

Freshwater Ecosystem Conservation:  
Towards a Comprehensive Water  
Resources Management Strategy

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# Executive Summary

From the coastal estuaries and deltas of Mexico, to the lakes of Central America, to the rivers and oxbow lakes of Amazonia, to the Pantanal of Brazil, Latin America and the Caribbean (LAC) is a region of vast and diverse freshwater ecosystems. The diversity of species present in these ecosystems is also truly extraordinary, particularly in the case of fish. Invertebrates and plants are also extremely diverse throughout the Amazon. Large portions of the region are still in the process of being occupied by humankind and developed, thus providing new opportunities for sustainable development.

Freshwater ecosystems (wetlands, lakes and rivers) are critical habitats for a variety of threatened species and provide many benefits to mankind. In addition to being the source of the region's water supply, they prevent and regulate floods, prevent saline water intrusion, ameliorate erosion impacts by retaining sediments, provide nutrient retention and toxicant removal, offer micro-climate stabilization, act as a global carbon sink, serve as a means of transport and are excellent sites for tourism. Much of what freshwater ecosystems provide, including forest, wildlife, fisheries, forage, agricultural and energy resources, is available for human use. For example, the use of genes from wild species occurring in wetlands is an important way of improving cultivated varieties of plants. The value of these products is often measured in millions of dollars annually for any given locality, representing an important source of income for rural and urban communities alike. Some wetlands also have social, cultural and historical significance.

Despite their importance, many freshwater ecosystems are frequently considered useless. Widespread ignorance about their importance has contributed to this notion and has promoted their destruction and degradation. Conservation of freshwater biodiversity has been seriously neglected throughout the world, and entire ecosystems are threatened with extinction. The primary cause of resource loss is habitat alteration, fueled by rapid population growth and unwise development, both planned and unplanned. Erosion and deforestation of the catchment basin forests has reached dramatic intensity along the eastern slopes of the Andes, from Colombia to northern Argentina. Rural development (mostly for rice cultivation) is affecting wetlands in the entire region. Pollution from mining and industry, as well as urban development, is a growing cause of concern (Comisión de Medio Ambiente y Desarrollo de América Latina y el Caribe, 1996). The construction of dams and river channelization may also undermine important freshwater resources. Today, Latin America's

main water resources are chemically and biologically contaminated to a considerable degree.

Unfortunately, freshwater sustainability issues do not appear to be a primary consideration in the planning and implementation of water use projects, nor in the allocation of use permits. In fact, water rights in most LAC countries are not conditional on their potential environmental impacts, nor can they be amended to ameliorate environmental threats. Present trends indicate that unless a sustainable water resources management policy is developed and put into practice effectively, the resource base will deteriorate at an accelerating rate (Lee, 1990).

Developing a sustainable water resources management policy should be based on the following leading principles:

- A holistic, ecosystem-based approach is required in order to ensure the long-term sustainability of the region's ecosystems. By ecosystem approach, we mean a management policy that perceives water resources as part of functional systems (such as whole basins or river/floodplains systems) in which the complex interconnections among physical and biotic components are adequately considered.
- Freshwater resource management should be part of a comprehensive approach to long-term planning and monitoring for the sustainable use of natural resources, including ecological, economic, and social aspects.
- A new balance is required between the growing tendency toward privatization and globalization of the economy and the role of both civil society and the state in preventing the degradation of water resources.

Implementing these principles is far from easy. However, the environmental, social and economic losses that can be expected in the region if the present rate of degradation of its freshwater resources is not reverted are enormous.

# Introduction

Population growth and a rapidly expanding economy are fueling an exponential increase in the human use of resources in LAC. Indeed, globalization of the economy and the development of regional trade markets (such as NAFTA in North America and MERCOSUR in South America) will exert a strong pressure for even more intensive resource use in the region. These trends are facilitated by improved communications and road building, and the weakening of long-term geopolitical conflicts among the countries that share the continent. The expansion of agricultural frontiers, deforestation, mining, industrialization and urban development are among the more visible results of this pressure. In nearly all cases, a growing demand for natural resources implies greater water consumption. In South America, for example, it is expected that water consumption will grow by about 45 percent between the years 1990 and 2000, from 150 to 216 cubic kilometers per year (Gleick, 1993).

The need to meet the exponential growth in the demand for fresh water in LAC will be further complicated if, as suggested by present tendencies, the resource base is allowed to continue to deteriorate. Deforestation of basin catchments, erosion, pollution and depletion of underground water stocks are among the main threats to the region's freshwater supply. For example, deforestation and erosion of the eastern slopes of the Andes, from Colombia to Argentina, is increasing at an alarming rate, with far-reaching consequences for the river basins that originate there.

Conservation of freshwater resources in the region is complicated by the fact that degradation of the resource base results not only from overexploitation at the commercial level but also, to a considerable degree, from the impact of subsistence family farmers. Overgrazing, deforestation, soil erosion and the mismanagement of water resources have contributed

to the continuing cycle of poverty in the region. Environmental problems associated with subsistence economies are difficult to evaluate and control, and are frequently ignored by development organizations. This signals the need for treating environmental degradation and poverty as correlated social and ecological processes requiring an integrated approach during control and management.

In the last two decades there has been a rapid growth in environmental awareness, largely due to a few key events which focused world attention. Three events have been of particular importance. The United Nations Conference on the Human Environment in Stockholm led to the establishment of the United Nations Environment Program in 1972, and of ministries of the environment in several countries. In 1987, the publication of *Our Common Future*, the report of the World Commission on the Environment and Development, increased public awareness of the link between environment and development. This linkage was emphasized in the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992 and the documents and treaties that resulted from it, particularly Agenda 21 (Duda and Munasinghe, 1993; IUCN/UNEP/WWF, 1991; Sitarz, 1993). Along the same perspective, more specific guidelines on water management have emerged from the Dublin Principles (1992), and the declarations of Miami (1994), San José and Buenos Aires (1996) (OAS 1996, WMO/IDB 1996, UNDP, 1994).

Still, environmental awareness varies widely among the countries of the region. In addition, the views of the developed countries are in contrast to those of the developing ones. Developed countries are able to devote the funds necessary to environmental protection without suffering unacceptable decreases in living standards. Perspectives from developing countries are different. Standards of living are gen-

erally low, and resources to protect the environment are usually inadequate. In fact, the overexploitation of natural resources is in some cases an easy alternative for survival, implying a cycle of increased resource destruction and poverty. This, in turn, forces many countries to mistreat the land, taking what is necessary for short-term survival without saving for the future.

The challenge of making development compatible with environmental protection is therefore becoming more and more pressing, particularly to development agencies at the international and national level. The current rate of growth in population and per capita use of resources suggests that past experience may not be adequate for dealing with the current situation. In an era in which natural capital, and more specifically water, was considered infinite relative to the scale of human use, it was reasonable not to deduct the consumption of natural capital from gross receipts in calculating income. That era is now past. The goal of environmental sustainability is to maintain the traditional meaning and measure of income in an era in which natural capital, and specifically fresh water, is no longer a free good, but is rapidly becoming the limiting factor in development.

Unfortunately, even though this concept may be easily understood, its implementation is not easy, particularly in developing countries. Moreover, the risk of financing interventions that may bring considerable and unforeseen ecological and social negative impacts is real and far from negligible. Additionally, there is a real threat that such interventions will promote perverse incentives that will favor “boom and bust” economies instead of sustainable growth. However, the answer cannot and should not be “no action,” if for no other reason than that the ongoing processes of development will not stop simply because multilateral agencies do not fund them. Indeed, these agencies have a responsibility to bring

their broad vision and considerable experience to bear on a situation that, without intervention, could become catastrophic.

But while the specialists readily perceive the problems at hand, the possibility of making a substantial contribution to their solution is, at best, difficult. In the case of multilateral agencies like the IDB, it demands the development of adequate and efficient mechanisms to stimulate sustainability and, at the same time, discourage the unwise use of the resource base. Among other things, this requires an effective and creative synthesis of economic and ecological thinking to respond to the new challenges. One obvious prerequisite for this is that no aspect or issue should be discarded simply because it sounds “too green” or “too pro-development.” Implementation is always more complex, more difficult to conceive and less clearly defined than theory. For too long political decisions underestimated the influence of land use, forest management and dam building on water scarcity and, therefore, on economic progress, food security and regional peace. Many policymakers have yet to realize that water problems can no longer be fixed through engineering alone.

At the same time, the opportunities for integrating freshwater ecosystem conservation into a comprehensive water resources management strategy are increasing. This is particularly the case given the processes of economic globalization, the development of regional trade markets, improved communications, the building of roads and better political integration among countries. However, a great deal of initiative and long-term vision is required to transform opportunities into reality. Latin American countries have, so far, paid little attention to environmental planning and wise resource use, despite the fact that after the Rio Conference on Environment and Development, it has become an important item in the political agendas of the countries of the region.

# Freshwater Ecosystems in Latin America

## Background

The diversity of species and ecosystems in Latin America's freshwater biome is remarkable. According to the *Directory of Neotropical Wetlands*, which lists sites of greatest importance according to the criteria of the Convention on Wetlands of International Importance (Scott and Carbonell, 1986), there are more than 500 such sites in the region.

Biologists have often called South America the Bird Continent, but it should be more appropriately referred to as the Fish Continent. Almost half of all described vertebrates are teleost (bone) fish, and a quarter of these are estimated to occur in the Neotropics. Three thousand species of fish are thought to live in the Amazon River basin alone, one of the world's largest and most diverse freshwater ecosystems. Scientists have recently discovered an amazing diversity of fish species in the leaf litter and detritus of smaller rivers. Many species normally associated with marine systems (including sharks, drums and dolphins) are found in the larger rivers.

The Amazon River basin alone has diverse freshwater habitats, including large rivers (whitewater, blackwater and clearwater), floating meadows, seasonally flooded forests (*varzea*), swamp forests, cataraacts, mangroves, small rivers, streams and oxbow lakes. And although the Amazon and Orinoco River ecosystems are two of the most dominant and widely recognized elements of Neotropical freshwater biodiversity, the region also contains a diverse array of freshwater habitats and communities. There are vast, seasonally-flooded savannas in the Llanos and the Pantanal; cold montane streams and cataracts, and high elevation freshwater and saline lakes are found in the Andes and other mountainous regions; the Pampas and Patagonian steppes boast lush wetlands; and large highland lakes are found in

Central America and Mexico. Unique bogs and swamps are found in the Southern Cone. *Nothofagus* forests, springs and cave waters are found in Chiapas and Oaxaca (Mexico) and in other limestone regions, and closed basin springs and pools are found in the Chihuahuan Desert.

## Present Status and Conservation Trends

In Latin America and the Caribbean there are considerable areas of land that are still uninhabited and/or undeveloped. The Amazon basin (a vast proportion of tropical South America), and considerable portions of the Chaco, the Llanos, and the Andean regions are still relatively empty areas, some of them holding vast freshwater resources. At the same time, other areas of the region (particularly Central America) are being affected by rapid and substantial changes in natural resource use due to high rates of population growth, extensive deforestation and expansion into the last remaining agricultural frontiers. Most of the present development is unplanned and has serious environmental, economic and social effects.

The primary cause of freshwater loss is environmental degradation (particularly extensive urbanization, deforestation, soil erosion, dams and other large-scale engineering works, and widespread pollution), fueled by rapid population growth and unwise development trends, both planned and unplanned. Mining activities are affecting water resources (mainly in the Andes), through regular operations and accidental spills. Urban development and tourism are having devastating effects on many coastal areas, such as the province of Buenos Aires in Argentina, southern Brazil, and parts of Ecuador, Colombia and Venezuela. Rural development is affecting wetlands in the whole region. In southern Brazil, northeast Argentina (Entre Rios and Corrientes provinces), Uruguay (Bañados del Este), and the

Llanos of Venezuela, for example, extensive wetlands are being transformed into rice fields. In Argentina, one of the few remaining native wet grasslands in the Pampas (Bajos del Salado) may disappear as new technologies are introduced to drain the area. Shrimp farms have replaced once extensive mangrove forests in many coastal areas, particularly in Mexico, Central America and Ecuador. The unfortunate irony is that, in addition to their importance in preventing coastal erosion, capturing nutrients and as fisheries, mangroves are nurseries for the larvae on which the industry depends.

River contamination is widespread in major industrial cities such as Buenos Aires, Bogota, Lima and Sao Paulo. Minor but daily oil spills may be causing insidious problems along the coasts of Patagonia, Venezuela, Colombia, southern Brazil and central Chile. The recent cholera outbreak in demonstrated the magnitude of problems that can result from contaminated wetlands and the lack of clean water, issues that are clearly interconnected. These losses erode the many benefits of freshwater resources and impinge upon their ability to serve as critical habitats for biodiversity (World Bank 1995, for a diagnosis of water pollution in Argentina).

To quote *Our Own Agenda*: “Latin America’s main hydrographic [i.e., freshwater] resources are today chemically and biologically contaminated. Several rivers in Colombia, among them the Medellin and the Bogota, are biologically dead (totally lacking dissolved oxygen); large agricultural zones have been biologically and chemically contaminated by coffee residue and pesticides, as is the case in the Quindio, Antioquia, Tolima, and Risaralda coffee-growing regions and the Meta rice-growing region; and waters in the Sogamosa Valley and the Magdalena, Dagua and Nechi rivers have been contaminated by industry and mining. Large quantities of agricultural contaminants are disposed of in streams flowing into the Caribbean Sea in which there is clear evidence of phosphorus, nitrates, potassium, pesticides (DDT, DDE) and highly organic effluents that are used in an indiscriminate fashion and are highly contaminating. Similar conditions prevail throughout Latin America.”

The construction of dams and the channelization of rivers undermine important wetland resources, as consideration is rarely given to the fisheries and other resources that form the local basis for generating income. There are already 885 dams over 15 meters high in South America, of which 516 are in Brazil. There are 23 dams constructed or under construction on the Parana River. Although their impact on fisheries has never been properly assessed, there is growing evidence that they affect fish migration. Alterations of the hydrologic regime of rivers (already evident, particularly in the Parana River system) may, in turn, affect the population dynamics of fish (Bonetto et al, 1988).

### **Critical Problems and Priorities**

Widespread ignorance about the importance of freshwater ecosystems has contributed to the notion that they are useless, and has promoted their destruction and degradation. There is also a widespread lack of perception of the link between the use of water resources and the ecosystems that provide that water. As a result, there is little impetus for sustainable management of water resources. Preserving water resources for future use does not appear to be a primary consideration in the planning and implementation of water use projects. Water development in LAC tends to favor privatizing profits while socializing costs, which provides little encouragement for conservation or sustainable use. By heavily subsidizing water, governments give the impression that it is abundant while evidence suggests the contrary.

Several factors contribute to the region’s poor awareness of the need for freshwater ecosystem conservation. People tend to focus their attention on terrestrial biodiversity that is more familiar and readily observed. Unfamiliarity with the full range of freshwater biodiversity also leads the public, administrators and conservation planners to focus on those species and habitats that directly interact with local and commercial activities. These include fisheries, ecotypes (such as wetlands that are important habitats for terrestrial species like migratory birds) and large aquatic vertebrates that are easy to

observe (manatees and giant river otters).

Effective freshwater conservation requires great attention to large-scale dynamics, complex interactions, and linkages to terrestrial systems—issues that are poorly understood and difficult to address effectively and, thus, are often avoided. The first step of effective conservation is a greater understanding of where the important areas of freshwater biodiversity are found, and what kinds of threats they face (Bucher, 1995). The World Wildlife Fund, in collaboration with USAID, the Biodiversity Support Program, and Wetlands International recently conducted a workshop to identify priority freshwater ecoregions for conservation. Thirty-eight regional experts worked to describe the freshwater biodiversity of the region and identify regional priorities (Olson et al. 1997) (figures 1 to 5).

The results of the analysis are preliminary, pending review by regional experts. Eight ecoregions were considered critical, 40 endangered, 44 vulnerable, 17 relatively stable and 2 relatively intact. Overall, 88 percent of the ecoregions of LAC were either vulnerable, endangered, or critical (see Figure 4). Critical ecoregions were found in the Caribbean lowlands and intermontane valleys of Colombia, Lake Titicaca and Poopo region, the delta of the Colorado River, and portions of the mediterranean region of Chile. Endangered regions included much of the *cerrado* and northeastern Atlantic region of Brazil, northern and southern Mexico, the higher elevation ecoregions of the northern Andes, and the coastal deserts of Peru and Chile. Some of the more intact ecoregions are in the central Amazon River basin, the Guianas and Guayanan Highlands, and the Patagonian steppes and grasslands. Eight ecoregions were considered to be globally outstanding in terms of their biological distinctiveness, particularly in regions of the western arc of the Amazon River basin, the Guayanan Highlands, the Chihuahuan Desert and high-elevation lakes of central Mexico, the Llanos and *varzea* forests of the Amazon. The highest priority ecoregions for conservation were the western arc of the Amazon, the Llanos and the Pantanal, the Guayanan Highlands, Cuatro Ciénegas

in the Chihuahuan Desert, Lake Titicaca, the upper Rio Bravo, and Lake Catemaco and Chapala in Mexico. High priority ecoregions are found in several regions including Hispaniola, the Chihuahuan Desert, the Petén and Miskito region of Central America, the Pacific coast of Colombia and Ecuador, the Monte and Matorral region of the Southern Cone, the *varzea* forests of the Amazon, and the large river basins of the Brazilian Shield including the Tapajós and Xingú Rivers.

These data led to several general conclusions:

- < The type, intensity, and scale of threat varies among regions and major habitat types. Widespread and pervasive threats include dams, water diversion, draining and channelization, pollution from toxins and eutrophication, loss of riparian and catchment basin forests with associated changes in sedimentation and physical conditions, introduced species and overexploitation of freshwater species.
- < Freshwater ecosystems and habitats in xeric (drier) climates are highly threatened. Direct competition for water with human activities and destruction of riparian vegetation are the major threats.
- < Two of the most endangered habitat types are large river floodplains such as floating meadows and *varzea* forests, threatened by logging and conversion to pasture, and cataracts, lost over vast areas due to dams and water diversion. Intensive coffee production and other agriculture in many montane areas has damaged streams due to sedimentation, eutrophication, pesticides and loss of riparian vegetation.
- < Headwater habitats and ecosystems are particularly critical for the maintenance of ecological processes and dynamics as well as the biodiversity of entire watersheds.
- < Complexes of small wetlands can be as important as large wetlands as wintering and breeding habitat for migratory birds.

Finally, a comparison with the WWF/World Bank analysis of terrestrial ecoregions shows that freshwater biodiversity is

more threatened than terrestrial biodiversity (Dinerstein et al., 1995).

# Values and Functions of Latin American Freshwater Ecosystems

In addition to their function as crucial habitats, freshwater ecosystems provide a great variety of benefits to society. For purposes of clarity, and following Adamus (1983), Claridge (1991), and Dugan (1992) freshwater ecosystem benefits can be classified as functions, products, and attributes.

## **Freshwater Ecosystem Functions**

*Water supply:* Includes direct extraction of water, water supply to an aquifer (groundwater recharge), groundwater discharge and water supply to another wetland.

*Flood regulation:* This function occurs through flood water storage and flood slowdowns caused by wetland vegetation. The disappearance of millions of acres of wetlands and riverine vegetation along the Mississippi River watershed played a critical role in amplifying the magnitude of the 1993 floods, with the ensuing loss of lives and property estimated at more than \$10 billion (see Case Study 2). In a similar fashion, the Pantanal in Brazil and Bolivia slows the flow of water in the Paraguay River, reducing the risks of catastrophic flooding downstream (see Case Study 3). In general, the disconnection of rivers from their floodplains due to engineering works is increasingly perceived as extremely negative to the system.

*Prevention of saline water intrusion:* This function is especially important in coastal areas where saline intrusion has a negative impact on the availability of fresh groundwater. It also occurs at the surface, where water flow usually limits sea water entry.

*Protection from natural forces:* This includes the stabilization of the shoreline and protection from storms, the provision of windbreaks, and erosion control. The destruction of coastal wetlands often

results in tremendous loss of life and property. In England, where bankside vegetation has been destroyed along rivers, the cost of reinforcement is estimated at \$425 per meter. In Bangladesh, tens of thousands of people are killed periodically by storm surges that could be prevented through the conservation of coastal wetlands.

*Sediment retention:* This function benefits downstream communities by maintaining water quality, and agriculture by renewing nutrients and soil.

*Nutrient retention and toxicant removal:* This function maintains water quality by absorbing excess nutrients and removing toxicants from the water. Florida's cypress swamp removes 98 percent of the nitrogen and 97 percent of the phosphorus from wastewater in this way. A study showed that the cost of replacing the tertiary waste treatment provided by wetlands in Massachusetts is \$123,000 per hectare.

*Biomass export:* The high productivity of wetlands yields biomass that is exported and used, especially by fisheries downstream.

*Microclimate stabilization:* Wetlands equalize climate, especially rainfall and temperature.

*Global carbon sink:* Many wetlands hold large amounts of carbon as peat. If released, this could add significantly to global warming.

*Water transport:* This is an important function, especially in rural areas. Lake Titicaca in the highlands of Bolivia and Peru, for example, played a crucial role well before the European colonization.

*Tourism:* Wetlands support a heavy recreational

industry that includes opportunities for hunting, fishing, birdwatching, etc. The importance of ecotourism in Latin America grows significantly every year. Popular places are the Pantanal in Brazil for ecotourism and wetlands, and northeastern and southern Argentina for fishing and hunting. Overall, tourism contributed \$55 billion to the national income of developing countries in 1988.

### **Freshwater Products**

The high rate of productivity per unit of land in freshwater ecosystems results in the availability of a variety of products, including forest, wildlife, fisheries, forage, agricultural and energy resources. Their value is often measured in millions of dollars annually for any given locality, and represents an important source of income for rural communities.

Two-thirds of commercially caught fish depend on wetlands at some point in their lives. This proportion is higher in some fisheries. For example, in the Gulf of Mexico 90 percent of the annual fish harvest (worth \$700 million) is made up of species dependent on coastal mangroves. Fish from rivers such as the Amazon, Parana and Orinoco are important sources of protein for local communities.

Peat is a source of energy in many rural areas. In Peru it is called *champa*, and it is regularly used as a household fuel, especially for cooking.

### **Freshwater Attributes**

Although it is often difficult to assign a monetary value to ecosystem attributes, they nonetheless represent an important and increasingly scarce resource that needs to be conserved not only for ethical, aesthetic, cultural and biological reasons, but more specifically as an essential requirements of sustainable development in the region.

Freshwater ecosystems are critical habitats to a very rich and highly threatened array of species. In general, however, the richness of freshwater biodiversity

is poorly known. While, on average, two new species of birds are described every year, about 200 new species of freshwater fish are described each year, suggesting that at least half of all vertebrates might be fish. Some of the most unusual freshwater species occur in the Amazon and its tributaries, including seed-eating fish that forage in seasonally flooded forests, the world's largest freshwater turtle, and the half-blind *boto* dolphin, which hunts its prey by echolocation.

The high productivity of freshwater ecosystems allows them to support very large numbers of birds, especially during breeding and migration periods. Wetlands also harbor numerous threatened and endangered species, illustrating their importance in maintaining the biological diversity of birds. In the United States, for example, even though wetlands comprise less than five percent of the total land area, seventy percent of federally-listed threatened species, and forty percent of all federally-listed endangered species are wetland dependent. One-fifth of all freshwater fish in the world are either extinct or endangered. In Latin America, this figure approaches ten percent (Castro, 1995).

The use of genes from wild species occurring in wetlands is an important way of improving cultivated varieties of plants. In addition, wetlands can host inordinate amounts of the genetic composition of some species. In some migratory shorebirds, for example, sixty to ninety percent of all individuals are sometimes found within a single wetland.

Wetlands also have social and cultural significance. They provide aesthetic values, are associated with religious and spiritual beliefs and activities, help maintain important cultural elements, and are often sites of historic importance. For example, the first flag of Peru was conceived by General San Martín while observing flamingoes in Paracas, Peru. This historic event helped in the creation of the Paracas National Reserve in Peru.

# Integrating Freshwater Ecosystem Conservation with the Sustainable Management of Water Resources: A Conceptual Framework

## Basic Concepts and Key Issues

The integration of freshwater ecosystem conservation into a comprehensive water resources management strategy in Latin America requires a clear understanding of the present ecological, institutional and social characteristics of the region, as well as a clear perception of the relevance and importance of the factors involved.

Developing a sustainable water resources management policy should be based on the following leading principles:

- < An ecosystem approach to managing water resources is required in order to ensure long-term sustainability. As stated earlier, an ecosystem approach is a management policy that perceives water resources as part of functional systems (such as whole basins or river/floodplains systems) in which the complex interconnections among physical and biotic components are adequately considered. Ecosystem-based management should not be confused with integrated management (described below).
- < Freshwater resource management should be implemented as part of a comprehensive approach to long-term planning and monitoring for the sustainable use of natural resources, including ecological, economic and social factors (integrated management).
- < A new balance is required between the growing tendency toward privatization and globalization of the economy and the role of both civil society and the state in preventing the degradation of water resources.

## The Ecosystem Approach to Managing Water Resources

Until a short time ago, water was seen as an unlimited resource. The only problem connected with it was how to make it available where and when it was needed. It was assumed that the natural system would be able to produce abundant, clean water and would also be able to purify wastewater returned to it. Today, we know that the volume of water appropriation for human use is such that it affects the ability of natural ecosystems to provide the “services” that were taken for granted. The fraction of annual renewable water resources withdrawn for human use grows continuously. At present it is close to 15 percent in Europe and Asia, 10 percent in North and Central America, and only one percent in South America. This statistic, however, is misleading because water is distributed very unevenly throughout the region and does not occur where human populations are settled. In Peru, for example, the rate of withdrawal reaches 15 percent, but Peru is considered a “water stressed” country (Gleick, 1993).

An ecosystem approach to managing water requires an understanding of the water cycle, a complex process that involves rainfall, absorption, runoff, evapotranspiration and infiltration processes over vast regions and long periods of time. Unless all phases of this cycle are properly understood and taken into account, sustainability may not be ensured. Such a perspective requires not only ensuring the efficient use and distribution of fresh water, but also safeguarding the health of the catchment basin and groundwater (“before the pipe”) as well as the adequate treatment and disposal of wastewater (“end of the pipe”).

Unfortunately, however, this new perception has neither been implemented nor institutionalized in Latin America. On the contrary, the aim of management plans in the region is still to increase the quality and quantity of water supply. Protecting freshwater ecosystems and ensuring the sustainability of the hydrological cycle does not generally enter into management plans.

One of the basic problems in adopting an ecosystem approach to water management is the still weak perception by both the general public and decision-makers of the magnitude and importance of the problems that can be expected if current environmental deterioration trends continue. It is difficult for laymen and politicians to accept that there are limits to the use of natural resources, and that decisions made today could significantly affect future options for development. As a result, both the private and government sectors continue to resist considering any kind of “ecological accounting,” fearing that it could affect economic growth (the false “job versus environment” dichotomy).

It is clear, however, that there is no chance for reverting the present tendency toward resource degradation unless basic ecological functions are preserved. Therefore, and despite the obvious pressure for dealing with urgent economic needs, there is an equally important need for medium- and long-term thinking and planning. Otherwise, the vicious cycle of poverty and environmental degradation will not be broken.

Ecosystems would be more likely to receive protection and dedicated water allocation if policymakers attach economic value to the services they provide. As mentioned before, wetlands, for example, offer flood protection, water purification and habitat benefits that are “public goods” for which no one in particular pays. As a result, these ecosystem services are not adequately taken into account by project planners and decisionmakers, and are lost or destroyed without adequate consideration. Under the current range of public and private water management systems, however, the externalities of water supply and use are numerous. Water use,

including extraction and return of polluted water to the ecosystem, has critical impacts on both human and ecosystem health. But when the benefits of water use are tied only to water “extraction” or diversion, biological or ecosystem benefits are disregarded.

### **Planning for the Sustainable Use of Freshwater Resources**

In Latin America and the Caribbean, there are still considerable portions of undeveloped land. The Amazon basin, a vast proportion of tropical South America, as well as considerable portions of the Chaco and Andean regions are good examples, some of them holding vast freshwater resources that make long-term planning still feasible. At the same time, other areas in the region (particularly Central America) are being affected by rapid and substantial changes in natural resource use resulting from high rates of population growth, extensive deforestation and expansion into the last remaining agricultural frontiers. There, urgent conservation measures are needed before changes become irreversible.

Unfortunately, most present development is unplanned. The region is full of examples of boom and bust episodes of resource exploitation and degradation resulting from lack of planning and enforcement which may be repeated and amplified in the near future. There is no doubt that global and regional planning is urgently needed. Otherwise, unplanned growth will continue leading to widespread economic, social and ecological crises. Water scarcity is the most worrisome of them all. But although it is widely accepted as an obvious need, the concept of long-term planning, environmental monitoring and enforcement at the regional, national and provincial level is extremely difficult to implement for the three reasons listed below.

- < lack of political and institutional tradition;
- < fragmented management of water resources between government agencies, and lack of coordination at the provincial, national, and

international level; and

- < a decrease in the ability of government agencies to plan and enforce sustainable development, associated with the present tendency to promote privatization and decrease the role of the state.

Development of a long-term planning and environmental monitoring policy for the region should be based on the conviction that its adoption will not create an obstacle to regional development. It is the only way to prevent a new cycle of boom and bust that may destroy the resource base of the continent. Today, the likelihood that the countries of Latin America will redirect the course of their economies toward sustainable development seems greater than in the past, given that they are redefining their relations with civil society, as well as liberalizing their economies. Additionally, international trade agreements like MERCOSUR and NAFTA, have a great potential for acting as catalysts for long-term planning throughout the region. These agreements provide an excellent platform for the development of long-term planning policies at the regional level (using catchment basins instead of political borders as management units), as well as coordinated legislation and enforcement of regulations on pollution control, watershed management, conservation of international wetlands, etc. Implementation of long-term planning policies under international trade agreements should not necessarily conflict with the predominant tendency for open economies and privatization, provided that stable long-term criteria and standards are established.

At the national level, sound strategies for the sustainable use and conservation of natural resources, including freshwater, are essential. These necessarily imply clear political and institutional support and effective involvement in long-term planning by economic policymakers. However, long-term planning for sustainability should not be imposed from the top. The effective participation of civil society, and in particular of stakeholders, is an important requirement of this process.

## **The Challenge of Merging Environment and Economics in Decision-Making**

The sustainable use of freshwater resources requires, an ecological approach to resource use and long-term planning. The implementation and institutionalization of this approach require changes in the institutional and governmental decision-making process. Although this is not the central focus of this report, we consider it necessary to briefly mention key aspects of this process.

*Integration of Environment and Economics in Decision-Making:* The most important condition for sustainable development is the merging of the environment and economics in the decision-making process. Despite the fact that economic and ecological systems are linked in the real world, they remain almost completely divorced at the institutional and decision-making levels. During the last twenty years, nearly all countries in Latin America established environmental protection and resource management agencies. But these agencies were hamstrung by limited mandates, limited budgets and little or no political clout. Meanwhile, governments failed to make the central economic and sector agencies responsible for the environmental implications of their policies and expenditures. The result is disequilibrium between economics and the environment. Governments should make the central and sector economic agencies responsible and accountable for formulating policies and budgets to encourage sustainable development. Fragmentation of water management among several countries (in the case of international watersheds), many government agencies, public and private enterprises, and federal, regional, and local agencies further complicate wise planning and decision-making.

*Internalization of environmental costs and investment in ecological services:* Internalizing environmental costs is essential for ecologically sustainable and socially equitable development, and requires government intervention. Investing in maintaining the ability of natural ecosystems to provide ecological services is also essential. Emerging alternatives such as market incentives,

national environmental accounting, etc., need to be fully investigated and adequately implemented. For example, privatization of urban water services may also include investments to prevent soil erosion and deforestation to protect catchment basins.

*Misguided incentive systems:* Government intervention often distorts the market in ways that lead to unsustainable development. Tax and fiscal incentives, pricing and marketing policies, and exchange rate and trade policies influence the environment and the resource content of economic growth. Yet, the people responsible for setting these policies seldom consider their impact on the environment or on stocks of resources. When policymakers do take these aspects into account, they often assume that resources are inexhaustible or that substitutes will be found. This is particularly true for water resources in the arid and semi-arid regions of Latin America.

*Financing:* With the gradual integration of the environment in economic decision-making, budgets for energy, agriculture and other sectors should begin to include funds to cover the environmental costs of these activities, specifically freshwater quality and availability. Meanwhile, the burden of financing sustainable development will demand large sources of new financing. Even if difficult, postponing these investments will only result in greater costs and a greater irreversibility of damage. In this sense, it is necessary to remember that the decision to address sustainable development issues has already been made, at the highest political level, by most Latin American countries, as indicated by the fact that the Agenda 21 document was signed by all the region's presidents. Otherwise, other more urgent needs will prevent developing countries from reversing the present tendency for overuse and degradation of natural resources and the environment.

### **Privatization and Globalization of Latin American Economies: Safeguarding Freshwater Ecosystems**

A recent study by the World Wildlife Fund examines the effects of privatization on Latin America's

environment (Steadman et al., 1997). According to the study, two fundamental shifts have occurred during the past decade: democratization and the revitalization of the private sector, which require the state to relinquish substantial power in shaping development processes. In the face of this, it is important for international and local nongovernmental organizations to expand their role in the regulation of development, thereby balancing economic growth with environmental needs. Democratization and liberalization create new possibilities for the state, civil society and the private sector to work together to ensure that economic development takes place within the bounds of sustainability. Both civil society and the state, as the democratic representative of society, have a large role to play in promoting the benefits of expanding markets while ensuring that economic development contributes to poverty relief and does not entail unnecessary or excessive environmental degradation.

Unfortunately, the region's widespread poverty and unequal income distribution limit the scope of grassroots political participation and tend to focus political efforts on immediate, local poverty relief at the expense of long-term sustainable resource use. Moreover, economic adjustment and privatization efforts have paid scant attention to the social and environmental ramifications of unregulated markets. Structural adjustments in Latin America has yielded mixed results and poorer regions have often paid a heavy price. Reform has emphasized regulatory and institutional changes, but has generally ignored environmental institutions or actively promoted their down-sizing. The consequences for the environment, which has not fared well under prior arrangements, are uncertain under the new order, given that there is little evidence that the private sector, acting independently in open markets, will produce sustainable development. There are several reasons to believe that markets and private sector efficiency will not produce environmental improvements at the aggregate level:

- < Constraints of profitability in many markets preclude sustainable resource use.

- < Externalities in natural resource extraction and management are numerous, but largely unaccounted for by markets or regulatory mechanisms such as national accounts.
- < Incentives to increase overall production may outweigh the impact of efficiency improvements and increases in the productivity of resources.

In other words, improvements in efficiency are not necessarily related to environmental improvements. Without government intervention or market-based incentives for sustainable resource use, private sector firms will attempt to maximize profits without regard for sustainability. Efficient resource use at the individual or company level will not guarantee sustainable use at an aggregate level, as private sector firms will not consider the aggregate impacts of private sector resource use.

Without the construction of adequate regulatory frameworks and environmental institutions at the local and national levels, the behavior of private enterprises in markets will not conform to the requirements of sustainable development. Latin America's freshwater resources are among the most vulnerable to unsustainable exploitation.

The withdrawal of the state from productive activities and the elimination of many distortionary interventions should not necessarily mean that the state should remove itself from its crucial role in planning, regulation and enforcement. The numerous externalities associated with the economic development of natural resources will require continuing government intervention to ensure that all benefits and costs are accounted for and that trade-offs are explicit and widely understood. The sound use of water resources in private hands will require effective institutions to address water quality and aggregate use issues. NGOs and local organizations can play key monitoring and decision-making roles. This requires technical skills and knowledge of the watershed, financial capacity, and political will for enforcement; in other words, a strong and well-funded community of nongovernmental organizations working in Latin America to protect the region's freshwater resources. Improving the information base and public awareness of the importance of the water cycle and the need for better management are also crucial in order to institutionalize the concept of sustainable, integrated water management in the region.

## Case Studies

The following case studies demonstrate different approaches to integration of freshwater ecosystem conservation within sustainable water management. The first case study examines a project with the Network of Private Reserves in Colombia. The primary aim of this project is to protect critical watersheds through the expansion of private reserves by means of incentives to private landowners. The second case study describes efforts to restore the Mississippi River Wetlands. This project illustrates that restoration of wetlands can produce benefits that are greater than the cost of restoration. It also shows that wetlands can be restored in ways that do not diminish the economic value of privately owned land, and that wetlands can generate revenue. The third case is the *Hidrovia*, the proposed 3,400 km waterway in the Paraguay and Paraná Rivers. This project shows the need to apply lessons already learned from altering and fragmenting large rivers in the developed world (such as the Mississippi-Missouri system) to the management of relatively untouched systems in South America. The participation of civil society and NGOs in the process of planning and implementing large scale projects leads to positive interactions with development agencies, as well as the inclusion of environmental concerns in development programs and policies.

### **Case Study 1 The Network of Private Nature Reserves Colombia**

Colombia is possibly the richest country in the world in terms of the number of species per unit area. While Colombia covers less than one percent of the earth's surface (1,138,891 km<sup>2</sup>), it contains at least 10 percent of the world's terrestrial plant and animal species, including more birds and orchids than anywhere else on earth. In an attempt to protect this rich biodiversity, the government of Colombia has

established a system of 42 protected areas, covering about nine million hectares (8.1 percent of the country). These areas are not extensive enough, however, to ensure the adequate protection of the country's vast ecosystem diversity. The expansion of private reserves in Colombia provides an alternative to the government's insufficient management of natural lands and resources. The private approach to conservation increases the total area of protected lands, and more importantly, directly involves citizens as stewards of their country's natural resources.

Private conservation can supplement not only the inadequate government-run system, but also offer valuable environmental, economic and social benefits to all Colombians. Most private reserves are located in Andean ecosystems. While the natural vegetation in these regions is highly fragmented, it still protects priceless genetic resources, cultural assets and watersheds. Thus, protecting these forests increases the reliability of the water supply. Two key pieces of legislation have made private lands conservation a reality in Colombia. The Constitution of July 1991 opened the door for more active citizen participation in decision-making and recognized conservation and long-term economic growth as related goals of national importance in Colombia. In 1993, the Congress passed Law 99, which recognized the role of civil society in conservation and named private reserves as legal conservation units.

Historically, the fertile mountains and valleys of Colombia have provided its inhabitants with abundant agricultural harvests. In recent decades, however, deforestation, linked to agricultural expansion, has become the highest priority environmental problem in the country. While Colombia is endowed with rich agricultural resources, many of the agricultural zones are mismanaged and the best lands are in the hands of a

small, rich minority. Thus, as the demand for land suitable for cattle ranching and farming escalates, land-poor farmers continue to push the agricultural frontier onto steep slopes and marginal areas. In the Andes region alone, at least 55 percent of the original vegetation has been cleared as colonization of the region increases (more than 70 percent of Colombia's population now resides there). More than 40 million hectares are used for agriculture. Unsustainable means of farming, grazing and timber extraction degrade ecosystems and threaten biodiversity conservation.

Deforestation has had devastating ecological impacts. It has degraded valuable watersheds and has resulted in erosion, sedimentation and a marked decrease in water quality and regulation. Many cities have had to ration energy and water during the dry season, and are threatened by flooding during the rainy season. Land clearing not only translate into the loss of over 600,000 hectares of forest per year; the forested patches which remain intact tend to be highly fragmented, weakening the potential for maintaining viable populations of large mammals, some birds and even insects.

In an attempt to address these environmental concerns, the Network of Private Nature Reserves in Colombia was established in 1991 to unify and strengthen private conservation efforts. The Network is a private, nongovernmental organization composed of NGOs, private farmers and landowners, community organizations and agricultural co-operatives. It is comprised of private reserves which range in size from one-half hectare to 3,200 hectares. As of June 1996, the Network had 95 members and there were more than 25 applications for membership pending approval.

The objective of the Network is to consolidate nature reserves as areas for conservation, sustainable production, and ultimately, the enrichment of Colombian society. The effectiveness of the Network as a strategy for conservation depends on creating linkages between the isolated fragments of forest cover that are scattered in reserves across the Colombian countryside. These fragments ideally

should serve as the nuclei around which other forest fragments are recuperated for conservation in order to establish forest corridors. Around these emerging corridors, ecosystem and habitat regeneration is prompted, and environmentally friendly production systems are developed.

The accomplishments of the Network include the following:

- < The Network of Private Reserves acquired legal status as a nonprofit organization in March, 1993. One of its first achievements was to influence the inclusion of the articles in Law 99 that recognize private reserves as conservation units and establish a framework for their role in the decision-making process.
- < The Network has been called upon to assist regional government agencies in incorporating private reserves in watershed management plans. It has initiated a dialogue with the authorities responsible for Los Farallones de Cali National Park (which protects the watersheds that provide water to the city of Cali) on the value of using private reserves as a means of managing the park.
- < Through their participation in the program entitled *Herederos del Planeta*, children of reserve owners are learning and teaching powerful conservation messages. During the program's first year, they produced T-shirts for sale, raised funds for conservation projects and purchased reserves. In 1995 the *Herederos* numbered over 300 children aged 7 to 17, and received the United Nations Global 500 Honor Roll award.
- < The reserves are now georeferenced in a Geographic Information System (GIS) that is being developed with the assistance of WWF. Also, a database has been created which records baseline information (size, species, land use, etc.) for planning future

network activities. By June 1996, 75 percent of the registered reserves had been included in the data base.

- < Its members' commitment to the guiding principles of respect for life, sustainability, tolerance, solidarity and intergenerational equity has been essential to the Network's success as an organization. The dedication, unity and participation of members are the backbone of the its effectiveness. Members have even volunteered their homes as sites for workshops or offered to speak at lectures.
- < The Network has developed a strong communications program to keep its members united and well-informed. It has produced a membership brochure and regularly publishes a monthly bulletin, *Redservando*, and a technical quarterly, *Aguador*
- < The Network has fostered environmental awareness by facilitating numerous workshops and exchanges between reserves, including seminars on environmental education, meetings of the *Herederos del Planeta* and *Mínimos Ecológicos* (community workshops aimed at providing a basic understanding of ecology, the environment and daily life).

Watershed conservation provides multiple benefits to society. As indicated, conserving entire watersheds is an excellent strategy to ensure long-term water supplies.

## **Case Study 2** **Restoring Mississippi River Wetlands**

The drainage patterns of the modern Mississippi River were formed over the course of 10,000 years by the interaction of varying climatic and hydrologic conditions with glaciation, precipitation, topography, soils, vegetation and wildlife. Wetlands were everywhere. In the upper Mississippi River basin, at least ten percent of the entire watershed (45 million

acres) was covered with wetlands. As trappers and settlers spread across the region, the prairie was drained, beavers and their dams were destroyed, and the humus-rich soils gradually eroded. Only forty percent of the original wetlands remain today.

Upland wetlands are lush areas where thick layers of vegetation capture rainwater as it falls, retain it in the soil, and release it back to the atmosphere through evaporation. When heavy spring rains cause these wetlands to overflow, excess water empties into stream channels and spreads out across the river floodplains. When upland wetlands are drained and floodplains leveed, however, that same rain produces torrents of water rushing along steep and narrow channels, causing damage to property and danger to living things. The 1993 floods alone caused more than \$16 billion in damage in the Midwest.

We know today that former wetlands can be restored, and that properly designed restored wetlands can produce even greater benefits than their natural predecessors. The carefully engineered Des Plaines River Wetlands Demonstration Project north of Chicago, for example, has shown that no more than five percent of a watershed need be restored to wetlands to produce a major reduction in flood flows. Substantial water quality benefits have also been demonstrated at this site: reductions in turbidity, nutrients and toxic substances have all been documented. We have a good idea of how a wetland restoration program would have affected the flood that hit the upper Mississippi River basin in 1993: thirteen million acres of wetlands, or less than half of what has been lost in the last two centuries, could have held all of the flood water.

Wetland restoration has not yet become an important part of flood control efforts in the United States for several reasons. First and foremost, government tends to move cautiously and changes slowly. We have not learned enough about the dynamics of wetlands across entire watersheds. Our tools are out of date. We measure water moving down channels, but we do not measure all of the effects upon water in a wetland, such as evaporation and seepage into the ground.

The Upper Mississippi River Wetland Restoration Project, demonstrates that the restoration of wetlands in this basin can produce benefits for the entire river basin that are greater than the costs of the restoration, and shows how to incorporate restored wetlands into the watershed. The project also shows that wetlands can be restored in ways that do not diminish the economic value of privately owned land, and that restored wetlands can generate revenue by producing alternative crops, providing recreational opportunities, and performing other useful functions.

In the first phase of the project, a search was conducted for several sites where large-scale wetlands could be restored to demonstrate how to reduce flood damages, improve water quality, enhance wildlife habitat and maintain property values. People from all areas of the basin helped to identify 50 potential wetland restoration sites, which were then narrowed down to 15 sites that could demonstrate real flood damage reductions. The following criteria were used to select sites:

- < Extent of flooding downstream
- < Adjacent land uses
- < Degree of hydrological disturbance
- < Amount of potential flood storage
- < Extent of community support
- < Presence of a local sponsor
- < Potential cooperation of local landowners
- < Economic impacts on the local area
- < Costs of acquisition and restoration
- < Existing wildlife habitat
- < Potential for improving water quality

Fifteen sites were rated using these criteria and the six highest scoring ones were selected. These sites were further investigated with field visits, technical analysis and meetings with local groups and state agencies. In a final rating session, a more refined version of the original criteria was used to rank the sites. The three highest ranked sites are: Redwood River Watershed, a drained agricultural watershed tributary to the Minnesota River, located upstream from Marshall, Minnesota; Goose Lake, a 3,000-acre agricultural drainage and levee district located near the mouth of the Iowa River in Louisa County,

Iowa; and the proposed Emiquon National Wildlife Refuge, an 11,000-acre leveed agricultural floodplain at the confluence of the Spoon and Illinois Rivers near Havana, Illinois.

*Redwood River:* The upper Redwood River watershed is part of the prairie pothole region, one of the most important waterfowl breeding areas in North America. The project will test whether hydrologic restoration in the watershed, which includes wetland restoration and soil and water conservation practices, can effectively reduce flood peaks in the downstream town of Marshall, which sustained high flood damages in the summer of 1993. It is estimated that 74,000 acre-feet of storage would contain the stormwater runoff from a 100-year flood in Marshall. A preliminary study of the watershed found 4,800 acres of drained wetlands that could hold back some of these flood waters. A combination of wetland restoration, small beaver-like retention dams along the streams, and soil conservation practices will be employed to accomplish downstream flood damage reduction while increasing waterfowl breeding habitat.

*Goose Lake:* Located on the floodplain of the Iowa River, upstream from its confluence with the Mississippi, this agricultural levee and drainage district contains more than 3,000 acres protected from floods by a levee and drained by ditches. The area is important for migratory waterfowl and birds. While one-third of the protected land is farmland, much of the remainder is poorly drained sloughs, oxbow lakes and sandy ridges. The project will demonstrate how agriculture and wildlife can coexist in a floodplain managed to store flood waters. A sluice gate installed in the levee will restore annual flood flows to the wetlands to create corridors of wildlife habitat connecting with an existing downstream wildlife refuge, while still protecting cropland from less frequent floods. A notched spillway in the levee will allow water from higher floods to spill over onto the floodplain to provide flood storage and reduce damage to the levee. Landowners will be compensated for the increased risk of flooding and easements will be purchased to restore wetlands. Technical and financial incentives

will be provided to encourage property owners to enhance the income-producing capacity of the land.

*Emiquon:* This proposed 11,000-acre national wildlife refuge will restore the once vast marshes, bottomland forests and backwater lakes that covered the floodplain at the confluence of the Illinois and Spoon Rivers near Havana, Illinois. Most of the land has been drained, leveed, cleared and converted to intensive row-crop agriculture. The project will show how to reconnect the river and floodplain, restore fish and wildlife habitat and protect the backwater lakes from sedimentation. Reconnecting the floodplain to the rivers will create critical habitat for migratory waterfowl, birds, fish, and other wildlife, including rare and endangered species such as the river otter and the Illinois chorus frog. The backwater lakes will be protected from the high sediment loads of the rivers through the installation of water control structures in the levee and the construction of series of wetlands, and by planting wooded buffers. The restored wetlands in the refuge will store flood water, convey flood flows away from the upstream town of Liverpool, and capture sediments coming down the Spoon River. Together with the existing Chataqua National Wildlife Refuge across the Illinois River, and Dickson Mounds State Museum to the west, this project provides the opportunity to recreate the entire river floodplain from bluff to bluff.

Wetland restoration is more than plugging a ditch or removing a levee. These simple techniques are always effective in reversing the action that destroyed the original wetland, but it takes much more to recreate all the functions and components of the wetland ecosystem. Restoration gives us the opportunity, through careful engineering design, to enhance those features that make the site the most useful, such as landscape and habitat restoration, sediment control, upland watershed management and economic enhancement.

*Landscape Restoration:* Restoring the hydrology, topography and plant communities can recreate entire landscapes in the same or similar arrangement and scale as they were prior to settlement. Landscape

restoration provides easy access to the functions that wetlands performed: water quality improvement, stormwater detention, flood damage reduction, soil stabilization, groundwater recharge, nutrient cycling and food chain support.

*Habitat Restoration:* Habitat restoration is a component of landscape restoration that is designed to attract targeted wildlife species to the site. Targeted species may include mussels, snails, crustaceans, insects, fish, birds, reptiles, amphibians and mammals. The natural habitat requirements of the target species are replicated on the site, including identified and appropriate plant communities and species that provide shelter and food.

*Sediment Control:* High energy flood flows carry large loads of sediments that can damage ecosystems, smother cropland and clog flood storage areas. Wetlands are excellent mechanisms for reducing flood flows and removing sediment loads.

*Upland Watershed Management:* The most effective way to control downstream flood flows is to hold and absorb rain and snowmelt in the upper watershed with the widespread application of soil conservation techniques, controlled drainage and networks of small holding ponds and check dams. These techniques, planned in a complementary and consistent way, make up a watershed management plan.

*Economic Enhancement:* The best restoration sites are usually found in converted cropland that floods frequently and receives government disaster aid, levee repair subsidies and crop insurance payments. Alternative crops and other income-producing activities developed on these marginal lands, when combined with the savings in federal payments, provide benefits that exceed the costs of restoration.

### **Case Study 3**

#### ***Hidrovia:***

#### **The Paraguay-Paraná Waterway**

The proposed Paraguay-Paraná Waterway Project would develop a complex navigation system on the

Paraná River and its major tributary, the Paraguay River, the second largest river system in South America. The *Hidrovia* would serve considerable portions of Brazil, Argentina, Paraguay and Bolivia from Cáceres to the harbor of Nueva Palmira in Uruguay. By allowing the year-round navigation of large ships and barge trains, the *Hidrovia* could provide a cheap alternative for the transportation of goods throughout the region.

In its original form, the project consisted of substantial initial and maintenance dredging, channel stabilization, rock excavation, realignment of channels and associated works. Complementary works include the enhancement of port and road infrastructure. The project originated in 1987, when the five La Plata Basin countries (Argentina, Bolivia, Brazil, Paraguay and Uruguay) declared their intention to promote navigation on the waterway as a priority issue. In 1989, the La Plata basin countries created the Intergovernment Committee of the Paraguay-Paraná Waterway (*Comité Intergubernamental de la Hidrovia Paraguay-Paraná, CIH*) in order to institutionalize the promotion, coordination and follow-up of the proposed project. At the Committee's request, the Inter-American Development Bank provided a loan for the initial studies, including the engineering project and the corresponding environmental impact assessment. The loan was administered by the United Nations Development Programme (UNDP).

From the outset, the project has attracted great attention and concern on the part of environmental organizations throughout the world, particularly because the waterway could potentially affect the Pantanal, one of the largest and more diverse wetlands in the world, which is included as a conservation priority in Brazil's constitution. Its magnificent biodiversity includes 658 species of birds, more than a thousand species of butterflies, more than 400 species of fish, and numerous threatened species of mammals and birds, including the hyacinth macaw, the marsh deer, the maned wolf, the giant anteater and the giant river otter.

Nongovernmental organizations made important and timely contributions to the *Hidrovia* project by producing technical reports at its early stages that showed the environmental risks of the proposal. From the long list of potential impacts detected, those described below were particularly relevant (Wetlands for the Americas 1993; Galinkin, 1994).

Among direct impacts, a particular source of concern was the hydrologic effects of dredging and straightening the river channel, particularly in the Pantanal. Such a change could increase the speed of water flow on the Paraguay River, thus raising the likelihood of seasonal floods downstream, as well as affecting the Pantanal ecosystem, given that its biodiversity dynamics are driven and maintained by periodic floods. Loss of the regulatory effect of the Pantanal could result in changes in the flooding regime; loss of wetlands; loss of local, regional and global biodiversity (particularly of fish species); decline in fish productivity and loss of landscape complexity along the river floodplain.

Indirect impacts could include pollution resulting from increased urban and industrial wastes, regular ship operation and accidental spills; deterioration of local lifestyles, particularly of indigenous communities; loss of recreation and tourism potential; and expansion of vector-borne diseases. Furthermore, induced development, if not adequately planned and monitored, could result in increased soil erosion, deforestation and loss of wildlife through the expansion of agriculture and forestry.

As a result of growing concern, it was decided to pay as much attention as possible to environmental aspects and safeguards in the project. First, the terms of reference for the environmental impact studies were expanded in order to include the concerns raised in the NGO technical reports. In addition, environmental specialists were incorporated to provide advice and follow-up. Finally, an open process of public participation was initiated in August, 1995. The participation process was structured around a series of meetings and technical workshops, wherein the reports produced by the consulting companies were submitted to peer review

and discussed in great detail. As never before in South America, concerns about the hydrology and ecological functions and services at the ecosystem level of a large, multinational watershed basin were at the center of widely publicized discussions.

One important outcome of the priority given to environmental aspects was the decision taken by Brazil of excluding major structural changes in the reach of the Paraguay River between Corumba and Caceres that flows through the Pantanal, including structural dredging, cut of meanders, and any other channel maintenance structures. Accordingly, navigation will be restricted to small barges adapted to present navigability conditions. Additionally, the initial port for the waterway was moved south from Caceres to Descalvados, avoiding an environmentally sensitive area.

The lessons from this project include:

- < Analysis of the potential environmental risks of the proposed project at the level of the entire basin provided considerable insight into the cumulative impacts along the system, helping the participating countries to begin a collaboration and coordination, effort to address environmental issues surrounding, the waterway.
- < There is an urgent need to incorporate experience gained from previous mistakes in the developed world, particularly when dealing with whole basin development and

large-scale engineering projects in undeveloped regions of Latin America.

- < Encouraging participation of civil society and NGOs in the planning and implementation process of large scale freshwater ecosystem use and conservation projects can yield new and positive ways of interaction and collaboration with government and financing institutions, including the IDB.
- < Collaboration among the five La Plata basin nations, multilateral organizations like the IDB and UNDP, and NGOs to develop a sound environmental risk assessment of the project showed that the opportunity for organizing basin-oriented development at the international level is greater than ever. Certainly, the process has been facilitated by the growing integration of the countries (at the political and commercial level) as a result of the establishment of the MERCOSUR common market.
- < The decision made by Brazil to drastically reduce structural engineering in the Pantanal because of the ecological implications of such works shows that governments are becoming increasingly aware of the need to include environmental concerns in regional development. This shift needs ample support and encouragement.

# Conclusions and Recommendations

## **Incorporate an Ecosystem Approach to Managing Water Resources**

### *Possible Implementation Activities*

- < Develop mechanisms for integrated impact assessment at the basin level that will complement individual assessments for each proposed development project, in order to prevent cumulative or compound impacts at the regional level.
- < Promote effective application of the precautionary principle in assessing the compound environmental risks of development projects that imply the appropriation of water resources for human use, particularly regarding long-term effects resulting from the use of heavy engineering, like in the case of dam building and large-scale irrigation projects.
- < Give priority to assessment of the safe limits for water appropriation and pollution by humans versus the need to ensure the proper functioning of the natural cycles and the biodiversity associated with them.
- < Give adequate consideration to the possibility of global climatic changes when planning and implementing water resource use, particularly in order to assess future risks and uncertainties. Involve local universities and research centers in long-term projects.
- < Promote and support the introduction of both the ecosystem and the integrated management concept in water resource

management in higher education within the region, possibly through the higher education.

- < Integrate watershed management policies into the national parks and other protected areas systems by adding catchment basin protection as another important justification for the creation of new reserves. Promote the creation of new categories aimed specifically at catchment protection.

## **Promote integration of freshwater management as part of a comprehensive approach to long-term planning and monitoring for the sustainable use of Latin America's natural resources (integrated management)**

### *Possible Implementation Activities*

- < Discourage uncoordinated and fragmented load of development initiatives for a given geographic region. Instead, promote basin-level management and maintain a comprehensive database of all planned developments in the region. Of particular importance is coordination among international and national development and financing agencies within the same basin or region.
- < Consider ways of reducing externalities in the exploitation of water resources. For example, analyze the possibility of linking investments in the conservation of upstream catchment basins to the provision of urban water services by utilities.

- < Promote the development of methods to quantify (in economic terms) freshwater ecosystem functions. When appropriate, incorporate environmental accounting into analyzes of the overall economic performance of a country or region in order to take environmental losses into account.
- < Promote the effective implementation of national and international ecosystem and biodiversity conservation agreements that relate to water management including, for example, migratory birds that live in wetlands, conservation of wetlands of international value, etc. Plan for sustainable resource use and land-use planning from local, national and international perspectives.
- < Support development of national environmental strategies regarding water use and coordinate these with regional and global strategies for sustainable development, in accordance with the requirements of Agenda 21. Ensure genuine and broad participation of civil society and the local scientific community.

Discourage unsustainable use of water resources. Pay special attention to groundwater use, as the available evidence indicates that there is a widespread tendency to overuse this resource

which, in general, has a very low replenishment rate. Misuse may result in serious ecological, economic and social damage.

**Ensure an adequate balance between promotion of privatization and globalization of the region's economy and strengthening the capacity of government agencies for developing and implementing adequate control and enforcement of environmental standards**

*Possible Implementation Activities*

- < Give priority to sustainable development over economic growth while seeking an adequate overall balance between ecosystem conservation and development.
- < Facilitate active participation of NGOs, local governments, universities and other civil organizations in environmental decision-making.
- < Strengthen government and private institutions that safeguard basic environmental quality and promote research on more sustainable resource use.

Promote transparency and understanding of trade-offs in resource use, including green accounting efforts.

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# Annex

## Methodology Used to Analyze Freshwater Ecosystems<sup>1</sup>

Each ecoregion was categorized to a major freshwater habitat type (MHT) to assist in ensuring representation and tailoring analytical criteria for both biological distinctiveness and conservation status to the ecological dynamics, patterns of biodiversity, and responses to disturbance characteristic of each major habitat type. Some examples of major freshwater habitat types are large rivers, endorheic or closed-basin habitats, montane streams and rivers, and high-elevation lakes.

We developed a simple integration matrix to help identify priority ecoregions for biodiversity conservation. Along the horizontal axis, we arranged ecoregions by their final conservation status. Along the vertical axis, we classified ecoregions by their biological distinctiveness. Conservation planners can use this matrix to decide which situations warrant the most immediate conservation attention. In order to achieve representation among all habitat types, a separate matrix was created for each of the MHTs. The matrix allows us to classify each ecoregion into four biodiversity conservation priority categories. Alternatively, the matrix can be used to identify the most appropriate set of conservation activities for different conservation scenarios (i.e., combinations of conservation status and biological distinctiveness), and different patterns of biodiversity associated with particular habitat or ecosystem types.

To maintain representation in priority-setting and to tailor analyses to the characteristics of different ecosystem types, a hierarchy will be created dividing North America into major ecosystem types (METs),

major habitat types, bioregions and ecoregions nested within each bioregion and assigned an MET and MHT category.

MET defines a set of ecoregions that: (1) have comparable ecosystem dynamics; (2) share similar response characteristics to disturbance; (3) have comparable levels of beta diversity; and (4) require a similar ecosystem-specific conservation approach. An MHT defines a set of ecoregions that: (1) share comparable climatic conditions; (2) have similar vegetation structure; (3) display similar spatial and temporal patterns of biodiversity (e.g., level of beta diversity); and (4) whose flora and fauna show similar guild structures and life histories.

Ecoregions are ecosystems of regional extent. More specifically, they define a geographically distinct assemblage of natural communities that: (1) share a large majority of their species and ecological dynamics, (2) have similar environmental conditions, and (3) whose ecological interactions are critical for their long-term persistence. Ecoregions, the unit of analysis for this study, will be resolved at a biogeographic level appropriate for regional conservation planning.

Aquatic ecoregions should be delineated on the basis of major watersheds, patterns of biodiversity, freshwater biophysical dynamics and geomorphological conditions. Many aquatic ecoregion classifications have already been proposed. We plan to base our ecoregions largely on existing efforts. We are currently evaluating existing classifications of freshwater ecosystems, such as the EPA's watershed framework and Maxwell's system for North America, for suitability for conservation planning. Our assessment of the biological distinctiveness of ecoregions moves beyond evaluations based largely on species lists to a framework that also considers levels of beta diversity

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<sup>1</sup> This section is based on the study of Olson et al., 1997.

(species turnover with distance or along environmental gradients) and endemism, unique ecological communities or phenomena, and rarity of ecosystem and habitat types.

Biological distinctiveness assesses the relative rarity of different natural communities and phenomena and can help estimate the opportunity for their conservation. All ecoregions are biologically distinct to some degree and this increases in comparisons made at broader biogeographic scales. However, some ecoregions are so exceptionally rich, complex, or unusual that they merit extra attention from conservation planners.

The biological distinctiveness of an ecoregion will be assessed within its MHT, thus ensuring that we compare lake ecosystems only with other lake ecosystems and not with desert springs or montane streams that differ greatly in ecological phenomena and patterns of biodiversity. We classified ecoregions as globally outstanding, regionally outstanding, bioregionally outstanding, or locally important. Ecoregions are classified as globally outstanding if they have extraordinary high levels of the attributes described in either criteria 1, 2, 3, or 4:

- < Criterion 1 is species richness, with an emphasis on the following taxa: plants, birds, mammals, reptiles, amphibians, and butterflies. These taxa are the ones primarily assessed by regional experts, but many other taxa were considered through further review of the technical literature.
- < Criterion 2 is endemism, or the number and proportion of species occurring only in that ecoregion, with an emphasis on the same taxa as that of species richness.
- < Criterion 3 is the complexity of species distributions within the ecoregion (e.g., beta diversity, gamma diversity at larger scales and patterns of local endemism).
- < Criterion 4 is the uniqueness and rarity of certain ecological phenomena in terms of

their structure or dynamic properties (e.g., on a global scale, Pacific Northwest rivers with remarkable seasonal migrations of fish or the biota of the Ohio River basin renowned for extraordinary endemism and richness).

Ecoregions are also classified as globally outstanding if they meet either criteria 5 or 6.

- < Criterion 5 is the relative rarity of ecoregions in the same MHT worldwide. An ecoregion is considered globally outstanding if less than seven ecoregions in its MHT exist in the world (e.g., the Everglades are globally unique), regionally outstanding if less than three occur regionally (i.e., within North America), and bioregionally outstanding if it is the only example of its MHT in its bioregion;
- < Criterion 6 is the ecoregion is the largest example of an MHT at global scales. Such an ecoregion is characterized as globally outstanding because it maintains biodiversity processes and components of that habitat type that are not always represented in smaller units.

Ecoregions will be classified as regionally outstanding if for criteria 1, 2, 3, or 4 they have levels that are exceptional for the Latin America and Caribbean region, but are not exceptional globally. Similarly, ecoregions are considered bioregionally outstanding if they have levels of either criteria 1, 2, 3, or 4 that are notable within a bioregion but cannot be viewed as exceptional from a regional or global perspective. Locally important ecoregions are considered to have average or below average levels for criteria 1 through 4 and do not meet either criteria 5 or 6.

Quantitative weights will be associated with the criteria where possible, but in some cases we must seek a consensus of opinion from experts. We recognize that assigning relative values to complex ecoregion attributes to yield a single index of bio-

logical distinctiveness requires some subjective assessments. This is a task made even more challenging by the incompleteness of biodiversity data for many regions and taxa and by the lack of global ecoregion maps of comparable scale and classification. However, we believe that the conservation community has access to sufficient information on continental patterns of biodiversity (through expert opinion and the technical literature) to identify ecoregions that are exceptionally distinctive at global, regional, and bioregional scales. As new data become available, some ecoregions might shift up or down one level. We assume that new data sets will not downgrade the classification of globally outstanding or regionally outstanding ecoregions, units that would likely be considered high priorities on a continental scale under almost any current or future priority-setting scheme.

The conservation status of freshwater ecoregions can be estimated using criteria that reflect the requirements, ecological dynamics and threats of aquatic systems. The categories for conservation status are the same as for the terrestrial systems: extinct, critical, endangered, vulnerable, relatively stable and relatively intact.

The method described here is based on a preliminary methodology developed by a team of freshwater ecosystem experts at a conservation priority-setting workshop for Latin America and the Caribbean held in Miami, Florida in October, 1994 and a final workshop for the region held in Santa Cruz, Bolivia in October of 1995.

The parameters described in this section can also be used to assess a “snapshot” conservation status for each ecoregion. The analysis of threats will modify (i.e., move the rating up or down) the “snapshot” categories for each ecoregion, if necessary. This modification step will produce the final conservation status for each ecoregion.

Suggested point values have been assigned to the different criteria for each parameter. These point values could be summed with higher values tending toward a more endangered conservation status. Some suggested point thresholds for different categories are given below:

- Extinct                      expert assessment
- Critical                      160-200 points
- Endangered                110-159 points
- Vulnerable                 60-109 points
- Relatively Stable         14-59 points
- Relatively Intact         0-13 points

**Criterion 1**  
**Assess the Degree of Alteration**  
**of the Catchment Basin(s)**

Changes in catchment basins that can affect aquatic ecosystems include alteration of the freshwater inflow from streams and runoff, increased sedimentation, increased deposition of pollutants, increased access by fishermen and loggers, and loss of surrounding terrestrial wildlife populations and resource areas for aquatic associated species. The following categories are suggested:

Degree of Alteration of the Catchment Basin	
80 - 100 %	30
60 - 79 %	22
40 - 59 %	12
20 - 39 %	4
0 - 19%	1

**Criterion 2**  
**Assess Water Quality and Integrity**  
**of Hydrographic Processes**  
**in Aquatic Ecoregions**

Aquatic ecosystems are known to be particularly sensitive to changes in water quality and hydrographic processes. Changes include such parameters as pH, turbidity, dissolved oxygen, pesticides, heavy metals, suspended solids, hydrocarbons (oil), and alteration of freshwater input and discharge cycles. The following categories represent the percent of watersheds within the ecoregion with original water quality:

Percentage of the remaining habitat affected by changes (assumed loss of habitat without restoration)	
81-100%	30
61-80%	22
41-60%	12
21-40%	4
0-20%	1

**Criterion 3**  
**Estimating Total Loss**  
**of Original Intact Habitat**  
**within Aquatic Ecoregion**

This analysis assess the amount of aquatic habitat loss due to physical (e.g., damming, siltation, dredging, channelization) or chemical anthropogenic disturbances.

Percentage of Loss of Original Habitat	
>90% (critical)	30 points
50% to 89% (endangered)	22 points
24% to 49% (vulnerable)	13 points
10% to 24% (relatively stable)	8 points
0% to 10% (relatively intact)	0 points

**Criterion 4**  
**Estimate the Degree of Fragmentation**  
**of Aquatic Ecoregions**

Fragmentation in aquatic ecosystems is defined as the degree to which human-induced breaks in the system affect biological activity because they act as barriers to the movement of aquatic organisms (e.g. dams, channelization, silted or dredged streambeds, areas of poor water quality). The following are some suggested fragmentation categories:

Degree of Fragmentation of Aquatic Ecoregions	
High: core habitat significantly affected, barriers preclude dispersal for most taxa	30
Medium: core habitat moderately affected, barriers to some taxa for long distance dispersal	15
Low: relatively contiguous, higher connectivity, long distance dispersal still possible	0

**Criterion 5**  
**Riparian Modification**

This criteria describes the amount of riparian habitat within the ecoregion lost due to anthropogenic disturbances such as channelization, destruction of riparian forests, intensive grazing, inadequate buffer

zones in logged areas (i.e., anything < 225 m on either side), road building, etc.

Riparian Modification (Loss of Original habitat)	
90% or more (critical)	20 points
50 to 89% (endangered)	16 points
24 to 49% (vulnerable)	10 points
10 to 24% (relatively stable)	5 points
0 to 10% (relatively intact)	0 points

### Criterion 6

#### Estimating Rates of Habitat Conversion (% per year) within each Aquatic Ecoregion

Here we estimate the percentage rate of change in chemical and physical parameters of habitats within an ecoregion. We suggest that investigators estimate rates that are relevant for the last five year period (the exact time period used being dependent on data availability). The following categories will be used wherever possible:

Annual Rates of Habitat Conversion	
> 4% per annum	20
3.1 to 4% per annum	18
2.1 to 3% per annum	16
0.5 to 2% per annum	12
no measurable amount of habitat conversion	0

### Criterion 7

#### Effects of Alien Species

This criteria estimates the level of degradation of the relative biological or physical integrity of the aquatic ecoregion due to the introduction of one or more alien species.

### Effects of Alien Species (Level of Degradation)

High: Major changes in species abundances or community composition (includes extirpation or extinction)	30
Medium: Moderate changes in species abundances, anticipated changes in community composition	23
Low: Anticipated changes in species abundances	10
None: No introduced species	0

### Criterion 8

#### Degree of Protection of Remaining Habitat within Ecoregions

Several aspects of protection should be considered:

- < the degree to which large stretches of intact habitat are adequately protected within a system of protected areas or by their remoteness;
- < the degree to which representative habitat types, communities, ecological gradients (e.g., how well protected areas capture beta diversity), endangered species, or critical habitats for species or ecological processes (e.g., spawning gravels or corridors, etc.) are contained within a system of protected areas;
- < the degree of connectivity among reserves for the dispersal of species and contiguity of large-scale ecosystem processes;
- < the level of redundancy (replication) of protected areas that is needed to help ensure the long-term persistence (e.g., > 3 units of similar habitat greatly enhances the likelihood of long-term persistence) of habitat types, communities, endangered species, or critical habitats for species or

ecological processes; and

- < the effectiveness of management of protected areas (e.g., adequate staff and resources are available, fishing is not permitted) and the ability of managers to defend protected areas based on their landscape configurations (e.g., the protected area encompasses the entire watershed).

The following are some suggested categories of protection, ranging from poor protection in category 1 to well-protected in category 5:

Categories of Protection	
1	No intact habitat incorporated into conservation areas <span style="float: right;">10</span>
2	Between 21% and 39% of intact habitat incorporated into a protected area system <span style="float: right;">8</span>
3	Less than 20% of intact habitat incorporated into a protected area system <span style="float: right;">6</span>
4	Between 40% and 50% of intact habitat incorporated into a protected area system <span style="float: right;">4</span>
5	>50% of intact habitat incorporated into a protected area system <span style="float: right;">1</span>

### Estimating “Snapshot” Conservation Status for Aquatic Ecoregions

The spreadsheet point totals for each of the aquascape parameters can be totaled at this stage and a “snapshot” conservation status assigned to each ecoregion. The snapshot conservation status assessments will subsequently be modified by the threat analyses (see below) to better reflect the long-term trajectory of the ecoregion based on significant, large-scale threats.

### Threat Analysis

The major threats to each ecoregion or major habitat type in terms of their type, intensity, and time frame are identified here. Threat analyses are inherently complex since factors may effect ecosystems directly or indirectly, and there are numerous and not well understood synergistic interactions among factors. For these reasons, the formal analysis of threats used here is based on general categories of habitat modification and ecosystem degradation. One should identify for each ecoregion and major habitat type the threats in terms of their type, general category, intensity, and time frame.

Suggested categories for threats include:

#### *Conversion Threats*

- < adjacent intensive logging and associated road building
- < adjacent agricultural expansion and clearing for development
- < adjacent intensive grazing
- < mining
- < dam building and channelization

#### *Degradation Threats*

- < pollution (e.g., oil, pesticides, heavy metals, defoliants)
- < burning in adjacent terrestrial habitats
- < introduced species
- < gold mining activities
- < grazing
- < road building and associated erosion and landslide damage
- < off-road vehicle damage
- < excessive recreational impacts (trail damage, stock impacts, overuse of sensitive habitats, overfishing)

#### *Wildlife Exploitation*

- < overfishing and poaching
- < unsustainable extraction of mollusks, crustaceans, or other invertebrates

< harassment and displacement by commercial

and recreational users

The general level of threat can be estimated from the points assigned above as follows:

70-100	High Threat
20-69	Medium Threat
0-20	Low Threat

### **Assessing Final Conservation Status for Aquatic Ecoregions**

Revise the snapshot conservation status of aquatic ecoregions on the basis of the threat analysis to develop final conservation status assessments. For example, an aquatic ecoregion may receive a snapshot status of relatively intact, but immediate threats of logging or damming might warrant shifting the final conservation status to vulnerable or endangered. The final conservation status assessments should reflect the urgency of conservation action as well as the ecological integrity of ecoregions.

### **Identifying Priority Ecoregions for Biodiversity Conservation**

A simple integration matrix of conservation status (horizontal axis) and biological distinctiveness (vertical axis) is the foundation we offer to identify priority ecoregions for biodiversity conservation within each MHT. The matrix, which produces 20 cells, allows us to classify each ecoregion into four biodiversity conservation priority and conservation activity categories (Levels I-IV). The following considerations determine the selection of the seven Level I cells.

Ecoregions with relative rarity worldwide or extraordinary biodiversity are designated as Level I (i.e., most of the globally outstanding cells). The exception is ecoregions that are globally outstanding but relatively intact. They are ranked as Level II, because these ecoregions are assumed to be under less threat over the next several decades and do not warrant proportionately greater attention at this

junction. However, the increasing rarity of relatively intact ecoregions and the high cost-effectiveness of conservation investment in such areas urges ongoing conservation planning, monitoring, and investment for all intact ecosystems. The risk of severe and rapid loss of biodiversity in critical and endangered ecoregions classified as globally outstanding or regionally outstanding justifies their designation as Level I.

Critical and endangered ecoregions that are bio-regionally outstanding or locally important contain unique species and communities and are certainly worth conserving; however, the integration model proposed here emphasizes that proportionately more attention should be given to ecoregions with the same conservation status but with higher biological distinctiveness. The opportunity to conserve biologically outstanding ecoregions that are on the precipice of major decline puts them at level I to guard against vulnerable ecoregions slipping into critical or endangered status.

We acknowledge the multiple values of conserving biodiversity everywhere. Thus, we emphasize that the biodiversity conservation priorities identified in this study are not intended to diminish or discourage conservation efforts in any ecoregion or habitat type. Rather they are meant to improve the balance of ecosystem conservation in the region and target areas needing urgent attention from donors interested in biodiversity conservation. We also recognize that ecological function and human utility are two discriminators of biological importance often suggested for priority-setting analyses. Ecological function is more appropriate for biodiversity analyzes at finer biogeographic scales than our study because of the difficulties in standardizing criteria and scales of processes. Human utility is a very fluid parameter and has a questionable role as a discriminator in first layer biodiversity analyzes.

Because of the potential abundance of resources for conservation in the region, we will also identify conservation activities most appropriate for each cell

and associated conservation scenario. This approach will help conservation donors and managers identify the most appropriate set of conservation activities for

each ecoregion based on its patterns of biodiversity and ecological integrity.