bush-meat as special dishes. Bush-meat is also used for preparing processed and dried meat.

Some indigenous communities still practice subsistence hunting (e.g., the Aché in Paraguay and some Mbya communities in Paraguay and Misiones). However, even traditional hunting practices are currently unsustainable in light of the relatively high human population densities in most areas of the Upper Paraná Atlantic Forest, the small size of the forest fragments[11], and the low density of game animals found throughout most of the ecoregion[12].

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[11] Small forest fragments are generally too small to maintain huntable populations (see Novaro et al. 1999).

The root causes of environmental degradation
Most of the causes of forest fragmentation and degradation described above are what can be called proximate causes. However the root causes of forest lost and degradation in the ecoregion include:

- High population growth rates (due to both high birth and immigration rates), high rates of illiteracy, and high rates of infant mortality—social indicators that constitute critical components of the socio-economic and environmental crisis of the Upper Paraná Ecoregion (Laclau 1994, SEPA 2000).
- The low value that most people place on the native forest, which has been historically seen as an impediment to development (Laclau 1994, Hodge et al 1997).
- Lack of law enforcement capacity due to fragile government institutions, lack of training of state officials, inefficient use of resources (Cinto & Bertolini in press), or simply due to widespread corruption.
- The lack of public awareness about the ecological problems in the ecoregion (Laclau 1994) due to lack of environmental education. This situation is exacerbated by the high rates of illiteracy in the three countries.
- The lack of economic alternatives and knowledge of sustainable use practices (Holz & Placci in press, Colcombet & Noseda 2000).
- The deep economic crisis of the region along with some political instability.

Most of these root causes can be traced to an inequitable economic system that has concentrated land and resources in the hands of a few and has marginalized a large proportion of the population, depriving them of their most basic needs. While it is not the objective of this Biodiversity Vision to solve the social and economic problems of the ecoregion, we must take them into account when planning a conservation strategy for the Upper Paraná Atlantic Forest ecoregion.

Opportunities for biodiversity conservation in the Upper Paraná Ecoregion

Despite the high degree of fragmentation of the forest in the Upper Paraná ecoregion, there are good opportunities for the conservation of biodiversity. These include a relatively well-implemented system of protected areas (particularly in Argentina and Brazil), an increasing interest in conservation issues by governments and local people, with many new local environmental groups, and a Tri-national Initiative for the Conservation of the Atlantic Forest Corridor.

Protected area system**.** There are 54 strictly protected areas (IUCN categories I-III) in the ecoregion, protecting 565,125 ha of native forest. There are 2,186,375 ha in 20 Sustainable Use Areas (IUCN categories IV-VI) including a large Biosphere Reserve (Figure 9a, 9b; Table 1). These protected areas belong to national (federal), state (provincial), municipal and private protected area systems in the three countries. Many of these areas are small (< 1,000 ha), and many are not well implemented, with land tenure problems, and still lacking management plans.

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[12] Most tropical and subtropical forests support less wildlife, especially ungulates and other large game animals, than tropical grasslands and savannas, because in the former, most productivity is located in the canopy (see Bennett & Robinson 2001, Bennett et al. 2002)

However, the number of protected areas has risen rapidly in recent years (Figure 10) and there is a lot of interest among governments and NGOs in the creation of new protected areas in all three countries. A large block of eleven protected areas, including the Iguaçu National Park in Brazil, the Iguazú National Park in Argentina, the Urugua-í Provincial Park, and eight other smaller private and provincial reserves account for a continuous protected area of 340,800 ha, that serves as a large and resilient reservoir for the biodiversity of the ecoregion.

Conservation laws**.** Despite problems with law enforcement in all three countries, there are indeed laws to protect the forests, particularly the riverine forests and areas with steep slopes. The Brazilian Forest Code also protects the mountaintops and makes mandatory the maintainance as a forest reserve at least 20% of the area of a property. If well protected, these areas could serve as critical corridors connecting forest remnants. Brazilian legislation prohibits the conversion of the last forest remnants of Atlantic Forest. A Brazilian 1990 Presidential decree prohibits cutting of primary or secondary Atlantic Forest. An NGO-led movement is mobilizing national support to transform this decree into permanent law, but they face strong opposition from large-scale agriculture sectors in the Upper Paraná ecoregion. The Green Corridor Law of the Misiones province in Argentina, has created a multiple use conservation area of over one million hectares, with the principle objective of maintaining the connections among the main protected areas of Misiones. This law has eliminated perverse incentives for forest conversion and has created incentives for the protection and restoration of the native forest. All three countries have legislation to protect watersheds. Brazil's new water law allows for the establishment of river basin commissions and a water users' tax to support conservation of watersheds. These laws create good opportunities for the conservation of the last forest remnants.

Tri-national Initiative. In 1995, a Tri-national Forum of government and non-government organizations of various sectors of the three countries gathered in Hernandarias, Paraguay, in a workshop called "La Conservación de la Selva Paranáense o Bosque Atlántico Interior". The institutions that participated in this workshop agreed on the necessity to create a Tri-national Corridor to connect the main protected areas in the ecoregion, extending from Mbaracayú Natural Reserve in Paraguay to Turvo State Park in Brazil, through the Green Corridor of Misiones. In successive meetings of the Tri-national Initiative (Curitiba, Brazil in 1997; Eldorado, Misiones in 1999) other important agreements and commitments were made among the participants. This forum is an important opportunity not only for the exchange of experiences and ideas among participants but to advocate for the creation of new protected areas and the implementation of existing ones, as well as to reach consensus on other priority actions.

Figure 2. Location of the Atlantic Forests Global 200 Ecoregion in South America

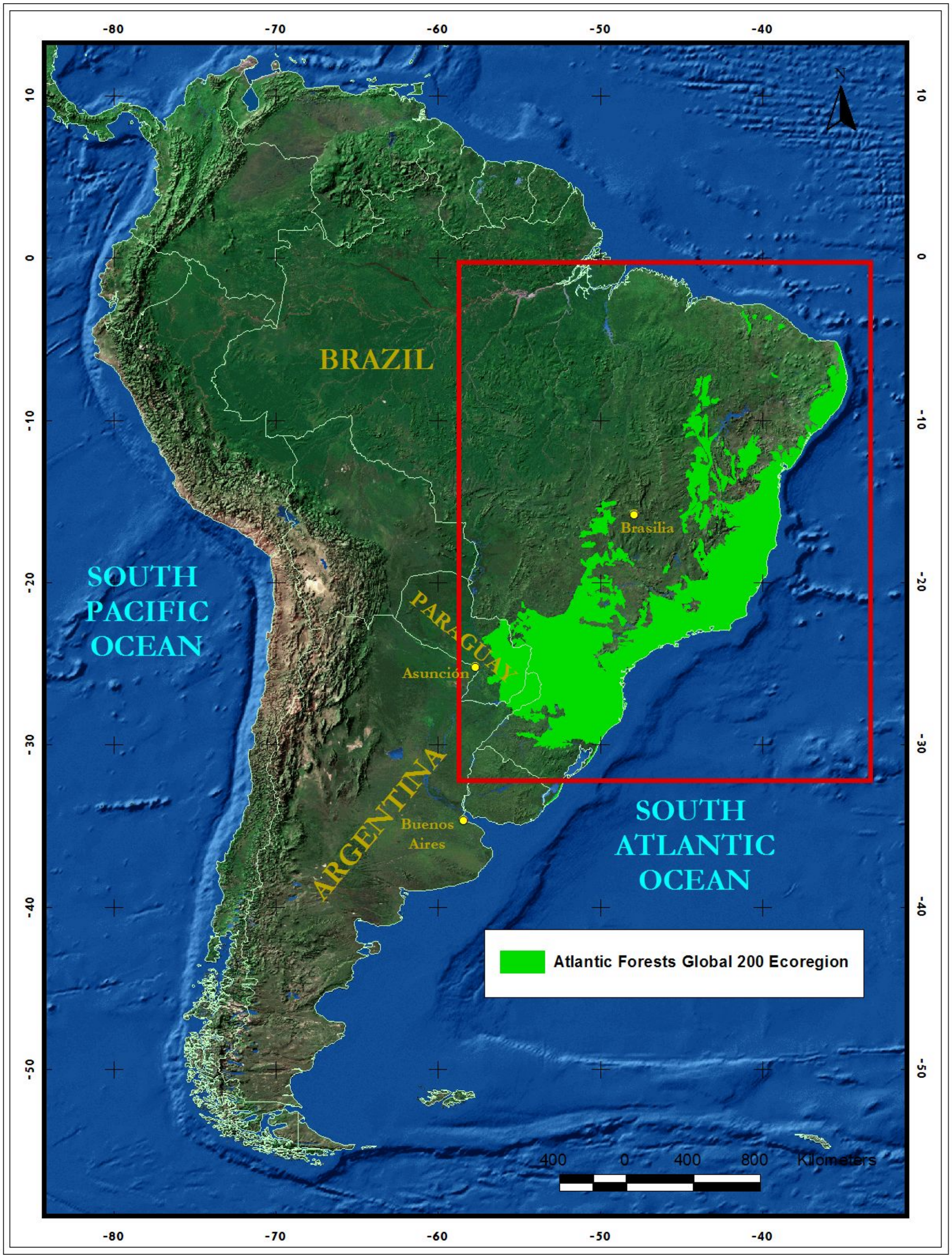


Figure 3. The 15 Ecoregions of the Atlantic Forests Global 200 Ecoregion Complex

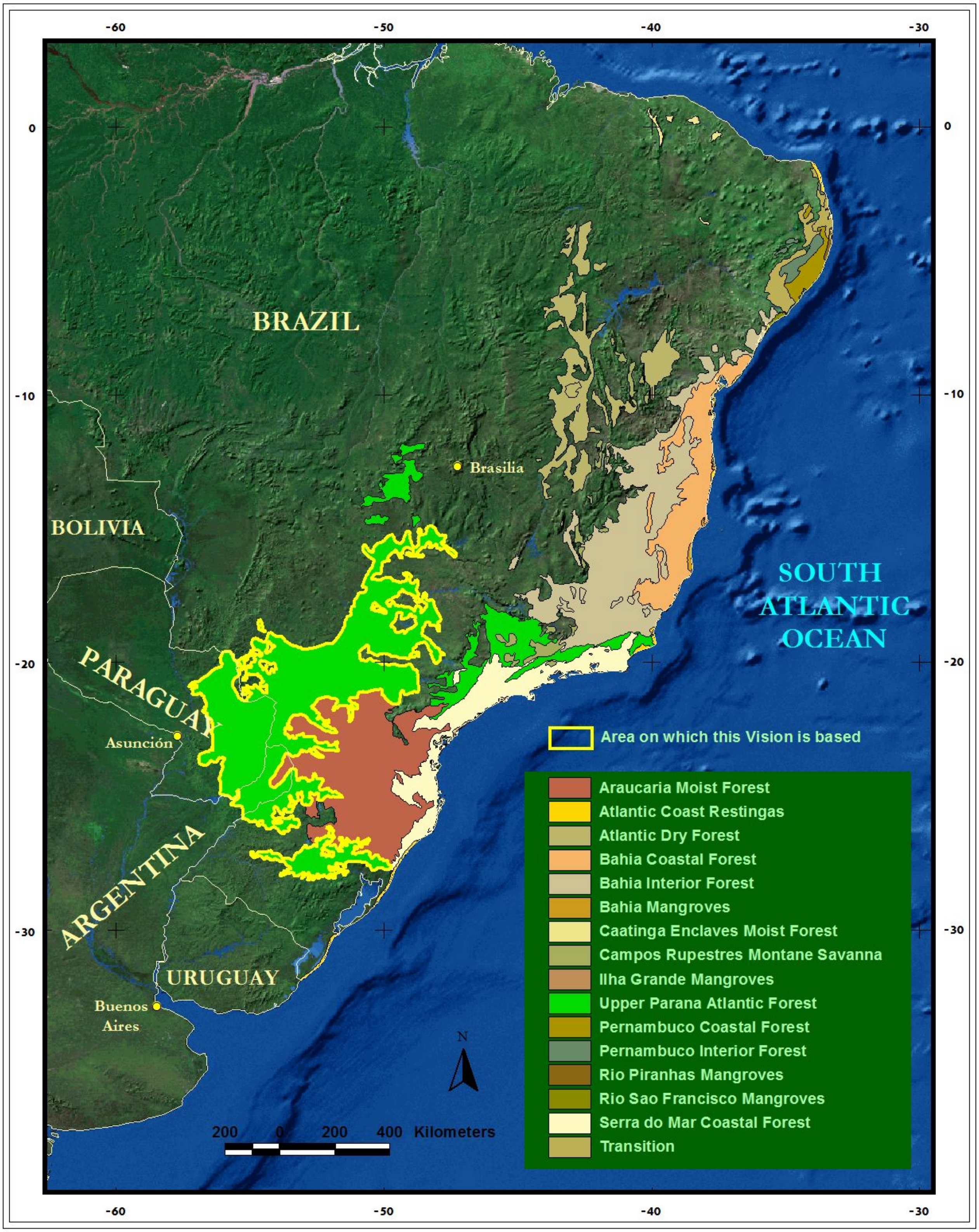


Figure 4. Forest Remnants of the Atlantic Forests Global 200 Ecoregion

Figure 5. The Upper Paraná Atlantic Forest Ecoregion

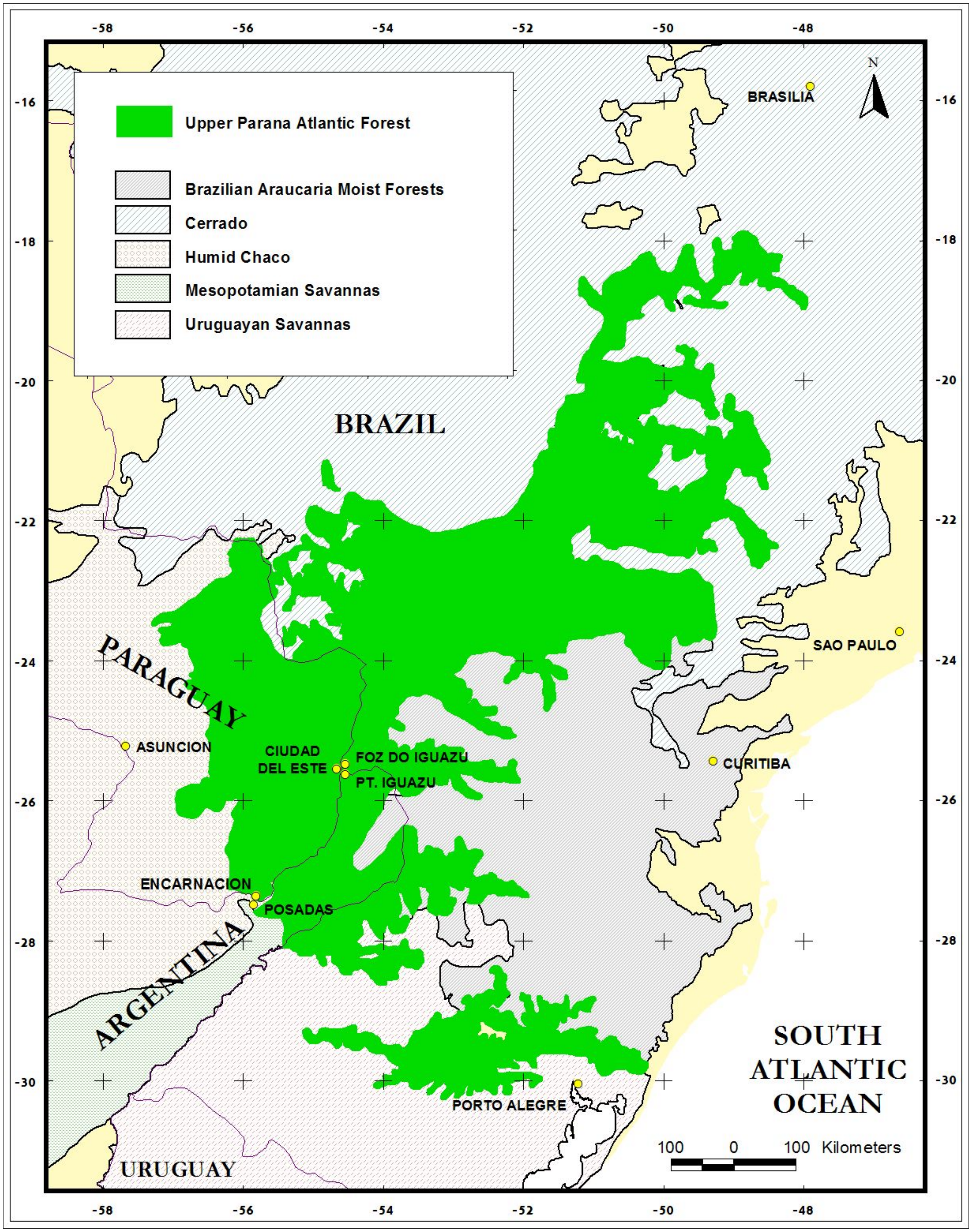


Figure 6. The Upper Paraná Atlantic Forest Ecoregion Overlaps Extensively with the Upper Paraná Rivers and Streams Global 200 Ecoregion

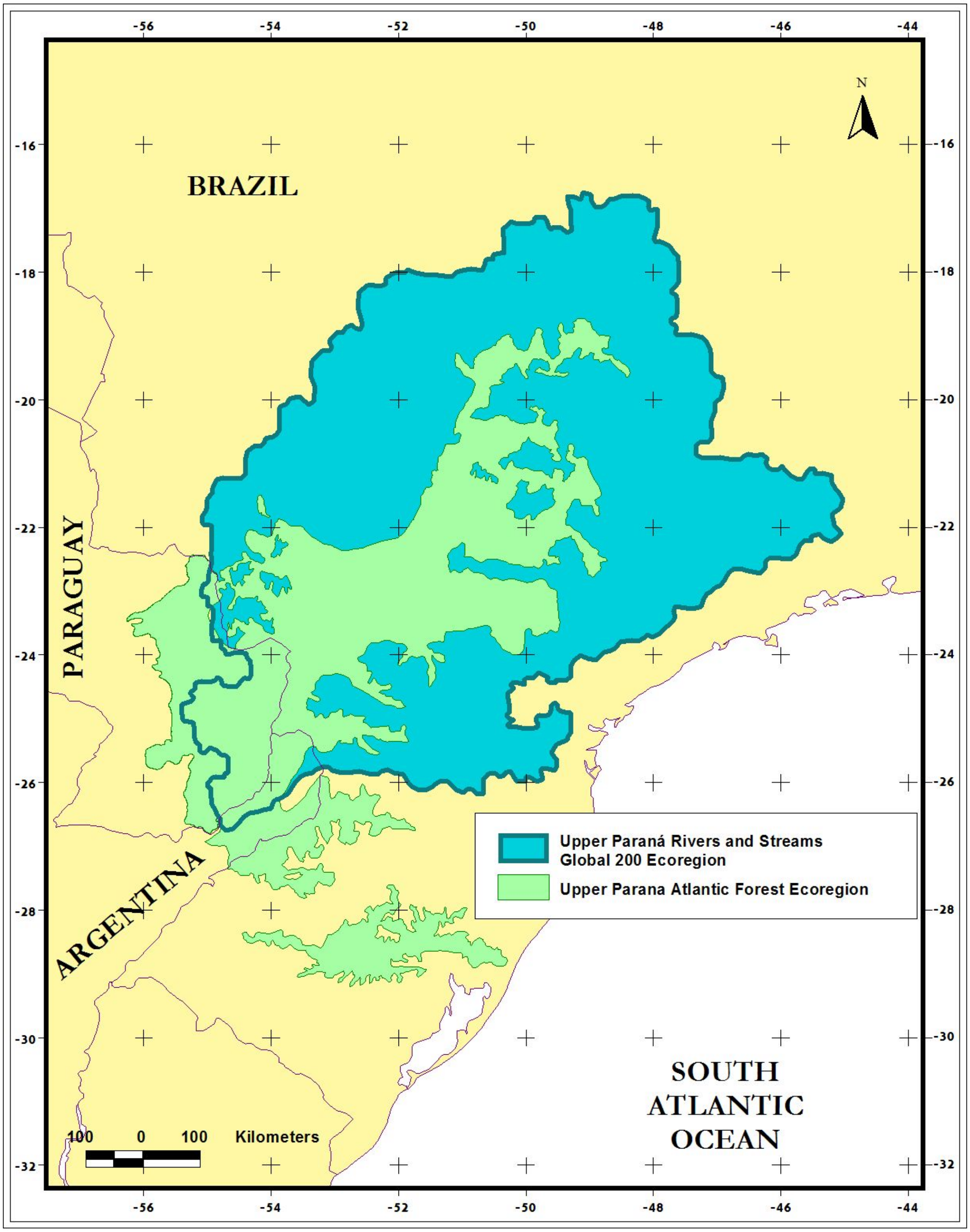
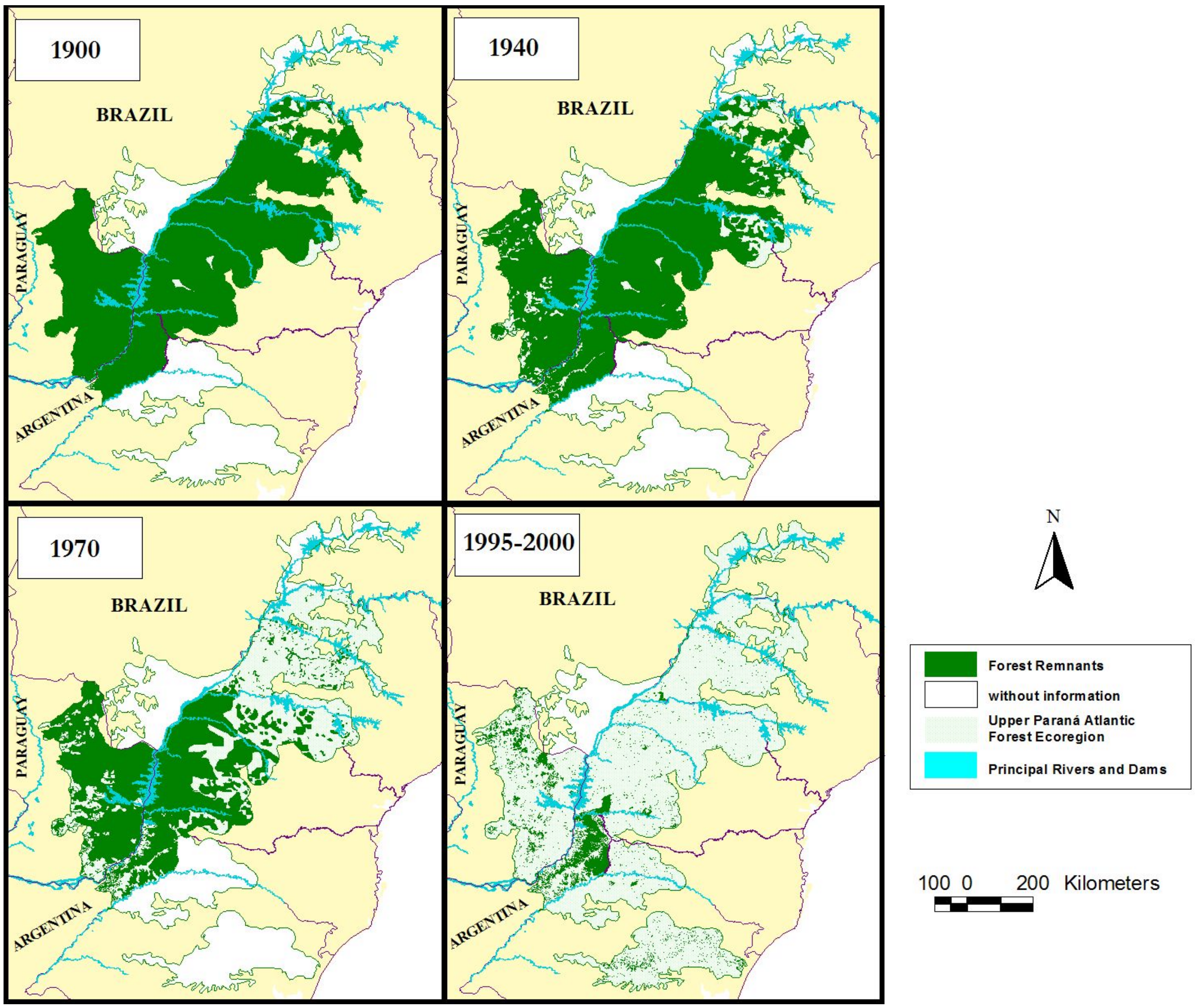
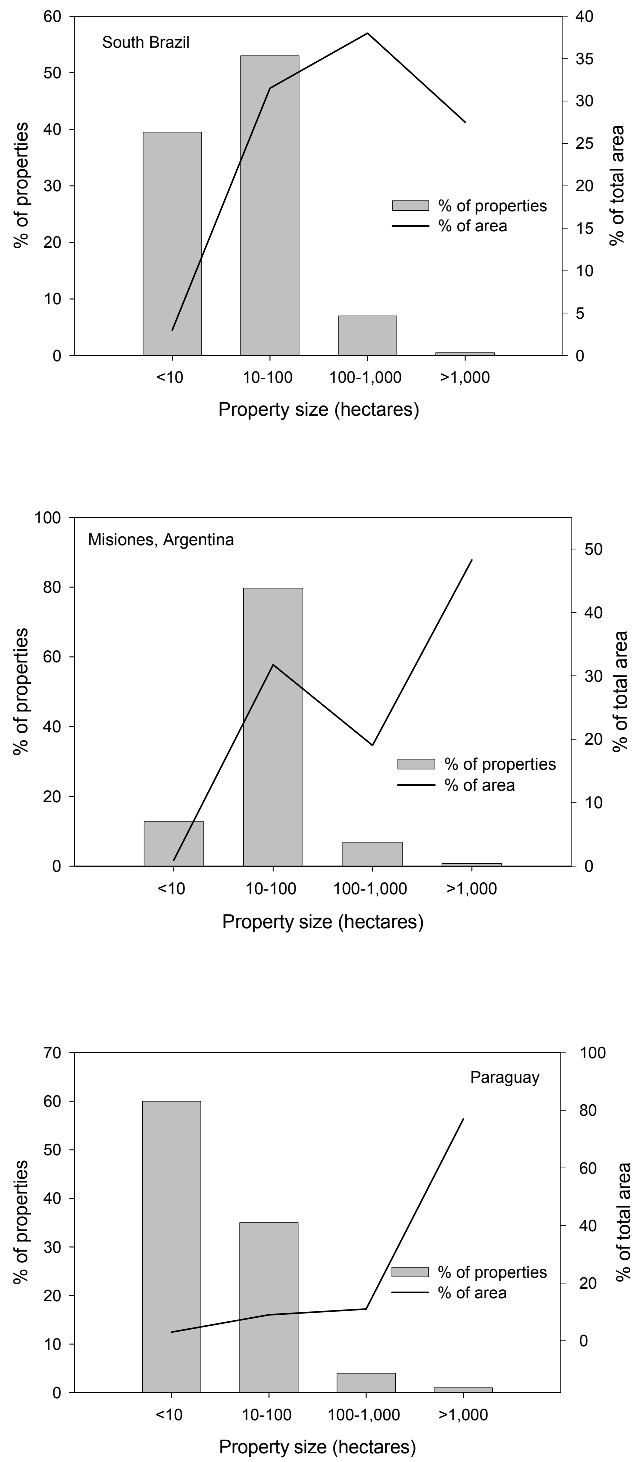


Figure 7. The Process of Destruction of the Upper Paraná Atlantic Forest



Modified from Holz & Placci in press.

Figure 8. Land Tenure Patterns in Different Parts of the Ecoregion



Modified from Laclau (1994) for Brazil and Argentina, and SEPA (2000) for Paraguay.

Figure 9a. Protected Areas of the Upper Paraná Atlantic Forest

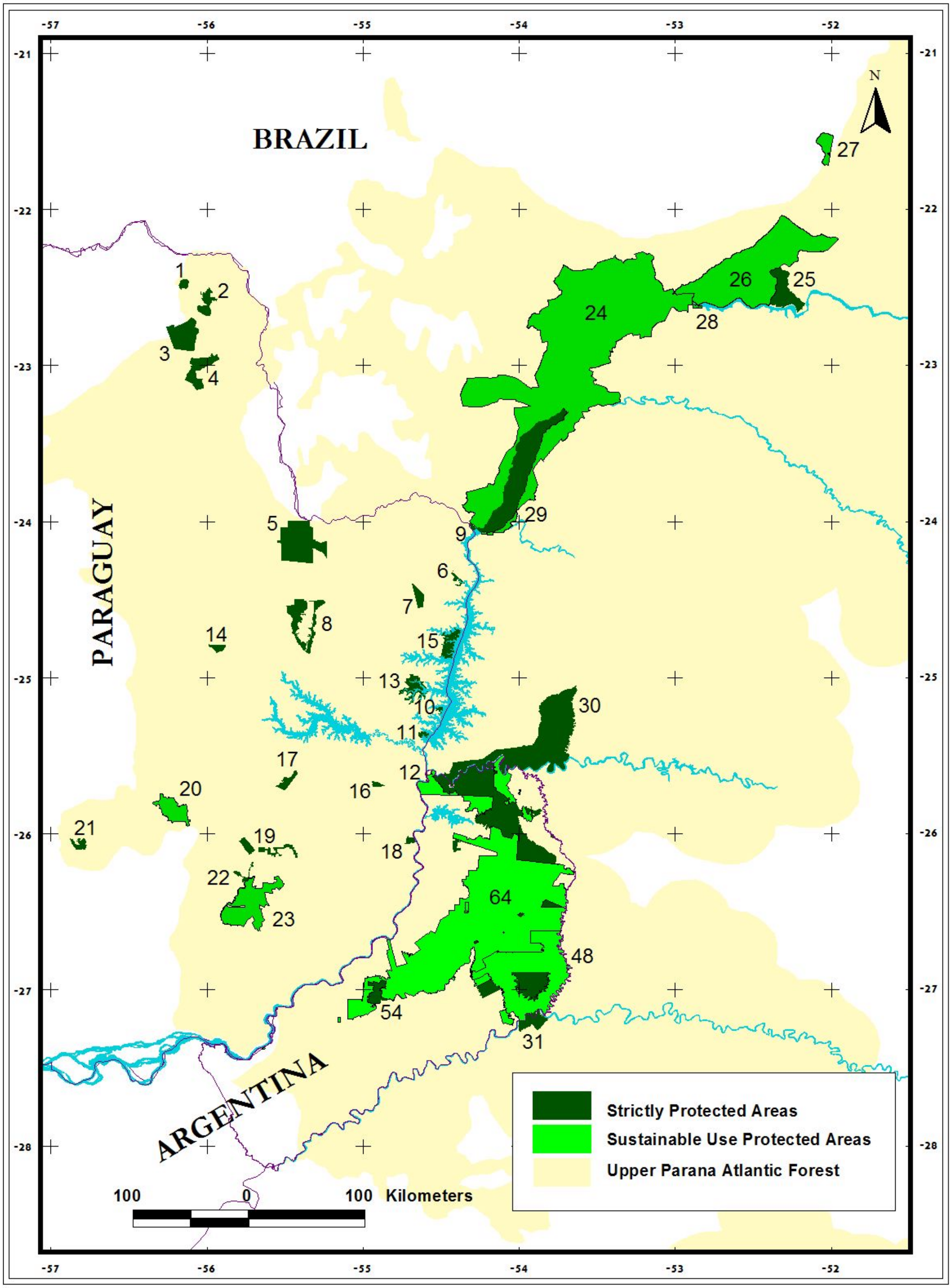


Figure 9b. Protected Areas of the Upper Paraná Atlantic Forest
(Enlarged Tri-national Area)

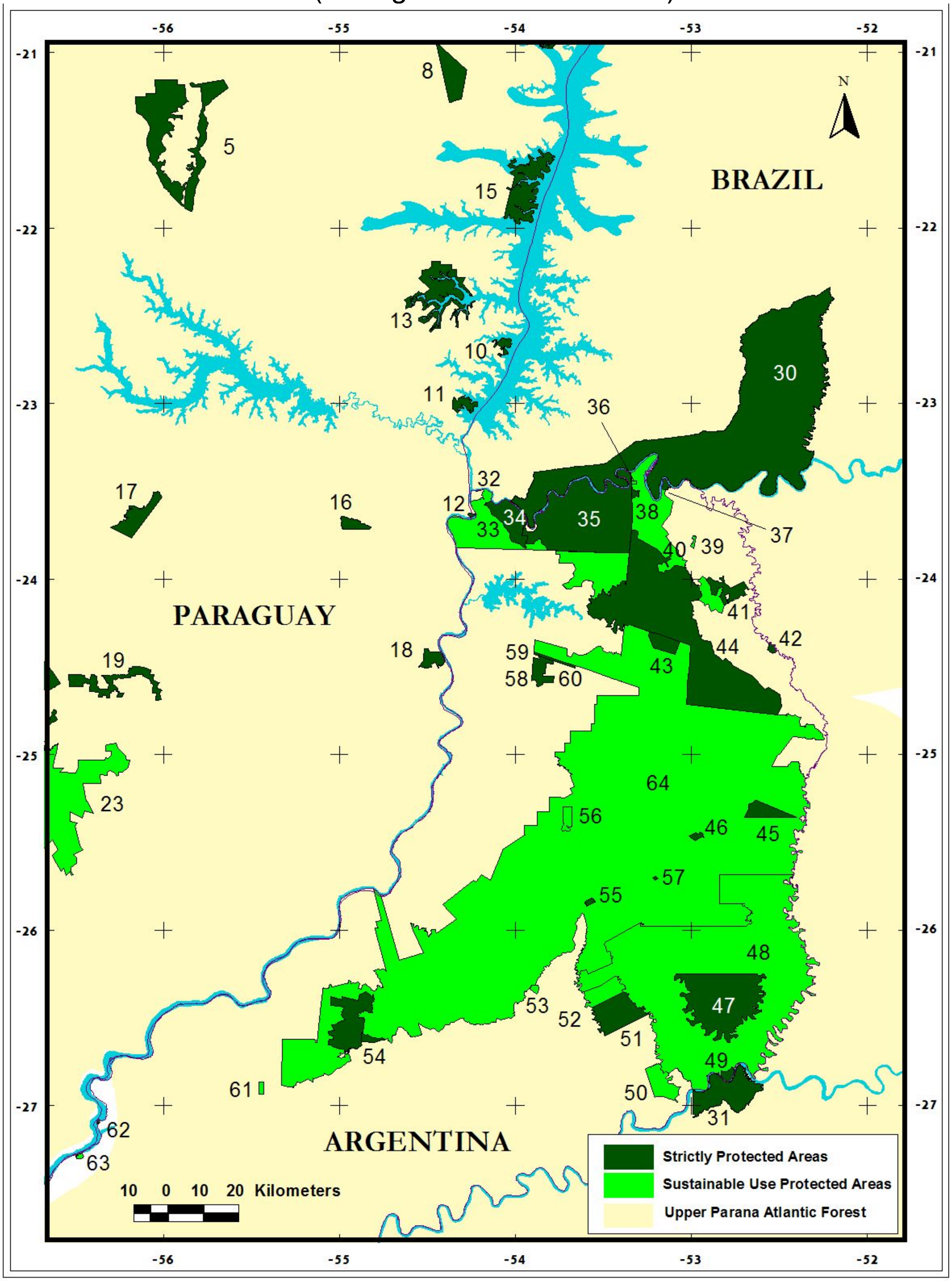


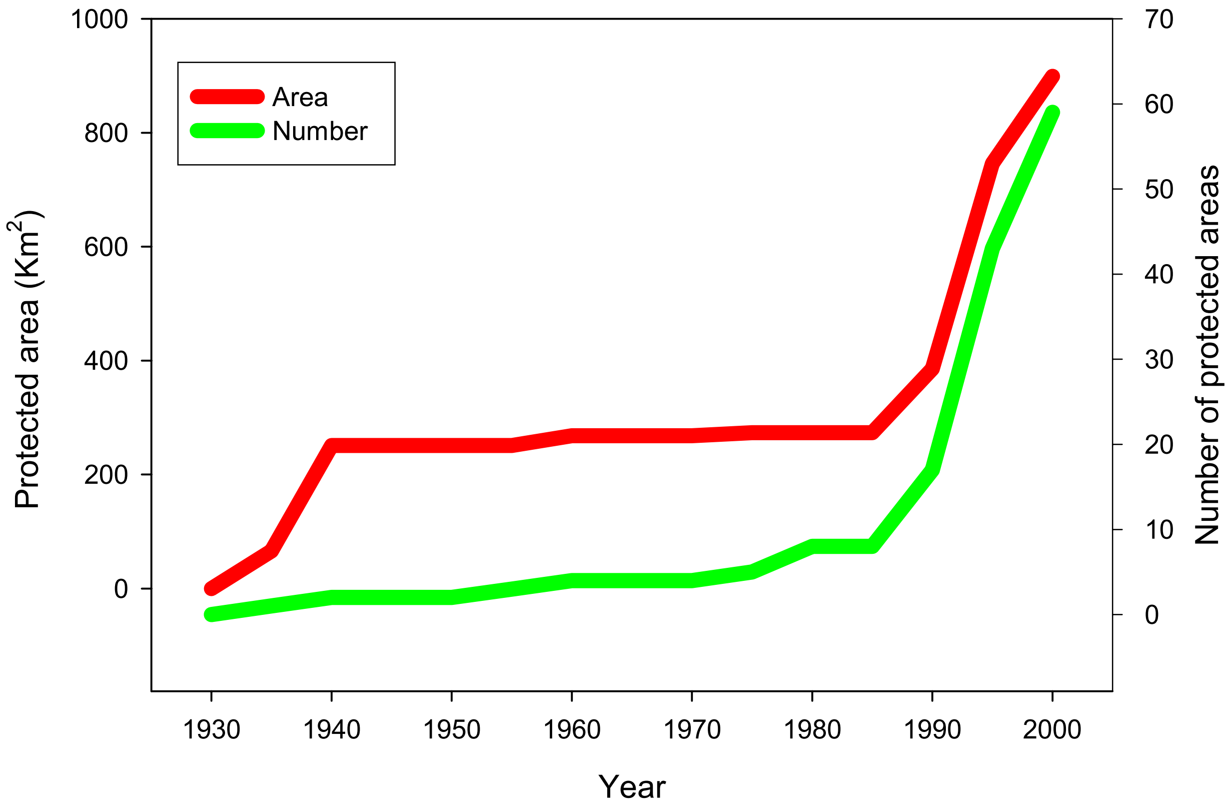
Table 1. Protected Areas of the Upper Paraná Atlantic Forest Ecoregion

Number in Fig 10a & 10b	Name	Country	Strict Protection (IUCN I, II, and III) or Sustainable Use	Hectares
1	Reserva Natural Priv. Arroyo Blanco	Py	SP	5,714
2	Parque Nacional Cerro Corá	Py	SP	6,005
3	Parque Nacional Cerro Sarambi	Py	SP	30,000
4	Reserva Indígena Cerro Guazu	Py	SP	*
5	Reserva Natural Bosque Mbaracayu	Py	SP	59,056
6	Refugio Biológico Carapá	Py	SP	2,915
7	Reserva Natural Privada Itabo	Py	SP	3,000
8	Reserva Natural Privada Morombi	Py	SP	25,000
9	Reserva Biológica Mbaracayú	Py	SP	1,396
10	Reserva Biológica Pikyry	Py	SP	2,959
11	Refugio Biológico Tati Yupi	Py	SP	1,128
12	Monumento Científico Moisés Bertoni	Py	SP	153
13	Reserva Biológica Itabo	Py	SP	9,885
14	Reserva Ecológica Capiibary	Py	SP	3,759
15	Reserva Biológica Limoy	Py	SP	11,866
16	Reserva Nacional Kuriy	Py	SP	2,004
17	Reserva Natural PrivadaYpeti	Py	SP	10,000
18	Parque Nacional Ñacunday	Py	SP	1,688
19	Parque Nacional Caaguazu	Py	SP	12,738
20	Reserva de Recurso Manejado Ybytyruzu	Py	SU	16,220
21	Parque Nacional Ybycui	Py	SP	3,804
22	Reserva Natural Privada Tapyta	Py	SP	4,085
23	Reserva de Recurso Manejado San Rafael	Py	SU	58,490
	Total area protected in Paraguay			**271,865**
	In Sustainable Use Areas			**74,710**
	In Strictly Protected Areas			**197,155**
24	Parque Estadual das Varzeas do Rio Ivinhema	Br	SU	73,300
25	Parque Estadual Morro do Diabo	Br	SP	36,000
26	Parque Estadual Pontal do Paranápanema	Br	SU	270,679
27	Parque Estadual Lagoa de São Paulo	Br	SU	34,764
28	Estación Experimental de Caiuá	Br	SU	1,563
29	Parque Nacional Ilha Grande	Br	SP	78,875
30	Parque Nacional do Iguazu	Br	SP	185,262
31	Parque Estadual do Turvo	Br	SP	17,491
	Total area protected in Brazil			**697,934**
	In Sustainable Use Areas			**380,306**
	In Strictly Protected Areas			**317,628**

32	Parque Natural Municipal L. H. Rolón	Ar	SP	13
33	Paisaje Protegido Andrés Giai	Ar	SP	12
34	Reserva Nacional Iguazú	Ar	SP	12,620
35	Parque Nacional Iguazú	Ar	SP	54,380
36	Refugio Privado deVida Silvestre El Yaguarete	Ar	SU	133
37	Refugio Privado de Vida Silvestre Yacutinga	Ar	SP	550
38	Parque Provincial Yacuy	Ar	SP	347
39	Reserva de Uso Multiple F. Basaldúa	Ar	SU	249
40	Refugio Privado de Vida Silvestre Caá Porá	Ar	SP	41
41	Parque Provincial Guardaparque H. Foerster	Ar	SP	4,309
42	Reserva Natural Estricta San Antonio	Ar	SP	400
43	Reserva Priv. Vida Silvestre Urugua-í	Ar	SP	3,243
44	Parque Provincial Urugua-í	Ar	SP	84,000
45	Parque Provincial Piñalito	Ar	SP	3,796
46	Parque Provincial Cruce Caballero	Ar	SP	522
47	Parque Provincial Esmeralda	Ar	SP	31,569
48	Reserva de Biosfera Yabotí	Ar	SU	236,313
49	Parque Provincial Moconá	Ar	SP	999
50	Reserva Privada San Miguel de la Frontera	Ar	SU	5,500
51	Reserva Natural Cultural Papel Misionero	Ar	SP	10,397
52	Area Experimental Guaraní	Ar	SU	5,343
53	Reserva de Uso Múltiple EEA Cuartel Victoria	Ar	SU	400
54	Parque Provincial Valle del Arroyo Cuña Pirú y Salto Encantado	Ar	SP	13,228
55	Reserva Privada Yaguaroundí	Ar	SP	400
56	Reserva Privada Tomo	Ar	SU	1,441
57	Parque Provincial de la Araucaria	Ar	SP	92
58	Reserva Privada Aguaraí-mi	Ar	SP	3,050
59	Parque Natural Municipal Lote C	Ar	SP	84
60	Parque Provincial Esperanza	Ar	SP	686
61	Reserva Privada Los Paraisos	Ar	SU	440
62	Parque Provincial Del Teyú Cuaré	Ar	SP	78
63	Reserva Privada Puerto San Juan	Ar	SU	250
64	Corredor Verde Misionero	Ar	SU	708,906
	Total area protected in Argentina			**1,183,791**
	In Sustainable Use Areas			**958,975**
	In Strictly Protected Areas			**224,816**
	Total area protected in the Upper Paraná Atlantic Forest Ecoregion			**2,153,590**
	Total area protected in Sustainable Use Areas			**1,413,991**
	Total area protected in Strictly Protected Areas			**739,599**

* It is unclear what is the area of this protected area since different sources mention different figures.

Figure 10. Protected Areas in the Ecoregion Have Increased



Data source: Chalukian 1999

CHAPTER 3

Goals for Achieving Biodiversity Conservation Results

Our conservation plan must work toward achieving the broad goals of biodiversity conservation that are widely adopted as the foundation of the science of conservation biology (Noss, 1992). This Biodiversity Vision defines four conservation goals that should be accomplished over the next fifty years. These goals include:

1) **Resilience** - conserve blocks of natural habitat that are large enough to be responsive to short- and long-term environmental changes. We discuss below why large forest blocks are more resilient than smaller ones.
2) **Viable Populations** - maintain viable populations of all native species in natural patterns of abundance and distribution, and the evolutionary potential of lineages.
3) **Healthy Processes** - maintain ecological processes and selective factors characteristic of this ecoregion such as disturbance regimes, hydrological processes, nutrient cycles, and biotic interactions, including predation.
4) **Representation -** maintain within a protected area network and Biodiversity Conservation Landscape all native biological communities and successional stages across their natural range of variation.

What do we need to do to achieve these goals?

In contrast to most other forest ecoregions of the world, the high degree of habitat fragmentation and degradation of the Upper Paraná Atlantic Forest ecoregion presents a large challenge to attaining the goals of biodiversity conservation delineated above. It is usually suggested that at least 10% (ideally 15-25%) of each landscape unit[13] should be preserved in order to adequately represent existing ecological communities. It is impossible to achieve this goal in 50-100 years when only about 7.8% of the original forest cover remains in the Upper Paraná Atlantic Forest ecoregion.

What does remain of the original forest is highly fragmented, and a fragmented landscape represents a daunting challenge for biodiversity conservation resulting from a series of relatively well-understood edge- size- and isolation-related effects. There are only 28 forest fragments larger than 10,000 hectares in the entire ecoregion, and only two of them are larger than 100,000 hectares. However, these few large fragments represent over half of the remaining forest area (Figure 11). Ninety-two percent of the Upper Paraná Atlantic Forest ecoregion is degraded by cities, roads and other infrastructure, private lands, and areas of large-scale and subsistence agriculture. This landscape modified and degraded by humans reduces the opportunities for connecting the remaining forest fragments.

Despite the conservation problems described above, the few relatively large forest blocks that remain in the ecoregion still contain umbrella species (see footnote 7) such as jaguars, eagles, and white-lipped peccaries, suggesting that biodiversity and the main ecological processes remain essentially intact[14]. These large blocks of forest continue to be degraded and fragmented —

[13] See footnote 5 on page 3 and Landscape Units Analysis in Chapter 4.

[14] Although umbrella species remain in these large forest blocks, this is not an indication of their long-term survival in the forest remnant. Most of these forest blocks need to be connected to other forest remnants for the long term viability of these populations.

factors that will likely reduce overall biodiversity and resilience. To achieve the first three conservation goals described above we need to protect the few large native forest blocks that remain in the ecoregion. Despite a long debate among ecologists and conservation biologists on the issue of whether or not several small fragments can maintain more or fewer species than one large fragment (Bierregaard et al. 1992), a large fragment is generally superior to a small one in terms of its ability to conserve biodiversity at all levels. Only the largest forest blocks (>10,000 ha of continuous and relatively intact forest) are resilient to short-term environmental changes, are able to keep individuals of umbrella species and can maintain ecological processes and selective factors such as important biotic interactions like the pollination of keystone species (e.g. fig trees) and predation. It is important to recognize, however, that protecting the remaining large blocks of habitat, while absolutely critical, is by itself not sufficient to achieving conservation goals.

Although our efforts will be focused on preserving large blocks of relatively intact forest, and on connecting these to other forest fragments through corridors of native forest, we do not disregard the conservation value of small forest fragments. There are several ways by which small fragments can contribute to conservation. First, small forest fragments may play a role in the protection of watersheds and soils. Second, they may serve as stepping-stones toward creation of future biological corridors. Third, they may function as wintering ground for some local and long-distance migratory birds. Fourth, they may contain the seeds that facilitate local forest restoration programs (Cullen et al. 2001, Valladares-Padua et al. 2002). Fifth, some of the small fragments may still contain species not found elsewhere in the ecoregions. Finally, they may play important cultural and educational roles.

The major challenge to achieving enduring biodiversity conservation goals in the Upper Paraná Atlantic Forest ecoregion is thus to maintain the large blocks of relatively intact forest and connect them to other such blocks through a system of corridors. Small fragments may serve as stepping-stones and may help in the design and implementation of the corridors. Through the creation of new protected areas, the effective management of existing ones, and the creation and implementation of biological corridors, along with environmentally friendly economic activities, we believe that it is still possible to maintain the critical ecological processes that sustain biodiversity in the ecoregion. Designing a landscape that will allow us to achieve these conservation goals requires a thorough analysis of fragmentation, coupled with an analysis of threats and opportunities. Our vision for the Upper Paraná Atlantic Forest is that within the next 50 years, the Biodiversity Conservation Landscape we have designed will become a reality. The next chapter describes the process by which we designed this Biodiversity Conservation Landscape.

Box 4 discusses some of the important biological aspects of fragmentation that are particularly relevant for this ecoregion.

BOX 4

The Problems of Fragmentation: Edge effects, Size effects and Isolation

Edge effects. One of the most deleterious consequences of the extreme fragmentation of forests is that the organisms that remain in a forest fragment are exposed to the conditions of a different ecosystem that surrounds the forest. These conditions are more pronounced near the edge of the fragment, at the interface between the forest and the new ecosystem that surrounds it. The intensity of the edge effect is usually measured as the distance up to which the effect is still noticed within the forest fragment (Murcia 1995, Laurence et al. 2000). Edge effects could be classified into three broad types: abiotic effects (e.g., temperature, solar radiation), direct biotic effects (e.g., changes in species composition or introduction of exotic species), indirect biotic effects (e.g., changes in species interactions near the edge, such as increased rates of predation) (Murcia 1995). Annual rates of tree mortality, tree damage, and gap formation sharply increase up to 100 m from the forest edge and result in increased loss of living biomass and increased emissions of carbon dioxide (Bierregaard et al. 1992, Laurence et al. 1998, Laurence et al. 2000). Some edge effects can be noticed up to several hundred meters into a forest fragment, especially the biotic effects such as invasion by exotic or disturbance-adapted species and nest predation (Murcia 1995, Laurence et al. 2000, Bright & Mattoon 2001). As a consequence of these edge effects, forest communities are drastically altered near the edge. For example, old-growth forest interior tree species are replaced by pioneer or secondary-growth trees (Benitez- Malvido 1998, Tabarelli et al. 1999).

To the three edge effects described above, we add a fourth and very important edge effect in our ecoregion – that of human activity. Hunting, illegal logging, illegal harvesting of non-timber forest products are more pronounced near the forest edge, but human activities penetrate up to a thousand meters into the forest. Hunting tends to decrease population sizes of most large vertebrate species in the Neotropics and to produce changes in the structure of mammal communities (Bodmer et al. 1997, Peres 2001, Bennett & Robinson 2001). Hunting in small forest patches can completely extirpate some species over the short term. For example, heavily hunted forest fragments of about 2,000 ha in the Upper Paraná Atlantic Forest in the western portion of the state of São Paulo, Brazil, were emptied of tapirs, white-lipped peccaries, and brocket deer (Cullen et al. 2000, 2001).

In forest fragments with highly irregular shapes, perimeter-to-area ratios are large and thus edge effects include a larger proportion of the fragment (Davies et al. 2001). For similar reasons, smaller fragments have a larger proportion of the area affected by edge effects than larger ones (Furlan et al. 2000). Very small forest fragments are entirely affected by edge effects and as a consequence are unlikely to preserve intact communities of the Atlantic Forest (Tabarelli et al. 1999).

Size effects. Ecologists have long recognized that there is a direct relationship between fragment size and number of species (Rosenzweig 1995). Just by chance alone (i.e., "sampling error"), a small fragment may fail to include individuals of rare or sparse species. In like fashion, sampling theory predicts that small forest fragments will include a smaller number of ecological communities. Because ecological communities are composed of unique sets of species, forest fragments that are missing communities will have decreased species diversity. The risk of a species´ local extinction within small fragments is also greater because of several factors that contribute to the extinction risk of small populations. First, random environmental variation such as fires or severe droughts can wipe out a small population. Second, deterministic threats (e.g., continuous deforestation or habitat degradation) can also decimate a population. Third, random demographic effects (e.g., a pronounced bias in the sex of new offspring) can drive small populations to extinction. Fourth, inbreeding and the loss of genetic variation are more common in small populations and render these populations less responsive to environmental change and more prone to extinction (Davies et al. 2001). In tropical rainforest fragments of about 100 ha, substantial numbers of under-story bird species are lost within two decades following fragment isolation. For many tropical bird species, forest fragments of less than 100 ha will have little conservation value (Ferraz et al. in press).

Some species have large habitat requirements and small fragments cannot fill those requirements. Chiarello (2000) estimated that only forest fragments in excess of 20,000 ha can sustain viable populations of medium-size to large mammals in the Atlantic Forest. A literature search of the habitat requirements of a small set of birds and mammals from the Upper Paraná Atlantic Forest shows that, even for species with relatively small habitat requirements (e.g., squirrels, armadillos, agoutis, and monkeys), a forest fragment of less than 1,000 ha is not large enough to maintain a viable population. For species with large habitat requirements (harpy eagles, jaguars, tapirs), it is necessary to maintain forest fragments of at least a few hundred thousand hectares (Table 2).

The disappearance of vertebrate species from forest fragments has a cascade effect on the ecosystem with consequences affecting other animal guilds, and even ecological processes like dung decomposition (Klein 1989), pollination and seed dispersal. In forest fragments, the absence of predators can result in an increase in herbivores, which can in turn have a dramatic effect on the forest structure and overall species diversity (Terborgh et al. 1999, 2001). The lack of top predators may allow for an increase in mid-sized predators, which may result in higher predation rates on birds and small mammals (Davies et al. 2001, Terborgh et al. 1999). This effect may explain the sudden increase in predation on the highly-endangered golden lion tamarin of the Atlantic Forest (J. Dietz pers. com.).

Our ability to preserve umbrella species, those with large habitat requirements, will thus be a good indicator of our ability to preserve intact biodiversity and healthy ecological processes. In order to maintain intact ecological communities and processes, it is essential to preserve the largest forest fragments that still contain individuals of umbrella species such as jaguars and tapirs. In the Upper Paraná Atlantic Forest, isolated forest fragments of about 2,000 ha have already lost jaguars, and those that are heavily hunted have lost many other large mammals as well (Cullen et al. 2000). However, forest fragments with several tens of thousands of hectares still have umbrella species and most of its biodiversity, including Morro do Diabo State Park in São Paulo Brazil with 35,000 ha (Cullen et al. 2000, Valladares Padua et al. 2002) and Mbaracayú National Park in NE Paraguay 59,000 ha (Zuercher et al. 2001, D. Ciarmiello pers. com.).

Based on species' home range requirements in this ecoregion (Table 2; op. cited above), we may thus use 10,000 ha of well-protected forest as the lower limit for what we will consider a large forest fragment. The figure of 10,000 ha also corresponds to the minimum area requirement for a male jaguar (P. Crawshaw 1994 and pers. com.). A block of about 10,000 ha of well-preserved forest can contain one adult male jaguar and 1-2 adult females, thus constituting the area required by a minimum breeding unit for this species. For these reasons, we have chosen the jaguar as an umbrella species for this analysis and we will use this species to monitor the effectiveness of our Biodiversity Conservation Landscape design in the future.

Isolation. Considerable evidence suggests that isolated areas are difficult to re-colonize once their species are lost. Many forest species find it difficult or impossible to traverse the cattle pasture that often separates forest islands. The lack of gene flow into small and isolated forest populations contributes to the deleterious effects of inbreeding and increased probability of extinction (Dobson et al. 1999). The maintenance of biological corridors connecting forest fragments and allowing the movement of individuals and consequent gene flow, can reduce the deleterious effects of genetic isolation (Mech & Hallett 2001).

Forest fragments are not oceanic islands that have precise boundaries with the surrounding ecosystem, but they are usually surrounded by other terrestrial ecosystems. The matrix in which forest fragments are embedded may facilitate or preclude connectivity among forest patches. The more similar the matrix is to the original forest, the more opportunities for the native species to disperse to other forest fragments. The matrix can even provide alternative habitat for generalist species if the structural differences between the matrix and the original forest are small (Gascon et al. 1999, Davies et al. 2001). For example, scientists studying tropical rainforest dung beetles living in forest fragments of Amazonia near Manaus, found the rainforest beetles in only one surrounding clearcut - one containing extensive second growth vegetation (Klein 1989). However, to allow all native species to disperse among forest fragments those forest patches should be connected through corridors of native forest.

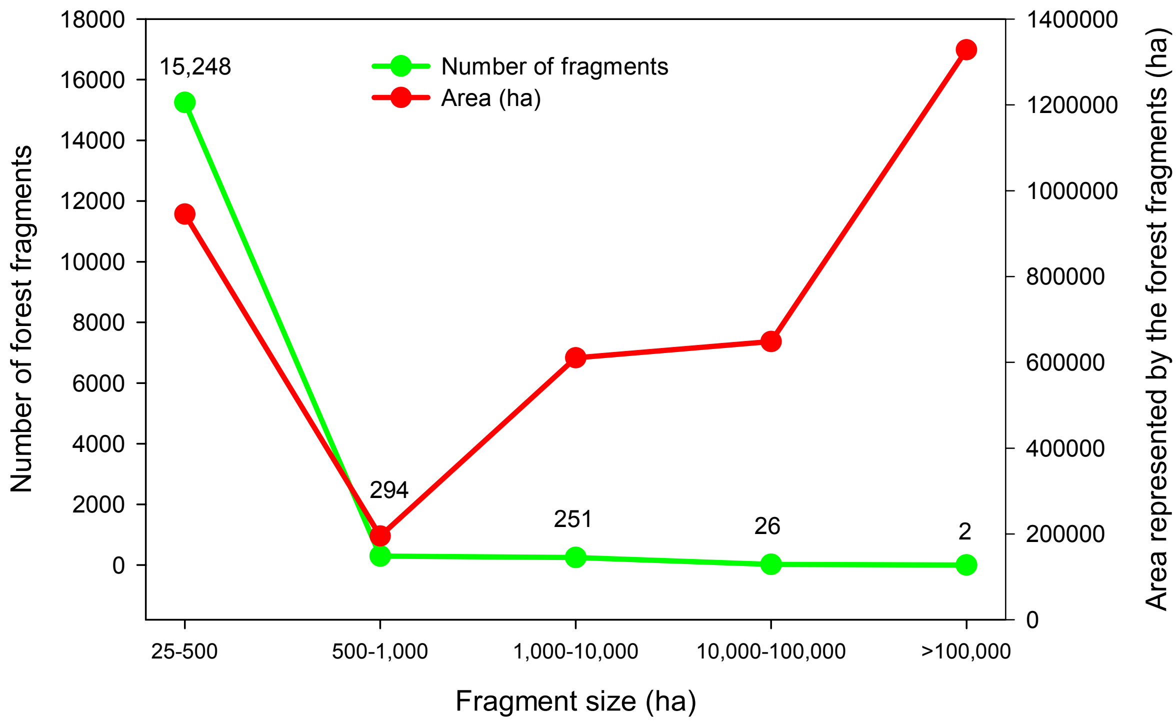
Table 2. Density Estimates and Area Requirements for Individuals and Populations of Different Sizes of Typical Vertebrate Species of the Upper Paraná Atlantic Forest.

Species	Density	Area per individual	Area per 50 individual	Area required to guarantee a viable population (N_e=50)[1]		Area required to guarantee adaptive evolution (N_e=500)[2]	
	Indiv/Ha	Ha/indiv	Ha/50 indiv	Ha/150 indiv	Ha/500 indiv	Ha/1500 indiv	Ha/5000 indiv
Harpy Eagle	0.0002	5,000	250,000	750,000	2,500,000	7,500,000	25,000,000
Jaguar	0.0003	3,500	175,000	525,000	1,750,000	5,250,000	17,500,000
Tapir	0.0039	254	12,712	38,136	127,119	381,356	1,271,186
Brocket deer	0.0157	64	3,191	9,574	31,915	95,745	319,149
Black lion tamarin	0.0186	54	2,694	8,082	26,940	80,819	269,397
South American coati	0.0408	25	1,227	3,680	12,267	36,801	122,669
Collared peccary	0.0414	24	1,207	3,621	12,071	36,214	120,715
White-lipped peccary	0.0561	18	891	2,672	8,907	26,722	89,074
Azara´s agouti	0.1019	10	491	1,473	4,908	14,725	49,084
Nine-banded armadillo	0.1275	8	392	1,176	3,922	11,765	39,216
Brown capuchin	0.1366	7	366	1,098	3,661	10,982	36,607
Brown howler monkey	0.1595	6	314	941	3,135	9,406	31,352
Guianan squirrel	0.1795	5	279	836	2,786	8,357	27,858

[1] To guarantee an effective population of 50 individuals (the minimum required for a population to be viable), it is necessary to maintain between 3-10 times that number of individuals (150-500 individuals). Thus, estimates for both 150 and 500 individuals are presented.
[2] To guarantee an effective population of 500 individuals (the minimum required for adaptive evolution) it is necessary to maintain between 1500 and 5000 individuals.

Source: Crawshaw 1994, Chiarello 2000, Cullen et al. 2000, Di Bitetti 2001, C. H. Janson pers. com.

Figure 11. Number and Total Area of Fragments in Size Categories



CHAPTER 4

Designing a Biodiversity Conservation Landscape – Methods

The aim of this Biodiversity Vision analysis is to design a Biodiversity Conservation Landscape that, if implemented, would accomplish the biodiversity conservation goals described earlier: maintenance of large and resilient forest blocks, maintenance of viable populations of umbrella species, healthy ecological processes, and representation of the native ecological communities.

During the past three years, WWF has led a tri-national participatory process, involving local organizations representing multiple sectors and disciplines, to develop this Vision for the time frame and geographic scale necessary to conserve the biodiversity of the Upper Paraná Atlantic Forest ecoregion. Thirty-six partners and WWF staff gathered in Foz do Iguaçu, Brazil, in April 2000. In preparation for the workshop, various partner organizations in Paraguay and Argentina were contracted to collect and compile the best data available for fauna and flora distributions, geomorphologic, and socio-economic aspects that would be compatible with the information already collected for Brazil in the PROBIO[15] national Atlantic Forest workshop held in Atibaia, Brazil on August 1999. Many of these organizations provided information and data critical to produce this Biodiversity Vision[16], which will continue to be refined over time as additional information becomes available.

This Biodiversity Vision is a product of various scientific analyses using ArcView, a Geographic Information System (GIS). We used the Spatial Analyst module of ArcView, using a grid cell size of 500 x 500m (1/4 km^2). The basic information for the analyses is expressed in maps that represent the spatial distribution of a variety of different biological and socio-economic variables. Various layers of information were overlaid or combined to obtain new maps providing more integrated information. A buffer zone of 25 km on the ecoregion border with the Araucaria Ecoregion was used for the analyses. We initially conducted three separate but interdependent analyses, described below.

Landscape units analysis. We first discriminated landscape units within the area of analysis. A landscape unit is an area that contains a set of species, communities, or ecological processes that differs from other such landscape units. Each landscape unit usually has a characteristic climate, soil type, and set of species. Thus, to get a good representation of the full range of species and natural communities of an ecoregion, it is necessary to preserve representative portions of each landscape unit.

Since we did not have sufficient biological data to define and map landscape units, we used climatic and topographic information as proxies for developing a biological model. The assumption behind this simplification is that geographic units with different climatic conditions and topography will be correlated with distinct ecological communities. This approach to define the landscape units is similar to those used in other Biodiversity Vision analyses[17], where actual biological data were not available. To discriminate the landscape units we used three data layers.

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[15] See footnote 18 on page 47.

[16] See Acknowledgements

[17] For example, in the Biodiversity Visions for the Southwestern Amazon Ecoregion, the Northern Andes Ecoregion, and the Madagascar Spiny Thicket Ecoregion.

The first layer is the number of dry months in three categories: areas without dry season, areas with one to two dry months, and areas with three or more dry months (Figure 12). The second layer of information is altitude. We divided the ecoregion into two altitudinal ranges: above or below 500 m asl (Figure 13). For the third layer, using topographic data, we created a map that describes the degree of slope. We then defined three categories: plains, moderate slopes, and steep slopes, representing areas of increasing steepness and increasing topographic variation (Figure 14). The combinations of these three layers of information gave us a total of 18 landscape units (Figure 15). It will be important to test if these landscape units actually represent distinct ecological entities.

Fragmentation analysis. This analysis is aimed at discriminating those native forest fragments with the highest potential for achieving conservation goals. The basic information for this analysis is a map of forest fragments obtained from satellite images (Figure 16). This forest fragment map was created combining the SOS Mata Atlântica forest fragments map (Fundação SOS Mata Atlântica 1998) for the Brazilian portion of the ecoregion (based on satellite images from 1990-1995); a map produced by Fundación Moisés Bertoni, the Dirección de Ordenamiento Ambiental (DOA), and the Carrera de Ingeniería Forestal for the Paraguayan portion of the ecoregion (based on satellite images from 1997); and a map produced by Fundación Vida Silvestre Argentina (based on satellite images provided by the Ministerio de Ecología y Recursos Naturales Renovables de Misiones from 1999).

We rated the forest fragments according to their importance for conservation. The importance for conservation of a forest fragment was evaluated using five variables:

1) *Fragment size*—The larger the fragment, the higher its importance for biodiversity conservation. (Figure 17).
2) *Fragment Core*—The forest fragment area after excluding a buffer zone of 500 m, a distance to which edge effects are proven to be significant (see Chapter 3). This serves as an indirect measure of the shape and border effect of the fragment (Figure 18).
3) *Nearest Neighbor*—The distance from the fragment to another forest fragment. This is a measure of connectivity/isolation of the forest fragments.
4) *Altitudinal range within the forest fragment*—An indirect measure of variation in topographic, soil, and microclimatic conditions within a forest fragment.
5) *Location of a fragment within a river basin*—Measure of the contribution of a forest fragment to watershed conservation. For this purpose we constructed a watershed position index.

We analyzed the contribution of each of the five variables to total fragment importance variability with a Principal Components Analysis. This multivariate analysis indicated that the first four variables contributed most of the variation in forest fragments' conservation importance. As the last variable (location of a fragment within a river basin) did not contribute any new information, it was discarded.

We developed a "Fragment Importance Index" using the first four variables. Each was placed in one of four categories (using the natural breaks ArcView function) assigning a value from 0 (least important category) to 3 (highest). The Fragment Importance Index is the average of the values of the four variables used in the analysis. We then ranked each forest fragment according to its Fragment Importance Index (Figure 19).

Threats and opportunities analysis. The objective of this analysis was to map the areas that represent critical threats to biodiversity conservation and areas that represent opportunities for biodiversity conservation. This map was created using land use data, with different land uses representing threats or opportunities for conservation.

We began the threats and opportunities analysis by assigning and mapping different levels of threat and opportunity to different variables (types of land use). For example, a road is usually a threat to biodiversity conservation while a protected area is an opportunity for conservation. We weighted the different variables used in this analysis according to the level of threat or opportunity they represent for biodiversity conservation, carrying out two separate analyses, one for threats and one for opportunities.

The **threat variables** we used in this analysis included:

1) *Cities*—Cities are represented by circular areas on a map. The area of the circle is equivalent to the area actually occupied by the city. In the analysis we identified three buffer zones around each city, with the threat to conservation decreasing as the distance from the city increases, the city itself representing the highest threat. The buffer zones around the cities are directly proportional to the size of the city, with larger cities having a larger area of negative influence on biodiversity conservation. (Figure 20).
2) *Agriculture*—This variable represents the impact of agriculture, and was measured as the percentage of a municipality or departmental area devoted to agriculture, including both annual and perennial crops (Figure 21). We acknowledge that perennial and annual crops may have different impacts on biodiversity conservation, but the area occupied by perennial crops was so small in comparison to that of the annual crops, it was determined that it would not justify a separate data layer.
3) *Cattle Ranching*—This variable represents the impact of cattle ranching on biodiversity conservation. It was measured as the percentage of a municipality or departmental area devoted to this activity (Figure 22).
4) *Rural Population Density*—Due to the widespread cultural tradition of hunting and harvesting of non-timber products, and the fact that most people see the forest as an obstacle for development (see Chapter 2), the presence of rural population in the ecoregion usually has a large negative impact on the conservation of the native forest remnants. Thus, this variable represents the impact of rural population density on biodiversity conservation and is measured as people per hectare in each municipality or department (Figure 23).

(Notes: 1. Due to the extreme fragmentation, and the high density of roads, almost any single forest area in the ecoregion is easily accessed by road. We did not consider roads as another threat variable because roads already impact nearly the entire ecoregion.
2. For illustration purposes the maps are presented with their original scales (e.g., actual rural population density). However, for the analysis we divided all variables into four categories following natural breaks in their frequency distribution (a function of ArcView does this automatically). These four categories were assigned values of 1, 2, 4 and 8, with each category having double the value of the previous one.)

We weighted threat variables differently according to the degree of threat each poses to biodiversity conservation. Cities pose the highest threat, thus we assigned to this variable three times the weight we assigned to the variables posing a lesser threat. Agriculture represents the second highest threat to biodiversity because it is the economic activity with the most negative impact on biodiversity because it is mainly large-scale monoculture plantations that usually require high loads of herbicides and pesticides. It also usually has a high opportunity cost in relation to cattle-ranching, an activity usually restricted to the less productive areas. We assigned to agriculture two times the weight we assigned to the least threatening variables. Finally we assigned to the threat variables cattle ranching and density of rural population the least weight because both have less impact on biodiversity conservation than agriculture or the presence of a city. With these four threat variables, we created a map, that depicts areas with high and low threat to biodiversity conservation (Figure 24).

As **opportunity variables** we used:

1) *Proximity to a strictly protected area (IUCN categories I-III)* —Protected areas present an opportunity for conservation because there is usually an interest to increase their area by incorporating nearby areas of high potential for conservation. Also the implementation of buffer zones around protected areas, usually an important component of management plans, facilitates the development of local conservation programs. Areas closer to a strictly protected area have a higher potential for becoming a protected area, a biological corridor, or a Sustainable Use Area (Figure 25). We assigned to each protected area three possible areas of influence (buffers) surrounding it 1,000, 5,000 and 20,000 meters, representing decreasing opportunities for conservation as the distance from the strictly protected area increased.
2) *Proximity to a river*—We assumed that rivers in this ecoregion constitute potential biological corridors that may help to connect forest fragments. Because in the three countries there is legislation that protects the riverine forests, areas closer to rivers have higher potential for connectivity (Figure 26). On the other hand, since the majority of rivers in this ecoregion are not navigable, they do not represent ways to access the forest as they do in other ecoregions. We assigned three buffer zones of 1,000, 2,500 and 5,000 m on both margins of the rivers (all rivers have a width of 500m the minimum unit of analysis, irrespective of their size), representing areas of decreasing potential for connectivity to other conservation areas.
3) *Zones of planned conservation*—Sustainable Use Areas (IUCN categories IV-VI) and areas prioritized for conservation by PROBIO[18] constitute areas identified by government or other institutions as areas with potential for conservation (Figure 27). The political consensus around these areas gives them a higher potential for conservation. PROBIO defined five categories of areas: category A corresponds to areas of extremely high biological importance; B to areas of very high biological importance; C to areas of high biological importance; D to insufficiently known areas but of probably high biological importance; and L to corridors. We assign a value of 8 to existing Sustainable Use Areas, a value of 4 to category A PROBIO areas, a value of 2 to category B PROBIO areas and a value of 1 to areas categorized as C, D, and L by PROBIO.

We weighted the three opportunity variables according to their potential for conservation, with strictly protected areas representing three times and rivers constituting two times the potential for conservation of the zones of planned conservation. These three layers of

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[18] PROBIO is a project of the Ministry of Environment of Brazil for the Conservation and Sustainable Use of Biodiversity. PROBIO identified priority areas and priority actions for the conservation of the Atlantic Forest (Conservation International of Brazil 2000).

information were combined to produce a map of opportunities for biodiversity conservation (Figure 28).

We combined these two maps of threats and opportunities into one consolidated map (Figure 29) that depicts areas with the highest threats (in blue) and areas with the best opportunities (in green) for biodiversity conservation.

Using the three analyses described above, we then conducted two additional analyses: Representation analysis—We combined the landscape units map, the forest fragments map, and the protected areas map to analyze the current status of forest cover and representation of the different landscape units within the protected area system. We assessed representation in terms of: 1) percentage of a landscape unit that is under strictly protected areas, 2) percentage of a landscape unit that is protected under Sustainable Use Areas, and 3) percentage of forest cover still remaining from each landscape unit. This representation analysis gives an idea of how well each landscape unit is represented in the current landscape and may guide decisions on how to improve representation of those underrepresented landscape units in the final Biodiversity Conservation Landscape.

Biodiversity Conservation Potential Analysis—The first step in this analysis is to cross the fragment importance index map with the threats and opportunities map to construct a map of biodiversity conservation potential (Figure 30). The assumption of this analysis is that the best forest fragments located at the least threatened places with highest opportunities for biodiversity conservation constitute the areas with the highest biodiversity conservation potential. This combined analysis indicates where those areas are located in the ecoregion. The conservation potential map that resulted from this analysis represents a broad-scale cost-benefit analysis. The resulting map shows the areas where we should focus our conservation efforts because they have good potential for biodiversity conservation (green areas in the map) and the areas where we should not, because the costs for achieving conservation goals are too high (blue areas in the map). **This map constitutes the most important layer of information we used to design the Biodiversity Conservation Landscape**.

Design of the Biodiversity Conservation Landscape — The Biodiversity Conservation Landscape was designed following a series of logical steps using the biodiversity conservation potential map. We began the process by identifying the building blocks of the conservation landscape and linking them in a series of steps according to their contribution to biodiversity conservation. The following steps, ordered by their conservation priority, were taken into account when designing the Biodiversity Conservation Landscape:

- *Identify the large native forest blocks* that will constitute the Core Areas (>10,000 ha of core forest, excluding a 500 m buffer zone where edge effect is high). These are the forest fragments large enough to sustain the whole life cycle of umbrella species.
- *Identify other priority areas for biodiversity conservation* that would include those with high potential for conservation (as indicated by the biodiversity conservation potential map), although they may not have sufficient forest or may not be large enough to sustain viable populations of native species over the long term. However, they may play an important role in biodiversity conservation (e.g., may constitute Stepping Stones).
- *Connect the Core Areas and other Priority Areas* through the creation of corridors and the development of Sustainable Use Areas. The specific location of these corridors and

Sustainable Use Areas was dictated by the biodiversity conservation potential map (e.g., the areas with the highest biodiversity conservation potential).

- *Increase the area of protected forests* through the protection of small fragments or the restoration of forest fragments that could then be connected to the main corridor, thus increasing the resilience of the conservation landscape. The location of secondary corridors and Sustainable Use Areas that connect these areas to the Core Areas and Main Corridors was also dictated by the biodiversity conservation potential map.
- *Increase the representation of underrepresented landscape units* through the inclusion of forest fragments belonging to the less represented areas. These were also connected (when possible) through secondary corridors to the main corridors or Core Areas.
- *Identify the most important river basins for watershed conservation and management*. These river basins were selected based on the intactness of the basin, the presence of protected areas in the basin (both strictly protected areas and Sustainable Use Areas), the presence of ongoing conservation initiatives in the river basin, and the potential of the river basin for connecting the ecoregion to other ecoregions (see next step).
- *Facilitate the connectivity of the resulting Biodiversity Conservation Landscape* with neighboring ecoregions to guarantee long-term evolutionary processes.
- Finally, we *checked the socio-political viability* of certain areas of the Biodiversity Conservation Landscape and based on expert opinions we made small adjustments to the final landscape.

Thus, to achieve our conservation goals, the Biodiversity Conservation Landscape is focused on the objective of connecting the Core Areas through corridors and establishing buffer zones around Core Areas, priority areas, and corridors. As one of the important last steps in the design of the Biodiversity Conservation Landscape, we overlaid a preliminary landscape map with the landscape units map to assess the degree of representation of each conservation unit and to seek ways to obtain the best representation possible. To define the final map, we also used expert opinions and socio-political viability analyses of individual areas when available. We did not include this information as another layer of information in the threats and opportunities analyses either because it was not available for all the three countries or because it was information regarding specific places, and we wanted to use the same criteria for the entire ecoregion. However, this information was used as the last step to fine-tune the final Biodiversity Conservation Landscape to the socio-political reality of the ecoregion. When expert opinions or socio-political considerations were used in decisions whether or not to include some areas in the final Biodiversity Conservation Landscape, it will be indicated in the text (next Chapter). A visual representation of the methodology for the entire analysis used to design a Biodiversity Conservation Landscape is summarized in Figure 31.

Figure 12. Number of Dry Months

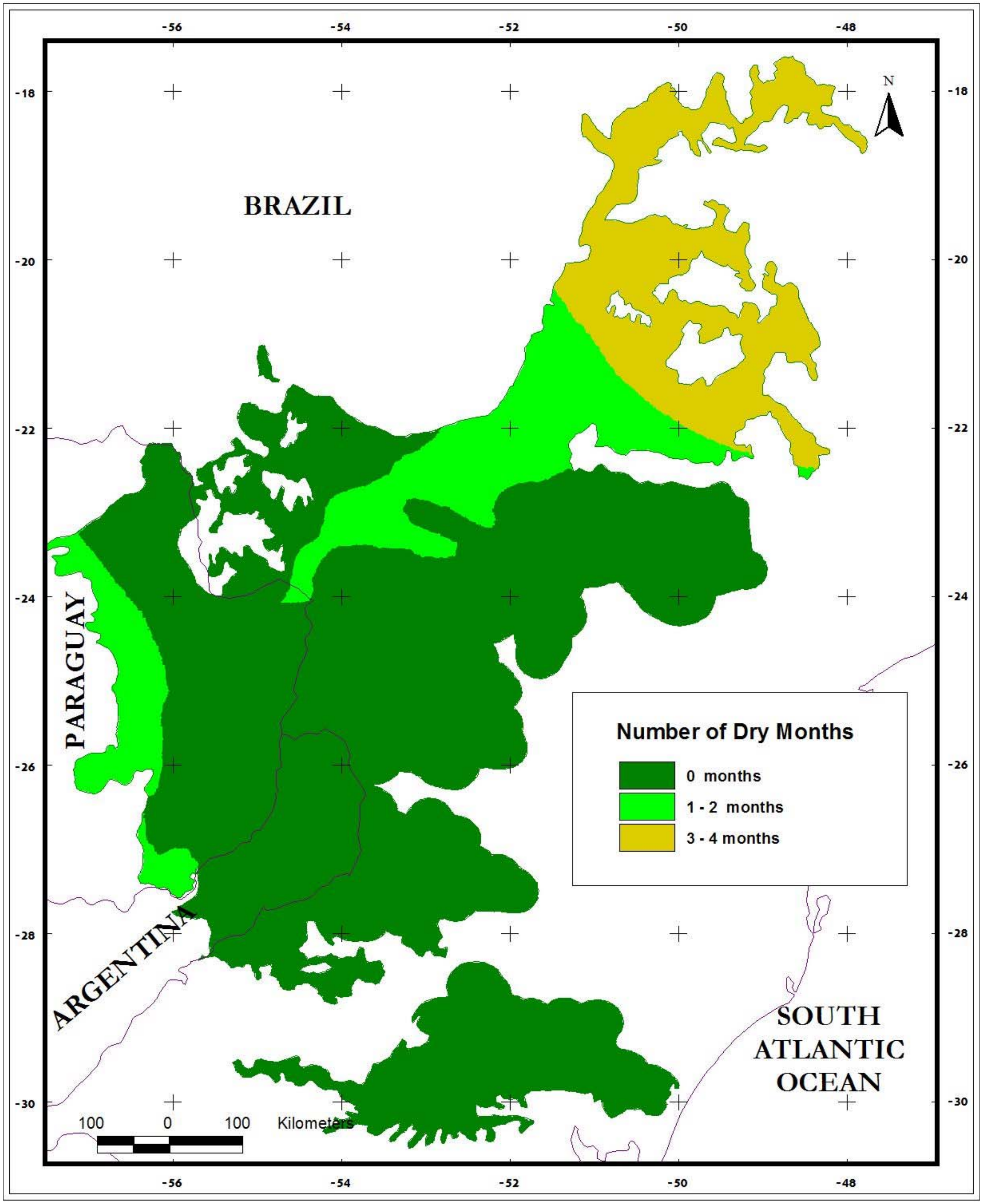


Figure 13. Elevation Range

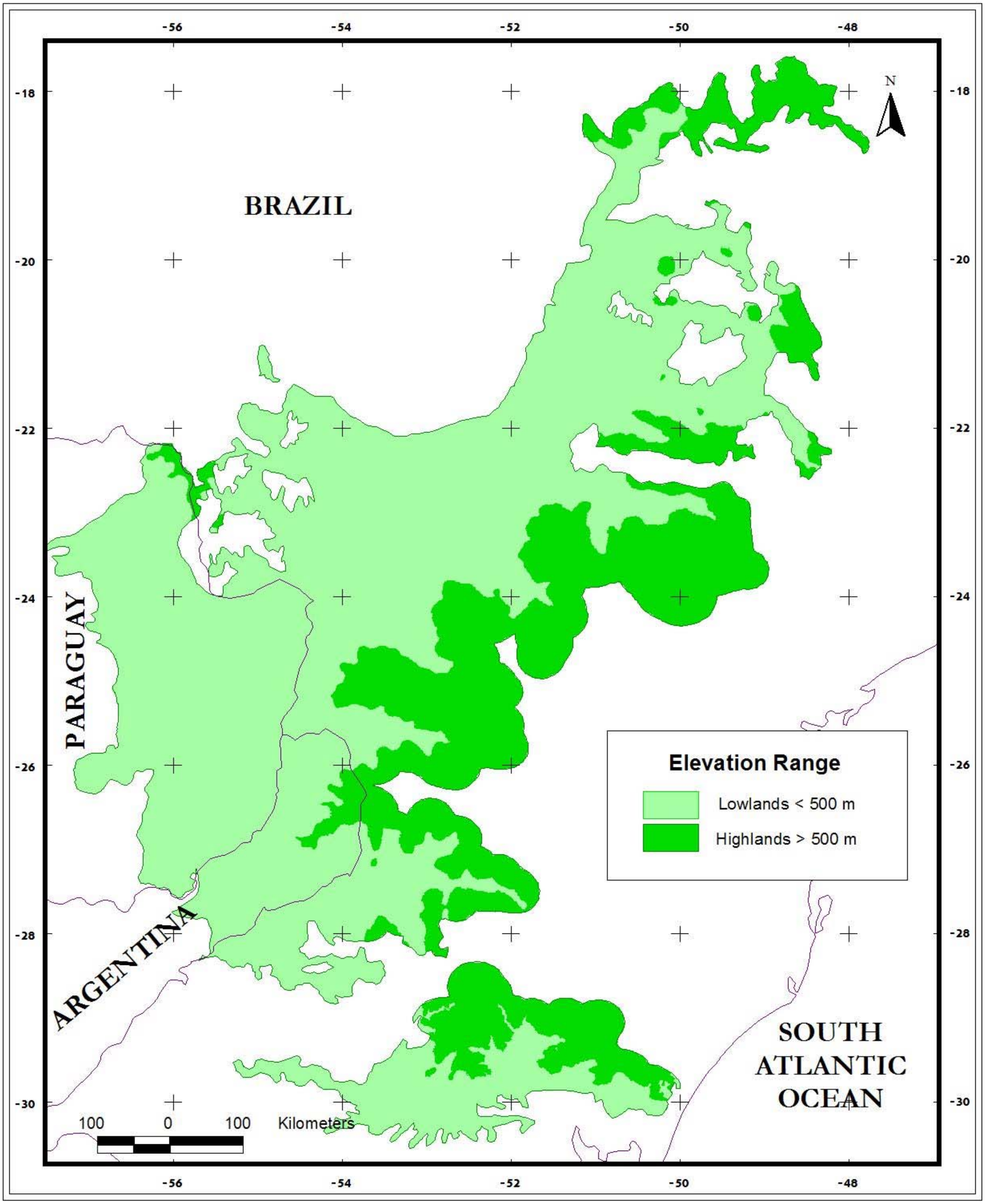


Figure 14. Slopes Index

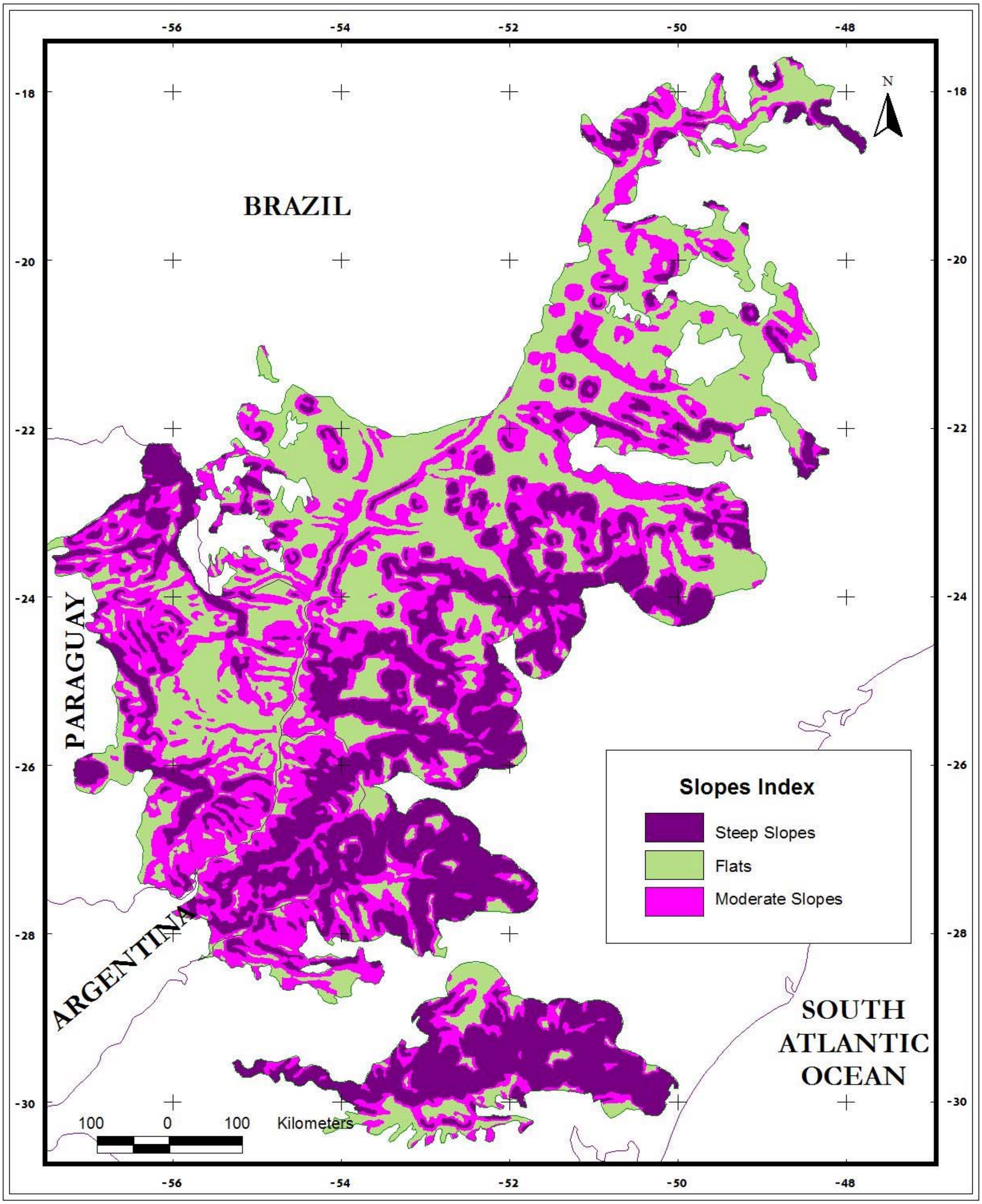


Figure 15. Landscape Units

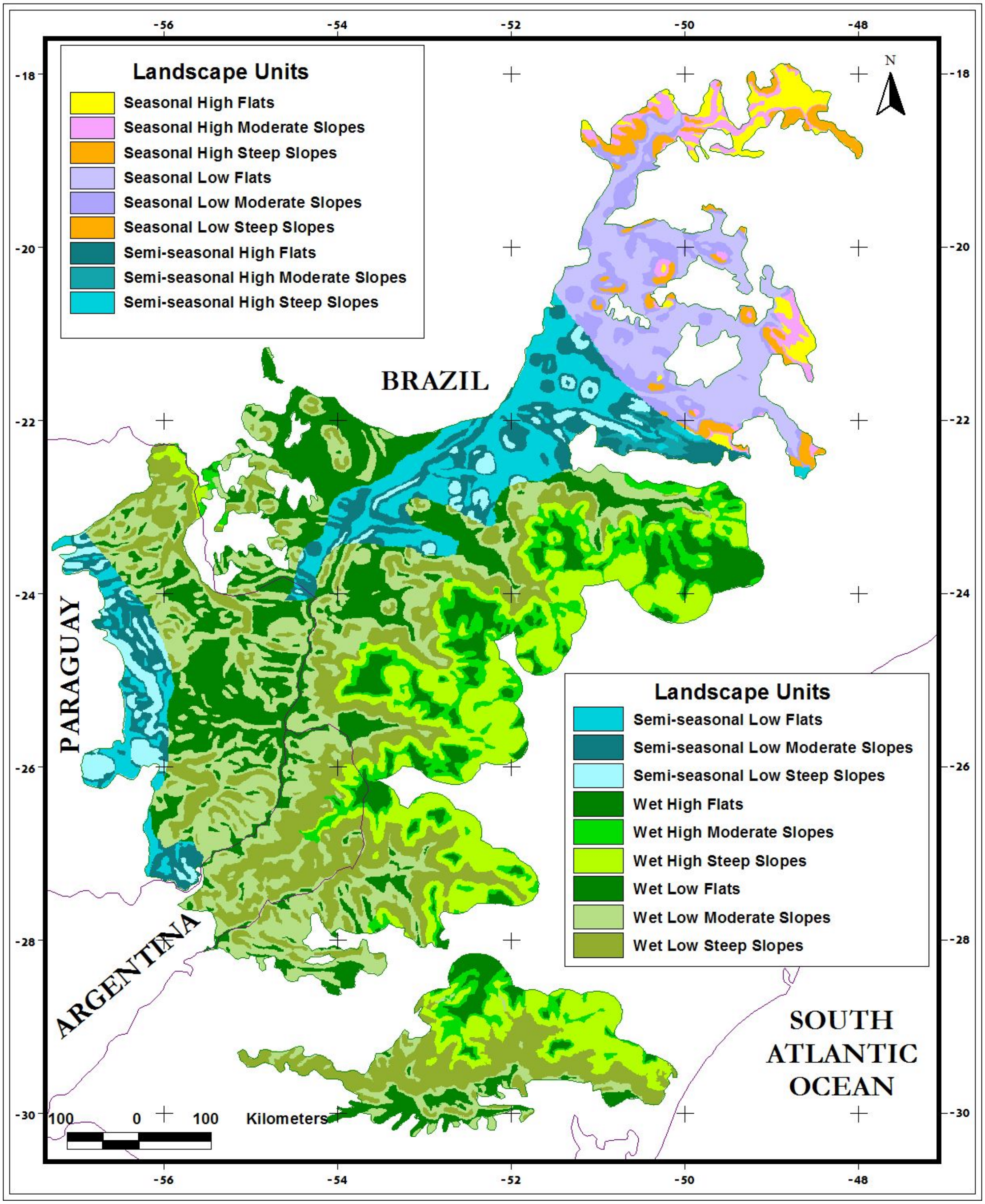


Figure 16. Forest Remnants of the Upper Paraná Atlantic Forest

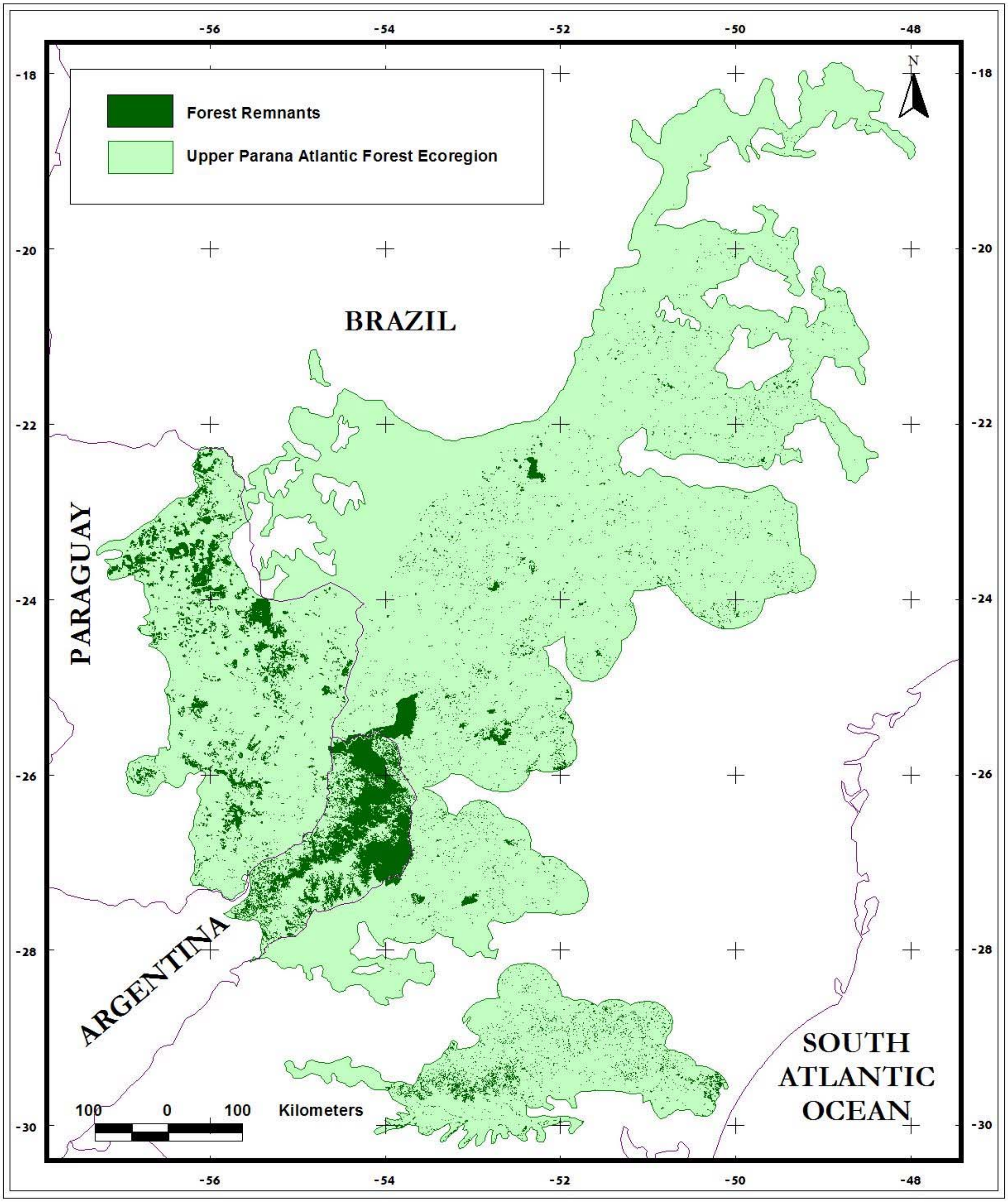


Figure 17. Forest Fragments Discriminated by Size Categories

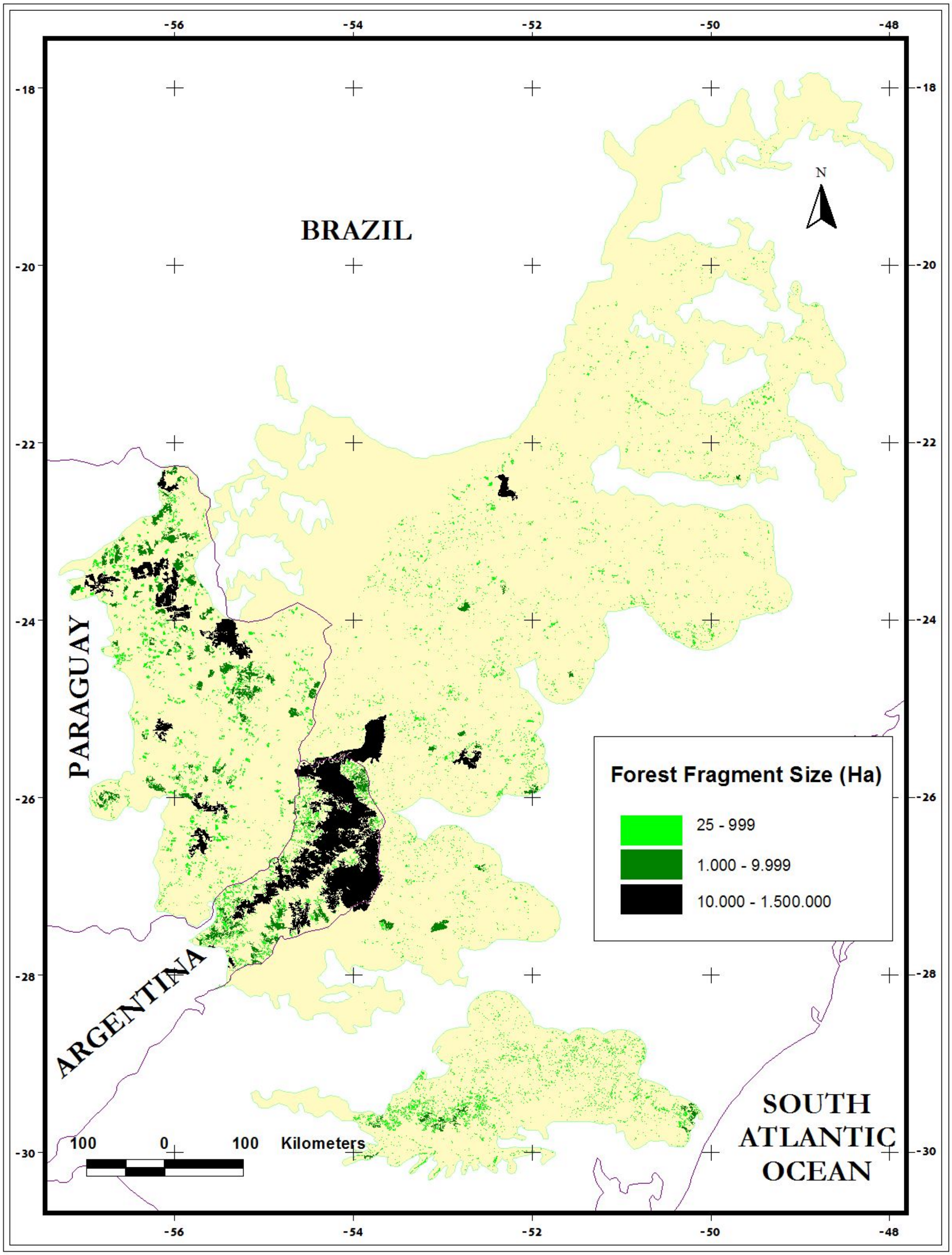


Figure 18. Forest Fragment Cores Discriminated by Area Categories

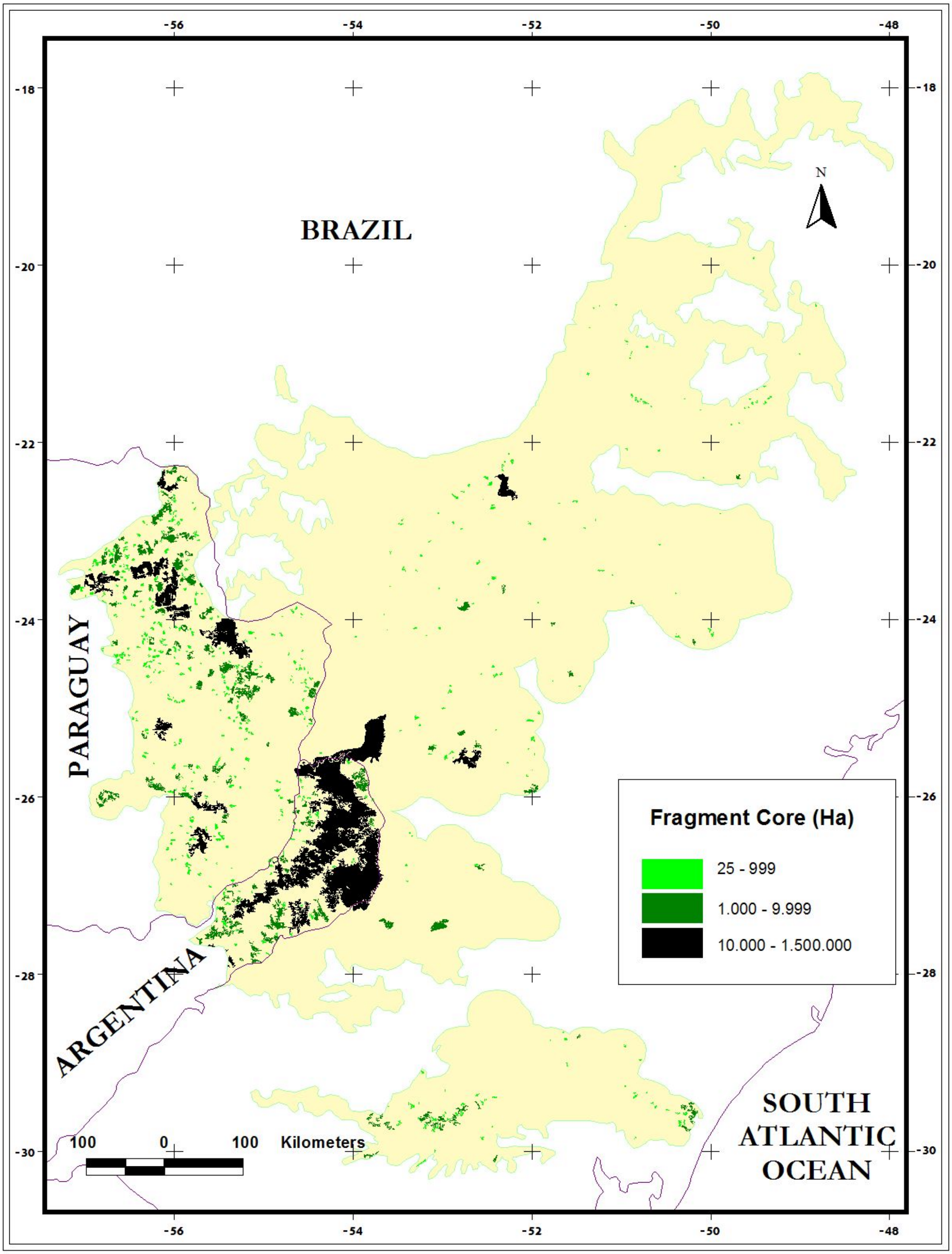


Figure 19. Fragment Importance Index

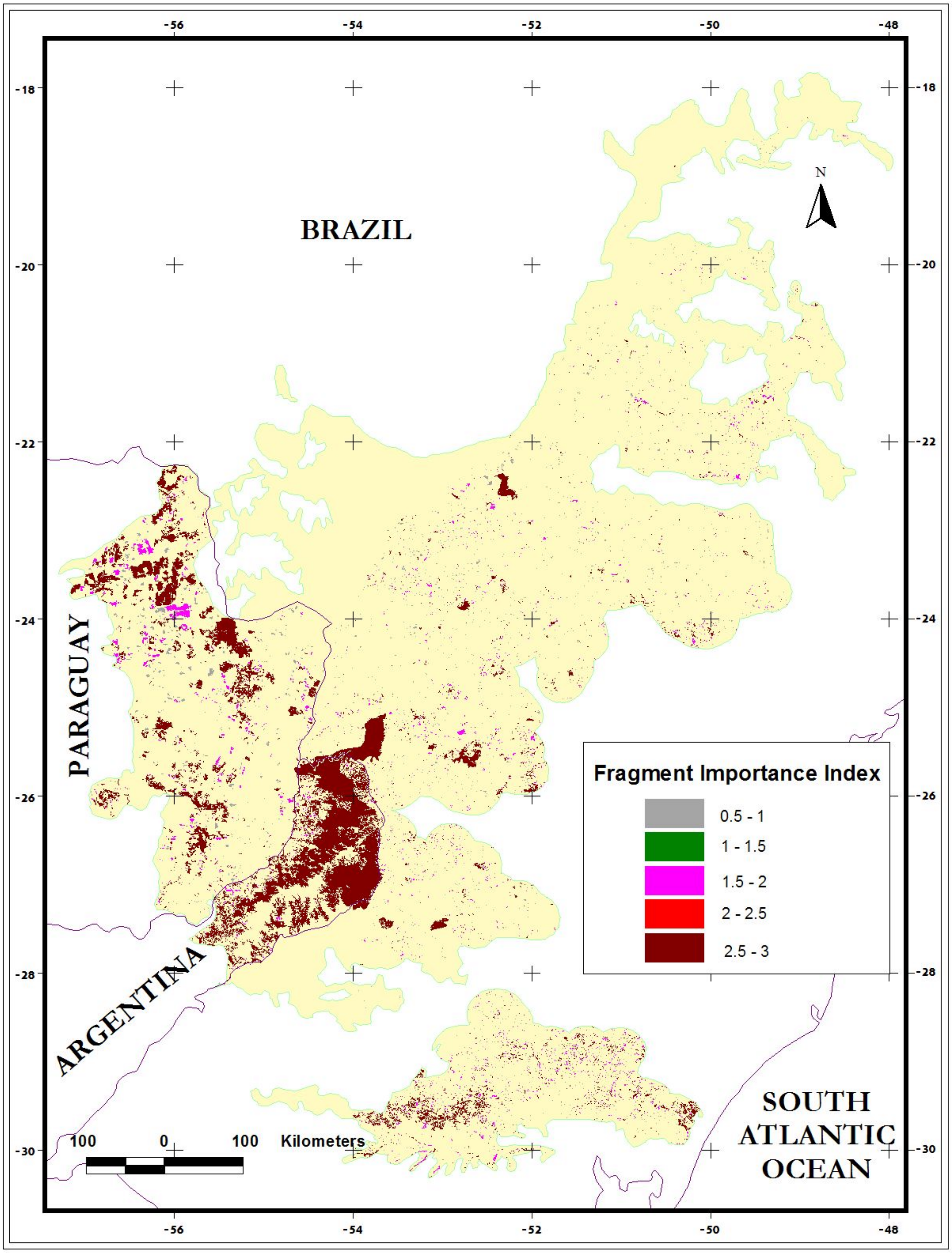


Figure 20. Cities

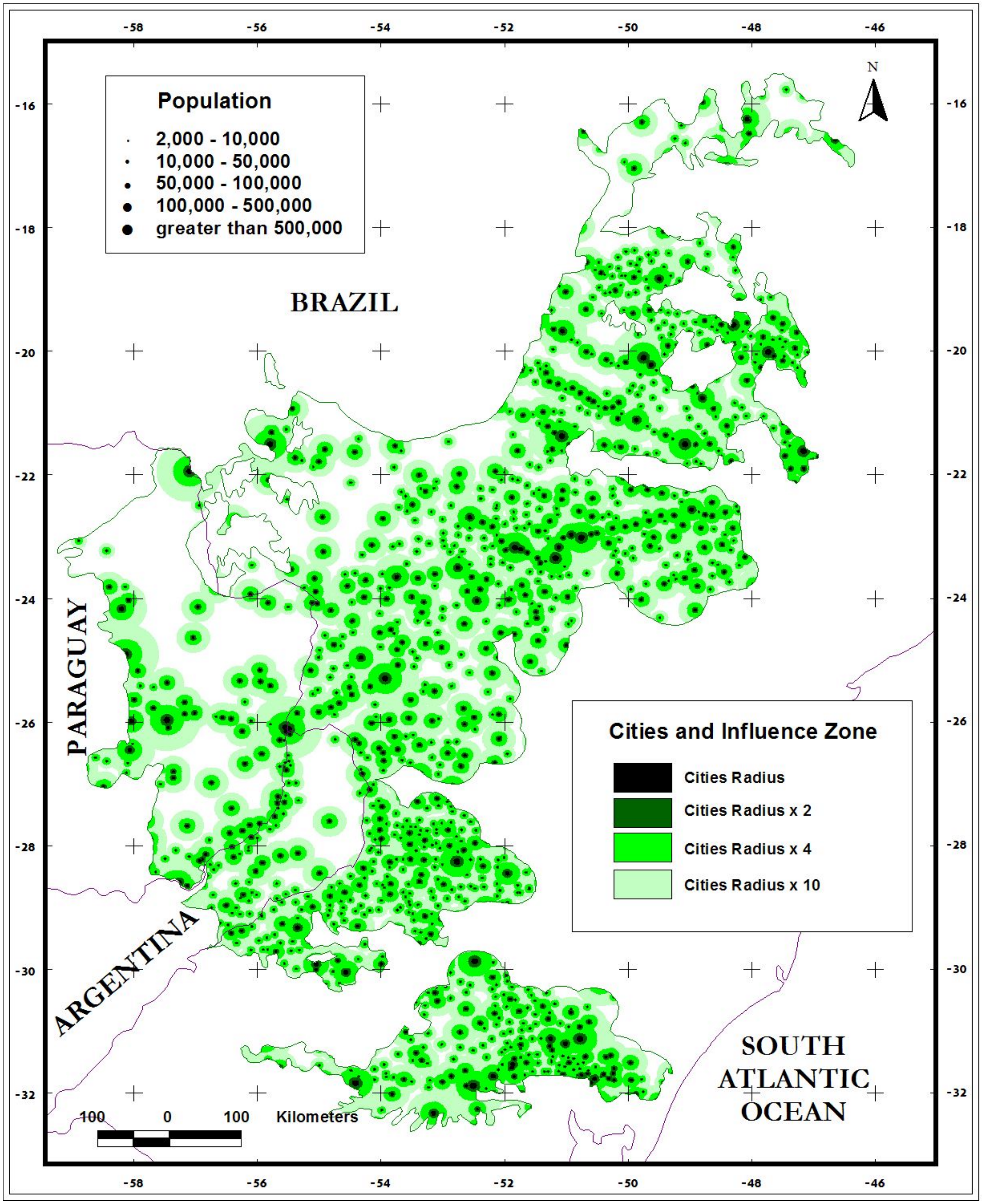
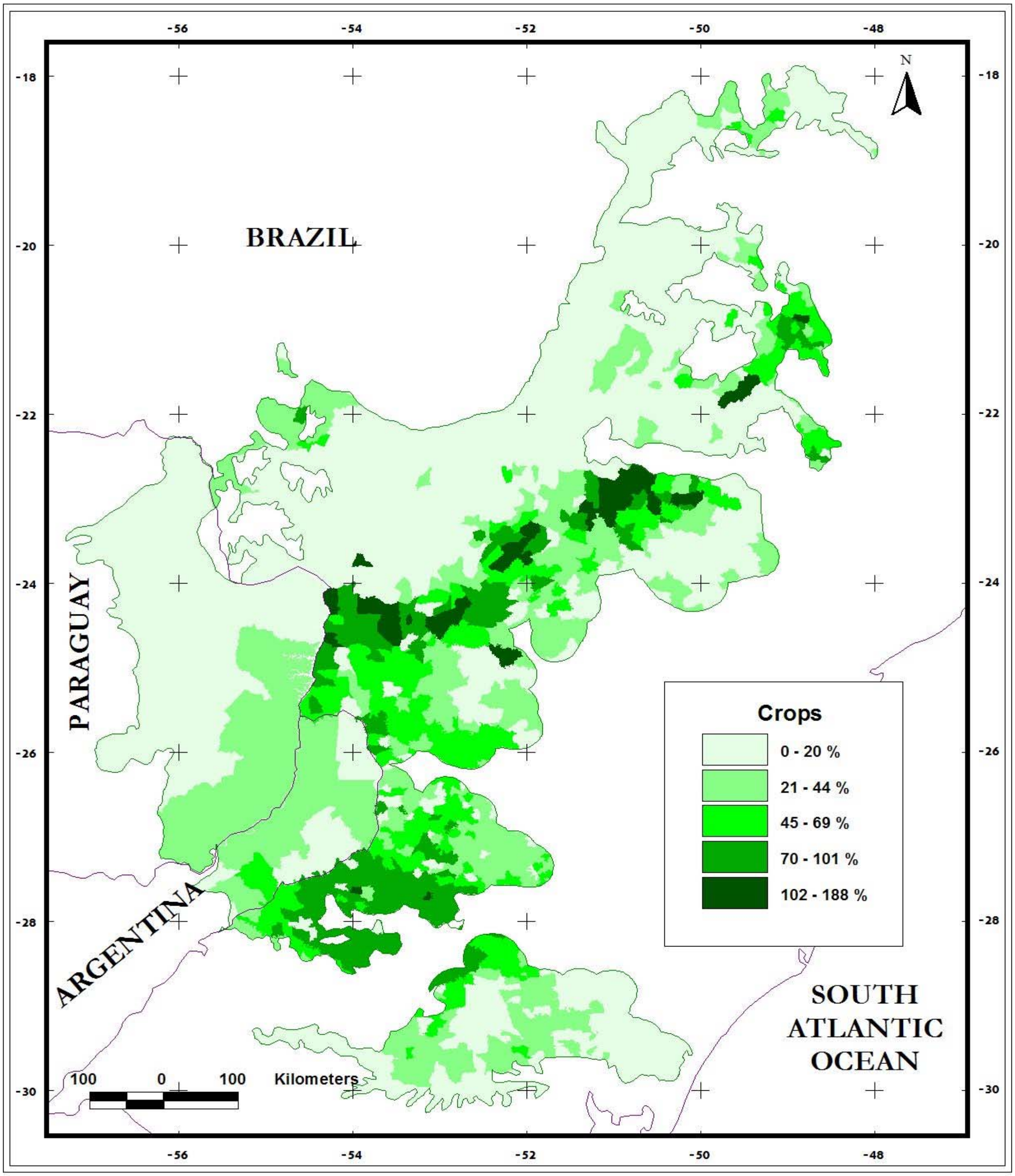


Figure 21. Crops



The percentages in the map represent the sum of the percentages of the area used by different crops. Since in most of the ecoregion two annual crops are produced in a year they can sum up to more than 100%.

Figure 22. Cattle Ranching

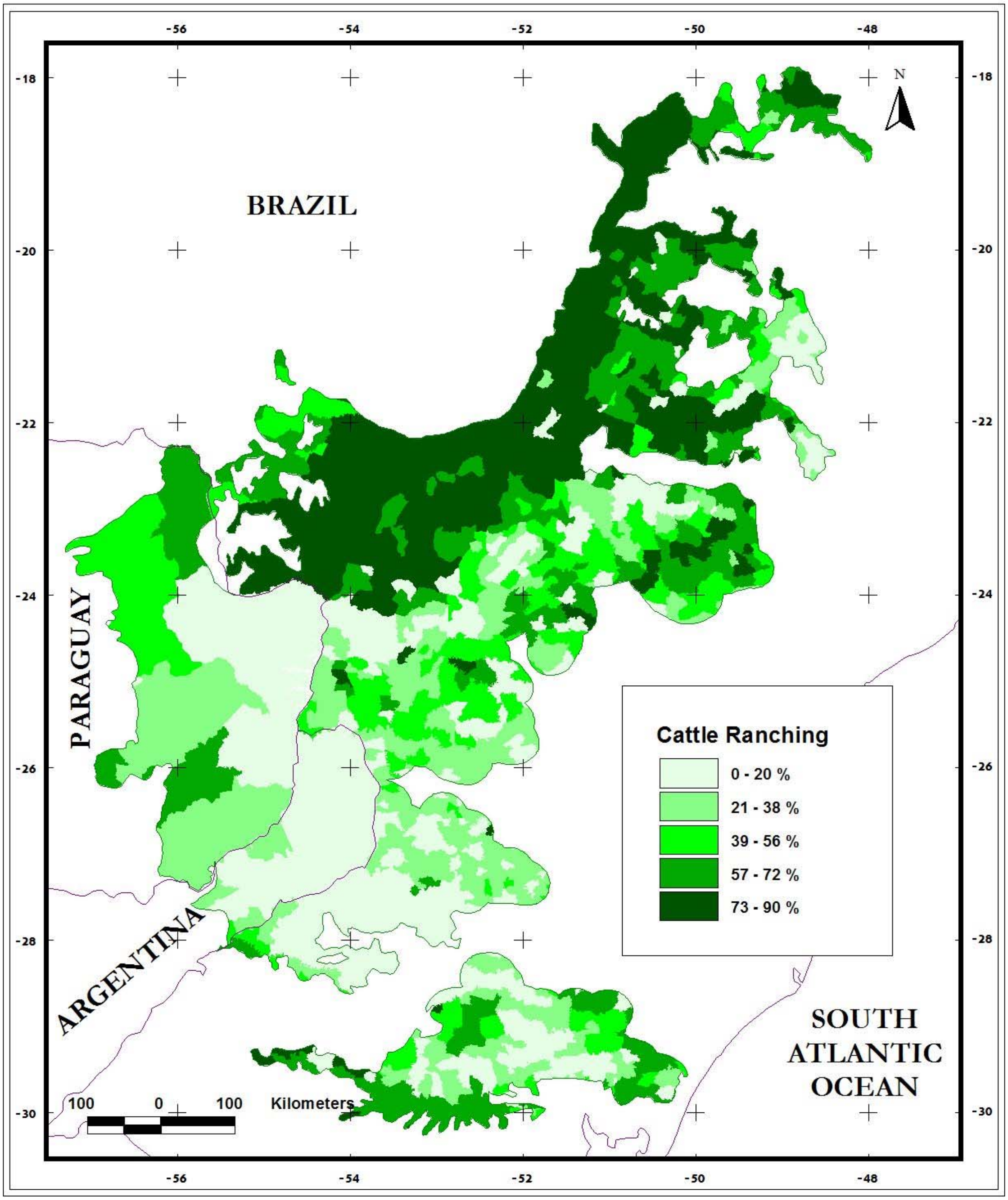


Figure 23. Rural Population Density

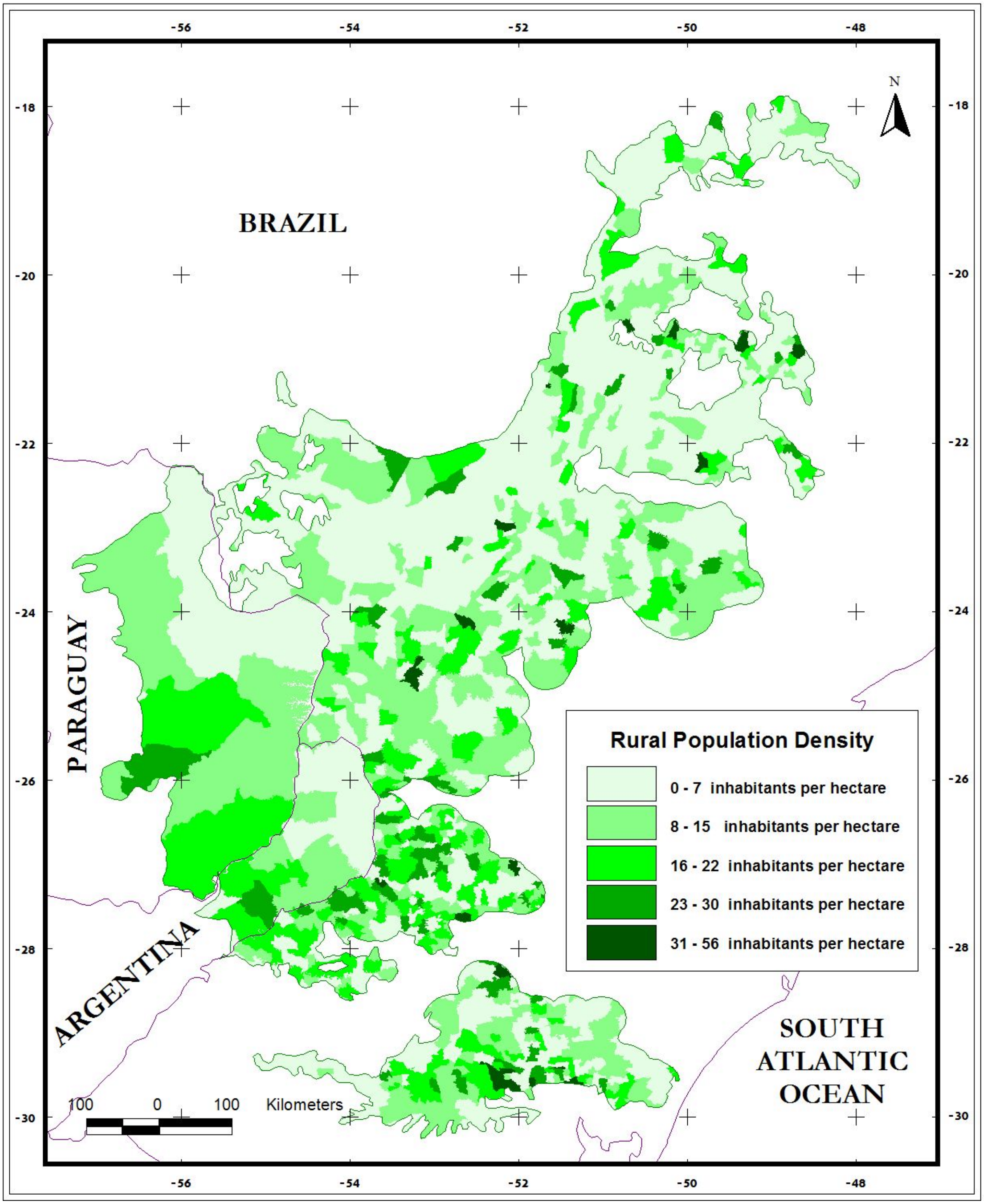


Figure 24. Threats to Biodiversity Conservation

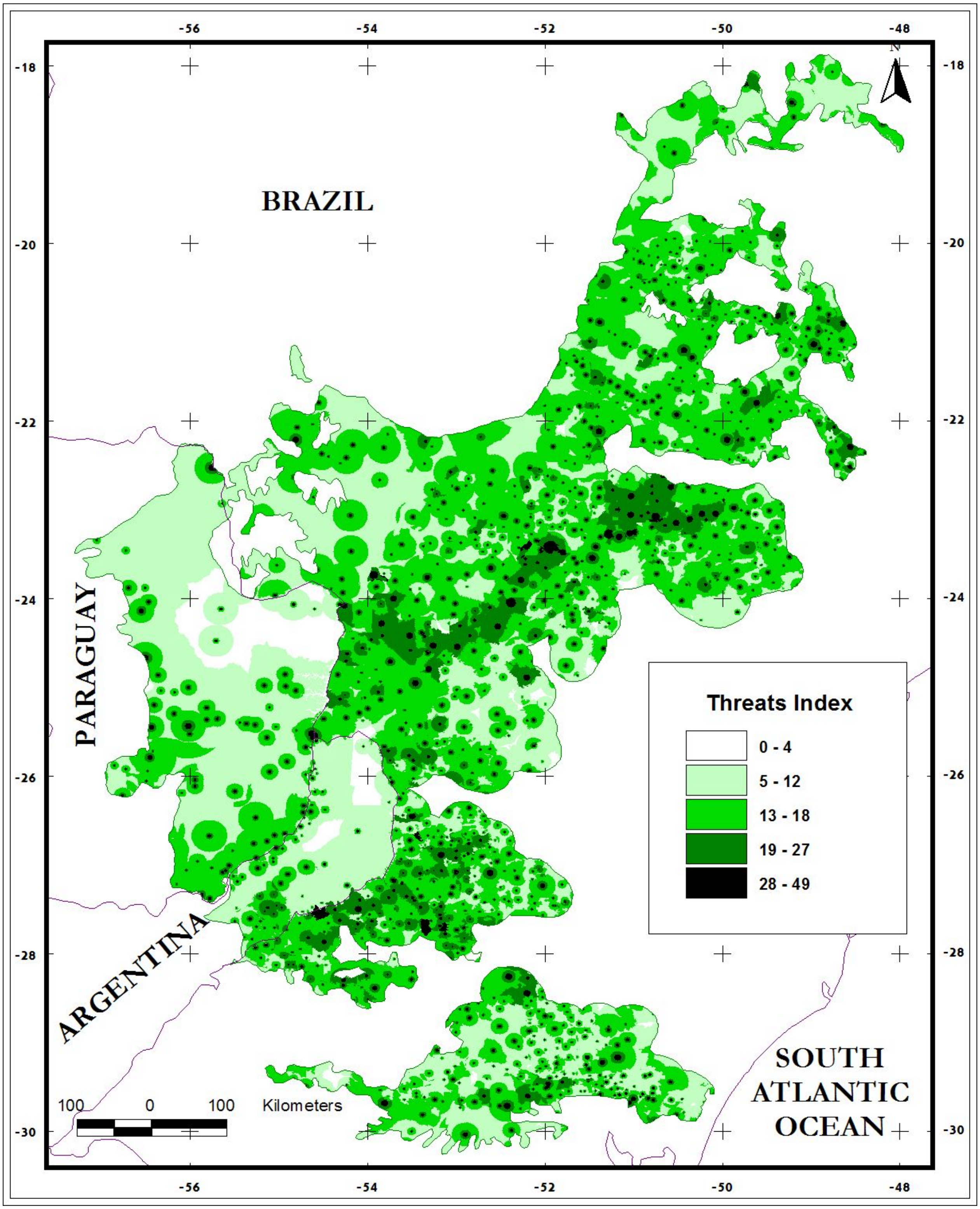


Figure 25. Proximity to Strictly Protected Areas

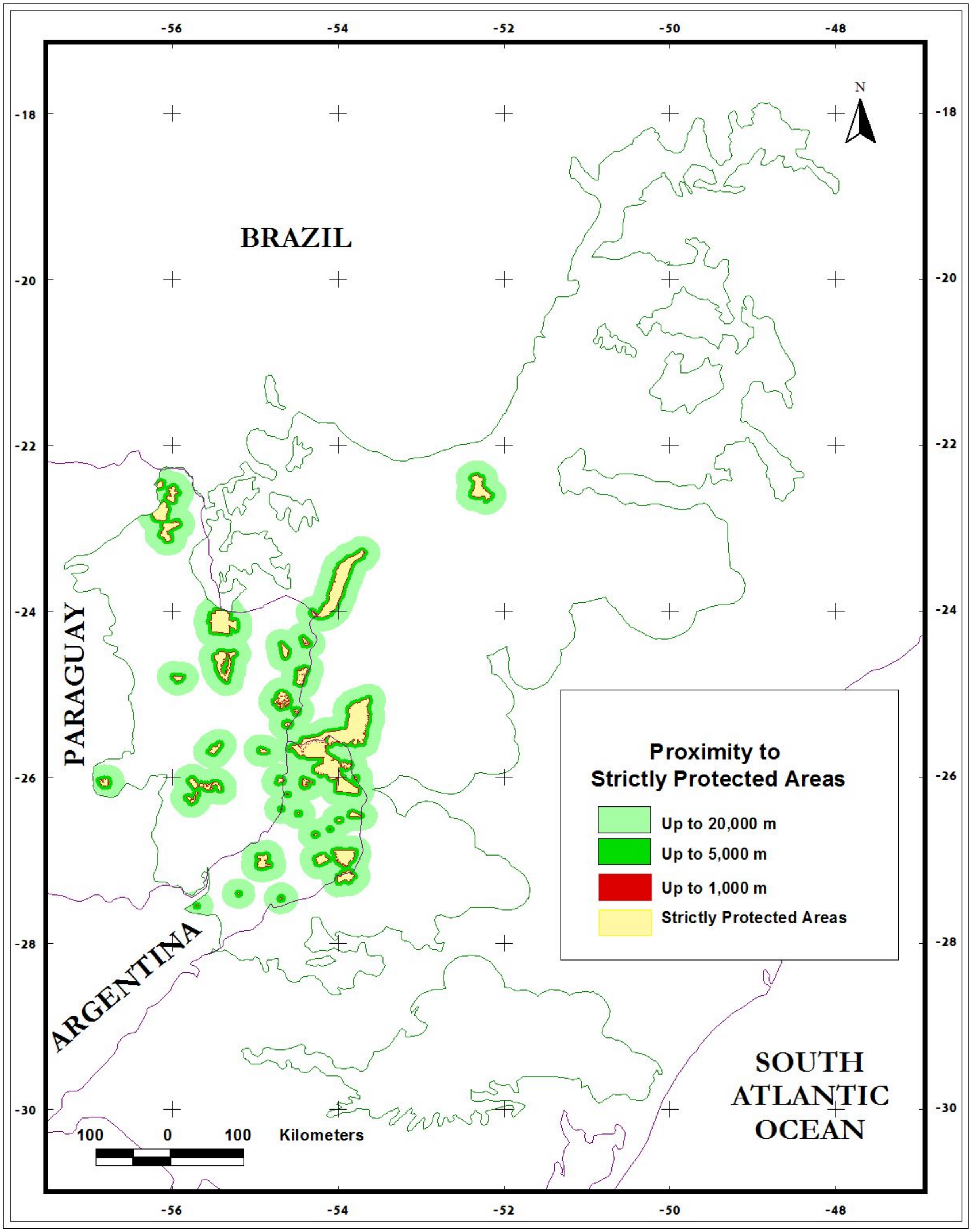


Figure 26. Proximity to Rivers

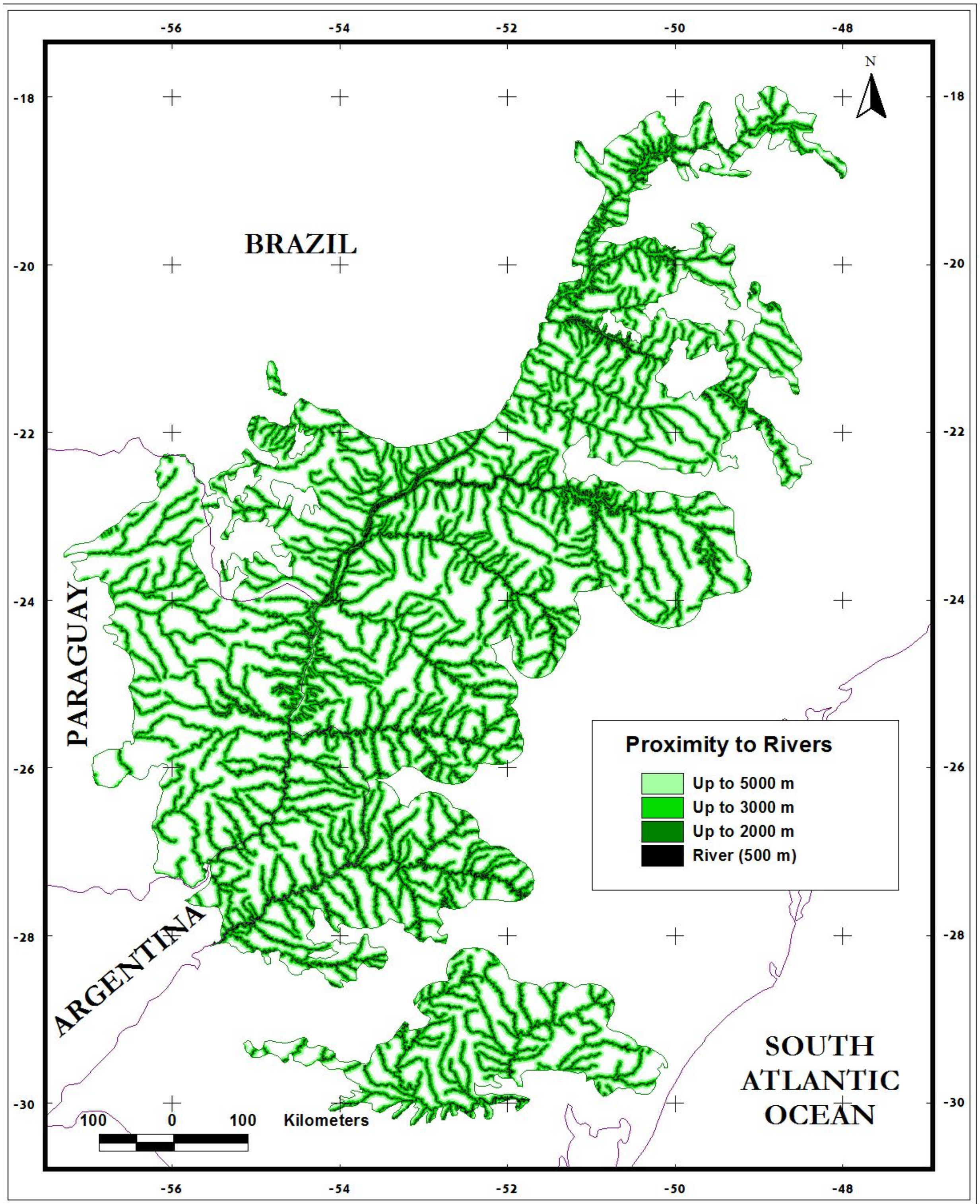


Figure 27. Zones of Planned Conservation

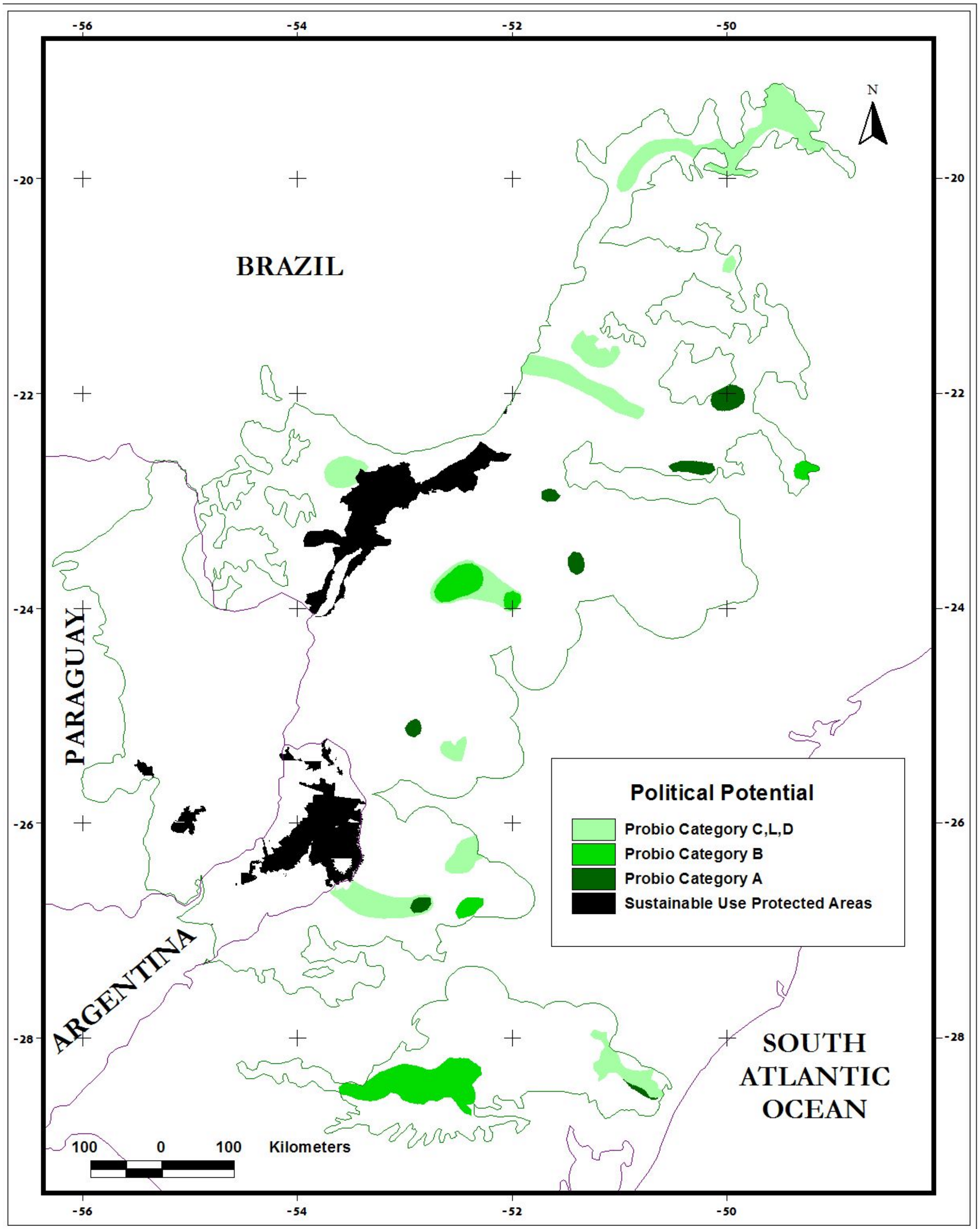


Figure 28. Opportunities for Biodiversity Conservation

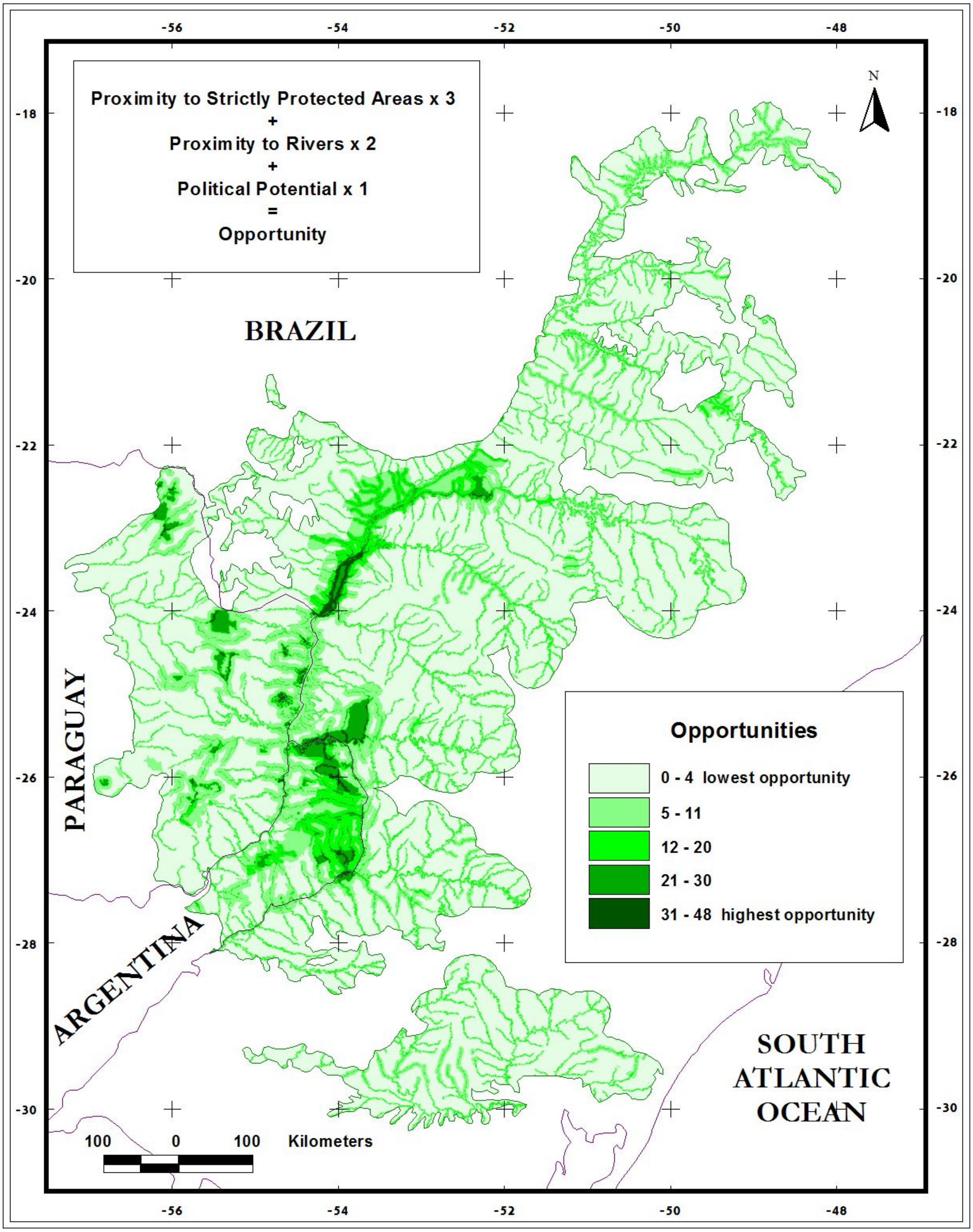
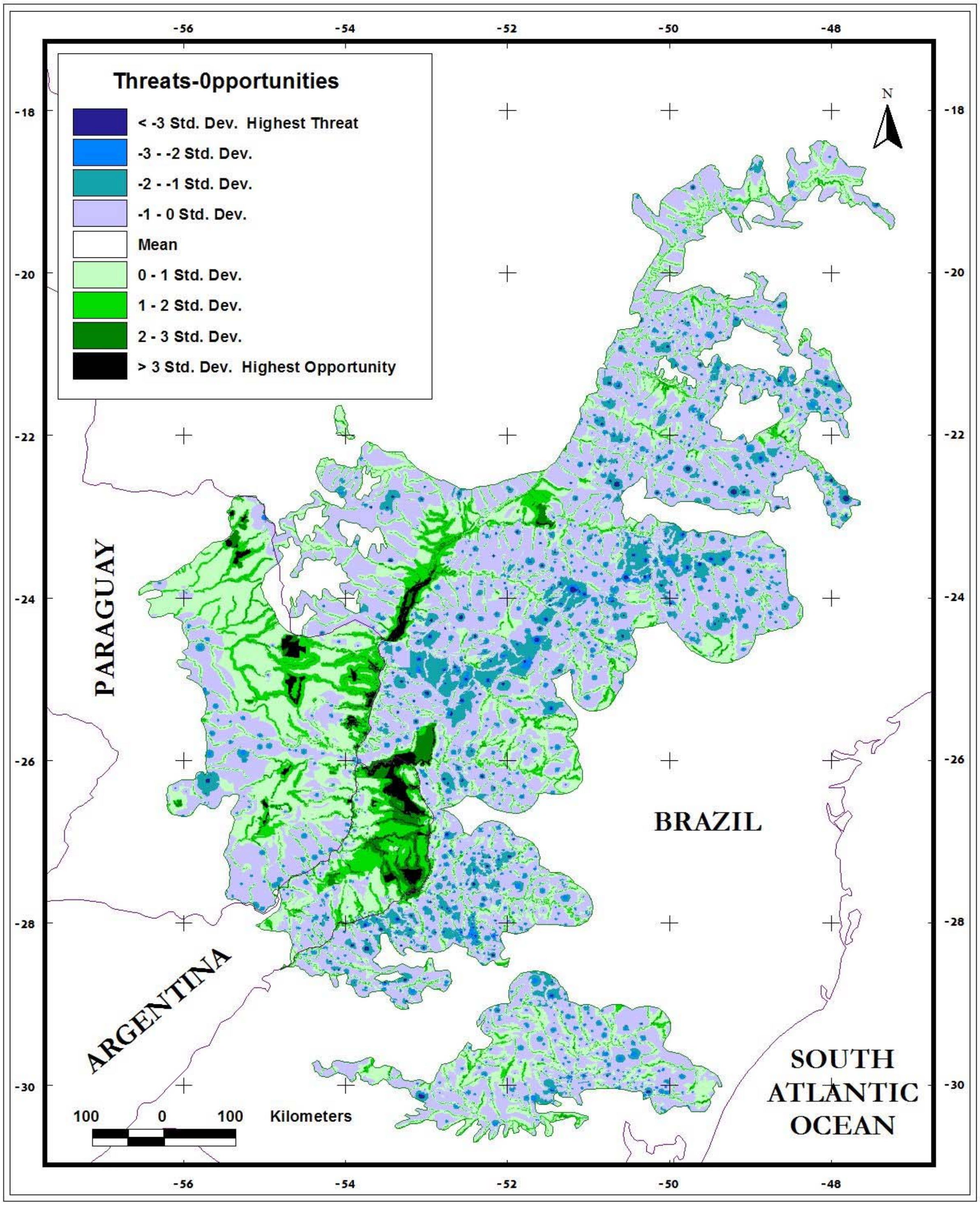
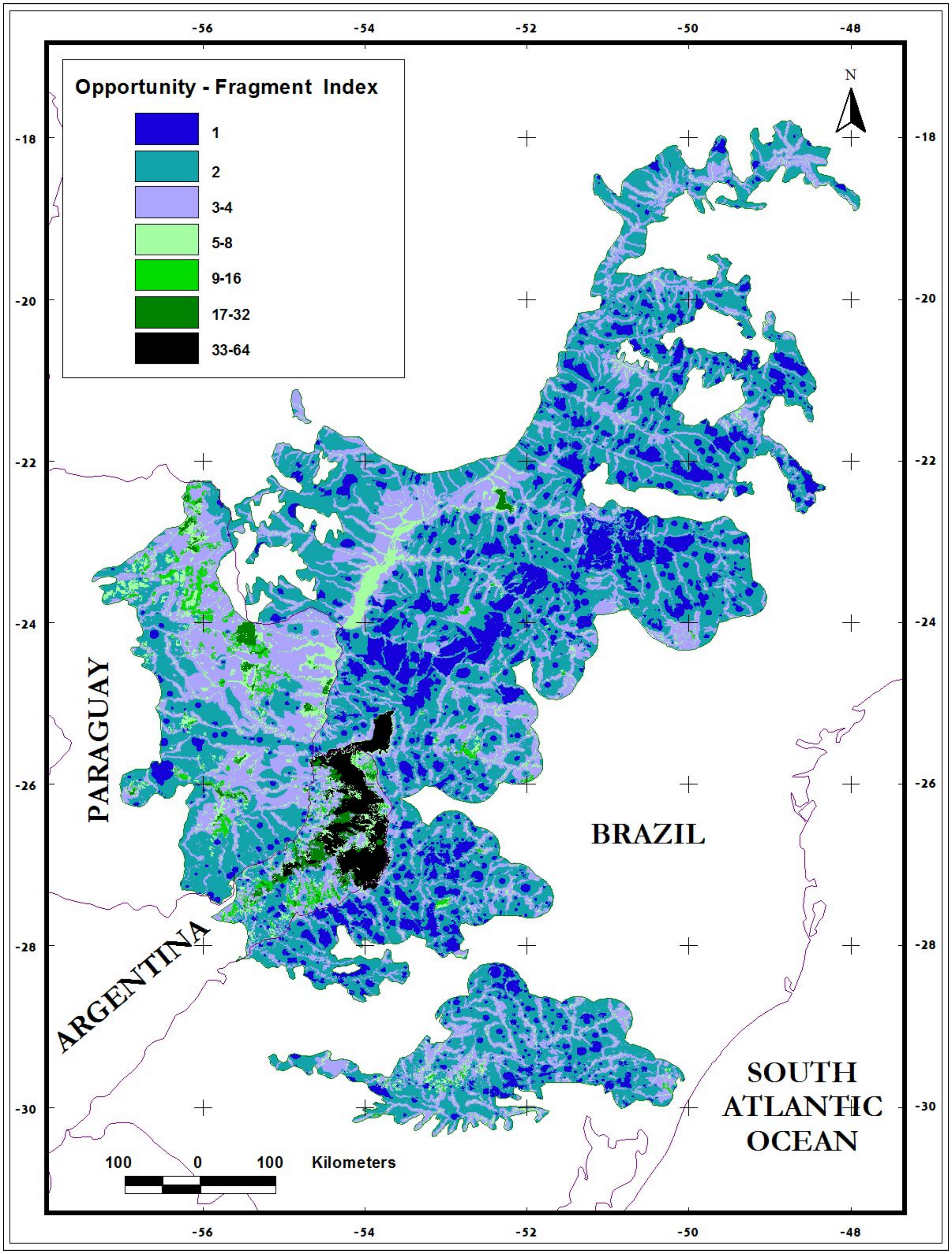


Figure 29. Threats and Opportunities



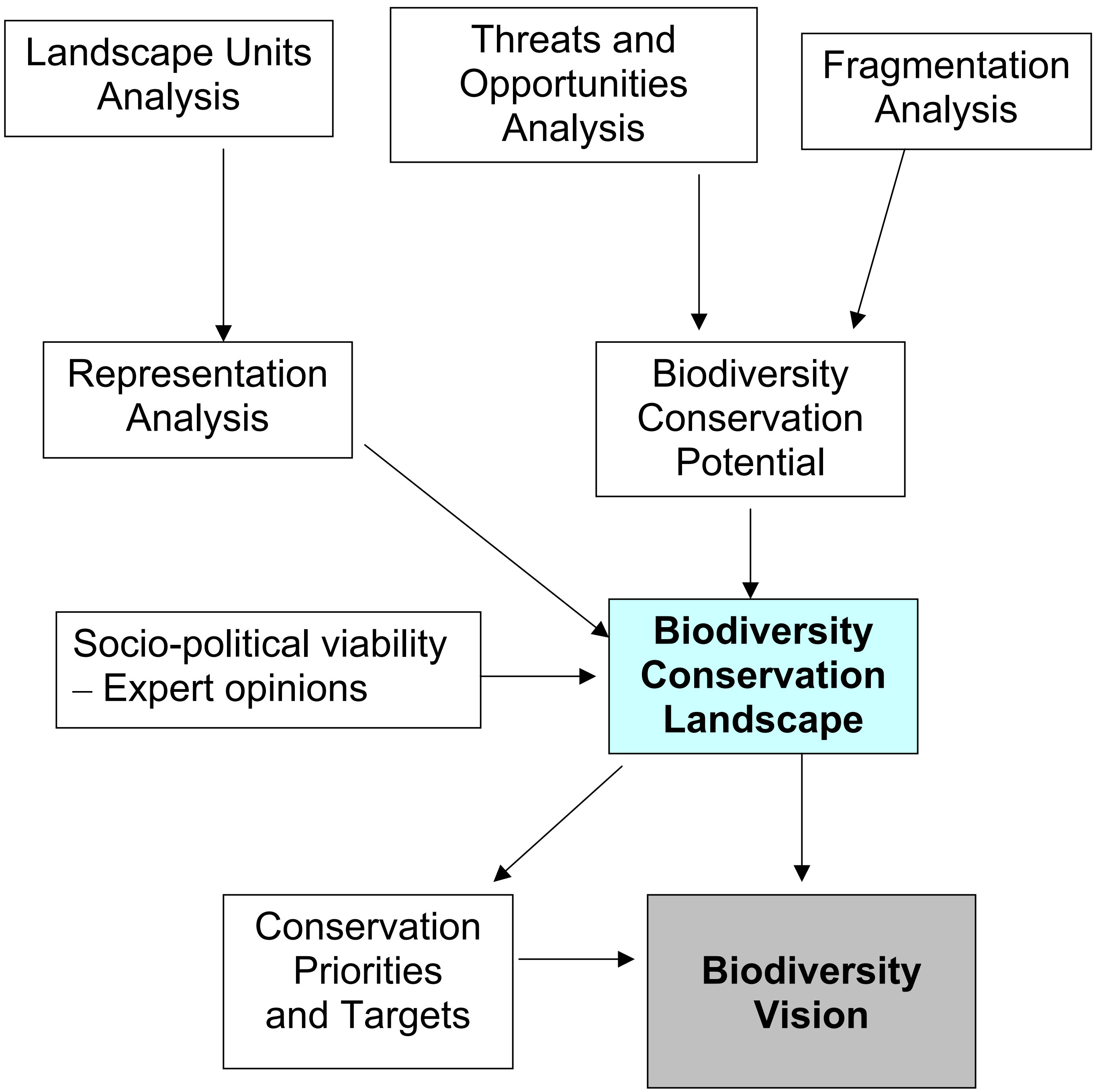
The standard deviations of the values of the threat and opportunities index assigned to each of the grid cells were used in this map for illustration purposes.

Figure 30. Biodiversity Conservation Potential



Areas with the largest values (in dark green) are those with the highest biodiversity conservation potential.

Figure 31. Process of Development of the Biodiversity Conservation Landscape



CHAPTER 5

Results: The Biodiversity Conservation Landscape

Representation of the Landscape Units

Ten of the 18 landscape units have less than 3% of their area remaining in native forest cover — the best-represented landscape unit has only 19%, and what remains is highly fragmented. The representation of the landscape units within strictly protected areas ranged from zero percent (nine landscape units) to 3.45% (the best represented unit) of their original area (Table 3).

Only eight of the 18 landscape units are represented in at least one forest fragment larger than 10,000 ha (Table 4). The ten landscape units that do not have large forest fragments and have little representation within the protected area system also do not have any fragment with a high fragment importance index value. There are practically no possibilities to obtain a good representation of these ten landscape units in the final Biodiversity Conservation Landscape[19]. The eight landscape units that still have forest fragments larger than 10,000 ha are represented in strictly protected areas. Due to this situation, long-term biodiversity conservation efforts in the Upper Paraná Atlantic Forest ecoregion should focus on ensuring the resilience of the areas that can maintain viable populations of umbrella species and healthy ecological processes. Only this will enable the long-term conservation of the majority of the species. At the same time, we should try to include the best representation possible, but knowing that achieving the goal of at least 10% representation of each landscape unit is nearly impossible in the Upper Paraná Atlantic Forest and the final Biodiversity Conservation Landscape will not attain this goal (see below further discussion on the implication of this on the biodiversity conservation goals).

The Biodiversity Conservation Landscape

The Biodiversity Conservation Landscape is composed of **three main types of areas** (Figure 32).

A) Priority Areas for Biodiversity Conservation

We defined five categories of priority areas:

1. **Core Areas:** The Core Areas are the blocks of well-preserved native forest large enough to be resilient to threats causing biodiversity loss. These are the most biologically important and strategic zones for conservation, either public or private. In addition to harboring biodiversity, they make an important contribution to the maintenance of environmental services important for human quality of life (such as carbon sequestration, balance and quality of water supply, and aesthetic landscape). Here human activities must be reduced to a minimum and must be of low impact. Each Core Area should be managed under strict protection to maintain an area of continuous native forest large enough for the life cycle of individuals of large range species such as jaguars and white-lipped peccaries.

[19] Our Ecoregion Action Plan includes field surveys to test the validity of the landscape units identified in this analysis and to assess whether there are Atlantic Forest species that are unique to the landscape units not represented in the Biodiversity Conservation Landscape. If there are, and these species do not require a large area to have a viable population (e.g., small vertebrate), the conservation of forest fragments in these landscape units could become part of the Biodiversity Conservation Landscape. See Chapter 6.

To attain this goal, Core Areas must meet the following criteria:

- They are larger than 10,000 ha.
- They have high potential for conservation (their conservation potential index should range from 32 to 64) in more than 60% of the area.
- They have an area of continuous forest cover larger than 10,000 ha after excluding an area of 500 m (buffer) under edge effect.

We included four areas in this category that did not fully meet these criteria. Araupel (Brazil) and part of San Rafael (Paraguay) were included even though their conservation potential index was lower than 32, but it would have been higher if recent changes (the creation of new strictly protected areas) increasing their conservation status had been included in the analyses. Caaguazú (Paraguay) and Morombí (Paraguay) were included although they do not have more than 10,000 ha of forest cover without edge effect, they are very close to that figure (9,950 ha and 9,650 ha respectively). The final Core Areas are depicted in Figure 33.

Note: Due to the high degree of fragmentation of this ecoregion, no Core Area alone will be large enough to sustain viable populations of umbrella species. To fulfill the critical role of Core Area, each of them must be effectively connected through corridors to other Core Areas. If isolated, the Core Areas will eventually lose the presence of umbrella species and the ecological processes that depend on them.

2. **Forested Areas with High Potential to Become Strictly Protected Areas (FAHPSPA)**: Most of the forested areas of Misiones meet the requirements for becoming a Core Area. However, the probability that the entire area will eventually constitute a strictly protected area is very low according to socio-political assessments. For this reason, we selected those areas of the Green Corridor with the highest conservation potential index as Core Areas and the remaining areas were categorized as Forested Areas with High Potential to Become Strictly Protected Areas (Figure 34). Part of these areas may thus become strictly protected and probably incorporated into Core Areas and part of them will become Sustainable Use Areas. Thus, the FAHPSPA do not belong to either of these categories (sustainable use vs. strictly protected areas) yet. However, we considered them Priority Areas for Biodiversity Conservation even though not all the area will end up being strictly protected.

3. **Potential Core Areas:** These areas meet only two of the three requirements for becoming Core Areas (they are larger than 10,000 ha and they have a high potential for conservation index in more than 60% of the area). After excluding an edge of 500 m, however, they do not have an area of continuous forest cover larger than 10,000 ha. Nevertheless, due to their high conservation potential, they may become Core Areas in the future if restoration and good management initiatives are implemented, especially along their borders (Figure 34).

4. **Forest Areas that Need Assessment (FANA)**: These are areas with relatively low conservation potential. In 1997, they each had a forested core larger than 10,000 ha (this was the date of the satellite images used to create the forest fragments maps from Paraguay). However, they are located in the area with the highest deforestation rate in

Paraguay, and they probably have been reduced to less than 10,000 ha (Guyra Paraguay, pers. com.) (Figure 34). We need to update our information on their current condition before defining their role in the Biodiversity Conservation Landscape. In this sense FANA are areas in a condition similar to the FAHPSPA, where it is not possible to define if they will belong to the category of Sustainable Use Areas or strictly protected areas yet.

5. **Satellite Areas:** These are areas with high potential for conservation but are only 5,000–10,000 ha in size. (Figure 34). It will be difficult to increase their size because areas with low conservation potential surround them. However, if they can be connected to the Core Areas they will play an important biodiversity conservation role.

B) Strategic Areas for Biodiversity Conservation

Because only one of the 18 landscape units reaches 10% representation within the priority areas (Table 5) we have identified a series of small-sized areas to increase the representation of other landscape units. These areas are either small (< 5,000 ha) but have high conservation potential or have low conservation potential but still maintain a forest fragment larger than 1,000 ha. Although these areas are not sufficiently resilient in isolation, they can play a strategic role in biodiversity conservation by facilitating the implementation of biological corridors as well as by increasing the representation of landscape units. According to their location and role we have classified the Strategic Areas into two categories:

Stepping Stones: When located within 50 km of a priority area, these strategic areas serve in our Biodiversity Conservation Landscape as "Stepping Stones" to be connected to form corridors. In certain cases they help increase the representation of some landscape units.

Isolated Areas: Strategic areas that are located more than 50 km from the nearest priority area, we considered Isolated Areas. If they have a potential for being connected to a Priority Area (e.g., there is a river nearby) we traced a possible corridor between the Isolated Area and the Priority Area. If there are limited possibilities for connection, these areas will remain isolated, reducing their potential for biodiversity conservation. However, they may still play an important local role in conservation (e.g., in environmental education or in the conservation of species restricted to these landscape units).

We categorized Stepping Stones and Isolated Areas as high importance when they belong to underrepresented landscape units, and of low importance when they belong to a well-represented landscape unit.

C) Sustainable Use Areas

Sustainable Use Areas are large areas that function as buffers and connections surrounding the Core Areas and Biological Corridors. They maintain environmental services in combination with "environmentally friendly" economic activities such as eco-tourism, agro-forestry and sustainable production of "yerba mate", "palmito" (palm heart), timber, and non-timber forest products. In 50 years, these areas should be managed under land use plans or zoning based on social, environmental, and economic sustainability principles. These land use plans should include native forest protecting the watersheds and biologically important areas, a network of biological corridors, and appropriate economic activities. Within the Sustainable Use

Areas, fine-scale analyses to complete the land use plan may identify additional biological corridors and areas for protection.

In the design of the Sustainable Use Areas, we included areas with a medium potential for conservation index (8 to 16: not high enough to be a Priority Area or a Stepping Stone). We also included as many as possible Stepping Stones of underrepresented landscape units.

We identified four categories of Sustainable Use Areas:

The Main Corridor connects the Core Areas (Figure 35). Main Corridors should ensure the gene flow of umbrella species and thus their population viability. Together with the Core Areas, they constitute the central pieces of the Biodiversity Conservation Landscape. In 50 years, Main Corridors should be managed under a fine-scale landscape design that maintains a minimum of 30% forest cover. New protected areas should be identified and created (Core or Satellite areas) and biological corridors should be established (protected and restored).

Secondary Corridors connect other priority areas with the Main Corridor or Core Areas (Figure 35). The expansion of the Main Corridor through the secondary corridor increases the resilience and representation of the Biodiversity Conservation Landscape**.**

Lateral Expansion of Corridors connects the Stepping Stones that are not on the way to Priority Areas (Figure 35), increasing the diversity of landscapes represented in the corridor.

Potential Corridors: Due to the extreme degree of forest fragmentation, most of the corridors follow rivers, as these areas have a higher conservation potential. However, these corridors may not be viable or sufficient to maintain the gene flow among Core Areas. For this reason we have identified alternative corridors, even though these have lower conservation potential. Similarly, we have identified potential corridors with neighboring ecoregions (Figure 35). The final design of these Potential Corridors will depend on an analysis conducted at a different scale and in coordination with other ecoregions' biodiversity assessments.

It is important to make the distinction between the Corridors we identified in our Biodiversity Conservation Landscape (Main Corridors, Secondary Corridors, etc.), which are actually Sustainable Use Areas, and the biological corridors that have to be implemented within the first ones. Biological corridors are relatively narrow areas of native forest, either natural or restored, that connect Priority Areas for biodiversity conservation to allow the movement of the wildlife and sufficient genetic interchange to maintain viable populations. The final design of biological corridors requires a finer-scale analysis and better knowledge of the biological requirements of umbrella and other key species. The Main Corridors, Secondary Corridors and other categories of Corridors are the areas where the biological corridors will be implemented after finer-scale landscape design. One of our targets (Chapter 6) is to implement a multidisciplinary program, a "Corridor Program", aimed at studying from different perspectives the best ways to implement biological corridors and Sustainable Use Areas surrounding them in order to achieve connectivity among the Priority Areas for Biodiversity Conservation.

Other important areas of the Biodiversity Conservation Landscape

Area Needing a Corridor: The connectivity between the two main sectors (north and south) of the Biodiversity Conservation Landscape is critical for the implementation of this Biodiversity Vision. At this scale of analysis, the area between these two sectors has a very low biodiversity conservation potential index. Even though a project is being implemented in Brazil to create a 50 meter wide corridor (Iguaçu– Itaipú) that connects the two sectors, we can anticipate *a priori* that it will not be sufficient to guarantee adequate connectivity between them. This is because the edge effect along this narrow corridor will be extremely high (see Box 4) and there are no opportunities in the area to greatly increase its width or to create a good buffer zone along the corridor. Only very generalist species (or edge specialists) may make use of this critical corridor. Since we do not have fine-scale information available to design this corridor, we have identified a a broad area where the corridor should be designed and implemented (Figure 35).

Priority River Basin: Finally, we have identified areas that are important for the development of watershed management and conservation programs (Figure 36). River basins where selected based on several criteria: intactness of the basin, presence of protected areas in the basin (both strictly protected areas and Sustainable Use Areas), presence of ongoing conservation initiatives in the river basin, and potential of the river basin for connecting the Upper Paraná Atlantic Forest ecoregion to neighboring ecoregions. In relation to this last criteria, two of these river basins (Iguazú River and Jejuí River), are especially important because they constitute potential connections to the Araucaria ecoregion and the Chaco-Pantanal ecoregion respectively.

The final Biodiversity Conservation Landscape is depicted in Figure 36. The achievement of this conservation landscape within 50 years will ensure that our biodiversity conservation goals are met. This is not a static landscape since small-scale analyses and small-scale landscape designs may slightly modify its final shape. New opportunities for biodiversity conservation may arise in the future that would allow for other areas to be restored and incorporated in this Vision. Monitoring of the actual situation and adaptive management of the priorities represented in this Biodiversity Conservation Landscape are critical to ensure the achievement of our long-term goals of biodiversity conservation. These results will be refined over time as a result of more detailed and ongoing conservation planning, landscape design, and decision-making processes.

Representation of the landscape units in the final Biodiversity Conservation Landscape. We can divide the ecoregion's 18 landscape units into five groups according to their representation in the final Biodiversity Conservation Landscape (Table 6). Eight of the landscape units have no representation in the final Biodiversity Conservation Landscape. These same landscape units have no forest fragment larger than 1,000 ha (six have no fragment larger than 500 ha). The small fragments that remain in these landscape units are very isolated and located in areas of high threats and low opportunities for conservation. Most of the landscape units that have no representation in the final Biodiversity Conservation Landscape are located in the northern part of the ecoregion. They include all the seasonal units (with more than two dry months) and two semi-seasonal ones. These areas are close to the Cerrado Woodlands and Savannas Global 200 Ecoregion, and they probably represent transitional areas with this ecoregion.

A second group is composed of a landscape unit poorly represented by just one isolated area. This is a high altitude, semi-seasonal but flat area. Only 2.8% of this landscape unit is represented in the Biodiversity Conservation Landscape, but not within strictly protected areas.

A third group is represented by five landscape units that have low representation in the strictly protected areas (0.3 - 2.7% of their original area), and Sustainable Use Areas but have good representation in several isolated areas and river basin management areas. The final representation of these landscape units in the Biodiversity Conservation Landscape ranges from 16.0 to 27.6% of their original area.

The fourth group is comprised of three landscape units that have some representation in the Priority Areas (4.0 – 5.1% of their original area) and a good representation in Sustainable Use

Areas (13.7 – 15.5% of their original area). Their final representation in the Biodiversity Conservation Landscape is about 30% of their original area.

Finally, one landscape unit (non-seasonal, low altitude but hilly), has a fairly good representation in Priority Areas (12.5%) and Sustainable Use Areas (12.2%), reaching a 32.5% representation in the final Biodiversity Conservation Landscape.

In sum, even though some landscape units are not represented in the final Biodiversity Conservation Landscape, some others are fairly well represented. As we mentioned before, for this ecoregion, setting as a goal a good representation of all the landscape units is practically impossible. Thus, one of the four conservation goals set at the beginning (representation of all the ecological communities typical of this ecoregion) may not be attained, since many of the landscape units identified in our analysis are not going to be represented in the final Biodiversity Conservation Landscape. However, we strove to attain the best representation possible of all landscape units. Our goal is thus to preserve large forest blocks that are sufficiently resilient and capable of maintaining viable populations of umbrella species and the typical ecological processes that originally characterized the ecoregion. The lack of full representation of all the landscape units in the conservation landscape may preclude to some point attaining the goal of maintaining viable populations of **all** the native species characteristic of the Upper Paraná Atlantic Forest ecoregion. Future field surveys may identify populations of species that are unique to landscape units not represented in the Biodiversity Conservation Landscape. If these species are found we should analyze alternatives for their long-term survival if this is still possible. This may include the possibility of slightly modifying the design of our Biodiversity Conservation Landscape to include representation of the small forest fragments where these species are found.

As a crude lower estimate, an area of at least 525,000 ha is needed to preserve a viable population of jaguars. A larger area of about 750,000 ha is needed to preserve a population of harpy eagles (see Table 2 in Chapter 3). Our final Biodiversity Conservation Landscape has more than 1,200,000 ha in Core Areas of strict protection. However, the minimum area requirement estimates presented above are for areas of continuous forest. Ensuring the connectivity of the Core Areas through the establishment of the Main Corridors is thus critical to achieve the goal of protecting umbrella species. To achieve the Biodiversity Vision, it is also critical to ensure that within 50 years 100% of the Core Areas, as well as a portion of the Priority Areas in other categories, are under effective strict protection. Presently, less than 50% of the 1,200,000 ha of Core Areas are strictly protected and a similar situation occurs in the other categories of Priority Areas (Figure 37). To attain full protection of the priority areas, a minimum of 1,284,100 ha of Strictly Protected Areas must be created and effectively implemented and maintained.

Similarly, to implement this Vision it will be necessary to create and implement more than 4,000,000 ha of Sustainable Use Areas. These areas do not need to have continuous forest, but at least 30% of forest cover is desirable. Especially critical for the implementation of this Vision are the Main Corridors that total more than 1,200,000 ha, of which only about 30% are under Sustainable Use Protection (Figure 38).

To achieve this landscape, besides securing a relatively large portion of the Biodiversity Conservation Landscape under strictly protected areas and sustainable use, the native forest will need to be restored in some areas. We have set as a goal to achieve in 50 years: 100% continuous native forest cover in the Core Areas and other areas under strict protection; at least 70% of forest cover in the Forested Areas with High Potential to Become Strictly Protected Areas; at least 30% forest cover in the corridors and Sustainable Use Areas; and at least 20% forest cover in the watershed management areas (the minimum Brazil's Forest Code requires on private properties in the Atlantic Forest). This means that at least 10% of the Core Areas (more than 100,000 ha) and at least 50% of the Main Corridors will need to be restored. In total, a minimum of at least 2,606,678 ha of native forest needs to be restored to implement this Vision (Figure 39). This is a very ambitious and costly, but potentially feasible goal.

Table 3. Representation in Protected Areas and Remaining Forest Cover in Landscape Units

Landscape Unit	Size		Strictly Protected Area		Sustainable Use Area		Forest Cover	
	Ha	%	Ha	%	Ha	%	Ha	%
Seasonal High Plains	727,025	1.54	0	0	0	0	3,500	0.50
Seasonal High Steep Slopes	604,075	1.28	0	0	0	0	2,300	0.44
Seasonal High Moderate Slopes	726,750	1.54	0	0	0	0	3,400	0.45
Semi-seasonal High Moderate Slopes	190,225	0.40	0	0	0	0	3,375	1.73
Semi-seasonal High Steep Slopes	84,775	0.18	0	0	0	0	1,275	1.36
Seasonal Low Steep Slopes	262,650	0.56	0	0	0	0	1,350	0.55
Seasonal Low Plains	3,051,150	6.48	0	0	0	0	39,600	1.25
Seasonal Low Moderate Slopes	1,439,450	3.05	0	0	0	0	13,000	0.82
Semi-seasonal High Plains	229,125	0.49	0	0	0	0	6,875	3.00
Semi-seasonal Low Plains	2,949,775	6.26	4,650	0.16	376,100	12.75	67,825	2.28
Semi-seasonal Low Moderate Slopes	2,644,875	5.61	17,550	0.66	361,875	13.68	118,575	4.51
Semi-seasonal Low Steep Slopes	1,147,875	2.44	35,675	3.11	94,400	8.22	122,725	10.62
Wet High Moderate Slopes	2,817,725	5.98	8,650	0.31	93,875	3.33	135,400	4.78
Wet High Plains	2,253,350	4.78	9,675	0.43	23,300	1.03	85,300	3.90
Wet High Steep Slopes	5,906,300	12.53	36,750	0.62	90,800	1.54	373,175	6.31
Wet Low Plains	6,609,650	14.03	218,250	3.30	263,725	3.99	445,200	6.70
Wet Low Moderate Slopes	8,082,475	17.15	211,375	2.62	256,000	3.17	862,850	10.63
Wet Low Steep Slopes	7,393,175	15.69	255,375	3.45	614,275	8.31	1,399,050	18.97
Total	47,120,425	100.00	797,950	1.69	2,174,350	4.61	3,684,775	7.82

Table 4. Number of Fragments and Forest Cover (Ha) per Landscape Unit and per Fragment Size Category.

Landscape Unit	25-500ha		500-1,000ha		1,000-10,000ha		10,000-100,000ha		100,000-1,000,000ha		Total	
	#	Ha	#	Ha	#	Ha	#	Ha	#	Ha	#	Ha
Seasonal High Steep Slopes	56	2,300	0	0	0	0	0	0	0	0	56	2,300
Seas. High Moderate Slopes	91	3,400	0	0	0	0	0	0	0	0	91	3,400
Seasonal Low Steep Slopes	27	1,350	0	0	0	0	0	0	0	0	27	1,350
Semi-seas. High Steep Slope	21	1,275	0	0	0	0	0	0	0	0	21	1,275
Semi-seas. High Mod. Slopes	64	3,375	0	0	0	0	0	0	0	0	64	3,375
Seasonal High Plains	58	3,500	0	0	0	0	0	0	0	0	58	3,500
Seas. Low Moderate Slopes	222	12,325	1	675	0	0	0	0	0	0	223	13,000
Seasonal Low Plains	637	34,925	8	4,675	0	0	0	0	0	0	645	39,600
Semi-seasonal High Plains	95	4,600	0	0	1	2,275	0	0	0	0	96	6,875
Semi-seasonal Low Plains	590	39,450	19	12,825	8	15,550	0	0	0	0	617	67,825
Wet High Plains	982	51,450	4	2,625	8	12,125	1	19,100	0	0	995	85,300
Wet High Moderate Slopes	1,224	44,325	8	16,200	6	37,775	1	20.275	0	0	1,239	118,575
Semi-seas. Low Mod. Slopes	564	60,100	24	5,400	16	14,000	1	55,900	0	0	605	135,400
Semi-seas. Low Steep Slopes	278	21,425	9	5,900	8	29,725	4	65,675	0	0	299	122,725
Wet High Steep Slopes	3,623	116,000	27	41,925	21	114,975	1	71,050	1	101,250	3,673	445,200
Wet Low Plains	1,481	188,825	62	17,350	48	46,325	2	18,175	1	102,500	1,594	373,175
Wet Low Moderate Slopes	2,495	191,750	79	53,500	96	247,525	6	115,875	1	254,200	2,677	862,850
Wet Low Steep Slopes	3,603	224,475	67	45,725	76	198,575	11	244,050	1	686,225	3,758	1,399,050
Total	16,111	1,004,850	308	206,800	288	718,850	27	610,100	4	1,144,175	16,738	3,684,775

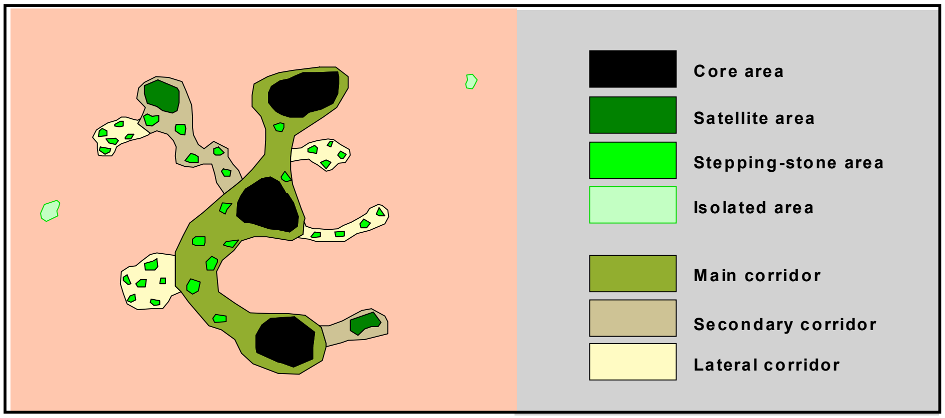
Table 5. Representation of Landscape Units in the Priority Areas

Landscape Unit	Ha	% of landscape unit area
Seasonal High Plains	0	0.0
Seasonal High Steep Slopes	0	0.0
Seasonal High Moderate Slopes	0	0.0
Seasonal Low Steep Slopes	0	0.0
Semi-seasonal High Moderate Slopes	0	0.0
Semi-seasonal High Steep Slopes	0	0.0
Seasonal Low Plains	0	0.0
Seasonal Low Moderate Slopes	0	0.0
Semi-seasonal High Plains	0	0.0
Semi-seasonal Low Plains	8,900	0.3
Semi-seasonal Low Moderate Slopes	25,200	1.0
Wet High Plains	27,725	1.2
Wet High Steep Slopes	134,950	2.3
Wet High Moderate Slopes	76,875	2.7
Wet Low Plains	263,500	4.0
Semi-seasonal Low Steep Slopes	45,175	4.0
Wet Low Moderate Slopes	411,250	5.1
Wet Low Steep Slopes	953,850	12.9

Table 6. Representation of Landscape Units in Final Biodiversity Conservation Landscape

Landscape unit	Priority Area		Sustainable Use Area		Isolated Area		Priority River Basin		Conservation Landscape	
	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%
Seasonal High Plains	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Seasonal High Steep Slopes	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Seasonal High Moderate Slopes	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Seasonal Low Plains	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Seasonal Low Moderate Slopes	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Seasonal Low Steep Slopes	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Semi-seas. High Moder. Slopes	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Semi-seas. High Steep Slopes	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Semi-seasonal High Plains	0	0.0	0	0.0	6,450	2.8	0	0.0	6,450	2.8
Wet High Plains	27,725	1.2	36,125	1.6	14,650	0.7	281,400	12.5	359,900	16.0
Wet High Moderate Slopes	76,875	2.7	78,400	2.8	14,500	0.5	341,200	12.1	510,975	18.1
Semi-seasonal Low Plains	8,900	0.3	193,925	6.6	19,750	0.7	338,450	11.5	561,025	19.0
Wet High Steep Slopes	134,950	2.3	132,950	2.3	112,425	1.9	809,600	13.7	1,189,925	20.2
Semi-seas. Low Moder. Slopes	25,200	1.0	187,300	7.1	52,450	2.0	464,100	17.6	729,050	27.6
Wet Low Moderate Slopes	411,250	5.1	1,249,825	15.5	29,900	0.4	612,125	7.6	2,303,100	28.5
Wet Low Plains	263,500	4.0	908,000	13.7	49,925	0.8	764,925	11.6	1,986,350	30.1
Semi-seas. Low Steep Slopes	45,175	4.0	162,400	14.2	40,850	3.6	126,125	11.0	374,550	32.6
Wet Low Steep Slopes	953,850	12.9	900,450	12.2	175,450	2.4	374,300	5.1	2,404,050	32.5

Figure 32. Illustration of *Concept* of Categories of Areas Included in the Biodiversity Conservation Landscape



Note: Not part of the actual Biodiversity Conservation Landscape

Figure 33. Core Areas

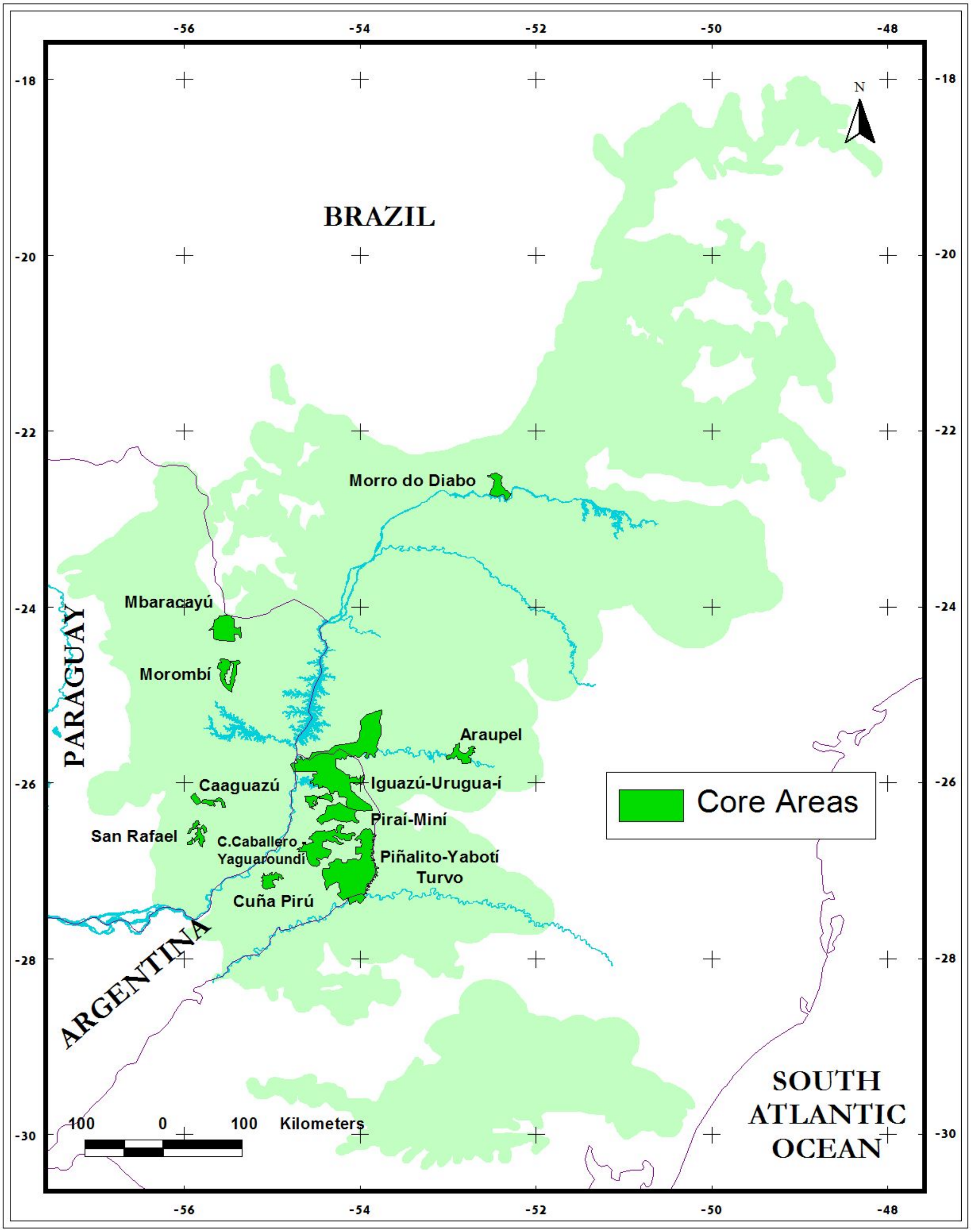


Figure 34. Priority Areas

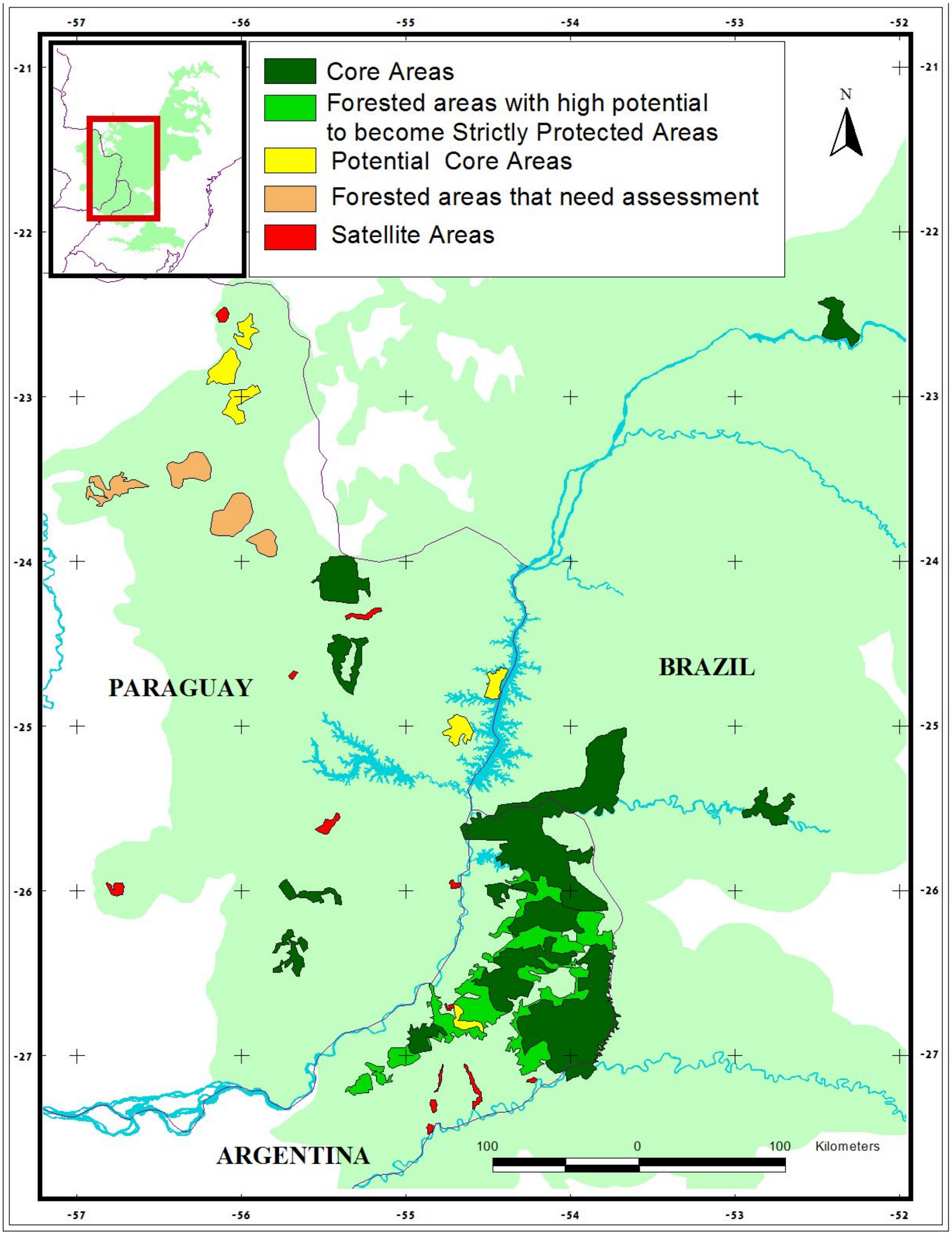


Figure 35. Sustainable Use Areas Connecting the Priority Areas

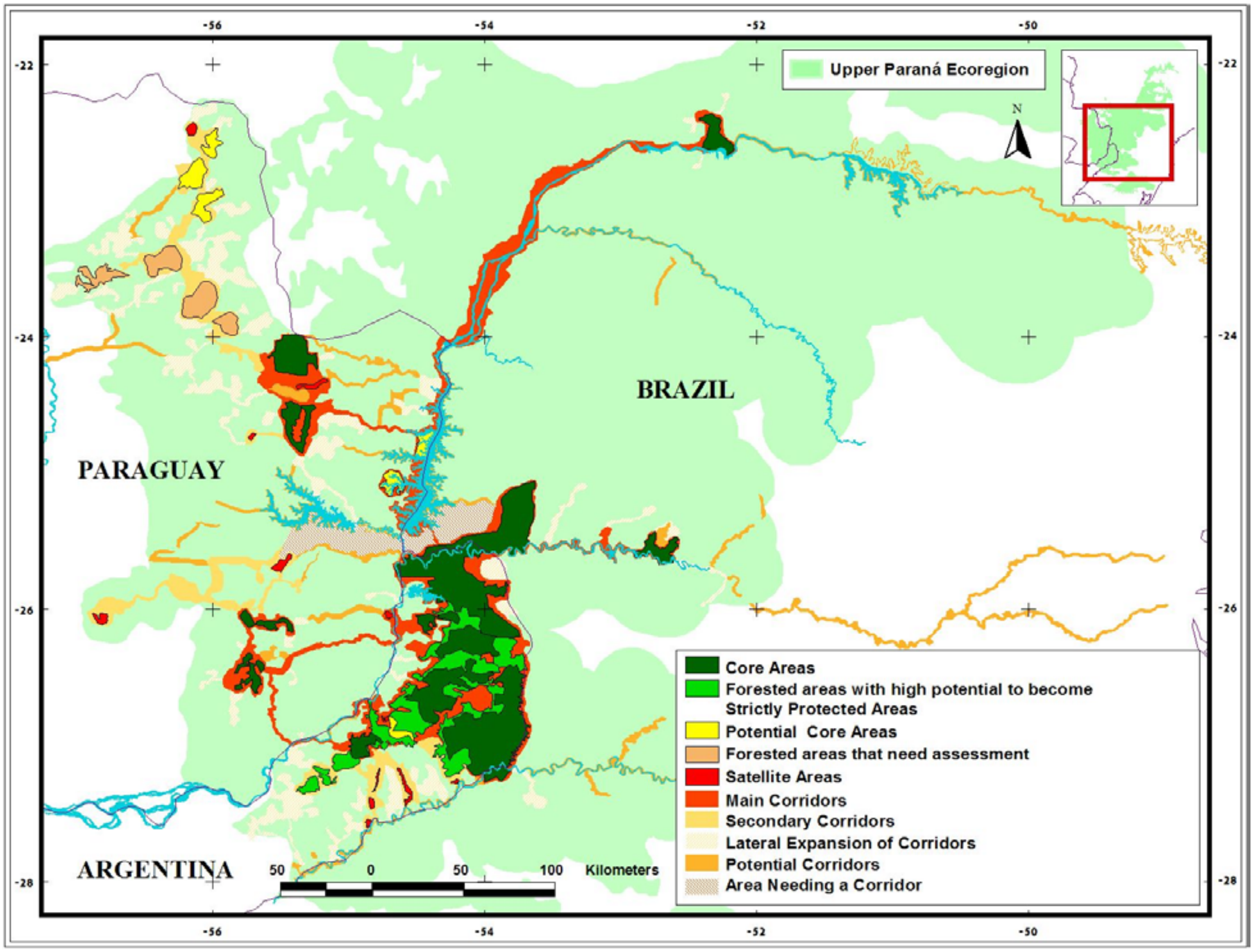


Figure 36. Biodiversity Conservation Landscape

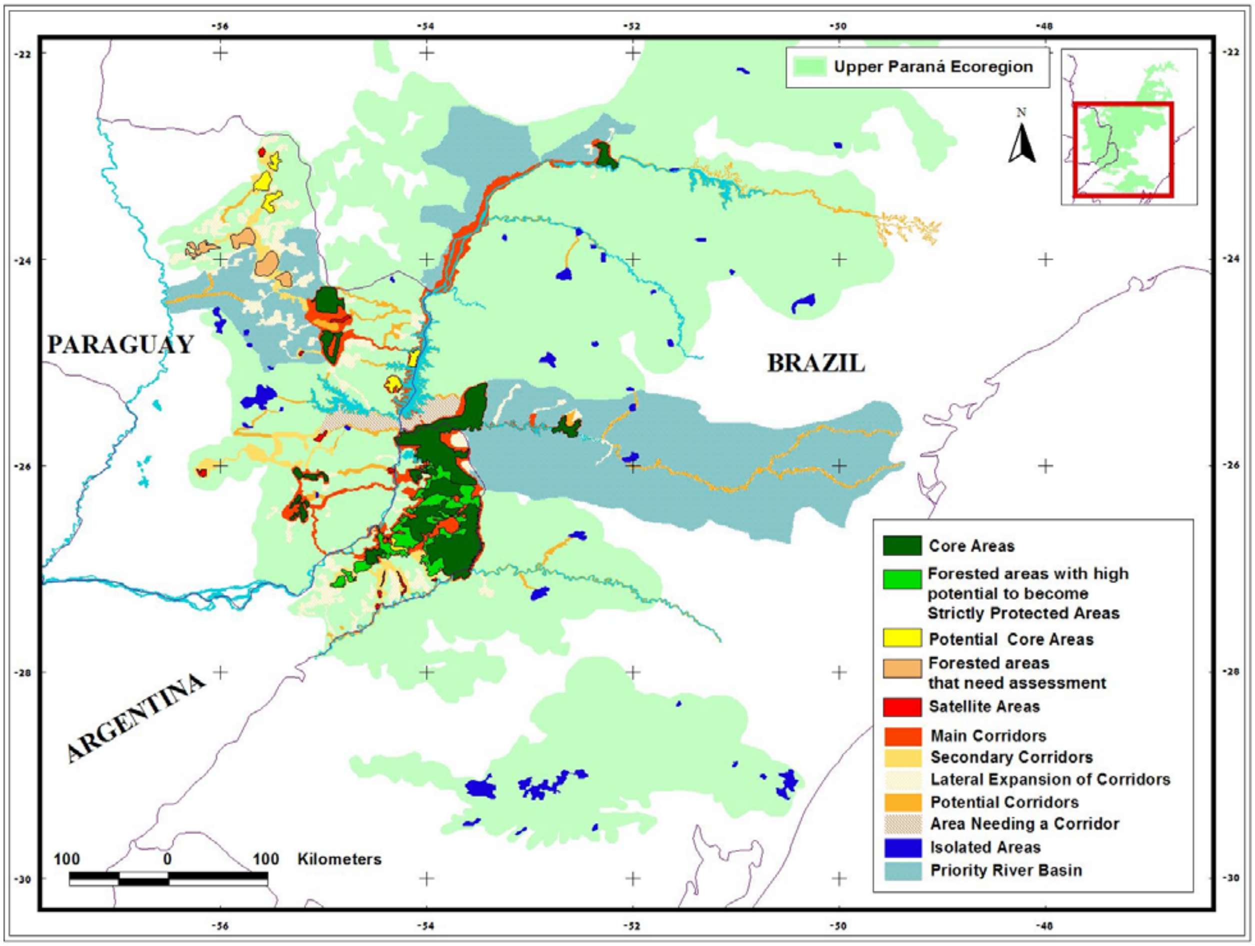
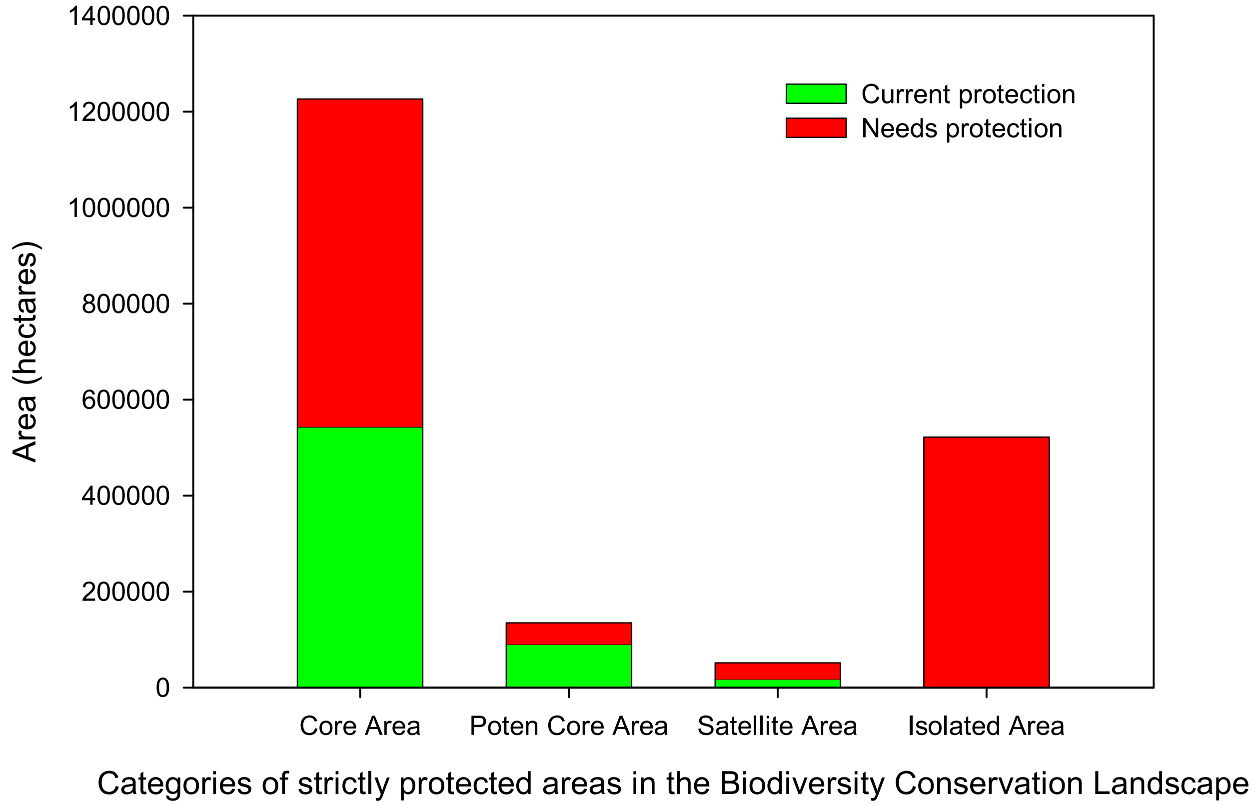
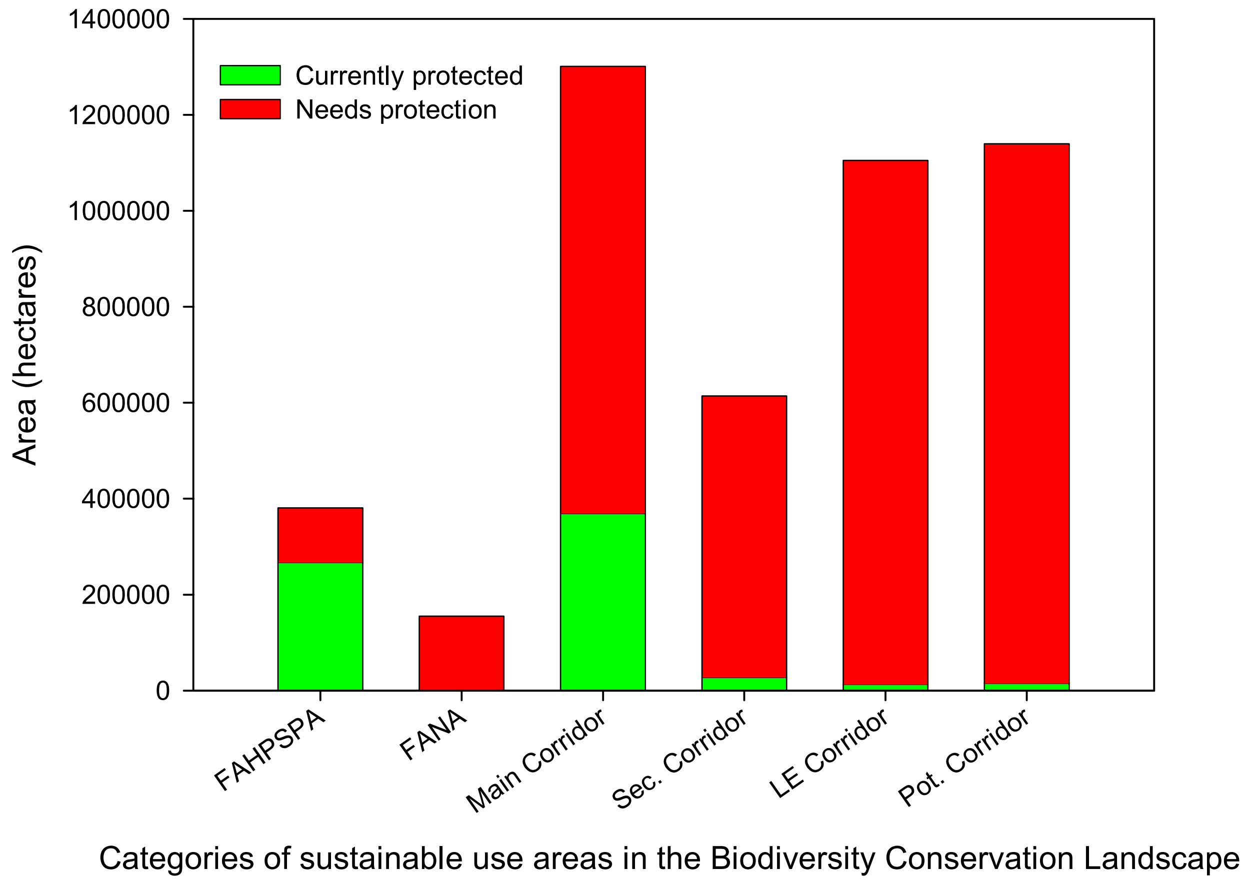


Figure 37. Area Under Strict Protection (present and future) in the Biodiversity Conservation Landscape



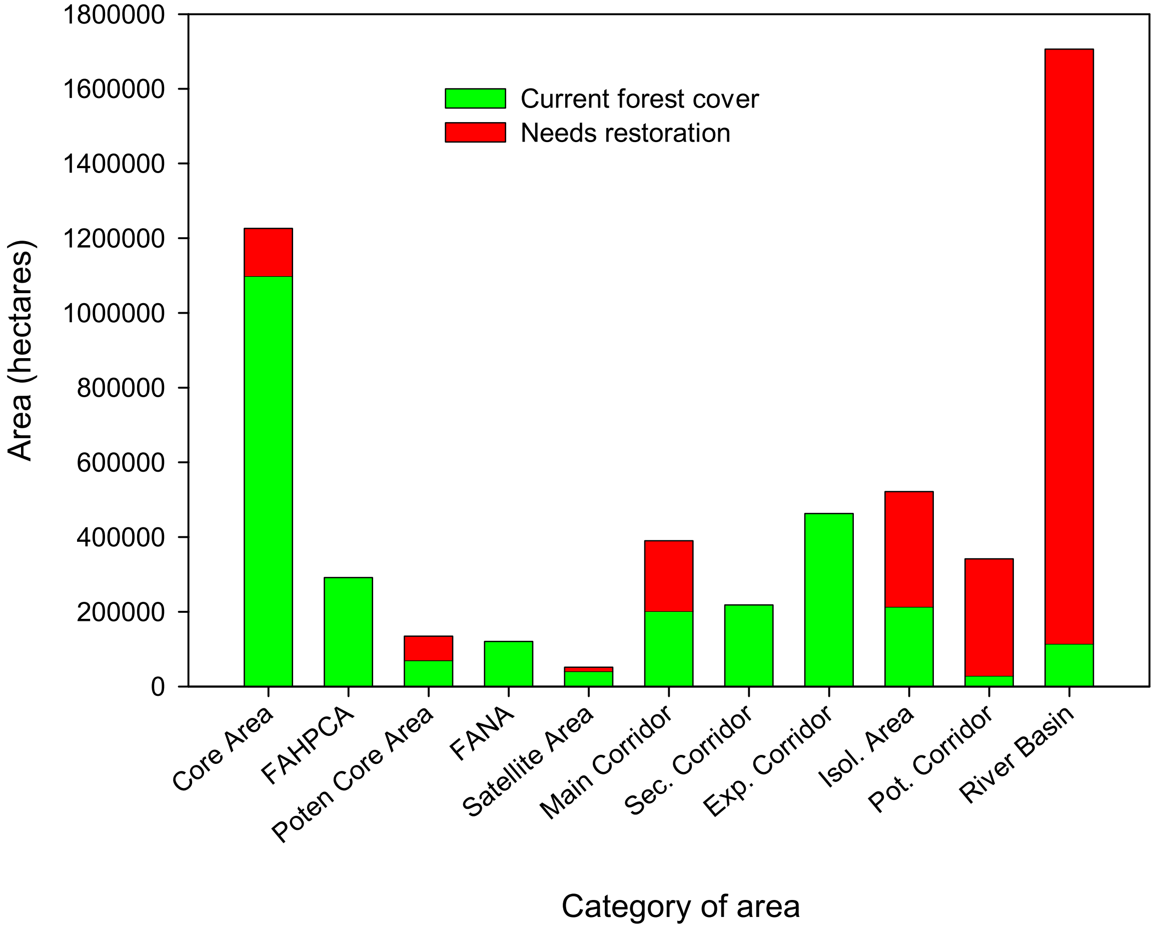
Minimum Total Indirect Use Protected Area to be created: 1,284,100 hectares.

Figure 38. Area Under Sustainable Use Areas



Sustainable Use Area to be created: 4,003,300 hectares.
The first two categories (Forested Areas with High Potential to Become Strictly Protected Areas (FAHPSPA) and the Forested Areas that Need Assessment (FANA) corespond to areas that may eventually be included (at least part of them) in the category of strictly protected areas.

Figure 39. Forest Cover in Units of the Biodiversity Conservation Landscape



Minimum Total Area to be restored: 2,606,678 hectares.

Chapter 6

Setting priorities for conservation action – Conservation Targets

Defining the Biodiversity Conservation Landscape is just the beginning. The implementation of this Biodiversity Conservation Landscape will require a series of actions at different time frames and spatial scales. Since no one organization can achieve results at the large scales required to implement this Vision, actions must be coordinated among governmental and non-governmental organizations of a variety of sectors in Brazil, Paraguay, and Argentina. Achieving this Vision will require governments to incorporate it into their regional development programs and policies.

This Biodiversity Vision document should serve as a guide for all to prioritize actions. In this chapter we identify a series of targets and milestones critical for the implementation of this Vision. However, these targets, milestones, and time frames will need to be under constant review and adaptation as implementation proceeds. Partners and stakeholders must discuss and define clear roles for the implementation of this Vision and develop processes for coordinating and monitoring progress as well as adapting the actions and goals. The next step is to develop an Ecoregion Action Plan identifying specific targets and milestones together with realistic time frames for achieving them as well as indicators of success. New strategies must be developed to identify and involve additional stakeholders and to generate the incremental funding needed to support this new scale of urgent actions. However, conservation action in the Atlantic Forest cannot wait for the perfect plan.

Thus, this chapter outlines general targets and milestones that clearly emerge from the Biodiversity Conservation Landscape, and from our analysis of threats and opportunities, to serve as a starting point for all institutions to prioritize specific immediate actions. We have identified a series of targets for the next three years (to be implemented by the end of 2005), for the next seven years (by the end of 2010), and for the next 43 years (by 2050). The targets are essential to achieve the entire Biodiversity Conservation Landscape (Figure 36). The milestones are priority steps toward achieving the targets. Some milestones are specific to certain portions of the Biodiversity Conservation Landscape or to one or two countries.

Target 1:
All existing strictly protected areas (IUCN protected area categories I-III), effectively managed by 2010 (48 areas totaling 791,775 ha).

These protected areas, both private and public, are located in *Core Areas*, *Potential Core Areas,* and *Satellite Areas* (Figures 9a & 9b; Table 1). Of the 48 existing target areas, 21 areas totaling 197,155 ha are in Paraguay; 4 areas totaling 317,628 ha are in Brazil, and 23 areas totaling 224,816 ha are in Argentina. The status of implementation for these areas currently ranges from relatively well managed to public "paper" parks with land tenure problems and no government presence. As new strictly protected areas are created (see Target 2) this target will increase to a total of 1,284,100 ha under effective management—100% of core areas (1,226,175 ha) plus a portion of the Priority Areas of other categories (*Potential Core Areas, Satellite Areas, Isolated Areas).*

Milestones:
For each protected area:
1. Demarcation and land tenure resolved.
2. Management plan developed and implemented that integrates the protected area into the Biodiversity Conservation Landscape and addresses external and internal threats.
3. Effective law enforcement in place.
4. Effective management of buffer zone in place.
5. Management committee established and local community support for the protected area achieved.
6. Sustained funding secured to support long-term management and enforcement.

For the protected area systems:
1. A baseline evaluation of the implementation of these protected areas completed by 2005.
2. A system in place for long-term monitoring of effective implementation of these protected areas by 2005.
3. Institutional and individual capacity developed to implement target protected areas (private and public) by 2010.
4. At least one mechanism developed in each of the three countries to provide sustained funding for maintenance of target public and/or private protected areas by 2005.
   - Potential mechanisms include the Green Corridor government fund in Argentina, the Private Fund to support the Green Corridor (FONPAC) in Argentina, a national environment fund in Paraguay, water usage taxes in Brazil, other ecological service payments, tourism fees.

Target 2:
New protected areas created and some existing ones expanded to ensure that 1,934,200 ha of forest are under strict protection (IUCN protected area categories I-III) by 2053.

The target of total protected areas includes 100% of the *Core Areas* (13 areas totaling 1,226,175 ha-see Figure 33), plus 708,025 ha of Priority Areas in three other categories - *Potential Core Areas, Satellite Areas, Isolated Areas* - See Figure 34. If protection is determined to be a feasible option for *Forest*ed *Areas Needing Assessment* and *Forested Areas with High Potential to Become Strictly Protected Areas*, then protection of these categories of priority areas could also contribute to this target. Currently less than 50% of the Core Areas are under strict protection, and a similar situation exists for the other categories of Priority Areas (Figure 37). The current area under strict protection must be increased by a total of 1,284,100 ha to achieve this target. Types of potential protection mechanisms include private and public reserves, conservation easements, conservation concessions, environmental services payments, and implementation of forest laws.

Milestones:
1. For all *Forest Areas Needing Assessment* (Figure 37), stop deforestation by 2004, complete assessments of forest cover and determine potential to become *Core Areas* by 2005; create new areas under strict protection as indicated in the assessment by 2010.
   - These areas are all located in Paraguay, in the area of highest deforestation rate. None of these forest areas is currently under any type of protection.

2. For all *Core Areas* (Figure 33), 13 areas, 1,226,175 ha, complete a fine-scale landscape design identifying targets for additional protected areas by 2005. Create 683,475 ha of new protected areas by 2010.
3. For each *Potential Core Area* (Figure 34), complete an evaluation of its potential to become a *Core Area* by 2004. For areas where potential to become a *Core Area* is confirmed, complete a landscape design identifying targets for additional protected areas and restoration needed (to expand forest fragments to 10,000 ha) by 2005.
   - These areas are located in Paraguay and Argentina.
4. For *Forested Areas with High Potential to Become Strictly Protected Areas* (Figure 34), complete a fine-scale landscape design identifying target areas for protection by 2005.
   - These areas are all located in the Misiones Green Corridor in Argentina.
5. Identify opportunities for protection of *Satellite Areas* and *Isolated Areas* (Figure 34) by 2010.
6. Develop three mechanisms to provide incremental funding for acquisition and establishment of public and private areas under strict protection (IUCN categories I – III) by 2005.
7. At least two demonstration projects underway by 2005 to test the effectiveness of economic incentives for creation and maintenance of private or public protected areas in priority areas: Clean Development Mechanisms (carbon sequestration – appropriate for *Potential Core Areas* that need restoration), water usage taxes for watershed protection, conservation concessions, conservation leasing, other ecological service payments, ICMS Ecológico in Brazil, ecotourism, and others.
8. At least one improved legal tool for private reserves and private forest protection developed in each of the three countries by 2005.
9. At least six initiatives underway to provide additional incentives for private land protection by 2005.

Target 3:
***Sustainable Use Areas* (IUCN protected area categories IV-VI) totaling 4,003,300 ha created and effectively implemented to maintain 30% forest cover by 2010.**

Currently, 16 *Sustainable Use Areas* totaling 1,413,991 ha (2 areas totaling 74,710 ha in Paraguay, 4 areas totaling 380,306 ha in Brazil, and 10 areas totaling 958,975 ha in Argentina) have been created (Figures 9a and 9b; Table 1). None of these areas has yet been zoned. This target will require the creation of 2,589,309 ha of new Sustainable Use Areas. Categories of *Sustainable Use Areas* include: *Main Corridors*, *Secondary Corridors*, *Lateral Expansion Corridors*, *Potential Corridors* (Figures 35 and 38). The two categories of areas needing further assessment (*Forested Areas with High Potential to Become Strictly Protected Areas* and *Forested Areas Needing Assessments*) may eventually be included as *Sustainable Use Areas* as well. Especially critical are the *Main Corridors* that total more than 1,300,000 ha, of which only about 30% are currently under sustainable use protection.

Milestones:
1. An ecoregional "Corridor Program" developed and underway by 2005 with an interdisciplinary team doing research, design, and monitoring of corridors, studying legal mechanisms, implementing policies, consulting with local residents, etc.
2. Create 930,000 ha of new Sustainable Use Areas in the *Main Corridors* by 2010, thus assuring that 100% of the Main Corridors are under sustainable use protection.

3. Landscape designs underway in all Main Corridors (1,200,000 ha) by 2005, and completed by 2010.
4. Management of at least one pilot area of the Main Corridors according to landscape designs maintaining 30% forest cover, begun by 2005.
5. Implement Misiones Green Corridor Law by 2010.
6. At least five alternative economic activities or environmentally sustainable agricultural practices identified (i.e., ecotourism, palmito, yerba mate cultivated under forest cover, sustainably-managed production forests, forest and non-timber forest product certification under FSC, best practices of soy production), viability studies completed, and initiatives developed to positively impact maintenance of forest cover in the *Main Corridors* by 2005.
7. At least one policy action planned and promoted to reduce perverse incentives and create positive incentives for forest conservation in each of the three countries by 2005.
8. Increased capacity of agricultural technicians in environmentally friendly practices.
9. GIS capacity of municipal level institutions developed to promote, facilitate, coordinate, and monitor fine scale landscape designs in the Main Corridors by 2010.
10. The *Forested Areas with High Potential to Become Strictly Protected Areas* managed (totaling 380,000 ha, all in the Misiones Green Corridor of Argentina) according to landscape designs (land use plans) that maintain 70% forest cover by 2010.

Target 4:
Restore 2,606,678 ha of native forest in the Biodiversity Conservation Landscape by 2050.

This target would ensure our goal of 100% continuous native forest cover in the *Core Areas* and all areas under strict protection, 70% forest cover in the *Forested Areas with High Potential to Become Strictly Protected Areas*, at least 30% forest cover in the *Sustainable Use Areas*, and at least 20% forest cover in the W*atershed Management Areas*. This means that at least 10% of the *Core Areas* (more than 100,000 ha) and at least 50% of the *Main Corridors* must be restored (Figures 36 and 39).

<u>Milestones</u>:
1. A pilot Clean Development Mechanism (carbon sequestration) project developed for marketing by 2005, and generating long-term funds for restoration and maintenance of carbon sink forest by 2010.
2. The most efficient restoration techniques developed for each situation by 2007.
3. Restoration to achieve 30% forest cover of the *Main Corridors* (connecting Core Areas) underway between the northern and southern portions of the Tri-national Biodiversity Corridor by 2010, including:
   - Fine-scale design of biological corridors and stepping stones based on biological data analyses, opportunities, threats, and cost-benefit analysis
   - Stakeholder participation in the design
   - Initiatives underway to ensure protection and/or restoration of forest cover in biological corridors and stepping-stones.
4. Forest Landscape Restoration Pilot Project underway in the Capanema-Andresito area of the Iguaçu/Iguazú River Basin and Main Corridor by 2005.
5. Forest landscape restoration underway on the borders of Potential Core Areas (all in Paraguay and Argentina) to expand the forest to 10,000 ha (after subtracting a 500 m edge) by 2010.
6. Initiatives underway to restore 100,000 ha of *Core Areas* by 2010.

7. A strategy developed for restoration of the *Iguassu River Basin* (Brazil & Argentina) to 20% forest cover and implementation initiated by 2010.
8. A strategy developed for restoration of the *Jejui River Basin* (Paraguay) to 20% forest cover and implementation initiated by 2010.
9. A strategy for restoration of the Ilhas & Varzeas do Rio Paraná A.P.A. portion of the *Upper Paraná River Basin* (Brazil and Paraguay) to 20% forest cover and implementation developed and initiated by 2010.

Target 5:
Long-term public support and participation in conservation of the Biodiversity Conservation Landscape

Milestones:
1. Development of private and government financial mechanisms in all three countries to provide long-term funding for conservation in the ecoregion by 2005.
2. Development of mechanisms to identify and involve additional stakeholders by 2005.
3. Involve stakeholders in all landscape planning activities.
4. Political recognition of the Biodiversity Conservation Landscape by the governments of the three countries by 2005.
5. Increased public awareness of the value of the Upper Paraná Atlantic Forest and the need to implement the Biodiversity Conservation Landscape by 2005.
6. Stakeholders, including government development initiatives, incorporating Biodiversity Vision targets into their programs by 2005.
7. Permanent environmental education programs in all three countries targeting empowerment of community actions for the implementation of the Biodiversity Conservation Landscape initiated by 2005.
8. Tri-national Forum strengthened for developing dialogue, consensus on strategies, coordination of actions, and sharing of experiences among stakeholders of the three countries
9. Increased local technical capacity, creating a critical mass of professionals conducting applied conservation research and conservation programs by 2010.
10. Community participation resulting in improved law enforcement to achieve a significant reduction by 2005 of:
    - illegal logging and illegal trade of forest products
    - illegal hunting and illegal wildlife trade.

Target 6:
A permanent system of monitoring and adaptive management of the Biodiversity Conservation Landscape and Action Program in place by 2010.

Milestones:
1. Conservation, research, and monitoring program for populations of umbrella species (jaguars, white-lipped peccaries, tapirs) underway by 2005.
2. Systems in place by 2005 for long-term monitoring of:
    - Forest cover and land use, using compatible methodologies in all three countries
    - Illegal hunting and illegal wildlife trade
    - Presence of exotic species and their impact on biodiversity

- Effective implementation of protected areas
- Effectiveness of public policies.

3. Mechanisms functioning for coordination of efforts among institutions within and across country borders, including periodic review and adjustment of goals and strategies by 2005.
4. Mechanisms in place for coordination of protected area management and law enforcement activities among different governmental agencies within and among the three countries by 2005.
5. Field surveys conducted to test the validity of the landscape units identified in the Biodiversity Conservation Landscape by 2010.
6. In order to maintain genetic variability, field surveys conducted to assess if there are species, communities, or populations unique to the landscape units (particularly in the extreme north and extreme south of the ecoregion) not represented in the Biodiversity Conservation Landscape by 2010. If there are, and these species do not require large areas (for example, small vertebrate species), evaluate the viability of incorporating these landscape units into the Biodiversity Conservation Landscape by 2010.

From Vision to Action – implementing an Ecoregion Action Plan

With this Biodiversity Vision as a guide, WWF and local partners need to each transform short-term actions already underway to an *Ecoregion Action Plan* that lays out specific targets over the short-term (1-5 years) and medium-term (10-15 years). This Plan should clearly identify threat mitigation strategies, and focus on clear targets for conservation achievement as well as on the roles of partner institutions, long-term financing possibilities, structures for effective governance, communication and campaign activities, and capacity building. These clear targets are essential to guiding, focusing, and monitoring progress. Together with this inspiring Vision, the clear targets and transparent reporting of achievements are necessary to build the commitment and ownership by partners for continued and active engagement. Embedded in the crafting of an Ecoregion Action Plan is the need for flexibility. As more information is collected and actions are monitored, the Plan can be easily updated and allow for sound judgment when a change of course or tactic is necessary. In addition to helping the ecoregion action programs organize their strategic efforts in an ecoregion, the Plan has other benefits. The Ecoregion Action Plan can help openly articulate the biodiversity agenda, and can help leaders recognize the importance of this agenda among other national and international priorities. It is clear that appropriate institutional development of partners is necessary to strengthen advocacy on a variety of levels. Since Brazil, Argentina, and Paraguay are all (to varying degrees) recently emerging democracies, this capacity building overlaps significantly with the development of active participation in government and taking an active role as citizens.

Implementation may take place at levels below the ecoregional scale, or outside the ecoregion, depending on the issue involved. A threat analysis is an essential filter for determining at what scale and timeframe we should act. All conservation activities must be conceived and implemented in relation to the social and political realities in which they take place. In the Upper Paraná Atlantic Forest ecoregion, these realities are different in each of the three countries and even in different regions of the same country. Most of the actions will be implemented on a national or regional level within each country. However, strategic planning, monitoring of the threats and conservation results, and necessary adjustments must be conducted at an ecoregional scale.

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Appendix 1

UPPER PARANÁ ATLANTIC FOREST

ECOREGION ACTION PLAN
and
WWF TARGET DRIVEN PROGRAMS

The Upper Paraná Atlantic Forest Ecoregion Biodiversity Vision (Biodiversity Landscape Design and Conservation Targets) prioritizes actions that will contribute significantly to the achievement of targets for two WWF Global Target Driven Programs (TDPs) – *Forests for Life* and the *Living Waters Campaign*. The following is a list of the relevant TDP targets with explanations of how the Upper Paraná Atlantic Forest Ecoregion Action Plan relates to them.

Forests for Life

Target 1: (Protect)
The establishment and maintenance of viable representative networks of protected areas in the world's threatened and most biologically significant forest regions, by 2010

Milestones**:**
The completion of a gap and threat analyses for all focal forest ecoregions by 2002

Gap and threat analyses were conducted as part of the development of the Biodiversity Vision for this ecoregion.

Identification and mapping of target Protected Area sites to enhance representation of Protected Area systems in focal forest ecoregions by 2004

The Biodiversity Vision includes a Biodiversity Conservation Landscape designed to increase the representation of biodiversity under protection as well as to protect forest blocks large enough to be resilient and capable of maintaining viable populations of umbrella species and healthy ecological processes. The Ecoregion Action Plan targets the fine-scale landscape design of Core Areas and corridors to identify specific sites for the creation of new protected areas.

Management improved in 50 million ha of existing forest Protected Areas by 2005

The Ecoregion Action Plan targets:

- Improved management of 791,775 ha of existing strictly protected areas (IUCN Categories I-III) by 2010.
- Improved management of 1,413,991 ha of existing Sustainable Use Areas (IUCN Categories IV-VI) by 2010.

50 million ha of new forest Protected Areas created in focal forest ecoregions by 2005

The Ecoregion Action Plan targets:

- Creation of 728,025 ha of new strictly protected areas (in Core Areas and Potential Core Areas) by 2010.
- Creation of 2,589,309 ha of new Sustainable Use Areas by 2050.

Target 2: (Manage)
100 million ha of certified forests by 2005, distributed in a balanced manner among regions, forest types, and land tenure regimes.

Milestones**:**
New working groups or national standards recognized by FSC in at least 20 countries by 2004.
The Ecoregion Action Plan targets viability studies and initiatives developed for forest certification under FSC as an alternative economic activity targeting critical areas of the Biodiversity Conservation Landscape by 2010. Brazil already has a national working group as well as national standards established for Atlantic Forest non-timber forest products, viability studies are currently underway for Paraguay, and a national FSC working group was recently established in Argentina.
High Conservation Value Forests national protocols in place in at least 20 countries by 2005
Argentina has established a commission to develop standards for the Atlantic Forest and Brazil has recently established standards for the Atlantic Forest. Our Ecoregion Action Plan targets this for Paraguay, aiming to reduce the rate of Atlantic Forest conversion to soybean cultivation.
Community forest management protocols in place in at least 20 countries that can lead to, or maintain, community forest certification by 2005
We are evaluating the economic and biological viability of community forest management for Sustainable Use Areas in Paraguay.

Target 3: (Restore)
By 2005, at least 20 forest landscape restoration initiatives underway in the world's threatened, deforested or degraded forest regions to enhance ecological integrity and human well-being.

Milestones**:**
A gap and threat analysis of priority conservation landscapes in all focal forest ecoregions by 2002.
The Biodiversity Vision includes gap and threat analyses**.**
Socioeconomic and ecological criteria and indicators for tracking progress with forest landscape restoration developed by 2002
We are developing ecological indicators as a part of the process to develop a monitoring mechanism for the Biodiversity Vision.
At least 10 forest landscape restoration initiatives underway in the world's threatened, deforested or degraded forest regions by 2003
Over the next 50 years, the Biodiversity Conservation Landscape identifies 2,606,678 ha requiring native forest restoration. We plan to have a Forest Landscape Restoration Plot Project underway in the Capanema-Andresito area of the *Iguaçu/Iguazú River Basin and Main Corridor* by 2005. Funding proposals have already been developed in 2003. The project could begin as soon as funding is obtained.
The elimination of at least one economic, financial and/or policy incentive that contributes to forest loss and/or degradation by 2004
We are working to establish effective enforcement of the forest law in Paraguay by 2005. In addition, we are working to establish economic incentives to soy producers in Paraguay and

Brazil and wood producers in Argentina to reduce the rate of native forest conversion and to encourage native forest restoration according to our Biodiversity Landscape Design.

Living Waters

Target 1: (Water Infrastructure Development)
Ecological processes are maintained or restored in at least 50 large catchment areas of high biodiversity importance by 2010

Milestones***:***
1. Sustainable water or river basin management initiatives that promote conservation and restoration of ecological processes of high priority freshwater ecosystems are adopted by 2004 in at least 10 countries or international processes.

Our Ecoregion Action Plan includes the development of a conservation strategy to maintain ecological processes (watershed; catchment) for three watersheds: the Iguassu River Basin (Brazil and Argentina), the Jejui River Basin (Paraguay), and the Ilhas & Varzeas do Rio Paraná APA portion of the Upper Paraná River Basin (Brazil and Paraguay). These river basins are included in the Upper Paraná Global 200 Freshwater Ecoregion as well as the terrestrial Upper Paraná Atlantic Forest ecoregion.

The Conservation Landscape Design calls for the fine-scale design and implementation of biological forest corridors along rivers and streams in these watersheds to connect *Core Areas* both surrounded by *Sustainable Use Areas* to maintain a minimum forest cover of 20% to maintain ecological processes (watersheds; catchments). To achieve these fine-scale landscape designs, we will need to develop and implement social and legal mechanisms to ensure effective participatory management.

By 2004 work is underway at key locations that results in cessation or reorientation to of at least 10 water infrastructure developments that threaten high priority freshwater ecosystems by 2007.

Although systematic data on hydroelectric initiatives planned for the Upper Paraná Atlantic Forest ecoregion was not available for our Biodiversity Vision analysis, we know that there are a significant number of dam projects under consideration for all three countries, mainly to supply electricity to the heavily-populated Rio de Janeiro - São Paulo region. We intend to monitor the plans for and construction of these new dams to minimize the threat they pose to both terrestrial and freshwater biodiversity. We view the existing dams in the region as potential opportunities to join watershed and biodiversity conservation efforts. The Itaipú Binational Dam (Paraguay and Brazil) is the largest in the world. We are establishing a technical partnership with Itaipú for implementation of the Biodiversity Vision in the dam's area of influence—right in the heart of the Biodiversity Conservation Landscape.