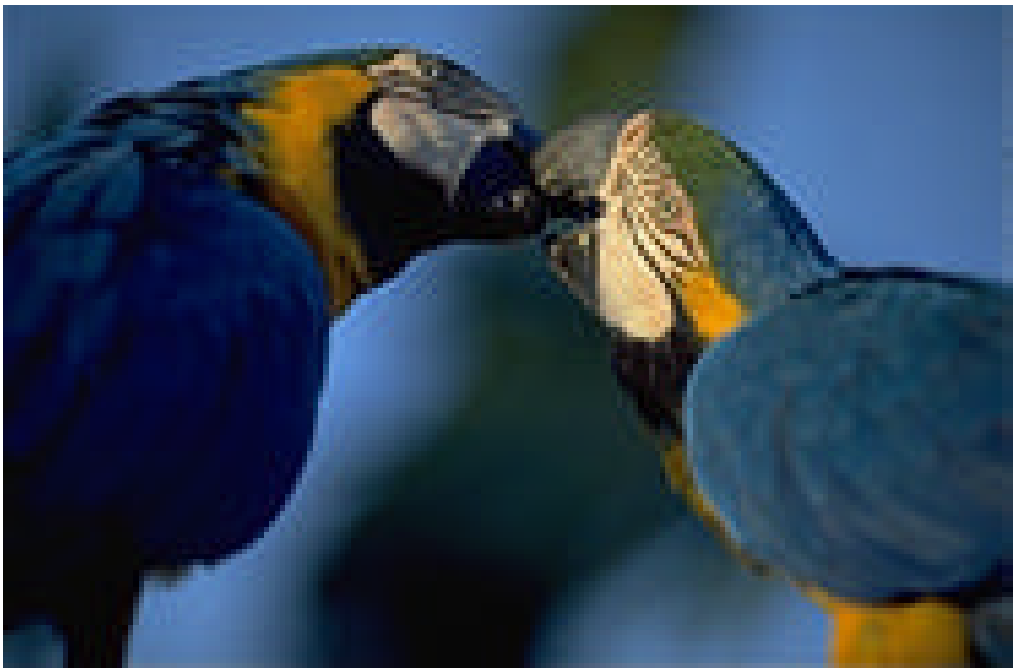


# Chapter I
# Brazilian Biodiversity

The nation with the richest biodiversity in the world, Brazil was the first signatory of the Convention on Biological Diversity - CBD, and has been endeavouring to fulfil the committments involved, after playing a decisive part in its negotiation, adoption, and approval during and after the Conference on Environment and Development - UNCED, held in Rio de Janeiro in June 1992. Fulfilling this objective requires vision and action on numerous fronts to tackle the complex biodiversity issues covered by the CBD:

I. Considering biodiversity in all its different forms;

II. Planning for conservation of biological diversity, the sustainable use of its components and a fair and equitable sharing of the benefits derived from the use of genetic resources;

III. Considering options for the management of biological diversity; and

IV. Considering the principal means to promote the rational use and management of biological diversity.

It is important to remember, however, that different levels of responsibilities and interests exist between the countries which are sources of, and conserve, biological diversity (Brazil and other tropical countries) and the nations that are principally users of such biodiversity (the industrialised countries, consumers of the products of biodiversity and of genetic resources for their biotechnological development). The latter are concerned with high rates of extinction and the erosion of biodiversity, and are proposing measures according to their specific interests. The source countries, on the other hand, have legitimate concerns in increasing their economic returns from the use of their biological heritage in order to improve the quality of life for their people as well as to offset the costs involved in its conservation.

It was precisely this divergence of interests that, for the first time in the history of diplomatic negotiations, led the

CBD to establish differentiated responsibilities and, in consequence, a fair and equitable sharing of the commercial and scientific benefits arising from the development of biotechnological products between the countries providing the genetic resources and those using them. Moreover, the CBD established the principle of sharing the costs of conservation and of sustainable use of biodiversity, both *in situ* and *ex situ*, with the richer countries having the incremental expense of being responsible for a significant portion. An asymmetry exists, therefore, between responsibilities and interests.

Biodiversity, as a whole and by its dimensions, represents an incalculable guarantee, an insurance for the future against the unexpected, providing alternatives and opportunities under adverse conditions.

The Commission for Genetic Resources of the United Nations' Food and Agriculture Organisation - FAO has pointed out that more than half of the varieties of the world's twenty most-important foods have been lost since the beginning of the century, including those of such as rice, wheat, maize, oats, barley, beans and peas: each with their unique, specific and irreplaceable genes allowing for adaptation to different soils, climates, diseases and pests. We will become more and more dependent on hybrid strains to create new varieties with increased vigour and resistance if we are to ensure food supplies for the ever-increasing world population.

Biological diversity also holds the key to substituting increasingly scarce materials, especially true for those of mineral origin.

Biodiversity is of decisive importance in economic development. The agribusiness sector, for example, accounts for about 40% of Brazil's GNP (US$ 774 billion in 1997). That of forestry accounts for 4% of the GNP, while fisheries are responsible for 1%. Products of biodiversity, especially coffee, soybeans and oranges, represent 31% of Brazilian exports. More than 3 million people are employed in plant extractivism and fisheries. Plant biomass, here including sugar-cane alcohol, firewood and charcoal from native and from planted forests, provides 26% of the country's energy demands (in some regions, the North-east, for example, this figure is more than 50% for domestic consumption and industry). Demand for the use of medicinal plants is increasing, be it in therapeutic medicine or alternative medicine based on popular traditions.

Recent studies by Costanza *et al*. (1997, see Box 1.1) have provided a conservative estimate of between US$ 16 trillion and US$ 54 trillion a year, and a mean of US$ 33 trillion, as the value for ecological services provided by 16 world ecosystems. Given that Brazil has between 10% and 20% of the world's biodiversity, 12.7% of the world's river water (5,190 km³ a year), a vast territorial extension and 3.5 million km² of coastal and marine waters under its jurisdiction, it would hardly be an exaggeration to put the value of Brazilian biodiversity and the services of its ecosystems at billions of dollars yearly; several times higher than the GNP. It is clear that such a heritage represents enormous scientific, economic and cultural possibilities, depending only on the availability of the appropriate technology since the raw materials and the markets are evidently guaranteed.

It should be remembered that in the USA alone 25% of commonly prescribed pharmaceutical products contain active ingredients derived from plants, and that there are over 3,000 antibiotics derived from micro-organisms. The environmental scientist Thomas Lovejoy estimated the turnover in the chemical-pharmaceutical industry to be US$ 200 billion a year for products based on biodiversity.

Despite Brazil's natural riches, however, most of its economy is based on non-native species. Sugar-cane comes from New Guinea, coffee from Ethiopia, rice from the Philippines, and soybeans and oranges from China. Forestry depends on Eucalyptus from Australia and pines from Central America. Cattle-ranches use African grasses for pasture, Indian cattle, and horses from central Asia. Fish-farms depend on carp from China and *Tilapia* from East Africa. The bee-keeping industry depends on bees from Europe and Africa.

For these and other reasons, Brazil must secure ways to protect its biodiversity and genetic resources, while still retaining access to non-native genetic resources, essential for improving agriculture, cattle ranching, forestry and fish-farming.

Brazil is the richest of the world's megadiversity countries (Mittermeier *et al*., 1997), with its fauna and flora comprising at least 10% to 20% of the world's species described to date. It has the most diverse flora, with 50,000 to 56,000 described species of higher plants, or 20% to 22% of the world's total.

Many of the species important for the world economy originated in Brazil. Examples include, ground nuts, Brazil nuts, Carnaúba wax palm, rubber trees, guaraná (providing soft drinks), pineapple and cashew nuts, in addition to countless other species important for fodder, fruit, oil, medicine and timber.

At least 10% of the world's amphibians and mammals and 17% of all bird species occur in Brazil. Brazil has the world's richest diversity in three major groups of organisms. 1) Mammals. There are 524 species of mammals, of which 77 are primates - 27% of the world's total. Since 1990, eight new species of monkeys (seven in the Amazon and

one in the Atlantic Forest) have been described. 2) Freshwater fish. There are more than 3,000 species of freshwater fish: over twice the number in any other country. 3) Vascular plants, with over 50,000 species. Brazil is second-ranking in terms of amphibians, with 517 species, as well as for non-fish vertebrates as a whole, with 3,131 species. It is the third richest country in terms of birds, with 1,677 species, over 191 of them endemic. Of the 3,131 species of non-fish vertebrates, 259 are endangered or vulnerable. It is estimated that there are at least 5 to 10 million insect species, but most of them have yet to be described.

The dimensions and complexity of Brazil's biodiversity, both marine and terrestrial, may mean that it will never be completely described. It is distributed through biomes such as the Amazon, the world's largest remaining rain forest (40% of the world's tropical forest), 3.7 million km² of which lies within Brazil; the Cerrado of about 2 million km², including high altitude moorlands, the largest extent of savannah in any single country; the Atlantic forest, extending from the south to the north-east of Brazil over an area of more than 1 million km², including montane ecosystems, restingas (coastal forests and scrub on sandy soils), mangroves and the Araucaria forests and grasslands in the south, and one of the most important repositories of biodiversity in the country and in the world; the Caatinga, of about 1 million km², a vast semi-arid area in the north-east of Brazil, comprising thorn scrub and deciduous forest, as well as isolated rain forest patches (brejos); the Pantanal of Mato Grosso with about 140 thousand km² in Brazil, and one of the world's most significant wetlands; and the coastal and marine biomes, some 3.5 million km² under Brazilian jurisdiction, with cold waters off the south and south-eastern coasts (Argentinian zone) and warm waters off the eastern, north-eastern and northern coasts (Caribbean zone), supporting a wide range of coastal and offshore ecosystems which include coral reefs, dunes, wetlands, lagoons, estuaries and mangroves. There are numerous subsystems and ecosystems within these biomes, each with unique characteristics, and the conservation of ecotones between them is vital for the preservation of their biodiversity.

Brazil harbours a truly remarkable biological diversity in terms of genes, species, and ecosystems: the result of the wide variation in climate and geomorphology of a country with continental dimensions, more than 8.5 million km² in land area.

There is also a considerable cultural diversity (Box 1-2). Besides the descendants of numerous European, Asian and African colonists, there are more than 200 indigenous groups, each with their unique customs, languages and cultures, and a broad, profound and largely untapped knowledge of Brazil's fauna and flora, which comprise another significant and threatened heritage of the country.

Among the Europeans, the Portuguese, the first to colonise Brazil, have been the most influential in shaping the cultural patterns of today, but as of the 19th century there have been many immigrants from Europe, principally Italy, Spain, Germany, Poland and Ukraine, as well as from Asia, mainly Japan, Syria and the Lebanon.

The large majority of the slaves brought to the New World came from African ethnic groups. They included the Bantu from southern Africa (the Congo, Angola and Mozambique), as well as Samba, Moxicongo and Anjico, and ethnic groups from the north-western coast of Africa such as Nago, Jeje, Fanti, Achanti, Haussa, Mandinga, Tapa and Fula, originating from regions from Senegal to Nigeria.

More than 170 different languages and dialects are currently spoken among the indigenous peoples of Brazil. Of these, only 10% have been completely described, a fact which underlines our lack of knowledge of the country's remarkable cultural diversity. Many of these languages belong to the Tupi-Guarani tribes (40 languages); the Macro-Jê (21 languages and 16 dialects); the Karib (21 languages); and the Aruak (24 languages). In 1500, when the European colonisers first arrived in Brazil, there were some 340 languages spoken by over 1,400 groups of these four main linguistic classes, as well as many other isolated branches. At this time, the indigenous population was estimated at 5 million, but between 1900 and 1957 alone, 87 ethnic groups disappeared. Only in the last few decades, and for the first time since colonisation, have the indigenous populations of Brazil increased in number.

These factors resulted in Brazilian Congressmen dedicating an entire chapter of the Federal Constitution of 1988 to Indians (Chapter VIII, articles 231 and 232). The Federal Constitution begins by recognising the Indians and their "social organisation, customs, languages, beliefs and traditions, and their original rights over the lands traditionally occupied by them, and the duty of the State to delimit these lands and to protect and enforce respect for all their assets." These lands "are theirs forever, and they have exclusive rights to exploit the riches of the soil, the rivers and the lakes within them." This patrimony is inalienable and cannot be disposed of, and the indigenous rights to the territory are not subject to statutes of limitation. The exploitation of any resources on Indian land requires authorisation from Congress, following consultation of the parties involved.

Indigenous matters apart, in the last few decades economic growth has been accompanied by a significant loss of biological diversity resulting from the occupation and destruction of previously untouched natural ecosystems,

the extent of which varies from biome to biome. About 15% of the Amazon forest has now been destroyed, with the opening up of highways, through mining, colonisation, and timber exploitation, and with the advance of the agricultural frontier. The loss of the native vegetation of the Cerrado has been estimated at over 40%, likewise through the expansion of agriculture and cattle-ranching, and the dramatic increase in human populations. They have increased six-fold in the past 40 years and now number around 20 million people. Suffering from prolonged droughts, desertification, and soil erosion and salinisation, the Caatinga has lost 50% of its native vegetation. The Atlantic Forest, originally extending along most of the coastal region and well inland in the past, suffers from the highest concentrations of human populations in Brazil. Its widespread destruction over the centuries, and especially over the past decades, now means that only about 8.75% of the original forest cover remains.

Despite the varied and numerous problems, obstacles and complexities faced over the past five years following the UNCED in Rio de Janeiro, Brazil has achieved considerable progress in the implementation of the CBD.

Considering its magnitude, the management and conservation of Brazil's biological diversity is no easy task. The formulation of a National Strategy for Biological Diversity is a vital first step to provide the necessary framework for implementing the CBD and to ensure that financing, whether national or international, provided by the Government for conservation and the sustainable use of natural resources is used in a consistent and integrated manner throughout the country.

As a megadiversity country, Brazil fully assumes its responsibilities in the conservation and wise use of its natural resources. The Ministry of Environment - MMA was given the task of co-ordinating and implementing the CBD, ratified by the National Congress in February 1994. In 1996, the MMA outlined a proposal for the elaboration of a National Strategy, which included ample nation-wide consultation. This project is sponsored by the United Nations Development Program - UNDP, and has also secured financial support from the GEF, and a matching contribution from the Federal Government.

A number of mechanisms have been set up to co-ordinate the implementation of the Convention in Brazil.

The General Co-ordination for Biological Diversity (Co-ordenação Geral de Diversidade Biológica - COBIO) linked to the Secretariat for Co-ordination of Environmental Affairs (Secretaria de Coordenação de Assuntos do Meio Ambiente - SMA), was established in 1994 within the Department for Policy and Environmental Programmes (Departamento de Formulação de Políticas e Programas Ambientais - DEPAM) of the Ministry of Environment - MMA, in order to plan, co-ordinate, monitor and evaluate measures relating to the conservation and sustainable use of Brazilian biodiversity, especially those in the ambit of the National Biodiversity Programme (Programa Nacional de Diversidade Biológica - PRONABIO).

PRONABIO was created on 29th December 1994 to promote partnerships between Government and society in the conservation of biodiversity, the sustainable use of its resources, and the sharing of the benefits derived. Funding comes from the Treasury and overseas, meeting the priorities defined by a Co-ordinating Commission with parity between Government and society.

PRONABIO's specific tasks include: the definition of methodologies, mechanisms and processes; the promotion of international co-operation; the encouragement of research; the production and dissemination of information; training of personnel; institutional support; raising public awareness; and the development of concrete, demonstrative actions for the conservation of biodiversity and its sustainable use.

The United Nations Development Programme - UNDP has provided technical and administrative support to PRONABIO through its project 'Brazilian Biodiversity Management'. Financial and technical support for the implementation of PRONABIO has come also from two complementary projects funded by the Brazilian Government, the private sector and by the GEF (through International Bank for Reconstruction and Development - IBRD). Conditions concerning partnerships in conservation and the sustainable use of biodiversity have been established between the Government, nongovernmental organisations, academic institutions and the private sector. All are represented in the Co-ordinating Commission of PRONABIO.

The first of these complementary projects is that for the Conservation and Sustainable Use of Brazilian Biological Diversity (Projeto de Conservação e Utilização Sustentável da Diversidade Biológica Brasileira - PROBIO), which has US$ 20 million available, half of which is funded by the Brazilian Government and the remainder by the GEF. Implemented by MMA and with COBIO as its technical secretariat, PROBIO allows the Government and society to organise and disseminate information for decision-making in the area of conservation and sustainable use of biodiversity, as well as to support initiatives which identify priority action and stimulate the development of demonstrative studies and subprojects.

The identification and evaluation of priority action, involves, amongst other things, a series of biodiversity surveys in each of the major Brazilian biomes and the establishment of an Information Network on Brazilian Biodiversity. Five initial subprojects are under way with the participation of members of the scientific community, conservationists and environmentalists, as well as the suppliers and users of biological resources and representatives of governmental agencies at federal, state and local levels. Workshops will bring together and evaluate information on the Amazon forest, the Atlantic forest, the Cerrado, the Pantanal, the Caatinga, and the coastal areas and the sea, and will result in the proposal of priorities for conservation activities and the sustainable use of Brazilian biodiversity in each. The project is being carried out in collaboration with the Brazilian National Research Council (Conselho Nacional de Desenvolvimento Científico e Tecnologico - CNPq) of the Ministry of Science and Technology. With funding from the MMA (US$ 2 million), CNPq (US$ 2 million) and the GEF (US$ 2 million), PROBIO published a public tender in December 1997 which invited subprojects concerning research on ecosystem fragmentation.

The second project is the Brazilian Biodiversity Fund (Fundo Brasileiro para a Biodiversidade - FUNBIO). The initial capital was US$ 20 million provided by the GEF, but with contributions from the private sector as well as interest arising from its investment. It is administered by the Getúlio Vargas Foundation (*Fundação Getúlio Vargas - FGV*), and will provide long-term support for projects on the conservation and sustainable use of biodiversity.

Support for biodiversity research and conservation has also been available through other government programmes, including the National Environment Fund (Fundo Nacional do Meio Ambiente - FNMA), the National Environment Programme (Programa Nacional do Meio Ambiente - PNMA), and the Pilot Program for the Conservation of Tropical Rain Forests (Programa Piloto para a Proteção das Florestas Tropicais do Brasil – PPG-7). As a result, considerable progress has been achieved in such areas as the establishment of information networks and data bases, administrational infrastructure, in the implantation and consolidation of protected areas, in geographic and diagnostic research for the principal biomes, in setting up germplasm banks, in testing new models, and in increasing incentives for the sustainable use of biodiversity.

The last ten years have seen a major government-financed project concerning the monitoring of fires and deforestation in the Amazon. This programme has now been consolidated into the Surveillance System for the Amazon (Sistema de Vigilância da Amazônia - SIVAM), with the major participation of the National Institute for Space Research (Instituto Nacional de Pesquisas Espaciais - INPE), São José dos Campos, São Paulo, Brazil.

Another important mechanism for biodiversity conservation is what is known as the ´Green Protocol´ (*Protocolo Verde*). It is co-ordinated directly by the Presidency of Brazilian Government, and a Working Group for the Green Protocol was created on May 29th 1995. The aim is establish conditions whereby private and official funding agencies will release funds for maintenance and/or investment in agricultural properties and projects only if legal conservation standards are met.

With regard to legislation, the Public Attorney Office has been an important ally, with its powers to open inquiries and take legal action for the enforcement of environmental laws. The Brazilian programme for conservation of biodiversity and its sustainable use, and the commitments undertaken by Brazil in relation to the CBD, are legally underpinned by the Federal Constitution of the Republic of 1988, which devotes an entire chapter (article 225) to the environment.

Brazilian legislation makes provision for a National Environmental Policy, a National Council for the Environment (Conselho Nacional do Meio Ambiente - CONAMA), a National Policy for Water Resources (Política Nacional de Recursos Hídricos), a Land Statute (Estatuto da Terra), a Forest Code (Código Florestal), a Law for the Protection of the Fauna (Lei de Proteção à Fauna), a Decree-Law for the Protection and Promotion of Fisheries (Decreto-Lei de Proteção e Estímulo à Pesca), a Law of Biosafety (Lei de Biossegurança), a Law for the Protection of Cultivars (Lei de Proteção de Cultivares), a Law of Industrial Property (Lei de Propriedade Industrial), and a Law of Environmental Crime (Lei de Crimes Ambientais) which defines liability and civic-public action to be taken in the event of damage caused to the environment.

Concerned about the widespread forest destruction arising from the rapidly expanding agricultural and cattle-ranching frontiers and the increasing demand for logging concessions in the Amazon, in 1996 the Federal government issued a presidential provisional measure (Medida Provisória Presidencial, which has the force of a law) which increased the obligatory area for the conservation of native on each property from 50% to 80%. It also suspended the felling of mahogany and *Virola* trees, and further determined that all the management plans, which comprise part of the legal requirements for licensing timber extraction, be reviewed and revised.

With these and other measures, the annual rate of deforestation in the Amazon region during the period 1977 to 1994 has shown some tendency to stabilise. In 1977/1978, the annual rate was estimated at 0.54% a year of 3.7 million km². It dropped to 0.3% in 1990/1991, then rose to

0.37% in 1991/1992 and 0.4% between 1992/1994. It peaked at 0.81% in 1994/95, but fell once again to 0.51% in 1995/96, representing at this time 18,161 km² a year (the most recent statistics available from the National Institute for Space Research - INPE).

Brazil has also made significant progress regarding conservation areas *in situ*. The National System of Protected Areas now covers 4.59% of the country, including a number of different categories administered by the Brazilian Institute for the Environment and Renewable Natural Resources - IBAMA. These areas total more than 39.07 million ha. There are also 26.31 million ha of state-administered protected areas (3.50% of the country) and 341,000 ha of Private Natural Heritage Reserves (*Reservas Particulares do Patrimônio Natural - RPPN*), as well as numerous, if smaller, municipal protected areas (not included in these totals).

Efforts to establish the system of protected areas have resulted in significant qualitative advances, most especially through the National Environment Programme - PNMA which has supported the training of IBAMA personnel, and the National Environment Fund - FNMA which has allowed for considerable investment in the elaboration of management plans and in the reserves themselves, and has also financed research, training and the implementation of environmental educational programmes in and around protected areas. In addition to formal protected areas, indigenous lands which have been reserved, sanctioned, or registered now cover more than 61.37 million ha, or 7.18% of the country. These include some of the most important and best conserved areas for Brazilian biodiversity, principally in the Amazon region. This means that 130.55 million ha, or 15.37% of Brazil are legally declared as protected areas.

This is equivalent to the combined areas of France, Germany and Sweden. Forty-seven million ha (the majority) of the indigenous lands have been sanctioned since 1992, and 15.6 million ha just in the past three years. Likewise, 27 federal protected areas were sanctioned between 1992 and 1998, along with 131 RPPNs (80% of the total), giving a total of 8,030,816 ha.

A large number of private landowners have voluntarily created RPPNs, which involve the permanent and irrevocable registration of conservation areas on their properties. Besides this, the Forest Code also determines Areas of Permanent Preservation on private lands. These include, for example, forests along watercourses (gallery forests), springs, and forest on steep slopes. A conservative estimate would put these areas at 5% of the country. As explained above, the Forest Code also demands that natural forests be maintained over 80% of private properties in the Amazon and 20% of private rural properties elsewhere, and determines measures for the recovery of areas in these ´forest reserves´ which are degraded. Their exploitation or use is allowed only in the form of sustainable management.

In addition, an ambitious programme on the verge of being implemented is that of the ´biological corridors´ in both the Amazon and the Atlantic forests, comprising mosaics of landscapes managed for sustainable use and protected areas, which due to their extent and diversity, will favour the conservation of the integrity of reproductive cycles and food webs, besides allowing for links between ecosystems and faunal corridors. The key challenge is to consolidate and administer these protected areas for the benefit of society

Considerable advances have been made in *ex situ* conservation, particularly in relation to genetic resources for agriculture by the Brazilian Company for Research in Agriculture and Cattle-breeding (Empresa Brasileira de Pesquisa Agropecuária - EMBRAPA), which co-ordinates a major network of 107 germplasm banks with more than 200,000 contributors.

Notwithstanding the disposition of the Brazilian Government to carry out the determinations of the CBD, ratified by the National Congress nearly four years ago, the difficulties involved in a country the size of Brazil are enormous. With its 8.5 million km² and 3.5 million km² of coastal and marine waters, decision-making for concrete action in biomes such as the Amazon or the Pantanal requires the evaluation of innumerable variables, including such as local physical conditions, limitations in the infrastructure available, and local involvement of the community. Likewise, environmental monitoring and control of the coastal areas and territorial waters is complicated by the lack of adequate infrastructure and the sheer vastness of the area to be covered.

The Republic of Brazil is comprised of the Federal District, 26 states, and more than 5,000 municipalities, each constitutionally entitled to formulate and carry out their own economic, social and environmental policy, the articulation of which, along with the sharing of responsibilities, and joint implementation, results in considerable additional demands. The Federal Policy Commission for Sustainable Development and for Agenda 21 (Comissão de Políticas de Desenvolvimento Sustentável e da Agenda 21) is responsible for the co-ordination of environmental planning at the three government levels. It was set up in 1994, and is linked to the Chamber of Policy for Natural Resources (Câmara de Política dos Recursos Naturais) of the Government Council (Conselho do Governo), and involves various ministries, government representatives and members of a number of segments of

society.

The National Council for the Environment - CONAMA formulates and regulates environmental policy at the national level.

No less complex is the articulation of environmental action carried out independently by society, bringing it into line with the measures and strategies of the government. There are now thousands of governmental and nongovernmental organisations at work, at national and international levels, in the environmental area alone.

Despite these difficulties, funds for biodiversity conservation have been made available, principally through the PPG-7, the PNMA, the FNMA and the PRONABIO, as is detailed later in the Report. Recruitment and the training of personnel for surveys and for conservation of biodiversity and its sustainable use have involved co-operation with private and public universities, public organisations and the state foundations supporting research.

The lack of any real tradition of scientific and technological research in Brazilian private enterprise is an important aspect in this complex equation. Although there has been some progress in recent years, investment in scientific and technological research in 1994 was only US$ 3.85 billion, or 0.7% of the GNP. This included 0.11% from the state and 0.40% from the federal public sectors. The exact participation of the private sector is difficult to estimate, but investment in scientific and technological research arising directly from the Government or from research foundations can be assumed to amount to some 80% of the total.

Since the 1980s, Brazil, like many other countries, has been going through successive phases of harsh policies for fiscal adjustment which are not conducive to the allocation of funds for research or the establishment of programmes for environmental issues. Brazil is also a country that still has serious inequalities in its income distribution despite its efforts to control inflation and achieve economic stability. Poverty is a factor seriously damaging to natural resources and biodiversity. One example of this lies in the frequent internal migrations of people engaged in placer-mining or predatory logging, principally in the Amazon; activities carried out even within indigenous areas. Action has been taken by the Government to prohibit invasion of indigenous lands, as witnessed by the recent removal of goldminers from the Yanomami reserve. Nonetheless, this is one of the main causes of the loss of biodiversity, along with the advance of the agricultural frontiers in both the Cerrado and the Amazon.

In short, a realistic view of the conservation and sustainable use of biodiversity must take into account numerous biological, physical, social and economic factors, as well as the relative lack of funding. The problems are many, complex, delicate and difficult to separate. Overall, however, the commitment of the Brazilian Government, working in close co-operation with society, has resulted in definite progress regarding the implementation of the resolutions of the CBD, ratified in the National Congress on 3rd February 1994, Legislative Decree 2/94 (see Box 6-1, on international agreements signed by Brazil).

It is felt that Brazil, despite the major challenges it is still facing, has made a positive response to the CBD. The number of biodiversity-related projects has doubled, and the funding available has increased four-fold (although still only one-fifth of that desired).

Much further action is expected and planned. Brazil's determination in this area is proportional to its responsibilities as the holder of the richest biodiversity in the world. The Brazilian Government will continue in its efforts to meet the obligations undertaken in June 1992 and ratified in 1994, and we hope that international co-operation will increase accordingly to meet the challenges, the collective responsibility of every individual and all of humanity.


**Figure 1-1.** The states and regions of Brazil.
South: Paraná (PR), Santa Catarina (SC), and Rio Grande do Sul (RS)
South-east: Espírito Santo (ES), Minas Gerais (MG), Rio de Janeiro (RJ), São Paulo (SP)
Central-west: Federal District (DF); Mato Grosso (MT), Mato Grosso do Sul (MS), and Goiás (GO)
North-east: Alagoas (AL), Bahia (BA), Ceará (CE), Maranhão (MA), Paraíba (PB), Pernambuco (PE),
Piauí (PI), Sergipe (SE), and Rio Grande do Norte (RG)
North: Rondônia (RO), Acre (AC), Amazonas (AM), Tocantins (TO), Roraima (RR), Amapá (AP), and Pará (PA).

**Source:** IBGE (1996).

**Box 1-1**

**The value of the ecosystem-related services and of Brazil's natural capital**

In 1997, Robert Costanza, co-ordinating a team of North-American, Dutch and Argentinian scientists, together with a Brazilian, Monica Regina Grasso (M.A. in Oceanography at the University of São Paulo and a Ph.D. student at the University of Maryland), published a paper (Nature, volume 387, number 6230, pp.253-260, 1997) in which they estimated the economic value of 17 ecosystem-related-services (and the stock of natural capital which generates them) in 16 biomes. For the entire biosphere, the value is estimated to be in the range of US$16 trillion to US$54 trillion (1012) per year, with an average of US$33 trillion per year. By comparison, the global gross national product is around US$18 trillion per year.

The paper was the result of 18 months of research, and included a workshop at the National Center for Ecological Analysis and Synthesis of the University of California in Santa Barbara.

In this study, the value of the services identified have no price in world markets, and the values given correspond to those which would be required in terms of the human costs in substituting them if it were possible.

The ecosystem services include the flow of materials, energy and information of the stocks of the natural capital, which combine with the services of human and manufactured capital to produce human well-being.

The world's habitats were divided into 16 major categories or biomes, including coastal and oceanic waters. A mean value per ha was estimated for each, taking into account 17 different services including: regulation of the chemical composition of the atmosphere; regulation of the climate; control of soil erosion and retention of sediment; food production; supplies of raw materials; absorption and recycling of human waste; regulation of water flow; supply, storage and retention of water; regulation of natural disturbances (protection against storms, flood control and drought, for example); soil formation; nutrient cycles; pollination; biological control of animal populations; refuge for migrant and resident populations; genetic resources; leisure and culture.

The highest value per hectare was attributed to wetland and flood plains at US$14,785 a year. The open ocean was valued at US$252, and tropical rain forest at US$2,007 a year.

Some 63% of the total (US$20.9 trillion) was ascribed to the marine systems, one half of this from the coastal areas. Of the terrestrial systems, the main contributors were forests (at US$4.7 trillion) and wetlands (at US$4.9 trillion).

Nutrient cycles alone were estimated at US$17 trillion a year. The services provided by deserts, tundra, ice-caps and mountain ranges were not included due to the lack of consistent information. Had they been, and had the other services been estimated at their maximum values, the total would have reached US$54 trillion a year.

The authors argued that "ecosystem services provide an important portion of the total contribution to human welfare on this planet. We must begin to give the natural capital stock that produces these services adequate weight in the decision-making process, otherwise current and continued future human welfare may drastically suffer." (p.259).

The scientists also concluded that "If ecosystem services were actually paid for, in terms of their value contribution to the global economy, the global price system would be very different from what it is today. The price of commodities using ecosystem services directly or indirectly would be much greater. The structure of factor payments, including wages, interest rates and profits would change dramatically. World GNP would be very different in both magnitude and composition if it adequately incorporated the value of ecosystem services." (p.259).

It was also emphasised that the value of natural capital and of the services provided by ecosystems would go up as and when impacts reduced their availability.

The team involved in this study included Robert Costanza, Ralph d'Arge, Rudolf de Groot, Stephen Farber, Monica Grasso, Bruce Hannon, Karin Limburg, Shahid Nacem, Robert V. O'Neill, Jose Paruelo, Robert G. Raskin, Paul Sutton and Marjan van den Belt.

**Box 1-2**

**Brazilian cultural diversity**

Brazil has a rich ethnic and cultural diversity, including not only indigenous groups but also the descendants of African Negroes, brought to the country during the period of slavery, including members of such tribes as the Nagô, Jêje, Fanti, Achanti, Haussá, Mandinga Tapa and Fulá, from the north-eastern coast of Africa, from Senegal to Nigeria. Other Bantu groups came from the south-western and south-eastern coast of Africa (Congo, Angola and Mozambique) and included Samba, Moxicongo, Macua and Anjico. Dahomeyans (Jêjes, Nagôs and Yorubas) came from the Gold Coast and the Bight of Benin. Mixed with white, yellow and Indian ethnic groups, these Negro groups today represent an important component of Brazil's human population.

A truly extraordinary cultural diversity is represented by some 330,000 Indians, of 215 distinct social groups and with more than 170 languages, of which only 10% are fully described. Many of these languages stem from Tupi-Guarani (40 languages), Macro-jê (21 languages and 16 dialects), Karib (21 languages) and Aruak (24 languages), while others are isolated and have no distinct affinities. Many have been lost. When European colonists first arrived in Brazil in 1500, there were more than 340 languages among 1400 groups, with an indigenous population estimated at 5 million. Between 1900 and 1957 alone, 87 ethnic groups were wiped out, and only in the past few decades has the indigenous population begun to recover.

Indigenous societies can be found in all of the Brazilian states except for the Federal District. Many now live in cities, especially in the north and central-west. Their existence in these urban environments is invariably precarious. Some 1,500 Pankararu Indians from Pernambuco now live in the city of São Paulo, for example. The National Indian Foundation (Fundação Nacional do Índio - FUNAI) has estimated a population of 30,000 to 50,000 Indians today living in urban areas.

Brazil is one of the few countries where there are still indigenous groups which have never been contacted. They are isolated, autonomous, and reclusive, resisting contact and generally resorting to remote areas. There are references to 55 of them, nearly all in the Amazon region. The National Indian Foundation (FUNAI) has established contact with 20 of them and established means for their protection, even though they remain isolated and little is known about them. No information is available for the other 35 groups.

The 1988 Constitution includes an entire chapter determining the rights of the Indians (Chapter VIII, Articles 231 and 232). It begins recognising the Indians and their "social organization, customs, languages, beliefs and traditions and their traditional rights over the territories they occupy, the Union being responsible for their demarcation, for their protection, and for guaranteeing respect for their land and property.."

The lands they occupy "are for their permanent possession, and they have exclusive rights to the riches of the soil, the rivers and the lakes within them." Their patrimony is inalienable and cannot be disposed of and the indigenous rights to their lands are not subject to statute of limitation. Use of resources found on Indian lands requires authorisation from the National Congress, after full consultation of the interested parties.

# Chapter II
# The Status of Brazilian Biological Diversity

## 2.1 State-of-the-Art of the Knowledge of Biological Diversity

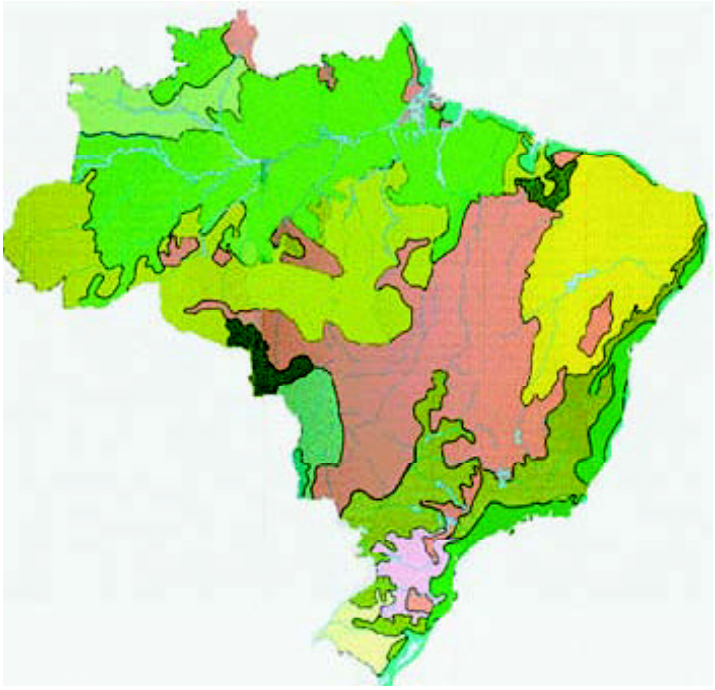
When Brazil signed the Convention on Biological Diversity in 1992, ratified in 1994, it took on a heavy responsibility which must be shared.

Due to the fact that it is largely unknown, the extraordinary richness of Brazil's biodiversity presents currently inconceivable possibilities regarding its use. This richness, however, also results in enormous difficulties in terms of setting up the necessary surveys and inventories for its documentation, as well as the necessary steps for its conservation and preservation, exacerbated by the current socio-economic status of the country, suffering impacts from the internalisation of global economic forces and the immense energy demands and the consumer society current in the industrialised countries.

The magnitude of Brazilian biodiversity can be perceived in the extraordinary wealth of its ecosystems. There are a number of classifications of the terrestrial ecosystems in the country, but one of the most commonly adopted is that of the classic work by Rizzini *et al*. (1988) in which seven principal ecosystems were identified based on phytogeographic criteria (Figure 2.1), corresponding to the 13 phytogeographic units defined by the Brazilian Institute of Geography and Statistics (Fundação Instituto Brasileiro de Geografia e Estatística - IBGE, Brazil, 1993). Numerous biogeographic or physiographic subunits can be identified within each of the Brazilian biomes (Table 2-1).

A report by Conservation International, published in December 1997, places Brazil as the top of 17 megadiversity countries, which combined harbour 70% of the world's animal and plant species (Mittermeier *et al*., 1997). Of these 17 countries, Brazil lies in first place in terms of the numbers of species of plants, freshwater fish, and mammals; in second place for amphibians; in third place for birds; and in fifth place for reptiles (Table 2-2).

In Brazil, there are 55,000 plant species, or 22% of the world total, 524 mammals (of which 131 are endemic), 517



| Term used in this report | Term used by IBGE |
|---|---|
| Amazon forest | Dense ombrophyllous forest / Flor. omb.densa |
| Amazon forest | Open ombrophyllous forest / Flor. omb. aberta |
| Amazon forest | Forest on sandy soil /Campinarana |
| Amazon forest | Seasonal forest /Floresta estacional |
| Atlantic forest | Dense ombrophyllous forest / Flor. omb. densa |
| Atlantic forest | Seasonal forest / Floresta estacional |
| Cerrado | Savannah / Savana |
| Caatinga | Steppe / Estepe |
| Pine forest | Mixed ombrophyllous forest (Aráucaria)/Flor. omb.mista |
| Pantanal | Pantanal complex / Complexo do Pantanal |
| Pantanal | Chaco (steppe savannah) / Chaco (savana-estepe) |
| Parkland savanna | Steppe savannah / Savana estépica |
| Mangroves, restinga, flooded savanna | Pioneer formations / Áreas de form. pioneiras |

**Figure 2-1**. Phytogeographic map of Brazil. Vegetation types.
**Source**: Rizzini *et al.* (1988).

amphibians (294 endemic), 1,622 birds (191 endemic) and 468 reptiles (172 endemic), besides 3,000 species of freshwater fish and between 10 and 15 million species of insects (Tables 2-3 and 2-4). The numbers for just one biome alone, the Cerrado, are remarkable (Table 2-5). Not only is the number of species high but so also is the level of endemism, combined placing Brazil at the top of the world ranking in biodiversity. Brazil, and the second-ranking country, Colombia, together outdistance by far all of the other 15 megadiversity countries (Table 2-6). Brazil disputes first place with Indonesia for the number of endemic forms (Table 2-7). It is the combination of species diversity and endemism that puts Brazil into first place in the ranking of these countries, all of which have a disproportionately large share of the planet's biological diversity and numerous forms which are endemic (Table 2-8). A large number of centres of endemism have been identified in the principal ecosystems of Brazil: in the Amazon region alone, there are 13 for butterflies (Lepidoptera) and six for terrestrial vertebrates (Table 2-9).

The problems of conserving this biodiversity are as great as its richness. More than 70 Brazilian mammal species and 103 birds are considered endangered. Five hundred years ago, the Atlantic forest, one of the richest in the world in biodiversity, covered more than one million km² along the Brazilian coast extending through 17 Brazilian states. It has now been reduced to less than 9% of its original area, mainly due to the high human population densities along the eastern coast. The Cerrado biome, which has suffered an enormous advance of the agricultural frontier in recent decades, has already lost over 40% of its native vegetation, and economic activities of some sort are present throughout the majority of the remaining area. The huge size of the Brazilian Amazon region, together with economic and social factors and an inadequate administrative structure, make the tasks of preservation, conservation and research extremely complex (the status, problems and progress are described later in this chapter).

Of the megadiversity countries, Brazil, although lacking in many areas, is among the few which have achieved a high level of scientific research, with an established and extensive system of academic and research institutions. This does not mean, however, that Brazil is autonomous in its capacity to acquire a full knowledge of its biodiversity. There are significant limitations, but many can be overcome to enable significant advances in the extent, organization and the use of information available on biological diversity.

One of the limitations concerns the concentration of researchers and their work in certain regions of the country. This has been well documented for certain research fields. For example, botanical collection is unevenly distributed in the Amazon (Figure 2-2), in the north-eastern Atlantic forest (Figure 2-3) and the state of São Paulo (Figure 2-4), as is ornithological research in the Amazon (Figure 2-5) and the Cerrado (Figure 2-6), and the distribution data available for amphibians throughout the country (Figure 2-7).

Workshops have proved to be an important tool for recovering, collating and organising the available information on Brazil's biological diversity and its distribution. A major event of this sort, ´Workshop 90 - Priority Areas for Conservation in the Amazon Region´, held in Manaus in January 1990, was organised by the Brazilian Institute for the Environment and Renewable Natural Resources (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais

**Table 2-1.** Indicators of ecological diversity in four Brazilian biomes.

| Biome | Physiographic Units[1] | Land Systems[1] | Eco Regions[2] | Phytogeographic Regions[3] | Zoogeographic Regions[4] | River Basins[5] |
|---|---|---|---|---|---|---|
| Amazon | 34 | 181 | 23 | 10[e] | 3 | 18[g] |
| Cerrado | >27[a] | >100[b] | 1[c] | 3 | 1[f] | 10[g] |
| Caatinga | n/a | n/a | 1[c] | 3 | 1[f] | 9[g] |
| Atlantic Forest | n/a | n/a | 10[d] | 5 | 2 | 15[g] |

[a] There are 4 additional units on the borderline between Atlantic Forest and Caatinga shown on five maps (1:1.000.000) not included in the study by the authors mentioned below[1], thus making an estimated total of 31 units.

[b] There are 13 additional systems on the borders of the Atlantic Forest with the Caatinga, estimated on five maps (1:1.000.000) not included in the study by the authors mentioned below[1], thus making an estimated total of 113 land systems.

[c] These large regions were not subdivided for lack of reliable biological data.

[d] 5 additional regions could have been recognised: upland moorlands (*campo rupestre*) and mountain savanna (*campos de altitude*), savanna (*campos gerais*), areas of cerrado and deciduous forests, thus making 15 eco-regions.

[e] Other authors have suggested between eight and 12 phytogeographic divisions for the Brazilian Amazon.

[f] Cerrado and Caatinga are considered to belong to the same zoogeographic region.

[g] First and second order basins and groups of small, isolated basins were recorded, eight of them having a large territorial extension in the Amazon Region, six in the Cerrado, two in the Caatinga and three in the Atlantic Forest.

n/a = data not available.

**Sources**:

[1]:Cochrane *et al*. (1985). *A Terra na América Tropical, CIAT & EMBRAPA*;

[2]:Dinerstein *et al*. (1995). Conservation Assessment of the Terrestrial Ecoregions of Latin America and the Caribbean. World Bank;

[3]:Hueck (1972). *As Florestas da América do Sul, Polígono & Editora UnB*;

:Stotz *et al*. (1996). Neotripal birds: Ecology and Conservation, University of Chicago Press;

[5]:IBGE (1993). Mapa da Vegetação do Brasil.

Renováveis - IBAMA), Conservation International, Washington, D. C., and its Brazil Programme (Conservation International do Brasil), and the National Institute for Amazon Research (*Instituto Nacional de Pesquisas da Amazônia - INPA). More than 100 scientists and conservationists*, representing all nine Amazon countries, worked for 10 days with the specific purpose of indicating and mapping high priority areas for conservation. Commissioned preparatory documents for this workshop included, country papers (overviews of each country), and information on soils, climate, biogeography and the existing systems of protected areas. The aim of the workshop was to identify key areas in terms of biodiversity through biogeographic analyses of endemism and species richness. Also taken into account was the presence of rare or threatened species, vegetation types, the existence of geological or geochemical phenomena of special interest, and current and future threats to the integrity of the ecosystems. These analyses were carried out by working groups of specialists in different taxonomic areas, as well as one which analysed the status of the protected areas, indicating those of priority in terms of biodiversity, and the threats to their integrity. This group concluded that mechanisms for biodiversity protection in the priority areas should concentrate on creating opportunities for sustainable extractivism and production over large areas, with management protocols to minimise adverse impacts on biodiversity caused by human activities.

**Table 2-2.** Species richness and endemism of Brazilian vertebrates and higher plants in relation to other megadiversity countries.

| Number of species | Freshwater fish | Vertebrates (except Fish) | Birds | Mammals | Reptiles | Amphibians | Flowering plants | Total |
|---|---|---|---|---|---|---|---|---|
| Total | >3,000 | 3,131 | 1,622 | 524 | 468 | 517 | ~50,000 | |
| Ranking | 1st | 2nd | 3rd | 1st | 5th | 2nd | 1st | 1st |
| Endemic | n/a. | 788 | >191 | 131 | 172 | 294 | ~17,500 | |
| Rank | | 4th | 3rd | 4th | 5th | 2nd | 1st | 2nd |

n/a = data not available.

**Source:** Mittermeier *et al.* (1997)

Also held in 1990 was the ´Workshop on Taxonomic Diversity and Distribution Patterns of Brazilian Angiosperms´. The idea for this workshop arose from the need for a better knowledge of Brazil's flora, focusing on a number of taxonomic groups, and based on morphological variation and their distribution patterns. Families of dicotyledons e monocotyledons were selected according to the availability of Brazilian and North American specialists.

Conservation International, the Biodiversitas Foundation (Fundação Biodiversitas), and the North-eastern Ecology Society (Sociedade Nordestina de Ecologia - SNE) combined forces in organising a Workshop ´Priorities for the Conservation of the Biodiversity of the North-eastern Atlantic Forest´, in 1993, at Itamaracá, state of Pernambuco. The principal objectives were to analyse existing information on the biodiversity of the region, to integrate information on biodiversity with socio-economic and environmental parameters, and to identify the priorities for biodiversity conservation.

Another important workshop, ´Methods for the Assessment of Biodiversity in Plants and Animals´ was held in Campos do Jordão, state of São Paulo, in May 1996 (Bicudo and Menezes, 1996).

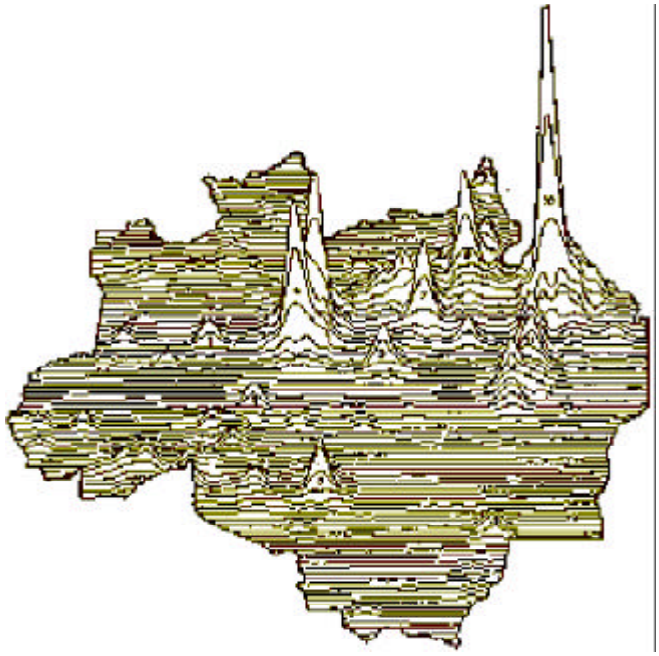


**Figure 2-2.** Density of scientific collections for arborescent angiosperms in the Brazilian Amazon.

**Source**: Nelson, B.W., INPA (1991).

Based on a sample of 1% of the Amazonian flora in the herbariums of INPA, MG, R. RB, IAN, SP, UB, NY and US. The relief indicates the number of specimens of the genus Inga in each 10,000 km² (1º latitude x 1º longitude). Collections in duplicate were discounted. Total sample = 2,779 specimens. The peaks on Manaus and Belém result from 160 and 320 specimens respectively. The secondary peaks are: Tefé, Humaitá, Aripuanã, Manaus, Itaituba and the waterfalls of the lower reaches of the Rio Tapajós, Óbidos, Santarém, Jari and Gurupá, Oiapoque, Belém, Tucuruí, Carajás, and Serra Buritirama and the expedition camp of the Royal Geographical Society (RGS) in Mato Grosso.

The Ministry of the Environment - MMA organised a workshop in Rio de Janeiro in June 1996 - ´Assessment, Monitoring and Indicators for Biological Diversity: Methods from a Perspective of Tropical Ecosystems´. More than 60 specialists were involved in evaluating and recommending options for methodologies in assessing and monitoring Brazilian biological diversity.

Marine ecosystems have also been the subject of exercises of this sort. The ´Workshop on Brazilian Coral Reefs: Research, Integrated Management and Conservation´, promoted by the Brazilian Society for the Study of Coral Reefs - Corallus (Sociedade Brasileira para Estudos em Recifes de Coral - Corallus), was held from 9th to 15th March 1997 at the Centre for Fishing Research and Extension of the North-East (Centro de Pesquisa e Extensão Pesqueira do Nordeste - CEPENE) of IBAMA. The results will serve as a basis for formulating policy and establishing priorities in applied research and management and the conservation of Brazilian reefs. The proposal will also be used by Brazilian Government agencies as a basis for a ´Brazilian Initiative on Coral Reefs´, an important step in the process of regulating the sustainable use of Brazilian coral reefs in line with international measures in this area.

A number of Brazilian states have been carrying out their own workshops. São Paulo, for example, held a workshop in October 1995 - ´A Basis for Conservation and Sustainable Use in the Cerrado of the State of São Paulo´. This event brought together some 100 people: from public and private universities; researchers and technicians from research institutes in the state; representatives of Worker's unions and landowners; non governmental organizations; businessmen and representatives of the Secretary for the Environment. This mix guaranteed representation of both socio-economic and conservation interests for the region. The workshop was organised by the Executive Co-ordination of the State Programme for Conservation of Biodiversity - PROBIO-SP, of the Secretariat of the Environment of the State of São Paulo (Secretaria do Meio Ambiente do Estado de São Paulo - SMA/SP), in conjunction with the Botanical Society of São Paulo (*Sociedade Botânica de São Paulo*). The aims for this workshop were to identify critical areas for the conservation of biodiversity and identify viable mechanisms for its conservation.

Another very important workshop held in São Paulo was ´A Basis for Conservation of Biodiversity in the State of Sao

Paulo´ (Bases para a Conservação da Biodiversidade do Estado de São Paulo - BIOTASP). This workshop resulted in a detailed diagnosis of existing knowledge of the biota of the state and of the existing collections and human resources available, and also proposed the establishment of a specific programme to accelerate research efforts on the biological diversity of the state: ´Biodiversity of the State of Sao Paulo - BIOTASP´.

Even though there are still enormous gaps in our knowledge, these various workshops and meetings demonstrate a substantial scientific community and a significant institutional capacity for documenting and researching the country's biological diversity.

A Biodiversity Working Group (Grupo de Trabalho de Biodiversidade - GTB), with funding from UNDP, has been established on the recommendation of the General Co-ordination of Biodiversity - COBIO of the Ministry of the Environment - MMA. Its main task is an analysis of the current state of knowledge of Brazilian biodiversity. The Working Group is comprised of biologists from various universities and research institutions along with representatives of a number of conservation NGOs, and is linked directly to the National Council for Scientific and Technological Development - CNPq. A first report, begun in November 1997, is being compiled in the Nucleus for Environmental Study and Research (Núcleo de Estudos e Pesquisas Ambientais - NEPAM) of the State University of Campinas - UNICAMP and should be concluded by April 1998.

The initial task is to collate information for each taxonomic group on: a) current capacity for research on systematics; b) present state of taxonomy; c) the extent of collections; d) their importance for basic and applied research, their economic use, and their use as indicators of environmental quality, risk or impact; e) genetic research; f) the state of knowledge of the group in Brazil and the world and; g) needs and priorities for further research. Although this initial diagnosis covers only genetic diversity, there is no doubt that a number of conceptual points will be raised which will contribute significantly to our understanding of ecosystem diversity.

## 2.1.1 Vertebrates

The following vertebrates are currently known to exist in Brazil:

- Class Agnatha, vertebrates with no mandible including lampreys and hagfishes. Of the 65 species known world-wide, one or two species of hagfishes occur in Brazil. Specimens collected off the coast of Rio Grande do Sul are kept in the Zoological Museum of the University of São Paulo (Museu de Zoologia - USP).
- Class Chondrichthyes, cartilaginous fishes, including sharks, stingrays and chimeras. About 850 species world-wide. Approximately 110 marine species and 20 freshwater species (stingrays) occur in Brazil. The main collections are in the Zoological Museum of the University of São Paulo - USP.
- Class Osteichthyes, sea-water and freshwater fish, the largest group of species among the vertebrates. Current estimates for Brazil indicate approximately 750 seawater and 3,000 freshwater species, of a world total of 24,000. It is believed, however, that the real number of freshwater species may be as high as 3,000

**Table 2-3.** Diversity and endemism of higher plant species[a].

| Country | Total diversity | Endemism | Endemism as % of global diversity of higher plants[b] |
|---|---|---|---|
| Brazil | ~ 50,000 - 56,000 | ~16,500 - 18,500 | 6.6-7.4 |
| Indonesia | ~37,000 | 14,800 - 18,500 | 5.9-7.4 |
| Colombia | 45,000 - 51,000 | 15,000 - 17,000 | 6.0-6.8 |
| Mexico | 18,000 - 30,000 | 10,000 - 15,000 | 4.0-6.0 |
| Australia | 15,638 | 14,458 | 5.8 |
| Madagascar | 11,000 - 12,000 | 8,800 - 9,600 | 3.5-3.8 |
| China | 27,100 - 30,000 | ~10,000 | ~4.0 |
| Philippines | 8,000 - 12,000 | 3,800 - 6,000 | 1.5-2.4 |
| India | > 17,000 | 7,025 - 7,875 | 2.8-3.2 |
| Peru | 18,000 - 20,000 | 5,356 | 2.1 |
| Papua New Guinea | 15,000 - 21,000 | 10,500 - 16,000 | 4.2-6.4 |
| Equador | 17,600 - 21,100 | 4,000 - 5,000 | 1.6-2.0 |
| United States | 18,956 | 4,036 | 1.6 |
| Venezuela | 15,000 - 21,070 | 5,000 - 8,000 | 2.0-3.2 |
| Malaysia | 15,000 | 6,500 - 8,000 | 2.6-3.2 |
| South Africa | 23,420 | 16,500 | 6.6 |
| Dem.Rep. of Congo | 11,000 | 3,200 | 1.3 |

[a] Taking into account a total of 250,000 species in the world.
[b] The 17 megadiversity countries have between 155,475 and 183,025 endemic species, that is, from 62.2% to 73.2% of global higher plant diversity.
**Source:** Mittermeier *et al.* (1997).

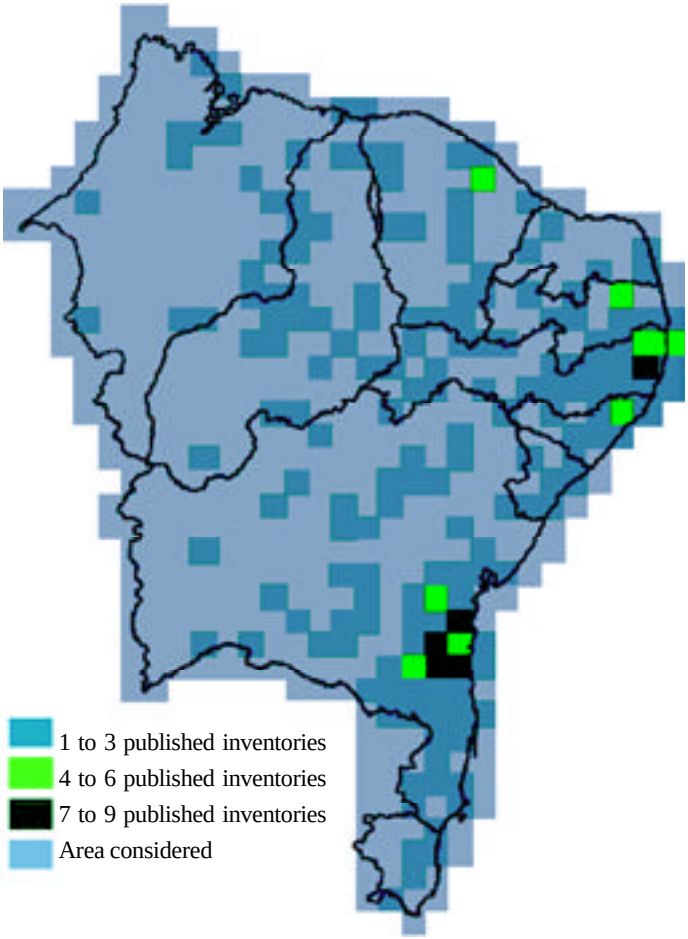



**Figure 2-3**. Knowledge of the flora of the north-eastern Atlantic forest. Number of published inventories.

**Source**: Conservation International *et al*., Base de Dados Tropicais (BDT) (1995).

to 5,000, the highest diversity of freshwater fish of any country in the world (compared, for example, to 320 species in European rivers and lakes). Diversity is still poorly documented in the Amazon basin, the centre of origin and dispersal of a large number of freshwater fish, and there are major threats to the existence of many species, mainly from hydroelectric dams. Outside the Amazon, current estimates indicate about 150 species in the São Francisco basin, and 500 species in the basins of Rios Paraná, Paraguai and Uruguai; about, 250 of them located in the Pantanal of Mato Grosso. An evaluation in 1978 argued that 30% to 40% of freshwater species were still unknown to science. There are important collections in various museums, universities and other institutions in the country.

- Class Amphibia, salamanders, anurans and caecilians. Brazil has about 517 species of an estimated 4,500 of the world total. This is the second highest diversity in the world for this Class, and includes mainly frogs, toads and tree frogs, but also some salamanders and blind snakes. This number will increase due to the current interest in collecting frog species in the Amazon region and in the Atlantic Forest. Some species, such as *Phylomedusa bicolor* and *Brachycephalus ephipium*, are being subjected to biochemical and pharmaceutical studies for the isolation of substances of medicinal use. There are numerous scientific collections in the country.

- Class Reptilia, including tortoises, turtles, snakes, lizards, alligators and crocodiles. Of the 6,400 known species, there are an estimated 468 in Brazil, the fifth ranking in the world for reptile diversity. Snakes and lizards are the most speciose group, especially in the Amazon. Important collections are maintained in museums, universities and other institutions throughout the country.

- Class Aves, the birds. There are 1,677 known species in Brazil of a total of 9,050 world-wide. Brazil is third in the world ranking. In Brazil, there are important private collections besides those in a number of museums, universities and other institutions.

- Class Mammalia, the mammals. There are 524 known species in Brazil, of a total of about 4,500 world-wide. The number of Brazilian species is certainly underestimated, especially for groups such as rodents. There are many collections of Brazilian mammals in museums, universities and other institutions, both in Brazil and abroad.

## 2.1.2 Invertebrates

The invertebrates are distributed through 33 Phyla, and comprise 95% of the known species of animals (the remaining 5% are vertebrates). Arthropods alone account for approximately 1.5 million described species; believed, however, to be just a small fraction of the total existing. Specialists argue that the total number of species is 10 times the current registered total in the case of insects, and 40 times bigger for the nematodes.

The first Brazilian collections begun by naturalists in the past century are kept in museums abroad. The groups best described are those of medical, veterinary or agronomic interest. Today there are numerous important collections in the country.

Of the 33 Phyla of invertebrates, 15 are exclusively, and five predominantly, marine. Nine include marine species, two only a few, and two have no marine species at all.

Research on the marine environment is comparatively recent in Brazil. A list of marine invertebrate Phyla, and the presence or otherwise of specialists for each in Brazil, is shown in Table 2-10. Table 2-11 indicates the diversity estimates for some of the marine invertebrate phyla in Brazil.

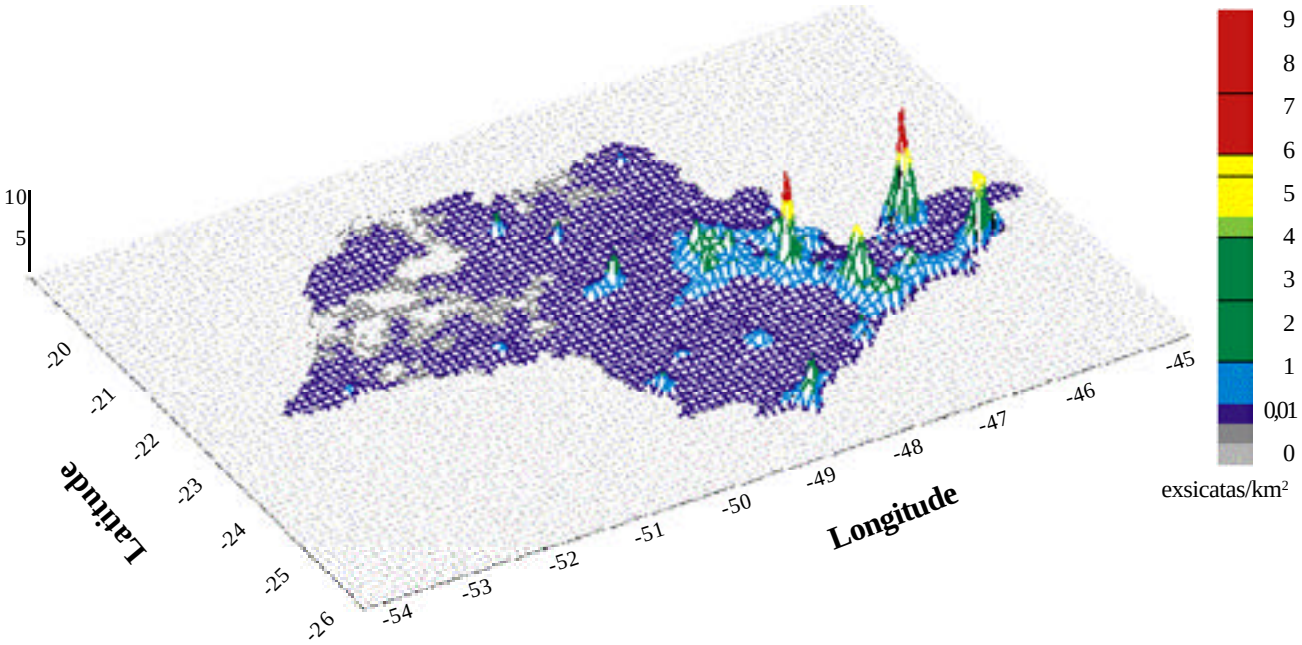



**Figure 2-4**. Density of scientific collections for the phanerogamic flora of the state of São Paulo.
**Source**: G.J. Shepherd, Base de Dados Tropicais (BDT) (1997).

Marine Mesozoa, Placozoa, Acanthocephala, Loricifera, Priapulida, Nematomorpha, Entoprocta, Brachiopoda, and Cicliophora are not included for lack of specialists, while for some such as Ctenophora e Ectoprota, tentative estimates are given even though there are no specialists currently working on them in Brazil.

This compilation shows that for most Phyla the number of species described for the Brazilian coastal waters is less than 10% of the number described world-wide. Exceptions are the Phoronida (11%), Hydrozoa (12%), Sipuncula (20%) and Mollusca (30%). It is probable that the number of species will double or triple if priority is given to collecting in areas poorly studied to date. An extreme example is that of the Nematoda. The global estimate is 1 to 1.5 million species, while only 230 to 400 have been described for the Brazilian coast. Geographically, the northern coast is considered the least known in terms of its marine fauna, while the south-eastern coast is the best known. The south and the north-eastern regions are also still poorly researched.

Our knowledge of the freshwater invertebrates is still far from complete. Most of the research has been carried out in the south and south-east of the country and the Amazon, while regions of the central-west and the north-east remain almost entirely unexplored. The maxim that the more people doing research the greater the number of new species described is clearly true for the freshwater invertebrates. Table 2-12 shows current species diversity estimates for freshwater invertebrates in Brazil.

Despite their importance in aquatic ecosystems, the Protozoa are the least-known group of the micro-invertebrates due to problems of sampling and identification. Currently, the global estimate is 30,000 species in the four Classes which comprise the Phylum. Very little is known of this Phylum, the few exceptions being *Trypanosome cruzi* a parasite which causes Chagas' disease, and *Leishmania*, which causes skin degeneration or fatal anaemia, neither of which occur in fresh water, along with some other parasites of medical interest. Species diversity in this case can only be guessed at. Perhaps best known are the amoebae of the Class Sarcodina. Twenty genera and 150 species of capsulated amoebae have been described in Brazilian fresh water ecosystems. The Heliozoaria, frequently found in fresh water, have not been taxonomically studied in Brazil. The ciliates (Ciliophora) make up the greatest part of the freshwater plankton, with 8,000 species described world-wide, and are as such important indicators of water quality. Although still incomplete, the total list for Brazil already includes 147 genera.

Sponges of the Phylum Porifera are largely a salt water group, only a few are found in fresh water. The number of living species in the world is estimated at between 20,000 and 30,000; 33 genera and 149 species are found in fresh water. In Brazil, their occurrence was reported by European naturalists at the end of the last century. Forty-four fresh water species in 21 genera have been recorded for Brazil.

The Phylum Coelenterata is also essentially marine, few species being found in fresh water. Nine thousand living species have been described world-wide, including corals (limnic and marine environments), hydra and jellyfish (limnic environments). Their susceptibility to pollution makes them important ecological indicators. In Brazil, only five freshwater species have been recorded.

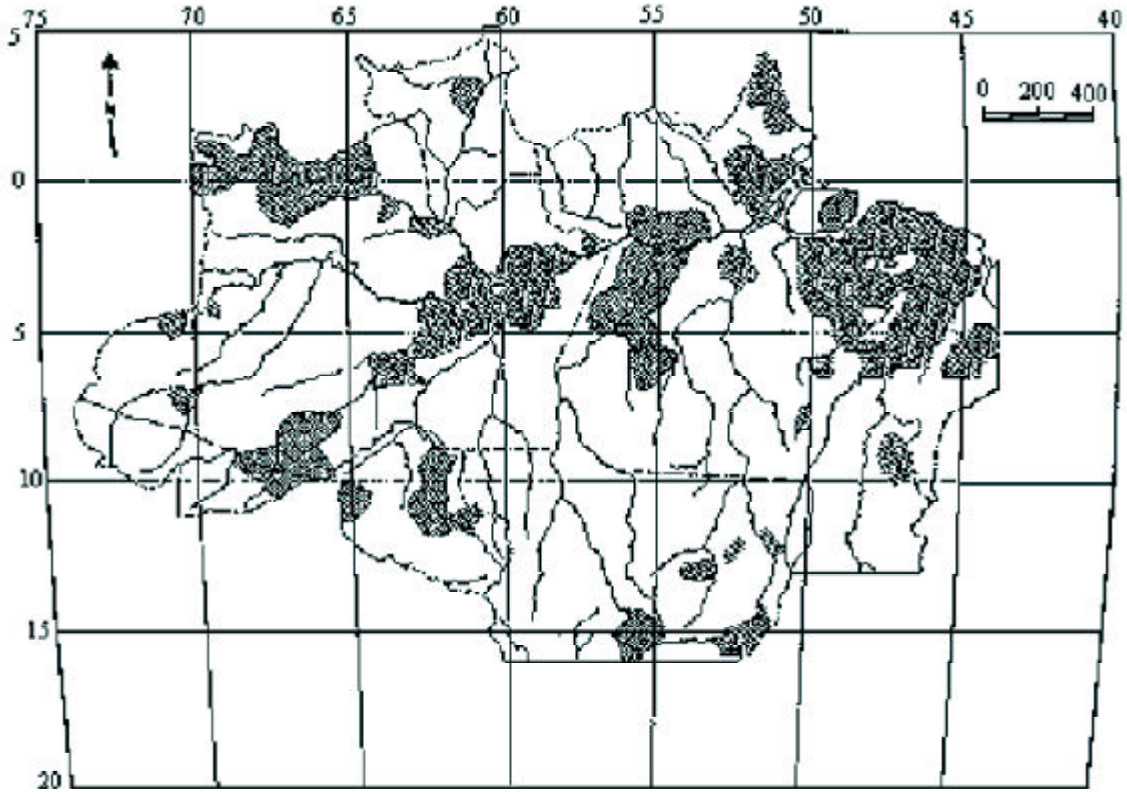



**Figure 2-5**. Areas which have been subjected to significant ornithological research in Amazonia.
**Source**: Oren & Albuquerque (1991).

The Phylum Platyhelminthes, the flatworms, is comprised of about 10,000 species in marine and freshwater habitats around the world. There are currently 96 Brazilian species in the Class Turbellaria. Little is known of the remaining Classes in this Phylum in Brazil, although much work has been done on a number of flatworms of medical or veterinary importance, such as Schistosoma mansoni.

The Phylum Nematomorpha (hairworms) includes 100 marine and freshwater species. Only three genera and nine species are known for Brazil.

There are 9,000 marine, freshwater and terrestrial species of annelid worms of the Phylum Annelida world wide. The Oligochaeta (earthworms) have been well-studied in Brazil. Seventy-three species and subspecies are known for Brazilian fresh waters.

The Phylum Rotifera (rotifers) is one of the best-studied groups of planktonic invertebrates in Brazil, with 457 species being found in nearly all freshwater habitats. Of these, 284 are found in the Amazon basin, 138 in the south and south-eastern regions, 89 in the north-east and 176 in the central west. Of these, 66 species have been described only recently and are probably endemic.

Freshwater Arthropoda include acarids and various groups of insects and crustaceans. Of these, the Suborder Cladocera (water fleas), microcrustacean branchiopods, are well-represented in inland Brazilian waters. Eighty-six species have been recorded. Endemism in the Cladocera is high, and will undoubtedly be higher when more taxonomic research is carried out. Another well-represented group of freshwater microcrustaceans are the Subclass Copepoda, with 273 species in four suborders in Brazilian waters: 102 species of the Cyclopoida, 58 of Calanoida, 56 of Harpacticoida and 57 of Poecilostomatoida. In the macrocrustacean Subclass Malacostraca, 12 genera and 76 species have been found in Brazilian fresh waters, including crabs, shrimps, crayfish and small lobsters.

The extent of our knowledge of terrestrial invertebrates is extremely variable, as is the number of researchers active in studying the different groups and the degree to which they are represented in scientific collections and the literature.

Terrestrial molluscs of the Class Gastropoda are relatively little diversified and well-known. Soil annelids of the Class Oligochaeta (earthworms) are likewise few in number, with local communities usually having fewer than 10 species. Even so, they are of considerable functional importance, both in natural and agro-ecosystems, and more research is required. By contrast, another important group, the nematode worms, is extremely diverse, including forms which are free-ranging as well as parasites of animals and plants. Parasitic forms are subject to considerable research efforts in Brazil because of

their economic impact, but the free-ranging species are almost entirely unknown.

The arthropods (Phylum Arthropoda) comprise by far the largest group of terrestrial animals. Included are the Arachnida, principally Acari (mites and ticks) and Araneae (spiders), which, along with the Order Opiliones (harvestmen), have been relatively well-investigated. There are important collections in a number of states, including São Paulo, Rio de Janeiro and Rio Grande do Sul.

The biggest and most diverse group of arthropods is the Insecta. Geographically and taxonomically, our knowledge of their diversity is very patchy. Of the principal Orders (those with more than 40,000 described species in the world and more than 10,000 in Brazil), only the Lepidoptera can be considered reasonably well known, although there are thousands of species of small moths, which make up the majority of this Order, which have yet to be described. In the Hymenoptera, bees, wasps and ants are relatively well-collected and studied, but the small parasitic wasps, for example, are very poorly known, and the number of uncollected and undescribed species could be in the order of tens of thousands.

Our knowledge of the other major Orders is even more irregular. Some families of Coleoptera (the largest) have been well-studied, for example the Cerambycidae (wood-boring beetles), while for others, such as the Curculionidae (weevils) and Scarabaeidae (dung beetles), there are very few specialists working in Brazil. Each of these families contains tens of thousands of species. There are no Brazilian specialists for the other families. This is considered a serious lack, especially for such diverse and important groups as the predacious beetles of the Family Carabidae, much studied in a number of other countries. There is at least one first-class collection, but not a single specialist for this group in Brazil.

The situation is similar for the Diptera, Homoptera and Hemiptera. Families with representatives which are of medical, veterinary and agricultural importance as parasites and pests, or extensively used in genetic research, are relatively well-

**Table 2-4**. Diversity and endemism of vertebrate species in megadiversity countries.

| Country | Mammals | Birds | Reptiles | Amphibians | Vertebrates except fish | Non endemic endemic | Endemism as % of global diversity: all vertebrates excluding fish | Freshwater fish [a] |
|---|---|---|---|---|---|---|---|---|
| Brazil | 524 (131)[b] | 1,622 (>191) | 468 ( 172) | 517 (294) | 3,131 (788) | 3.97:1 | ~3.3 | >3,000 |
| Indonesia | 515 (201) | 1,531 (397) | 511 (150) | 270 (100) | 2,827 (848) | 3.33:1 | 3.5 | 1,400 |
| Colombia | 456 (28) | 1,815 (>142) | 520 (97) | 583 (367) | 3,374 (634) | 5.32:1 | 2.6 | >1,500 |
| Mexico | 450 (140) | 1,050 (125) | 717 (368) | 284 (169) | 2,501 (802) | 3.12:1 | ~3.3 | 468 |
| Australia | 282 (210) | 751 (355) | 755 (616) | 196 (169) | 1,984 (1,350) | 1.47:1 | ~5.6 | 183 |
| Madagascar | 105 (77) | 253 (103) | 300 (274) | 178 (176) | 836 (630) | 1.33:1 | 2.6 | 75 |
| China | 499 (77) | 1,244 (99) | 387 (133) | 274 (175) | 2,404 (484) | 4.97:1 | 2.0 | 1,010 |
| Philippines | 201 (116) | 556 ( 183) | 193 (131) | 63 (44) | 1,013 (474) | 2.14:1 | 1.98 | 330 |
| India | 350 (44) | 1,258 (52) | 408 (187) | 206 (110) | 2,222 (393) | 5.65:1 | 1.6 | 750 |
| Peru | 344 (46) | 1,703 (109) | 298 (98) | 241 (>89) | 2,586 (342) | 7.56:1 | 1.4 | 855 |
| Papua & New Guinea | 242 (57) | 762 (85) | 305 (79) | 200 (134) | 1,509 (355) | 4.25:1 | 1.5 | 282 |
| Ecuador | 271 (21) | 1,559 (37) | 374 (114) | 402 (138) | 2,606 (310) | 8.41:1 | 1.3 | >44 |
| United States | 428 (101) | 768 ( 71) | 261 (90) | 194 (126) | 1,651 (388) | 4.34:1 | 1.6 | 790 |
| Venezuela | 288 (11) | 1,360 (45) | 293 (57) | 204 (76) | 2,145 (189) | 11.35:1 | 0.8 | 1,250 |
| Malaysia | 286 (27) | 738 (11) | 268 (68) | 158 (57) | 1,450 (163) | 8.90:1 | 0.7 | 600 |
| South Africa | 247 (27) | 774 (7) | 299 (76) | 95 (36) | 1,415 (146) | 9.69:1 | 0.6 | 153 |
| Dem.Rep. of Congo | 415 (28) | 1,094 ( 23) | 268 (33) | 80 ( 53) | 1,857 (137) | 13.55:1 | 0.6 | 962 |

[a] Data on endemism in freshwater fish are not available. Freshwater fish are included only in the total species diversity.
[b] Numbers in parentheses refer to endemic species.
The 17 megadiversity countries have 8,443 species of endemic vertebrates excluding fish, or 33.1% of the global diversity of these groups.
**Source:** Mittermeier *et al*. (1997).

studied. For others, very little or no research has been carried out.

Although an important factor, medical or economic importance, for example, does not necessarily guarantee research on these invertebrate groups. Research on numerous agro-forestry pests, pathogenic vectors and groups which could serve as bioindicators, is still incipient in Brazil, being restricted to very few specialist in the country or none at all. They include Coccidae and Aphidae of the Order Homoptera, Cecidomyiidae (Diptera), carabid and chrysomeline beetles (Coleoptera), and many important families of such as hymenopteran parasites and the Orthoptera.

## 2.1.3 Plants

Angiosperms (flowering plants) are the principal and economically most important group of terrestrial plants. They include nearly all of the cultivated plants, dominant in nearly all terrestrial environments in Brazil. Globally, there are about of 250,000 angiosperm species, by far the most diverse group.

No precise estimate can be given for the number of species in Brazil, but some inventories provide an idea. In the Atlantic Forest, for example, a team from the New York Botanical Garden working with the Botany Department of the Executive Commission for Cacao Cultivation (*Comissão Executiva do Plano da Lavoura Cacaueira - CEPLAC*) registered 454 tree species in a single hectare in the Serra do Conduru State Park in southern Bahia. An even more impressive figure was obtained during an inventory by researchers from the Mello Leitão Museum of Biology in the Santa Lúcia Biological Station in the state of Espírito Santo: 476 species in one hectare. Estimates range from 40,000 to 70,000 plant species in the country. The best accepted estimates indicate between 55,000 and 60,000, or 22% to 24% of the world's angiosperm species. By way of comparison, the estimate for North America is 17,000 species, that for Europe 12,500, and 40,000 to 45,000 species are believed to occur in Africa.

A significant portion of angiosperm biodiversity, therefore, can be found in Brazil. Regions such as the Atlantic forest, the Amazon basin, the Northeast and the Cerrado are rich in endemic species. Given its enormous economic (food, the pharmaceutical industry, timber) and ecological importance, this group has priority for its preservation, conservation, sustainable use and research.

The only systematic treatise on botany in Brazil is the *Flora Brasiliense* by Martius, compiled over the period 1840-1906. Although still a standard reference, it is of course now out of date, and there is an urgent need for a new synthesis.

The National Botany Plan (Plano Nacional de Botânica) has adopted the strategy of promoting the compilation of flora at the state level, which will hopefully lead eventually

**Table 2-5a**. Estimated biological diversity (number of species) in the cerrado region of Brazil.

| Phylum | Class | Common name | Richnesss |
|---|---|---|---|
| Chordata | Mammalia | Mammals | 150 |
| | Aves | Birds | 550 |
| | Reptilia | Reptiles | 150 |
| | Amphibia | Amphibians | 150 |
| | Osteichthyes | Fish | 1,000 |
| | Condrichthyes | Rays | 10 |
| Uniramia | Hexapoda: | | |
| | Coleoptera | Beetles | 35,000 |
| | Hymenoptera | Wasps, etc. | 20,000 |
| | Lepidoptera | Moths | 15,000 |
| | Diptera | Flies | 10,000 |
| | Other Orders | Other insects | 10,000 |
| | Myriapoda | Centipedes | 500 |
| | Tardigrada | | 50 |
| | Pentastomida | | 10 |
| | Onychophora | | 5 |
| Crustacea | 5 classes | Crustaceans | 500 |
| Chelicerata | Arachnida | Spiders, Etc. | 4,000 |
| Annelida | Oligochaeta | Worms | 100 |
| | Hirudinea | Leeches | 50 |
| Mollusca | Gastropoda | Snails | 500 |
| | Bivalvia | Bivalves | 50 |
| Bryozoa | 3 classes | Bryozoa | 10 |
| Platyhelminthes | 5 classes | Flatworms | 400 |
| Nematoda | 2 classes | Roundworms | 500 |
| Nematomorpha | 1 class | Hair Worms | 10 |
| Acanthocephala | 1 class | Worms | 50 |
| Gastrotricha | 1 class | Worms | 10 |
| Nemertini | 2 classes | Worms | 5 |
| Rotifera | 2 classes | Rotifers | 100 |
| Coelenterata | Hydrozoa | Hydras | 50 |
| Porifera | | | |
| Protozoa: | Demospongea | Sponges | 10 |
| Mastigophora | 2 classes | Flagellates | 1,500 |
| Sarcodina | 2 classes | Amoeba | 400 |
| Sporozoa | 2 classes | Sporozoa | 1,500 |
| Cnidospora | 2 classes | Sporozoa | 100 |

**Source:** Dias (1996).

to a new *Flora Brasiliense*. Surveys and taxonomic research are now under way in the states of Rio Grande do Sul, São Paulo, Mato Grosso, Minas Gerais, Bahia and Santa Catarina. The main institutions involved in the inventory for the state of São Paulo concluded the first stage of the project ´Phanerogamic Flora of State of São Paulo´ in 1993, with the support of the São Paulo State Science Research Foundation (Fundação de Amparo à Pesquisa do Estado de São Paulo - FAPESP).

Also under way is *Flora Neotropica*, a series of systematic monographs for the flora of the Neotropics, and covering much of the Brazilian territory. But the work proceeds slowly and, despite recent effort to speed it up, would take 400 years to complete at the present rate of progress.

The most recent samples of Brazilian flora have been deposited in about 70 herbaria in the country. Older collections are nearly all outside the country, mostly in Europe and the United States.

World wide there are about 650 species of gymnosperms, almost all trees. While Brazil has only 5-10 species, this is still an important group as a source of timber, notably naturally-occurring *Araucaria* in the south, and the imported species of such as *Pinus*. The genus *Gnetum* found in Amazonia is of special interest, having characteristics considered typical of angiosperms and probably being pollinated by insects: very rare among the gymnosperms.

The Pteridophyta are predominantly herbaceous and include the ferns and other less well-known plants. Of the 12,000 species known, 1,200 to 1,300 occur in Brazil, mostly in the Atlantic forest and the Amazonian forests.

The total number of bryophytes (mosses) in the world is estimated at 14,000 species, with Brazil having about 3,100: 20% to 25% of known species. This group is particularly well represented in the Atlantic forest and Amazonia. Although lacking in economic value, these plants are important as ecological indicators and for their evolutionary interest. They are the only group of land plants where the haploid gametophyte is dominant rather than the sporophyte, as in other groups.

**Table 2-5b.** Estimated biological diversity (number of species) in the cerrado region of Brazil.

| Phylum | Class | Common name | Richness |
|---|---|---|---|
| Ciliophora | | | |
| Prokaryote: | 3 classes | Cilia | 1,500 |
| Virales | 1 class | Viruses | 160,000 |
| Schizophyta | 5 classes | Bacteria | 1,500 |
| Cyanophyta | 1 class | Blue-Green Algae | ?10 |
| Fungi: | | | |
| Gymnomycota | 3 classes | Mould | 50 |
| Mycota | Ascomycetes | Yeasts | 15,000 |
| | Basidiomycetes | Mushrooms | 10,000 |
| | Deuteromycetes | Fungi Imperfecti | 10,000 |
| | 6 more Classes | | 5,000 |
| Lichenes | 2 Classes | Lichens | 1,000 |
| Algae: | | | |
| Euglenophyta | 1 Class | Phyto-Flagellates | 50 |
| Chrysophyta | 2 Classes | Golden Algae | 1,000 |
| Pyrrophyta | Dinophyceae | Dinoflagellates | 100 |
| Rhodophyta | 1 Class | Red Algae | ?5 |
| Chlorophyta | 1 Class | Blue-Green Algae | 1,000 |
| Bryophyta | 3 Classes | Mosses | 1,500 |
| Pteridophyta | 5 Classes | Ferns | 500 |
| Spermatophyta: | | | |
| Gymnospermae | Coniferae | Conifers | 3 |
| Angiospermae | Dicotyledoneae | Flowering Plants | 7,500 |
| | Monocotyledoneae | Flowering Plants | 2,500 |
| **Total** 35 Phyla | 89 Classes | | 320,000 |

**Source:** Dias (1996).

The bryophytes are extremely vulnerable and depend on undisturbed vegetation. Besides this, they are highly sensitive to atmospheric pollution depending as they do directly on rainwater. Their vulnerability, and the relative lack of knowledge on their diversity, biology and distributions, results in the bryophytes being one of the most threatened groups of plants in the Brazilian flora. Existing collections are few and urgently require expansion, involving collection especially in regions undergoing deforestation. Brazil has only five or six bryophyte specialists, evidently insufficient considering their diversity.

Globally, marine and continental algae are estimated to total about 218,270 species, of which only 17% are known to science. About 525 species of marine algae were listed for Brazil in 1997, a serious underestimate considering the complete lack of inventories in many parts of the country. Algal diversity is not uniformly distributed: certain regions of the Brazilian coast, especially the south-east, are known for their exceptionally large numbers of species of marine algae. Surveys and systematic studies are urgently needed for the coral reefs of the north-east of Brazil. Algae comprise the base of the food chain in marine ecosystems and are a major component of the oxygen cycle. Other economic factors arguing for the need to conserve and study these organisms include the extraction of algal products used in the food, pharmaceutical, textile and fertiliser industries.

**Table 2-6.** Diversity: world ranking of megadiversity countries in species richness.

| Country | Birds | Mammals | Reptiles | Amphibians | Freshwater fish | Butterflies | Tiger Beetles (Cicincelidae) | Higher Plants | Total |
|---|---|---|---|---|---|---|---|---|---|
| Brazil | 3 | 5 | 1 | 4 | 5 | 4 | 3 | 5 | 30 |
| Colombia | 5 | 2 | 3 | 5 | 4 | 3 | - | 4 | 26 |
| Indonesia | 1 | 4 | 2 | - | 3 | - | 5 | 3 | 18 |
| Peru | 4 | - | - | - | - | 5 | - | - | 9 |
| Mexico | - | 1 | 4 | 2 | - | - | - | 1 | 8 |
| China | - | 3 | - | 1 | 1 | - | - | 2 | 7 |
| Australia | - | - | 5 | - | - | - | - | - | 5 |
| Ecuador | 2 | - | - | 3 | - | - | - | - | 5 |
| India | - | - | - | - | - | - | 4 | - | 4 |
| Venezuela | - | - | - | - | 2 | 1 | - | - | 3 |
| Bolivia | - | - | - | - | - | 2 | - | - | 2 |
| Madagascar | - | - | - | - | - | - | 2 | - | 2 |
| Dem. Rep. of Congo | - | - | - | - | - | - | 1 | - | 1 |
| Philippines | - | - | - | - | - | - | - | - | 0 |
| South Africa | - | - | - | - | - | - | - | - | 0 |

Ranking of the five countries with the highest diversity in five groups of vertebrates (birds, mammals, reptiles, amphibians and freshwater fish), in two groups of invertebrates (butterflies and tiger beetles [Cicincelidae]), and in higher plants; and on the five countries with the highest endemism of four groups of vertebrates (birds, mammals, reptiles and amphibians), in two groups of invertebrates (butterflies and tiger beetles [Cicincelidae]) and higher plants.
Five marks are given to the first place, 4 to the second, 3 to the third, 2 to the fourth and l to the fifth.
**Source:** Mittermeier *et al*. (1997).

## 2.1.4 Micro-organisms

It is estimated that only 0.1% to 1.0% of terrestrial and aquatic micro-organisms are cultivated by conventional means in the laboratory.

Clinical microbiology is one of the most traditional research areas in Brazil, with a number of well-established, internationally-recognised, research laboratories working on tropical-disease-related protozoans and viruses (including the Oswaldo Cruz Institute - FIOCRUZ, the Evandro Chagas Institute and the University of São Paulo), in bacteriological research (for example the Adolfo Lutz Institute, and the Federal University of Rio de Janeiro), and in mycology (for example, the Department of Pathology of the University of Amazonas - DP/FUA, and the Institute of Tropical Medicine (IMT) of the University of São Paulo).

Research in environmental microbiology is gaining strength, with new working groups being established in a number of regions of the country. Considerably more training and infrastructure are required for research on microbial diversity, however; factors which have time and again been considered fundamental for the development of microbiology in the country.

Data collected between 1982 and 1989 for a *Catálogo Nacional de Linhagens* (National Catalogue of Lineages) demonstrated that Brazil held a number of extremely important scientific collections of micro-organisms, including micro-algae, protozoa, bacteria, filamentous fungi and yeasts, and cell cultures, mostly in research centres and universities in the south-east and the south of the country. The regions which are richest in biodiversity (the north and central-west) have relatively few collections.

Of the 36 collections catalogued, seven were of algae, 18 of filamentous fungi and yeasts, four for protozoans, one for viral lineages, and one for animal cell cultures.

A national programme has been established for micro-organism culture collections (*Programa Setorial de Coleções de Culturas - PSCC 1990/91*), funded by the Financing Agency for Research and Projects (Financiadora de Estudos e Projetos - FINEP), Rio de Janeiro. A number of collections have reorganised and updated their stocks and registers, with data being made available through the ´National Lineage Catalogue´ series, volumes 1 to 3, which for some collections is the only published reference to date.

**Table 2-7.** Endemism: world ranking of megadiversity countries.

| Country | Birds | Mammals | Reptiles | Amphibians | Butterflies | Beetles Cincitelidae | Higher plants | Total |
|---|---|---|---|---|---|---|---|---|
| Indonesia | 5 | 4 | - | - | 5 | 4 | 4 | 22 |
| Brazil | 3 | 2 | 1 | 4 | - | 3 | 5 | 18 |
| Australia | 4 | 5 | 5 | 1 | - | - | 1 | 16 |
| Madagascar | - | - | 3 | 3 | 1 | 5 | - | 12 |
| Colombia | 1 | - | - | 5 | 2 | - | 2 | 10 |
| Philippines | 2 | 1 | - | - | 4 | 1 | - | 08 |
| Mexico | | 3 | 4 | - | - | - | - | 07 |
| India | - | - | 2 | - | - | 2 | - | 04 |
| Peru | - | - | - | - | 3 | - | - | 03 |
| South Africa | - | - | - | - | - | - | 3 | 03 |
| China | - | - | - | 2 | - | - | - | 02 |
| Bolivia | - | - | - | - | - | - | - | 00 |
| Dem. Rep. of Congo | - | - | - | - | - | - | - | 00 |
| Ecuador | - | - | - | - | - | - | - | 00 |
| Venezuela | - | - | - | - | - | - | - | 00 |

Ranking of the five countries with the highest endemism in four groups of vertebrates (birds, mammals, reptiles, amphibians), in two groups of invertebrates (butterflies and tiger beetles [Cicincelidae]), and in higher plants. Five marks are given to the first place, 4 to the second, 3 to the third, 2 to the fourth and l to the fifth.
**Source:**Mittermeier *et al*. (1997).

## 2.1.5. Genetic Biodiversity

Studies of genetic diversity have concentrated on intraspecific variation, and only rarely on variation between species and analyses at higher taxonomic levels. Different techniques have been applied, depending on the research group and organisms under study. In Brazil, the majority of the cytogenetic research groups are already working with chromosome banding, while only a few use hybridisation in situ. A large number of plant and animal groups are being studied. Research groups of particular importance have been set up in the University of São Paulo, working on rodents, in the Federal University of São Carlos working on fish, in the National Cancer Institute (*Instituto Nacional de Câncer*), Rio de Janeiro, working on primates, and in the Federal University of Pernambuco, working on plants.

The majority of the research in molecular biology involves the use of mitochondrial DNA (mtDNA). Over half of the research programmes use Restriction Fragment Length Polymorphism - RFLP although the technique of Random Amplified Polymorphic DNA - RAPD is becoming more common; now in use in about one quarter of the research projects. Only a few genetic biodiversity research projects use sequencing. Important research laboratories include those of: the Genetics Department of the Federal University of Pará, which has sequenced three genes of 16 genera of primates; the State University of São Paulo - UNESP, Botucatu, using various techniques, including RAPDs, in plants; the State University of Campinas - UNICAMP, working with Polymerase Chain Reaction (PCR) - RFLP of mtDNA for various species of *Drosophila*; and the Federal University of Rio Grande do Sul in collaboration with UNESP - São José do Rio Preto, studying transposons in *Drosophila*).

In biochemical genetics, about one half of the research carried out in Brazil uses 10 to 20 isozyme systems, one

**Table 2-8.** Overall ranking of megadiversity countries in terms of species richness and endemism

| Country | Diversity | Endemism | Total |
|---|---|---|---|
| Brazil | 30 | 18 | 48 |
| Indonesia | 18 | 22 | 40 |
| Colombia | 26 | 10 | 36 |
| Australia | 05 | 16 | 21 |
| Mexico | 08 | 07 | 15 |
| Madagascar | 02 | 12 | 14 |
| Peru | 09 | 03 | 12 |
| China | 07 | 02 | 09 |
| Philippines | 00 | 08 | 08 |
| India | 04 | 04 | 08 |
| Ecuador | 05 | 00 | 05 |
| Venezuela | 03 | 00 | 03 |

Results obtained by adding the marks of the countries according to the data in Tables 2-6 and 2-7.
**Source:** Mittermeier *et al.* (1997).

quarter use fewer than 10, and one quarter use more than 20. There are many research groups working in this field. Some examples include: the Federal University of Rio de Janeiro - UFRJ, working on marine invertebrates; the University of São Paulo - USP, Riberão Preto, studying bees; the National Institute for Amazon Research - INPA, Manaus, studying Anophelini including the malaria vector; the Butantã Institute in São Paulo studying reptiles; UNESP - São José do Rio Preto studying insects; the State University of Campinas - UNICAMP, studying herbivorous insects; the Federal University of Rio Grande do Sul - UFRGS, Porto Alegre, studying plants; the Federal University of Minas Gerais - UFMG, Belo Horizonte, studying legumes; and the ´Luiz de Queiroz´ Higher School of Agriculture (Escola Superior de Agricultura ´Luiz de Queiroz´ - ESALQ/USP), Piracicaba.

Several groups in Brazil are working on quantitative genetics related to artificial selection in native and cultivated plant species. There is also an increase in research being carried out on wild species. The organizations involved include Brazilian Agricultural and Cattle-Breeding Research Company (Empresa Brasileira de Pesquisa Agropecuária - EMBRAPA), Petrolina (improvement of native species in semi-arid tropics, especially the ´umbuzeiro´ tree); EMBRAPA, Recife (improvement of native fruit trees); the University of Brasília - UnB studying the morphology of *Drosophila* and; the State University of Campinas - UNICAMP, studying rodents.

**Table 2-9.** Indicators of biodiversity for Brazilian biomes: Number of centres of endemism.

| Biome | Birds[1] | Primates[2] | Terrestrial Vertebrates[3] | Forest Butterflies[4] | Vascular Plants[5] |
|---|---|---|---|---|---|
| Amazon | 5 | 3 | 6 | 13 | 3 |
| Cerrado | 2 | 1 | 1 | 1 | 10 |
| Caatinga | 2 | 1 | 1 | 0 | 3 |
| Atlantic Forest | 7 | 4 | 3 | 4 | 6 |

**Sources**:
[1] Bibby *et al*. (1992);
[2] Ávila-Pires (1974), Rylands *et al*. (1996);
[3] Müller (1974);
[4] Tyler *et al*. (1994);
[5] Mendonça *et al*. (in press). Galera & Ramella (1997).

There are very few centres studying morphological polymorphism. Researchers at the Federal University of Rio Grande do Sul - UFRGS, Porto Alegre, have been working for some time on mimicry in butterflies.

These varied research fields and methodologies all contribute significantly to our understanding of genetic biodiversity in Brazil, although they are concentrated on relatively few organisms: Insects, especially Diptera (flies and mosquitoes), fish, amphibians, reptiles, mammals, especially rodents and primates, and plants, especially legumes and fruit. Notable amongst other groups which are less well-studied are the bats, birds (except macaws and parrots), Coleoptera (beetles) and Hemiptera (bugs), spiders, echinoderms (sea urchins, starfish), and ferns.

Considering the state of our knowledge on genetic biodiversity in Brazil overall, it can be seen that all the principal techniques and sub-disciplines available today are being employed. The research groups mentioned above are using the

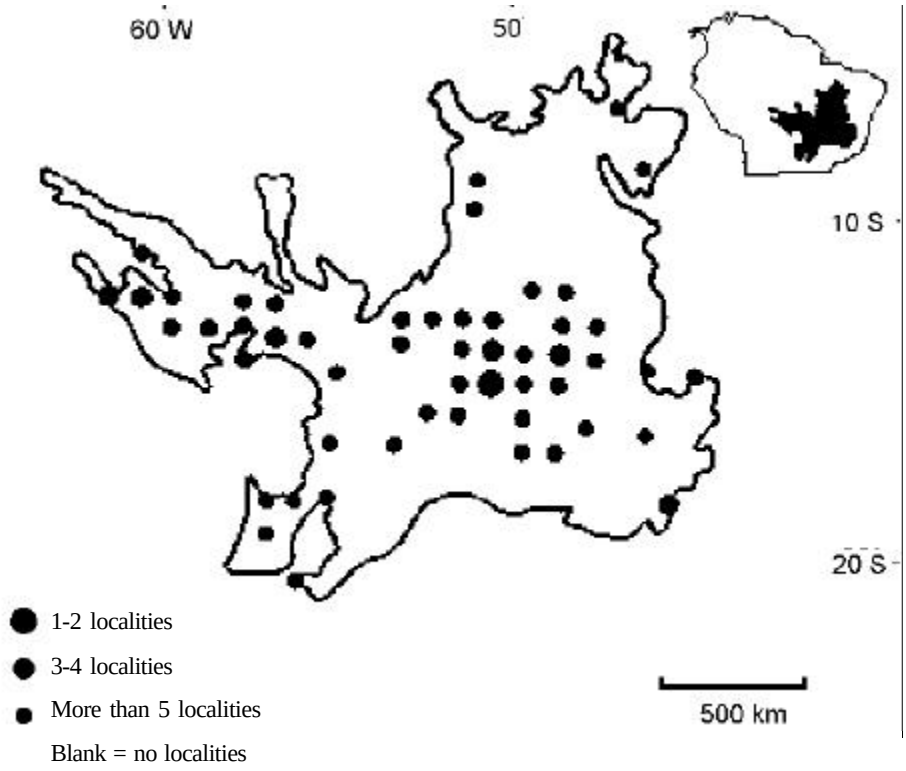



**Figure 2-6**. Number of localities per quadrat with bird surveys in the Brazilian Cerrado. Only localities regarded as "minimally sampled" are included. The map is divided into 186 quadrats of 1º x 1º.

**Source**: Silva (1995).

most up-to-date techniques, their research is internationally recognised, and, perhaps most important, there is ample scope for increasing their capacity and extending their research into new fields. Training is also considered to be an important component to stimulate the creation of new research groups in other regions of Brazil, and to expand the range of organisms under study.

## 2.1.6 Endangered Species

Avoiding the extinction of species is a commitment foreseen in Paragraph 1 of Article 225 of the Brazilian Constitution, which also names the State as the guardian of the diversity of the genetic heritage in the country. Identification of the threatened plants and animals, using scientific criteria, is a necessary first step.

The first official list of threatened plants was published in 1968 by the Brazilian Forestry Development Institute (Instituto Brasileiro de Desenvolvimento Florestal - IBDF) (IBDF Edict No. 303, 29th May 1968), and included 13 species. One more was added to the list in 1980 (IBDF Edict No. 93, 5th December 1980). The first official list of threatened fauna was first published in 1973 (IBDF Edict No. 3.481, 31st May 1973), and included 86 taxa.

By the 1980s, however, these lists were outdated. In January 1989, the Brazilian Zoological Society (Sociedade Brasileira de Zoologia - SBZ) set up a working group of 14 zoologists, with the task of bringing the list of endangered fauna up-to-date and proposing the norms for periodic revisions. Funded by IBAMA, this group produced a new list and submitted it to the National Council for Fauna Protection (Conselho Nacional de Proteção à Fauna), a committee linked directly to the presidency of IBAMA. The list was approved, and published in December 1989 (IBAMA Edict No. 1.522, 19th December 1989).

With Brazil a signatory (Decree-Law No. 54, 24th June 1975) to the Convention on International Trade in Endangered Species of Wild Flora and Fauna - CITES, the species on the official Brazilian list can be included in Annex 3 of the Convention. This guarantees the co-operation of the co-signatory countries in the control of international trade in these species. International transport requires a certificate of origin and specific authorisation from IBAMA.

The list must also be considered when undertaking any project requiring an Environmental Impact Report (Resolution No. 001/86, Article 6, paragraph 1 of 23rd January 1986, published by the National Environment Council [Conselho Nacional do Meio Ambiente - CONAMA]).

The official Brazilian lists do not discriminate the levels of threat to each taxon. In the past, the categories used by the International Union for the Conservation of Nature - IUCN were ´Endangered´, ´Vulnerable´, ´Rare´, ´Indeterminate´ or ´Insufficiently known´. In 1994, IUCN, now the World Conservation Union, reviewed the system of categories and redefined them. In 1996, they adopted a new scheme which included ´Extinct in the wild´, ´Critically endangered´, ´Endangered´, ´Vulnerable´, ´Low risk´, ´Insufficient data´ and ´Not assessed´. However, the Brazilian legislation makes no provision for discriminating threatened status (Edict No. 303/68 and Edict No. 3.481/73). Only the species considered ´probably extinct´ were marked with an asterisk in the edict. A second list of species, also drawn up by the Working Group of the Brazilian Zoological Society, included those probably threatened but insufficiently known. There is an urgent need for research to establish the status of these species.

The Brazilian List of Threatened Fauna (Lista Oficial de Espécies da Fauna Brasileira Ameaçada de Extinção), made official by IBAMA in the Edict No. 1.522 of 19th December

**Table 2-10**. Invertebrate marine animal Phyla and the existence of respective specialists in Brazil

| Animal Phyla | Specialists in Brazil? |
|---|---|
| Mesozoa | No |
| Placozoa | No |
| Porifera | Yes |
| Cnidaria | Yes |
| Ctenophora | No |
| Gnathostomulida | No |
| Platyhelminthes | Yes |
| Gastrotricha | Yes |
| Rotifera | Yes |
| Acanthocephala | No |
| Loricifera | No |
| Kinorhyncha | No |
| Priapulida | No |
| Nematomorpha | No |
| Nematoda | Yes |
| Chaetognata | Yes |
| Mollusca | Yes |
| Nemertinea | Yes |
| Sipuncula | Yes |
| Echiura | Yes |
| Pogonophora | No |
| Annelida | Yes |
| Tardigrada | Yes |
| Uniramia | Yes |
| Cheliceriformes | No |
| Crustacea | Yes |
| Phoronida | Yes |
| Entoprocta | No |
| Ectoprocta | No |
| Cycliophora | No |
| Brachiopoda | No |
| Echinodermata | Yes |
| Hemichordata | No |
| Chordata - Tunicata | Yes |

**Source**: Migotto (1997).

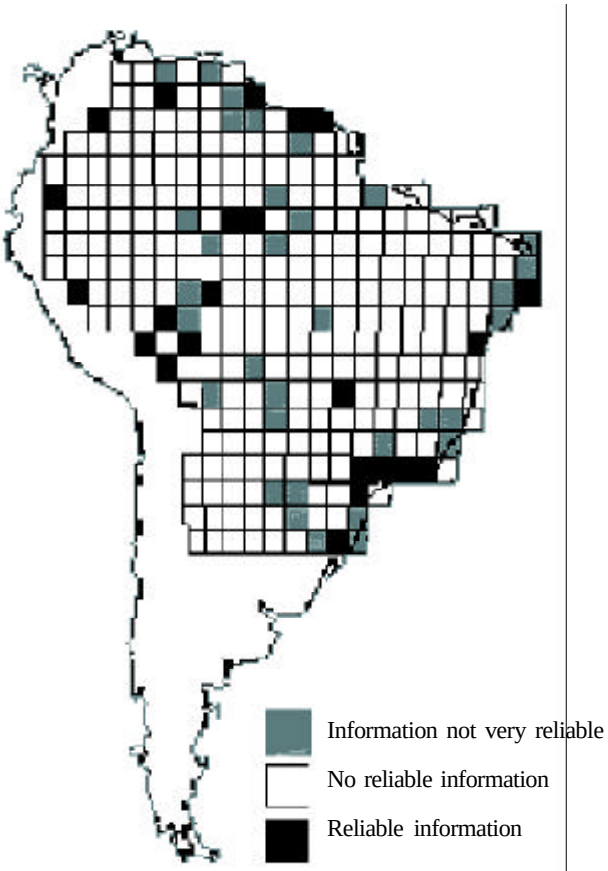



**Figure 2-7**. Data on amphibian distributions in eastern South America.

**Source**: Heyer (1997).

1989, includes 218 species (Box 2-1). A further 10 species have been added since (IBAMA Edict No. 45, 27th April 1992, and IBAMA Edict No. 62, 17th June 1997).

A new list of endangered plants was published in 1992 (Edict No 06-N, 15th January 1992), increasing the number from 13 to 100. Forty-one of them are ´Endangered´, 25 ´Rare´, 29 ´Vulnerable´, four ´indeterminate´, and one ´insufficiently known´ (Box 2-2).

An important aspect to consider regarding the threatened species lists is that a large number of species occur in more than one biome. The fact that a species is widespread in the Amazon, for example, means that it is not included in the threatened species list, when it is possibly highly threatened or even extinct in other parts of its geographic distribution. This obviates the need for regional lists. Figure 2-8 shows that many of the threatened species are those endemic to the Atlantic forest.

The uneven distribution of threats to Brazil's fauna has resulted in some Federal States taking the initiative of drawing up their own. This has already been carried out by the states of Paraná, Minas Gerais and São Paulo. These lists are an excellent means by which the state governments can introduce their own legislation and measures for the management and conservation of their natural resources, and will also stimulate fieldwork and programs for their threatened species.

Each state list is different (Tables 2-13 and 2-14), reflecting not only geographic distributions but regional differences in threats such as hunting, extractivist activities and habitat destruction.

The state of Paraná published its list of threatened fauna in 1995 (State Law 11.067, 17th. February 1995). The list for the state of Minas Gerais was published by the Commission for Environmental Policy (Comissão de Política Ambiental - COPAM) in 1996 (Deliberation No. 41/95, 20th January 1996), and that for São Paulo in early 1998 (State Decree No. 42.838, 4th February 1998).

State lists for threatened species of plants have also been drawn up. For Paraná, the list includes 236 plants as ´Endangered´, 106 as ´Vulnerable´ and 251 as ´Rare´. The state list for Minas Gerais includes 79 plants as ´Probably extinct´, 108 as ´Critically endangered´, 128 as ´Endangered´ and 221 as ´Vulnerable´.

There are also some initiatives to draw up threatened species lists dealing with specific groups of organisms. These have included to date mammals, bats, birds, and plants of the Families Myrtacae (guava family) and Bromeliaceae (pineapple family). Some groups, such as fish, and invertebrates in general, are under-represented or do not appear at all on the national list, for mere lack of information. Periodic reviews of the national list are the responsibility of the Division of Fauna of the Wildlife Department (Departamento de Vida Silvestre- DEVIS) of IBAMA, and a meeting to resolve the problem of criteria for categorising the species according to their threatened status was held in December 1997.

The Tropical Data Base (Base de Dados Tropicais - BDT) of the André Tosello Tropical Foundation for Research and Technology (Fundação Tropical de Pesquisas e Tecnologia ´André Tosello´) has placed a major list of threatened species in Brazil on the Internet, based on official, and complementary (insufficiently known) federal and state lists, (http://www.bdt.org.br/bdt/redlist/?index). This listing includes 627 species, but does not correspond to the national list, some species being threatened in some states but not in others.

**Table 2-11**. Known and estimated diversity of marine invertebrates in Brazil.

| TAXA | Known number of species | | | ESTIMATES | | | | | | | | | | | | | | Region (symbols same as in previous columns) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Brazil | | World | Environment/Ecosystem/Habitat<br>Status of collections / knowledge E = excellent, G = good, B = bad, N = None | | | | | | | | | | | | | | | | | |
| | literature | estimated | literature | intsol | Intsof | Intsol | Intsof | cp | cs | op | np | man | mar | rc | es | ci | oi | ot | N | NE | SE | S |
| Porifera | 250-400 | 600-900 | 10000- 15000 | G/B | - | G/B | B/B | B/B | B/B | - | - | B/B | - | B/B | - | B/B | B/B | - | B/B | B/B | G/G | B/B |
| Cnidaria, Hydrozoa | 470 | 600-800 | 4000 | G/G | B/B | B/B | B/B | B/N | B/N | B/B | B/B | B/B | N/N | B/B | B/B | B/B | B/B | - | N/N | B/B | G/B | B/B |
| Cnidaria, Scyphozoa and Cubozoa | 19 | ? | 216 | - | - | B/B | N/N | B/B | B/B | B/B | B/B | B/B | - | B/B | B/B | B/B | B/B | - | B/B | B/B | B/B | B/B |
| Ctenophora | 2 | 2 | 90 | - | - | B/B | - | - | - | B/B | B/B | - | - | N/N | N/N- | N/N | N/N | - | N/N | N/N | B/B | N/N |
| Gastrotricha | 61 | ? | 500 | - | - | - | - | - | | - | - | - | - | - | - | - | - | - | B/G | N/N | B/B | N/N |
| Kinorhyncha | 1 | ? | 150 | - | B/N | - | B/N | B/N | - | - | - | - | - | - | - | - | - | - | N/N | N/N | B/B | N/N |
| Nematoda | 240-400 | 10000-1,5x10 [6] | 4000 | B/N | G/B | N/N | B/N | G/B | N/N | - | - | B/B | N/N | N/N | B/N | N/N | N/N | - | B/N | G/B | G/B | B/N |
| Mollusca | 2400-3000 | 10000 | 100000 | E/G | E/G | B/B | B/B | B/B | B/B | B/B | B/B | E/B | - | G/G-B | E/B | G/G | G/G | - | B/B | G/B | E/B | G/G |
| Sipuncula | 30 | 70 | 150 | - | G-B/B | - | G-B/B | B/B | B/B | - | - | - | - | - | - | - | - | - | G/B | G/B | B/B | B/B |
| Pogonophora | 1? | ? | 72 | - | - | - | N/N | N/N | N/N | - | - | - | - | - | - | - | - | - | N/N | N/N | N/N | N/N |
| Crustacea, Copepoda | 650-700 | 1000-2000 | 11500-13000 | - | B/B | - | B/B | B/B | B/B | G/G | G/G | B/B | B/B | B/B | G/G | B/B | B/B | - | B/B | B/B | B/B | B/B |
| Crustacea, Amphipoda | 134 | ? | 5700 | G/G | G/G | G/G | G/G | B/G | B/B | - | - | - | G/G | G/B | G/G | - | - | - | B/B | B/B | G/G | B/B |
| Crustacea, Isopoda | 120-150 | 500-800 | 4000-4500 | B/B | B/B | B/B | B/B | G-B/ G-B | B/B | - | - | - | - | - | - | - | - | - | N/N | B/B | G-B/ G-B | B/B |
| Crustacea, Cirripedia | 79 | 140 | 1225 | G/G | G/G | G/G | G/G | B/B | B/B | B/B | B/B | G/G | G/G | G/G | B/B | G/G | B/B | - | B/B | B/B | G/G | G/G |
| Crustacea, Brachyura | 300-400 | 400-450 | 5000- 6000 | G/G | G/G/ | G/G | G/G | G/G | B/B/ | B/B | B/B | E/E | G/G | G/G | G/G | G/G | B/B | - | B/B | G/G | G/G | G/G |
| Phoronida | 2 | 4-6 | 16-18 | B/B | B/B | N/N | B/B | B/B | N/N | B/B | G/N | - | - | N/N | B/B | N/N | N/N | - | - | B/B | B/B | B/B |
| Ectoprocta | 175-210 | ? | 5500 | G/G | - | B/B | - | B/B | N/N | - | - | - | - | N/N | - | B/B | N/N | - | ?/? | B/B | G/G | G/G |
| Hemichordata | 7 | ? | 91 | - | G/G | - | - | - | - | - | - | - | - | - | - | - | - | - | N/N | ?/? | G/G | B/B |

**intsol** = intertidal solid substrate; **intsof** = intertidal soft substrate; **infsol** = infralittoral solid substrate; **infsof** = infralittoral soft substrate; **cp** = continental platform; **cs** = continental slope; **op** = oceanic pelagic; **np** = neritic pelagic; **man** = mangroves; **mar** = brackish water; **rc** = coral reef; **es** = estuarine; **ci** = continental islands; **oi** = oceanic islands; **ot** = others.
**Obs**. When the status of the estimates of status of collections/knowledge are uncertain, the range is indicated by a hyphen, for example, 'G-B' = possibly good, possibly bad.
**Source**: Migotto (1997)