Mainstreaming Conservation in Infrastructure Projects

Case Studies from Latin America

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Contents

Foreword

Biodiversity, defined as the variety of life on earth in terms of ecosystems, species, and genes, plays an essential role in sustaining economic sectors such as forestry, fisheries, agriculture, tourism, and industry. Biodiversity is the foundation of livelihoods and well-being, particularly for some whose geography and economic status make them directly dependent upon it. Moreover, biodiversity forms an important part of spiritual and cultural traditions. In a similar vein, it would be hard to overstate the importance of infrastructure investments for human well-being, poverty reduction, and social and economic growth and development. Both play an essential role in human development, and it requires attention and continued learning to perceive their optimal complementarities in different situations and contexts.

In 2006, the World Bank underwent a reorganization to "integrate units responsible for meeting basic human needs and infrastructure services with environmental and social units that guide our actions." The integration has produced new opportunities to see synergies and collaborate across traditional sectoral boundaries to mitigate adverse impacts and maximize benefits. In the context of the Sustainable Development Network integration, transport and environment staff developed a joint initiative to increase knowledge and stimulate discussion on the opportunities, risks, and linkages associated with transport infrastructure projects, biodiversity, and forests. The initiative is supporting publication of this report as one of its activities. The report highlights the Latin America and Caribbean Region Safeguard Unit's leading and cutting edge work in mainstreaming biodiversity and environmental management in large transport, energy, and water-related infrastructure projects. In these eight cases, project resources were mobilized to carry out habitat restoration projects, endangered

species conservation action plans, environmental education and awareness programs, identification of non-catalogued sensitive areas, establishment of new protected areas or strengthening of existing ones, management plans, and comanagement agreements, among others.

The author notes that sometimes the conservation measures and actions described were embedded within wider changes that involved raising institutional environmental standards, revising legal frameworks, and creating new divisions to address environmental issues. Such changes represent significant accomplishments likely to produce positive results over time. It should also be observed that in most cases, conservation efforts within these infrastructure projects had further profound spillover effects. These effects included building citizen responsibility, making environments more beautiful and healthy, and fostering pride in the surroundings and natural and cultural heritage to such an extent that complementary investments were made. Effects also included introducing innovative engineering ideas applicable in other contexts, increasing land values in previously dilapidated areas, and creating more skilled, informed, and confident government officials, engineers, contractors, and civil society. The cases in this report illustrate clearly that development effectiveness does not only come from direct sectoral investment. It arises also from wider ripple and even intangible effects that result from awareness of our reliance on the natural environment and application of sound principles.

This report exemplifies the kinds of win-wins that can be devised in large infrastructure projects when accounting for both direct and induced impacts on biodiversity, natural habitats, and ecosystem functions. We earnestly hope this publication will inspire new ideas, dialogue, and action and be of assistance to those who are interested and involved in making environment- and biodiversity-friendly infrastructure investments a reality.

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This report is dedicated to the memory of Guillermo Ruan, a great task team leader and a transport engineer with a green heart.

Summary

Eight infrastructure projects with outstanding natural habitat conservation practices were examined in depth to evaluate the mechanisms and approaches responsible for their environmental successes. The wide range of World Bank-financed projects included a hydroelectric dam, a gas pipeline, flood protection works, roads and drainage works, as well as water supply and sewerage investments, in both urban and rural settings across seven countries in the Latin America and Caribbean Region (LCR).[1]

Results from this review show that integrating natural habitat issues into the design and operation of infrastructure projects can both substantially reduce the associated environmental costs and create win-win results for conservation and development. Specifically, infrastructure projects can provide and/or leverage important resources that might not be available for strictly "green" projects, resulting in a significant conservation gain.

Breaking common perceptions, these projects redefine the role of infrastructure development with regard to conservation. Good design, as well as innovative engineering construction and operational techniques, were devised specifically to avoid natural habitats, reduce the area of the disturbed sites, minimize the magnitude and extent of unavoidable impacts, and mitigate all remaining impacts. Project resources were mobilized to carry out restoration projects, endangered species conservation action plans, environmental education and awareness programs, identification of non-catalogued sensitive areas, establishment of new protected areas along with the provision of their management plans, comanagement agreements, recurrent costs

[1] Case study projects were implemented in Argentina, Paraguay, Bolivia, Brazil, Honduras, Belize, and Colombia.

financing, personnel training, and provision of initial funds. In many cases these actions were embedded within more profound changes that involved raising institutional environmental standards, revising legal frameworks and creating new divisions to address environmental issues. These case studies demonstrate that leveraging funds from infrastructure projects can be highly effective in benefiting conservation efforts. Successful strategies used by the projects can be summarized as follows:

1. Promoting development through well-designed infrastructure projects can freeze and even reverse degradation of natural habitats and the loss of biodiversity;
2. Thorough Environmental Assessments are the foundation of successful environmental outcomes;
3. Early involvement of stakeholders improves project design, operation, and management;
4. Timing is crucial: the nature of key actions may be ineffective if they are not carried out at given times during the project;
5. Compensation and restoration measures with successful outcomes can be achieved even when impacts are identified during project implementation;
6. Efforts to establish new protected areas need to be started during project preparation;
7. Large-scale projects facilitate institutional strengthening and restructuring; and,
8. Localized projects enable more in-depth, site-specific actions.

Introduction

Mainstreaming conservation into infrastructure projects requires an appreciation for the extent of services they can provide to the environment and local communities. Although infrastructure projects comprise a trade-off between service benefits and environmental costs, the final balance need not be one of environmental losses. On the contrary, infrastructure projects can be vehicles for improving institutional and legal frameworks for natural resource conservation, identifying new high-priority habitats, improving and expanding protected areas, securing state-of-the-art advice for specific conservation issues, and even leveraging important funds for conserving otherwise unprotected habitats. The high visibility and political significance of typical large infrastructure projects can act as a catalyst for advancing conservation actions that might not otherwise be a country priority.

Given the large number and broad distribution of infrastructure projects in the LCR region—with more than US$15 billion in over 250 investment projects across 28 countries—the potential environmental benefits derived from infrastructure projects in the region are quite substantial.

This paper summarizes the results of an in-depth analysis of eight case study projects (see Table 1) from the LCR region that demonstrate the significant potential for achieving substantial environmental benefit through infrastructure investments. Close evaluation of these successful experiences reveals that win-win outcomes can be achieved by carefully planning and executing conservation actions throughout the project's lifetime. The evaluation also highlights the need to identify natural habitat issues early on in project development, because projects that overlook or underestimate these issues often face costly construction delays and increased environment-related economic losses.

Table 1. Case studies selected for review:

Sectors and projects	Countries
Transportation	
Roads and Municipal Drainage	Belize
Road Reconstruction and Improvement	Honduras
Tocantins Sustainable Regional Development	Brazil
Water Supply, Sewerage, and Flood Protection	
Santa Fe Bogotá Water Supply and Sewerage Rehabilitation	Colombia
Cartagena Water Supply, Sewerage, and Environmental Management	Colombia
Argentina Flood Protection Project	Argentina
Energy	
Bolivia–Brazil Gas Pipeline (Gasbol)	Brazil and Bolivia
Yacyretá Hydroelectric Dam	Argentina

The importance of incorporating conservation into the design of infrastructure projects

The conservation of natural habitats can help ensure the long-term resilience of ecological systems and their main properties. Among them, biodiversity—the diversity of plant and animal life or ecosystems[2]—has made the Earth a uniquely habitable place for humans. Healthy ecosystems carry out a diverse array of processes that provide humanity with both goods, such as food, construction materials, medicinal plants, and tourism/recreation opportunities, and services, such as hydrological cycle maintenance, climate regulation, soil generation and maintenance, nutrient storage and cycling, and cleansing of air and water.

It is cheaper and easier to retain biodiversity and ecosystem goods and services by preserving natural habitats than it is to recreate or replace them elsewhere. Because infrastructure projects often comprise large-scale civil works, they are likely to impact natural habitats directly through construction, or indirectly through induced development. Thus, accurate and early identification of natural habitats during project preparation is critical to ensuring that timely actions are implemented to minimize those impacts, improve management of natural resources, and facilitate conservation.

[2] A more rigorous definition of biodiversity is: "*the variety of organisms at all levels, from genetic variants belonging to the same species through arrays of species to arrays of genera, families, and still higher taxonomic levels; includes the variety of ecosystems, which comprise both the communities of organisms within particular habitats and the physical conditions under which they live*" (Wilson 1992).

By looking at the experiences of various infrastructure projects, this exercise has identified numerous opportunities throughout the project cycle for incorporating natural habitat issues into the planning, construction, and operation phases. In the long term, improving project environmental sustainability is both good practice and the most efficient and cost-effective way to maintain the important benefits we derive from the biodiversity and ecosystem goods and services provided by natural habitats.

RANGE OF IMPACTS ON NATURAL HABITATS

The human impact on the natural environment may affect to a greater or lesser degree different levels of ecological organization: a given species' population, biotic communities, ecosystems (and their services and processes), or any combination of these. The type and nature of the impact is often a function of the type, scale, magnitude, and location of works. Regardless of scale, impacts may be direct or indirect, short or long term. *Direct impacts* are caused by the construction itself; *induced impacts* are those caused by a given action related to the project and occur later in time or further in distance; *short-term impacts* refer to those occurring during or shortly after construction; and *long-term impacts* are generally linked to the operational phase and last several years or decades. Finally, *cumulative impacts* are the combined additive, multiplicative, or synergetic effects of several changes.

A FRAMEWORK FOR THE PROTECTION OF NATURAL HABITATS

Given the importance of accurate impact evaluation to sound project design, World Bank policies call for an Environmental Assessment (EA; OP/BP 4.01) during the preparation of all projects. The EA assesses project environmental feasibility, reviews alternative designs and construction engineering, potential impacts and mitigation measures, prioritizes potential conservation opportunities and challenges, and serves as the mechanism for addressing many other Bank "safeguard" issues, including Natural Habitats (OP 4.04).

The Bank's OP 4.04 outlines the requirements for projects regarding natural habitats, a definition which refers to both the physical features and resident species (see Box 1). Although all natural habitats are included in OP

Box 1. What are Natural Habitats according to OP 4.04?

The World Bank defines Natural Habitats as land and water areas where (i) the ecosystem's biological communities are formed largely by native plant and animal species, and (ii) human activity has not essentially modified the area's primary ecological functions. By definition, ecosystems include both the physical features and resident species. Although all natural habitats are included in OP 4.04, priority is given to those especially high-quality areas known as "Critical Natural Habitats", which include existing and proposed protected areas, and other areas of high conservation significance. *Critical Natural Habitats* are: (i) existing protected areas and areas officially proposed by governments as protected areas; (ii) areas initially recognized as protected by traditional local communities; (iii) sites that maintain conditions vital for the viability of these protected areas; or (iv) sites identified on supplementary lists prepared by the Bank or an authoritative source determined by the Regional environment sector unit. Such sites may include areas recognized by traditional local communities, areas with known high suitability for biodiversity conservation, and sites that are critical for rare, vulnerable, migratory, or endangered species.

Noncritical Habitats are those that are not legally protected or proposed for protection and do not have as high a conservation value.

4.04, prioritization is given to those especially high-quality areas known as "Critical Natural Habitats" (see Box 1).

As the definitions in Box 1 imply, not all Critical Natural Habitats will be catalogued when project preparation begins. Rather; it is through the EA and on-site field work that natural habitats will be assessed as critical or noncritical. It should be noted that a habitat may be critical in spite of not being in pristine condition. In accordance with OP 4.04, any World Bank-financed project must avoid the significant modification of Critical Natural Habitats.

Specifically, projects must avoid (if a Critical Natural Habitat) or minimize or compensate for (if a Noncritical Natural Habitat): 1) any major long-term change in land or water use that will eliminate or severely decrease the habitat's integrity (conversion) and/or 2) any action that will substantially reduce the habitat's ability to support and maintain viable populations of its native species—that is, any action that will substantially decrease the long term survival of a native species (degradation). Examples of conversion, or changes in land or water use, include canalization of wetlands, flooding, drainage, filling, land clearing, or replacement of natural vegetation. A project may also cause indirect changes in land or water use such as induced settlement or high levels of pollution.[3]

Although avoidance of these habitats is still recommended, and the Bank encourages use of sites on land that has already been converted, their modification may be allowed if no feasible alternatives are available. An exhaustive analysis of alternative project siting, design, and engineering must back up this resolution and demonstrate that the benefits derived far outweigh the costs on natural habitats in the short and long terms. It should also be accompanied by adequate mitigating measures, which often provide the opportunity for furthering conservation. Conservation actions go beyond impact amelioration and serve as a step toward ensuring the long-term protection of the natural habitats in question.

When natural habitats are affected through World Bank-funded projects, adequate mitigation/ conservation measures typically require that: 1) protected areas be established or strengthened as part of and funded by the project; and 2) the new or strengthened protected area is commensurate with the impacted area both in terms of ecological value and size. The result is significant long-term benefits, particularly when areas not previously acknowledged for their conservation value become new protected areas.

Within LCR, the main infrastructure sectors are Energy and Mining (24 percent of total projects), Transportation (43 percent), and Water and Flood Related (33 percent).[4] Each sector has a suite of specific associated impacts. (Table 2 shows a summarized list.)

[3] As defined in OP 4.04–Annex A.

[4] From WB Project Database. Projects included were active and fell into one or more of these sectors.

Table 2: Typical impacts by sector

Sectors: Energy, Hydropower

Environmental impacts	*Mitigation/compensation/conservation actions*
Flooding of natural habitats near reservoirs; displacement/loss of wildlife; loss of biodiversity; deterioration of water quality; accumulation of vegetation before reservoir filling; upstream and downstream hydrological changes; alteration of fish communities and other aquatic life; invasion of aquatic vegetation and its associated disease vector species; sedimentation of reservoirs; generation of quarries and borrow pits; construction of multiple dams in one river; human resettlement; changes in hydrodynamics	Creation of compensatory protected areas; species conservation in situ and ex situ; minimization of flooded habitats; water pollution control/vegetation removal; water release management; minimum (ecological) stream flow maintenance year round; construction of fish passages and hatchery facilities; application of fishing regulations; physical removal of containments; biological and mechanical pest control; draw-down of reservoir water levels; watershed management; sediment management techniques; landscape treatment; environmental assessment of cumulative impacts

Sectors: Energy–Gas/Oil Pipelines; Transportation–Roads; Telecommunications–Access Corridors (Linear Projects)

Environmental impacts	*Mitigation/compensation/conservation actions*
Barriers to species dispersal; habitat loss, fragmentation, and simplification; spread of tree diseases: insect infestation; introduction of invasive species; human and domestic animal intrusions; runoff, erosion, and landslides; fire generation and/or natural fire frequency alteration; land use changes; wetlands and stream deterioration; water quality alterations; modifications of indigenous peoples' and local communities' ways of life	Generation of wildlife corridors and of connections between habitats; minimization of road/corridor/ project footprint width; creation of compensatory protected areas; management plans; use of native plant species as barriers to avoid or reduce undesirable intrusions; minimization of access roads and right of way (ROW) width for pipelines; minimization of forest edges; implementation of management and maintenance plans for roads/corridors/ROWs; revegetation along roads/corridors/ ROWs; ROW maintenance; improvement of land use management; elaboration and implementation of zoning plans; environmental education and awareness programs

Sector: Water and Sanitation/Flood Protection

Environmental impacts	*Mitigation/compensation/conservation actions*
Coastal erosion downstream from river breakwaters; pollutant removal by dredging bottom sediment; pollution of water supply sources; deterioration of wetlands; loss of connectivity between rivers/wetlands/riparian zones; displacement/loss of wildlife; generation of artificial wetlands; invasions of aquatic weeds and disease vectors; worsening of water quality due to sewage disposal water bodies; encroachment; land use changes; storm-induced floods within enclosed areas protected by dikes	Land use management; implementation of zoning plans; execution of pollution controls and water quality monitoring; elaboration and implementation of environmental education and awareness programs; implementation of management plans for wetland areas; establishment/maintenance of wildlife corridors, channels, and flooded areas; mechanical control of aquatic weeds; biological control of disease vectors; adequate site selection and engineering design; establishment of physical barriers; adoption of design criteria aimed at discouraging encroachment into natural habitats

Mainstreaming conservation into infrastructure projects

The net outcome of the projects under revision proves that environmental costs can be kept to a minimum, so that upon completion of construction and the start of the operational phase, the results are a series of conservation actions and measures on a par with separate conservation and restoration projects. The roadmap is quite simple: first reduce environmental costs to a minimum, then maximize benefits to natural habitats. The following section outlines specific mechanisms or tools used during each step. Table 3 presents a summary of the major conservation/ mitigation actions implemented in each project.

REDUCING ENVIRONMENTAL COSTS

The identification of potential impacts on natural habitats is key to reducing environmental damages. The EAs of the projects evaluated, although of very different natures, shared some common qualities: 1) thoroughness; 2) evaluation of alternative sites,[5] designs, and techniques; and 3) adoption of a precautionary approach. These features must be eagerly pursued, as illustrated by the Gasbol project, where quality screening prompted new, revised EAs. Taking the time to revise this initial step proved fruitful: the project was subsequently awarded the World Bank Green Award for outstanding environmental management.

[5] With the exception of the Yacyretá Dam, which was started prior to Bank involvement.

Table 3. Conservation/mitigation actions implemented in infrastructure projects in LCR

	Avoidance of natural habitats	Innovative engineering/design	Rural/urban landscaping	Environmentally oriented operation	New protected areas (PAs)	Strengthening established PAs	Restoration of habitats	Endangered species programs	Environmental awareness/education	Furthering knowledge	Institutional strengthening	NGO strengthening/community involvement
Honduras Roads	✓				✓			✓	✓			
Belize Roads and Drainage					✓			✓		✓		✓
Tocantins Development	✓	✓			✓					✓	✓	✓
Cartagena Water Supply		✓	✓	✓		✓	✓		✓	✓	✓	✓
Santa Fe Water Supply		✓	✓	✓		✓	✓		✓	✓		✓
Argentina Flood Protection	✓	✓	✓				✓		✓	✓	✓	✓
Yacyretá Hydroelectric Dam		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
Bolivia-Brazil Gas Pipeline	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓

The EA should also match the scale and type of the project: The Argentina Flood Protection Program conducted a Regional EA, followed by standard EAs for each site. The Regional EA addressed the potential cumulative impacts of all the civil works within the basins (SUCCE-World Bank 1995a); site-specific EAs addressed local impacts and mitigation (SUCCE-World Bank 1995b). Cumulative impacts were also assessed for the Cartagena Water Supply Project where tourism, agriculture, transportation corridors, and other activities had to be considered in aggregate.

The timely recognition of non-catalogued critical natural habitats was key to minimizing costs. In terms of timing environmental cost-reducing actions and in order of preference, it is best to 1) avoid natural habitats, [2]) reduce the area of the disturbed sites, 3) minimize the extent, duration, and magnitude of unavoidable impacts, and 4) mitigate for all remaining ones.

AVOIDANCE OF NATURAL HABITATS

Avoiding natural habitats may sound trivial, but the action itself sets an important precedent because it is a reflection of the ecological relevance of specific regions or sites. Three ways of achieving this goal arise from the projects examined:

The first option is to set strict criteria for the characteristics of the civil works and their location. This was the approach of the Argentina Flood Protection Program, for which sites were only selected if: 1) the civil works did not

alter the structure and functioning of floodplain habitats and surrounding wild lands, and 2) there was an economic rate of return of at least 12 percent in the area. The latter economic criterion gave preference to converted lands.

The second option is to map out the location of natural habitats within a project's area of influence. Consequent prioritization of the habitats guides the decision-making process during the design and consideration of alternatives. The Cartagena Water Supply Project illustrates this approach. During project preparation, the EA evaluated several sites for final sewerage disposal (Cartagena Bay, Ciénaga de la Virgen, Caribbean Sea, reuse for irrigation) and once it was decided that a submarine outfall in the Caribbean Sea would be best, four locations were considered: off Ciénaga de la Virgen, La Boquilla, Punta Canoas, and Tierra Bomba Island (Figure 1). In both cases the potential environmental effects were involved in the final selection of the site; avoidance of high biodiversity and multiple habitats as well as disruption of ecosystem functions were among the main environmental concerns. Projects such as these, where routing is involved, allow in situ readjustment of the final route when not all sensitive areas were mapped in advance. This is exemplified during the execution of Gasbol (an over 3,000 km gas pipeline), where environmentally sensitive areas were avoided for the pipeline's ROW, despite additional costs. (See World Bank 2003a and 2003b for more details.)

A third innovative approach is that taken for Tocantins, Brazil. The network of roads is embedded in a zoning plan for the entire province, so that sensitive areas for conservation will be mapped out and economic activities matched to the resources available in the nonsensitive areas. The roads are therefore not planned on an individual basis but as a network, where conservation priority areas are considered all at once. This is by far one of the best examples of outstanding land-use planning, where conservation areas are identified as a desirable asset within a zoning plan from the start.

REDUCING AREA OF DISTURBED SITES

The size of the impacted areas is usually set by construction and operation requirements. These requirements can be reduced with adequate planning. For example, because existing roads in Brazil were able to facilitate truck passage to most places along Gasbol's pipeline route, the *width of the ROW* was narrowed from 30 to 20 meters, bringing down the impacted area within Brazil by one third.

During construction in Bogotá, works included the *incorporation of sheet-piling*, 15 m in depth, along construction sites of interceptors in order to protect the drainage of neighboring wetlands, restricting the area impacted to that where the works were specifically located.

A mathematical approach was used to evaluate the technical merits of the alternative sites for the submarine outfall in Cartagena. A *hydrodynamics model* incorporated the direction and velocity of ocean currents to estimate dilution and dispersal rates of the different effluent components. One of the reasons the site was chosen was the resulting combination of high dilution rates and smaller size of the maximum dispersal area.

Figure 1. Alternative sites for submarine outfall, Cartagena Colombia

MINIMIZING IMPACTS ON NATURAL HABITATS

Indeed, it is hard for infrastructure projects to avoid some overlap with natural habitats. Thus, the next step becomes crucial: to devise ways in which the magnitude, extent, and duration of the impacts can be minimized. This can be achieved by a combination of project design and engineering techniques. In other words, the design of the project can minimize the area required for the infrastructure itself, while engineering techniques can minimize the area needed to carry out projects works and their footprint.

Half of the described projects devised engineering techniques or designs that minimized impacts:

Gasbol

Manual tree removal along ROW: trees were manually removed with chain saws to ensure that they were felled within the ROW, avoiding damage to surrounding vegetation.

Pushing and pulling method for wetlands: State-of-the-art techniques were used to install the pipeline across the wetlands. The pushing and pulling method is used during the rainy season. It uses a preassembled section of pipe which is floated into position over an inundated trench. The buoys are removed and the pipe, coated with concrete jackets, sinks into the ditch. This method requires less clearing than conventional methods, because the construction space is limited to that required to allow the backhoe to cross the wetland to stockpile excavated soil. On the other hand, under conventional methods the entire area is usually cleared during the dry season in order to set the pipe.

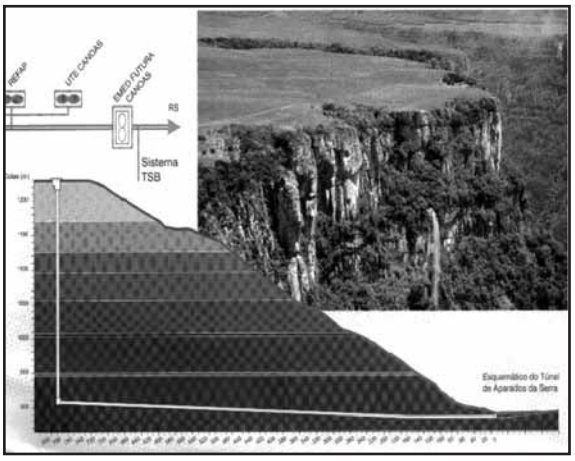
Drilling under river beds: Similar special works were commissioned for the crossing of 13 rivers to avoid negative impacts on vegetation and water quality. Horizontal drilling techniques were used to tunnel under river beds, minimizing disturbance to riparian vegetation and protecting the pipe from pipeline scouring.

Tunneling in steep terrains: to protect the Aparados da Serra region in Brazil, an L-shaped tunnel, 780 m horizontal and 320 m vertical, was built. In so doing, the project avoided the erosion, sediment accumulation, slope instability, and landscape alterations typically associated with pipeline construction in steep terrain (Figure 2).

Cartagena water supply

Water treatment prior to disposal: The engineering design of the submarine outfall in Cartagena, Colombia managed to both avoid sensitive marine environments and create the least disturbance in the surrounding water quality by adequately locating and using a water treatment prior to disposal into the sea. The treatment plant will remove 99 percent of suspended solids, 30 percent of oil and grease, and 75 percent of nonsuspended particles.

Figure 2. Aparados da Serra, general view and diagram showing the tunnel which was built to avoid major landscape alterations.



Treating the water will abate localized direct pollution in the marine environment, minimizing the footprint of the project during its operational stage.

Submarine outfall: The submarine outfall runs for 20.85 km on land and 2.85 km in the sea, to a depth of 20 m below sea level. The effluent is let out through a diffuser 500 m long with 27 double-mouthed elevated pipes. This again reduces the intensity of local direct pollution. One of the major benefits of the outfall toward the Caribbean Sea is that the effluent disposed of in Ciénega de la Virgen and Bahía de Cartagena can be transferred, preventing further degradation of both areas and allowing restoration programs to take place.

Argentina flood protection

Environmental criteria for civil works: the flood protection program in Argentina opted to ensure that civil works would maintain the integrity of specific ecosystem characteristics and functions. The same environmental criteria of avoiding high-priority habitats ensures minimum impact: throughout the 40 sites chosen, the works are designed not to interfere with the natural processes in the floodplains.

Bogotá water supply

Tree inventory: Because the wetlands in Bogotá harbor a large number of both resident and migratory birds, an inventory of all large trees to be removed was kept so that bird eggs and nests could be identified, moved if needed, and monitored.

Ad hoc construction scheduling: time management and scheduling of construction activities were the key to avoid impacts during nesting or breeding seasons, migration and/or feeding times. This prevented a potentially significant decrease in the breeding success and survival of chicks of the bird populations, which would have had an adverse effect on their population growth rates. Adequate timing of construction and operation activities is one of the most effective good practices.

MITIGATING IMPACTS ON NATURAL HABITATS

Mitigation involves the amelioration of impacts during and after project construction as well as operational activities, so that ecosystems will be disrupted as little as possible. Mitigation measures can be taken throughout the construction, operation, and maintenance of a project, as indicated in the examples below. In all these cases, solid design techniques facilitated infrastructure works to blend into the existing landscape, whether rural or urban.

Revegetation and geomorphologic reconstruction in rural sites goes a long way against erosion and turns areas into usable spaces by local flora and fauna. Two projects are notable for their implementation of these methods: Gasbol and Yacyretá. In the former, a 13-meter-wide strip along the ROW of the pipeline was revegetated and the trenches were refilled after construction. A recent environmental survey of the entire 3,150 km along the pipeline, including aerial views, shows little or no trace of ecological footprints from construction activities. In Bolivia, traces of the pipeline's ROW still exist in the Gran Chaco dry forest area. Despite a slower rate of revegetation due to a hostile climate and natural environment, the affected area has decreased considerably and continues to do so. At Yacyretá, borrow pits were reconformed to allow for natural flora to revegetate the area, which is now within the new network of protected areas stemming from the construction of the dam. The footprint of the borrow pits is now minimal and the areas can be used by local fauna.

Urban landscaping for the water supply and sewerage projects in Cartagena and Bogotá, Colombia, reincorporated the waterways, water bodies, and storage tanks into parks and recreational areas. The storage tanks in Bogotá were transformed into structural components of sports areas: the tops of the tanks were used as courts for basketball and other sports, their height conveniently allowing for a scenic view of the newly constructed park and gardens below, which are accessible by a road that goes around the tanks. The extensive river network in Bogotá is now bordered by 40 km of linear parks which provide roads for biking, skating, and strolling along the water and adjacent parks. The parks themselves were strategically located in flood-prone high- and medium-density areas so that when flows exceed the design capacity, the parks become active as natural permeable areas, preventing flooding of residential areas. The concept of linear parks was also applied at particular sites of the Flood Protection Project in Argentina.

Disposal of sludge, sanitation waste, and excavated materials: During the Bogotá water supply project a detailed management plan to control sludge and sanitation waste was drawn to guarantee that they would be disposed of in adequately protected tank sites. The excavated materials were disposed of on secured lands. Some of the materials were recycled within project works, such as at the canal dam at Tintal. Proper disposal of both sludge and excavation material prevented impacts on the water quality and terrain characteristics in wetlands and rivers.

Water quality-related monitoring/maintenance programs have been set in place in Yacyretá, Bogotá, and Cartagena to control and keep track of water quality and invasive species throughout the numerous water bodies and waterways. Particularly for Bogotá and Cartagena, the monitoring is essential to keep track of the amount of nutrients and pollutants entering the system, and the system's ability to recycle them. This is important: even though sewerage inputs have ceased or been controlled, nonpoint sources still prevail within the various watersheds. Surface runoff from agricultural lands and urban areas still ends up in the rivers and wetlands. At Cartagena, water samples from around the submarine outfall are constantly monitored and tested to ensure not only that the level of total coliforms and overall water quality stay within designed low levels, but also that high coliform levels do not spread beyond predicted areas. Keeping close track of the marine environment enables timely response should ocean conditions change.

The Yacyretá monitoring program, on the other hand, ensures that the new lake does not turn into an anoxic environment which would have an adverse impact on aquatic life. Controlled water releases ensure proper circulation in the lake and also keep seasonal stream flow variation downriver. The maintenance program also controls the density of invasive aquatic plants in order to prevent the colonization of disease vector species in the area (e.g., planorbid snails and insects), poor circulation, and other problems.

Fish passages, habitat, and regulations: As part of its operational program, the dam at Yacyretá left a minimum flow of 1,500 m^3/s along the Aña Cua branch to prevent this section from drying. This is a significant flow, equivalent to that generated by two turbines. Additionally, a fish elevator was installed to compensate for the disrupted access to upstream areas. The elevator is not designed to maintain high numbers of fish, but rather to conserve the genetic biodiversity of the area (De Francesco and Schnack 2003). To protect the fish stocks concentrating just below the dam, a no-fishing zone was declared within the area located 1 km downriver from the dam.

Monitoring of steep terrains involves keeping track of landmass movements in the Aparados

da Serra region of Brazil, a region crossed by the Gasbol pipeline.

As part of the tunnel's maintenance program, the aggregate loss of hill mass is monitored during operation by checking the inclination angle of strategically placed stakes, as well as indirectly by strain gages monitored by the Operation Center in Rio de Janeiro. This allows prompt action to prevent landslides or other threats.

Preventing urban sprawl can be one of the most challenging issues in urban settings. Unregulated settlement into adjacent areas which usually lack basic infrastructure and services poses a serious threat to natural habitats. Most projects which were located in urban areas set aside funds and resources to prevent urban sprawl. In Bogotá, the parks and corridors create a physical barrier between residential areas and wetlands; in Belize, the creation of the Gra-Gra National Park secured the boundaries of the mangroves and wetlands; and in Argentina, civil works were designed to encourage settlement out of the floodplains and into planned development areas. At the same time, new regulations discourage construction in high flood risk areas.

Operating and maintenance programs: Gasbol constantly monitors the ROWs to ensure that pipeline operation is environmentally and socially sustainable. The program covers environmentally sensitive areas, including approximately 300 critical areas such as river crossings, wetlands, areas with steep slopes, and trash disposal sites. This routine monitoring allows prompt action to prevent degradation of surrounding habitat, unwanted land use, and illegal exploitation of resources around the ROWs.

Maximizing benefits for natural habitats

To have a net gain in terms of conservation benefits, each of the projects reviewed not only matched the environmental costs but sought to exceed them by ensuring that long-term benefits were of equal or greater magnitude. One immediate benefit stemming from infrastructure projects was the identification of new high-priority areas for conservation yet to be catalogued. However, finding a critical habitat, a biodiversity hotspot, or avoiding pristine habitat is not a lasting benefit unless some form of protection is guaranteed for the long term. Six of the eight projects analyzed identified and secured legal protection for conservation priority areas that were either not previously catalogued or recognized.

New protected areas include:

1) Aguan Valley in Honduras: A conservation action plan was formulated to conserve critical thorn forest habitat for the endemic endangered Honduran Emerald hummingbird, *Amazilia luciae*, as well as 11 endemic plant species. To date, some 1,200 hectares of natural vegetation (of which 600 ha comprise Honduran Emerald habitat) are under permanent protection within the Poligono Habitat Management Area established in 2005.[6]

[6] During project implementation, the scope of the project changed, and the planned civil works along the road segment passing through critical habitats for the Emerald hummingbird were not implemented. A planned Payments for Environmental Services (PES) scheme, if successfully implemented, will lead to the long-term protection of an additional 1,000–2,000 ha on private lands. This, in turn, would address the main environmental concern associated with the proposed future paving of the Olanchito-San Lorenzo road.

2) Gra-Gra Lagoon in Belize: 484 ha were protected by establishing the Gra-Gra Lagoon National Park, which aims at the conservation of the lagoon and neighboring mangrove areas.
3) Biodiversity hotspots throughout the Paraná, Paraguay, and Uruguay river basins in Argentina will be protected once layered digital maps of flora and fauna identify best locations and required size.
4) Yacyretá Protected Areas Network: Legal protection has been secured for 58,000 ha. Once the dam operates at full capacity, the total network system will be 187,000 ha in 11 protected sites. The habitats include river islands and riparian habitats similar to those lost after flooding. These lands neighboring the dam harbor threatened and/or endemic species (Figure 3).
5) Tocantins conservation units: Six of eleven identified conservation areas will be established as part of the project. The eleven areas amount to 917,000 ha, six of them encompassing a minimum of 214,000 ha up to a maximum of 762,000 ha. The conservation units are part of the state's goal to secure 10 percent of its total area for conservation purposes.

Figure 3. Yacyretá Island Reserve (8,365 ha), one of eleven within the Yacyretá Protected Areas Network which will be completed once the dam operates at full capacity.

6) Ciénaga de la Virgen: Long neglected in spite of being widely recognized as an important area for endangered species and of great esthetic value for Cartagena, Ciénaga de La Virgen was legally established as a protected area. The accompanying Recovery, Conservation and Environmental Management Plan (RCEMP) is now under implementation through an arrangement with the regional environmental agency and Conservation International.

Establishing these areas brought both resources and awareness to specific sites that had been neglected or whose attributes had remained unknown. It is also worth noting that in the case of Belize, Argentina (Flood Protection), and Tocantins, the protected areas were not needed as compensatory or mandatory measures according to Bank policies. Hence, the projects went beyond what was required by local laws and Bank policies.

Strengthening existing protected areas: Where protected areas were already in place or had long been recognized, strengthening established ones was a viable option. This was the case for Gasbol, where 12 conservation units, mostly national parks and biological reserves covering over 218,000 ha, were chosen throughout the five provinces affected by the project. Brazilian law requires that 0.5 percent of project funds be allocated for ecological compensation. As a result, US$7.5 million were disbursed equally among the five provinces. The areas benefited include: 1) Parque Nacional da Serra da Bodoquena; 2) Floresta Nacional de Ipanema; 3) Centro de Manejo, Reabilitação e Triagem de Animais Silvestres do Parque Estadual Alberto Loefgreen; 4) Parque Nacional Superagüi; 5) Parque Estadual do Cerrado; 6) Parque Estadual de Guartelá; 7) Parque Estadual de Campinhos; 8) Parque Estadual da Serra do Tabuleiro; 9) Parque Botânico de Morro Baú; 10) Parque Nacional de São Joaquim; 11) Parque Nacional Aparados da Serra; and 12) Reserva Biológica Estadual Mata Palu-

dosa. The funds disbursed have been/will be used for land acquisition, maps, equipment, vehicles, education programs, and buildings, among other uses.

Restoration: The wetlands both at Cartagena and Bogotá were at varying degrees of degradation prior to the initiation of the respective Bank-financed projects. In Bogotá, this happened despite their protected status. The main problems affecting the wetlands around Cartagena and Bogotá involved: 1) illegal occupation of urban spaces; 2) loss of biodiversity; 3) destruction of mangroves; 4) filling of wetland ecosystems; and 5) public health issues. Both for Cartagena and Bogotá, a wetland restoration program is now being set in place. The civil works themselves helped stop and revert some of the damage because they: 1) ceased disposal of effluents directly into the wetlands; 2) improved or re-established flow among water bodies and waterways, thus avoiding the isolation of particular areas and restoring previously fragmented habitats; and 3) constitute physical barriers that will prevent future urban sprawl into the wetlands.

The restoration plans identify and prioritize related actions needed to further stop the degradation of the wetlands, such as: identifying areas with high rates of urban sprawl, as well as those where solid waste is being disposed directly into the waterways; identifying the magnitude of nonpoint sources of pollution; locating and controlling invasive species and stopping overfishing, among others. Once again, the variety of issues tackled as well as the wide range of agencies involved in the restoration plan goes well beyond the scope of direct project impact. The civil works brought benefits to the wetlands, but Bank funds and resources are being channeled into a far-reaching program that goes well beyond project participants and actively involves other parties who have contributed historically to the degradation of the wetlands.

The success of legally protected areas is largely dependent on their long-term maintenance and adequate management. Management plans are an indispensable tool, because they provide the guidelines for the location, magnitude, and level of intensity of future activities permitted within the protected area. Most projects funded and facilitated the elaboration of management plans. However, the stakeholders involved and specific mechanisms employed differed among them, as exemplified below.

Management Plans: The management plan for the Gra-Gra Lagoon National Park has been drafted by a consulting firm; it was reviewed by the Forest Department and the community-based NGO Friends of Gra-Gra, both of which are responsible for the Park under a comanagement agreement. Because Friends of Gra-Gra is a recently formed organization, the management plan package 1) specifically addresses its capacity building needs by providing workshops related to ecotourism and other activities of interest, 2) supervises the initial acquisition of equipment to fulfill its managerial responsibilities, and 3) provides training on the responsibilities of park rangers. The plan also contains a detailed section on the immediate actions that need to take place, such as demarcation, setting up signs, building the main trail, and equipment acquisition to ensure that short-term goals are met.

The Santa Fe I Project in Bogotá provides another example of establishing management plans. Here, the main challenge was to include in one plan multiple wetlands with varying degrees of ecological value. The Management Plan was prepared mainly by Conservation International, a well-established international NGO with past experience in management and restoration plans. The plan has a regional approach, setting the framework for individual plans to address the specific needs of the 13 wetlands in the city. Once again, the project's civil works affected only seven wetlands, but Bank funds were set aside for the management plans of all 13. The individual management plans take into account the ecological value of each wetland, local biodi-

versity, water quality issues, and other factors to determine zoning, suitable activities, density of visitors, etc.

Comanagement Agreements: Among the management schemes set up by the projects for the protected areas, comanagement is the most favored form. This is a win-win situation for government agencies and NGOs alike. There are multiple advantages to this approach. First, it circumvents the lack of government human resources assigned to administer the park, including park rangers, financial administrators, and clerical personnel. It incorporates an independent organization into activities such as fund-raising, environmental educational and awareness programs, tour guiding, public relations, and preventing new settlements. It is also a management scheme that is self-critical and self-policing, because each party oversees the other one. In the case of community-based NGOs, comanagement empowers local communities and brings their goals and concerns into view. Where large and well-established NGOs are involved, they are usually able to leverage national and international resources, to provide expertise, human resources, and financial funds in the protected area. These well-established NGOs are usually able to provide training to local people and set up large-scale environmental and educational programs.

In all cases where comanagement agreements were set up, project funds and resources were allocated to strengthen the NGOs. These funds were used for training, equipment acquisition, and other activities.

Other comanagement agreements within the projects include that of the community-based Fundación Bertoni and the Entidad Binacional Yacyretá (EBY), which are jointly responsible for the Yacyretá Island Reserve. The agreement, which was finalized in June 2000, stipulates that all costs related to managing the protected area be incorporated in the operating costs of reservoir and dam maintenance, thus guaranteeing a source of funding for the Reserve's recurrent costs throughout the project's lifetime. EBY also finances the off-site conservation of endangered endemic snails (which are bred in laboratories and slowly reintroduced) until new populations take hold of other areas downstream from the dam. Finally, a comanagement scheme was contemplated in Honduras once the protected area for the Honduran Emerald hummingbird was to be established. Management would be a joint effort of the government (DAPVS) and the Pico Bonito Foundation.

Securing traditional land for indigenous people: The Kaa-Iya National Park in Bolivia (Gasbol) is an example of how all the elements described above were incorporated in an innovative manner that benefited not only natural habitats, but indigenous communities as well. Kaa-Iya was established in 1995 and consists of the best conserved tropical dry forest of the boreal Chaco, covering 3,441,115 ha. The area houses a high number of plants and animals species; it is one of the largest legally protected areas in Latin America. It was also considered one of the most sensitive ecosystems within the pipeline's area of influence, which extends 140 kilometers within the park. To implement Gasbol's Environmental Management Plan within the park, an Executive Committee was formed by both Gas Trans Boliviano and the area's indigenous peoples. Management of the park is carried out by the indigenous organization Capitanía del Alto y Bajo Izozog (CABI), the Wildlife Conservation Society, and Bolivia's National Protected Areas Agency (SERNAP). A total of US$456,000 from the project's funds were allocated for the Environmental Management Plan of the park itself (CABI and WCS 2001) and an additional US$1 million was established as a Trust Fund to assist in the management of the Kaa-Iya National Park. The Bank's involvement was crucial in setting the high social and ecological standards that have characterized subsequent negotiations between Kaa-Iya and other energy companies.

Environmental education and awareness programs: All projects included environmental

education and awareness programs to raise local and national appreciation of important natural habitats within the area of influence of the projects. For the Argentina Flood Protection Project, local programs were set up in each of the 40 sites where civil works were located as well as throughout the provinces involved, extending the educational program outside the immediate area of influence of the works. The environmental education programs were aimed at informing people of the importance of maintaining floodplains and the consequences of creating impervious areas (mainly paving and house building). Another example is the Bogotá Water Supply and Sewerage Project, where signs along the parks and wetlands describe the site-specific fauna and flora, inform about migratory routes and ecosystem services, and provide other ecological information relevant to the wetlands. A collection of papers contributed by agencies, academic institutions, and NGOs were bound in a two-volume special edition that is to date the most thorough compilation of information available about the wetlands of Bogotá. The papers treat all aspects related to the wetlands, from their ecology to their historical exploitation, relevance to city services, and social and economic importance. They have become a vital tool for informing agencies and the public and well as for shaping the reconstruction plan for the wetlands.

Endangered species and special studies are often the focus of conservation-oriented grants and projects. But infrastructure projects can identify high-priority needs and provide the funds to address them. Multiple projects exemplify this approach: 1) the Honduras Road Improvement Project financed a habitat study for the Honduran Emerald hummingbird. The study indicated that there are only two sites where it can be currently found. The study also mapped and characterized this bird's habitat, identified other endemic and threatened species located in the area, and estimated the rate of deforestation in the area where the hummingbird lives. This study portrayed the urgent need for a conservation action plan. 2) The Belize Roads and Drainage Project launched a nationwide study to map and assess the population of threatened cycads. Such a large plant biodiversity study stands out even among others financed by the Bank. 3) At Yacyretá, the environmental studies of endemic snails from the Apipé rapids were carried out by the Museo de Ciencias Naturales of Buenos Aires and a local university (Universidad Nacional de Misiones). Together, they have been in charge of increasing public awareness of this species and managing the off-site conservation program, for which the development of new laboratory breeding and species conservation techniques has been required.

Archeological findings are particularly relevant when civil works related to Bank-financed projects are nearby or in areas known to have been inhabited during pre-Hispanic times. This was the case for the Belize Roads and Drainage Projects and for Gasbol. In Belize, one of the towns where civil works were required had been built atop an ancient pre-Hispanic city. Because there was no prior set of protocols for dealing with chance finds in the town of Corozal, the project undertook the task of establishing adequate procedures. The project also conducted and financed excavations in search of artifacts or historically important remains. In Gasbol, there were no pre-identified sensitive areas in terms of archeological importance. Rather, the magnitude and expanse of the works required for the pipeline provided a rare opportunity for chance finds along the route which went through largely uninhabited areas. A compilation of the archeological findings in Bolivia during the project was published in the book: *Al Este de los Andes, al Sur del Amazonas. Descubrimientos Arqueológicos en los Bosques Secos de los Llanos de Bolivia* (Dames and More 2001). The amount and quality of the findings changed the perception of human settlements throughout the region, but particularly in the area of the Bañados del Izozog. The recovered artifacts increased scientific knowledge of the

area and this cultural heritage was displayed in local museums including the Museo Arqueológico de Santa Cruz de la Sierra in Bolivia and the Universidade de Campo Grande in Brazil.

Institutional strengthening often involves not only the acquisition of equipment and training, but also changes within the organizational structure of the agencies involved. The required changes can be of varying degrees but they always aim at enhancing or improving environmental standards. For example, a new environmental department was established in the Bogotá water management agency. Prior to the project, the agency had no specific personnel assigned to deal with environmental issues related to the wetlands and rivers within the city. The new office is of a higher level, and is charged with ensuring that environmental standards are met, answering environmental concerns from the public, and serving as a liaison between the agency and NGOs in charge of comanagement.

One of the most profound impacts a project can have is on reforming the regulations and laws of a country to mandate higher environmental safeguards and standards. For the Argentina Flood Protection Program, multiple regulations at national, state, and municipal levels were changed to ensure, among other things, that: 1) the flood risk of an area is assessed prior to construction; 2) environmental assessments explicitly address impacts on floodplains; 3) urbanization of floodplains is avoided; and 4) protected areas where fauna can go in case of flooding are created. It is significant to note that municipalities other than those where project civil works were located have taken the initiative of implementing similar regulations and steps toward improving flood protection. A different legal change is exemplified in the case of Tocantins, where the province is setting forth a zoning plan that will guide future developments in terms of economic activities and land use. The proactive nature of this framework sets it apart from all the other projects.

Preventing adverse economic activities: In rural areas, the threat to neighboring habitats is land-use changes. As mentioned above, the Tocantins project is a unique example of an integral statewide assessment of preferred economic activities and financial needs. But small-scale projects can also have a strong impact. In Honduras, the project allocated financial and other resources to create a Conservation Action Plan for regulating future activities and development in the area of Olanchito.

Successful strategies

The mechanisms and actions described above had such positive results because they were part of well-thought-out strategies to approach environmental challenges. The collective review of the projects shows that the following approaches smoothed project advancement.

Well-designed infrastructure projects can freeze and even reverse degradation of natural habitats and biodiversity loss. Communicating this vision creates a much more receptive environment, where government agencies and the public are aware that infrastructure projects can simultaneously provide services and support conservation efforts. While individual population settlements creating their own service network to alleviate immediate needs may have insufficient resources to ensure environmental conservation, a well-designed infrastructure project can control encroachment into natural habitats, improve makeshift engineering solutions, and improve inadequate use and disposal of water resources.

Thorough Environmental Assessments are the foundation of successful environmental outcomes. Because an EA is the first line of identification of potential challenges and their magnitude, the thoroughness with which it is carried out will prevent surprises further into the project. Where environmentally sensitive areas are concerned, an EA should explore multiple routings, site locations, and nonstandard engineering techniques. An EA will also identify where the complexity of social and environmental issues should require a supervisory or executive committee to follow and keep track of impacts or programs that fall outside the scope of the direct civil works. Making the EA publicly available also allows stakeholders to voice concerns early on and creates an opportunity for greater participation throughout the project.

Early involvement of stakeholders improves project design, operation, and management. Generalizing from these projects, it is clear that conflicts commonly arise among multiple stakeholders, due to diverging interests as well as scales of perception. Communities are usually more concerned about local costs and benefits, while sectoral agencies often have a regional focus. By bringing all stakeholders together early in the project, selecting jointly from alternatives, and clearly assigning responsibilities, the risk of failure to achieve project goals or of poor project performance can be minimized. This collaborative approach also ensures that all issues within the project's area of influence are addressed, promotes studies and data collection, improves awareness of the ecological value of the project site, and often leads to improved long-term comanagement schemes. When stakeholders were involved early in the project, they were able to provide input that improved the project design. Such was the case in the Argentina Flood Protection Project, where input from the communities helped change the engineering design to improve protection against floods. The early involvement of Conservation International in Colombia's water supply projects improved the environmental management of local institutions and promoted environmental awareness among public and institutional stakeholders. A well-established and experienced local NGO will be able to provide highly specialized input. Newer, inexperienced NGOs will require capacity building; however, they can provide human resources to carry out specific conservation actions or to manage protected areas. This can be a real asset when agencies have limited personnel.

Timing is crucial: the nature of certain actions deems them ineffective if they are not carried out at given times during the project. The determination of routes, alternative designs, and engineering techniques should be carried out in the initial stages of a project. Construction schedules should take into consideration the natural life cycles of the impacted area to minimize disturbance. Other types of conservation actions should utilize the leverage in timing given by the project itself. For example, the implementation of the conservation plan for the Emerald hummingbird in Honduras was a requirement for initiation of the bidding of the works. In contrast to specific timing, there are continuous and routine actions to ensure that environmental actions are kept on schedule all along. The magnitude of Gasbol required routine weekly progress reports on all environmental issues; parallel conservation actions were instituted from design to project implementation and operation.

Compensation and restoration measures with successful outcomes can be achieved even when impacts are identified later on. Even when the Bank becomes involved at an advanced stage of the project, conservation measures can still be put in place, because many of them are not time-dependent. In addition, those that are specific to the later project phases can still be applied. The best example is the hydroelectric project at Yacyretá. The Bank became involved when the site had already been selected and construction was well underway. However, it was still possible to carry out operational adjustments, reconformation of landscapes, establishment of compensatory protected areas and biodiversity programs, among other measures (Quintero and Ronderos 1992, Quintero et al. 1997). While a best-case scenario cannot be achieved, much was done to avoid the worst-case scenario of no conservation actions being set in place at all.

Efforts to establish new protected areas need to be started early on. Across projects, this was the slowest and most time-consuming process. Common factors that extend timelines are: land tenure use and occupation; national timelines for laws or decrees to be issued; and a lack of human resources to carry out procedures. The easiest challenge to address is the latter, by identifying a local NGO and assigning it the

task of monitoring progress, as in the case of the Gra-Gra Lagoon in Belize. Even with adequate human resources, however, land tenure and legal timelines still must be dealt with. Thus, the earlier the procedures are started, the better the chances are to ensure the participation of all stakeholders within the project's schedule.

Large-scale projects facilitate institutional strengthening and restructuring. Among the projects reviewed, three were large scale: 1) Gasbol, the Bolivia-Brazil gas pipeline; 2) Argentina Flood Protection; and 3) Tocantins Sustainable Development. These three projects developed new institutional frameworks or legal regulations that set improved environmental standards. The impact of these innovations within the national context depends on the scale of the project, with large projects having more leverage to ensure that agencies and institutional stakeholders incorporate these frameworks and guidelines into their regular operations, thus benefiting future projects and institutional environmental management.

Localized projects enable more in-depth, site-specific actions. Because resources are concentrated in a smaller area, programs that address local biodiversity can be centered around individual species that may be threatened or have a particular interest. Such was the case in the Honduras Roads Project which developed a conservation plan for the Emerald hummingbird; the Yacyretá dam in Argentina where off-site conservation is being carried out for endemic snail populations of *Aylacostoma spp*. previously monitored in situ (Quintana and Mercado 1997), and protected areas were ensured for the threatened Saffron-cowled blackbird, *Xanthopsar flavus* (Clay, Madroño and Villanueva 1999); and in Belize, where the discovery of a threatened cycad within the project's area of influence prompted a nationwide program to assess the status of related cycads. Resources can be concentrated on the restoration of local habitats, landscapes, and ecosystem functions. In Colombia, water supply and sewerage projects addressed the deterioration of wetlands within or near the city.

As exemplified by the projects showcased in this review, it is possible to change widespread perceptions that infrastructure projects will necessarily have a negative impact on natural habitats. The technology and knowledge is available to enjoy the benefits of infrastructure services and conserve natural environments. By providing funds and expertise, and by leveraging conservation actions, infrastructure projects can redefine their role within society and play an important new role in ensuring the conservation of the Earth's ecosystems and the diversity of species that make them unique.

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Annexes

Yacyretá Hydroelectric Project II: raising environmental standards in started projects

SUMMARY

The Bank has been involved in the Yacyretá hydroelectric complex since the late 1970s. Since then, the Bank has adopted new policies, most notably the Environmental Assessment and Natural Habitats Safeguard policies. Despite its early involvement, by the time the Bank began financing the project the site had already been selected and the design was well advanced. A revision of the project's environmental management to finally fill and operate the dam at partial capacity resulted in new and extended compensating measures to ensure adequate environmental standards. The measures were extensive, and comprised:

- a network of 12 new compensatory protected areas;
- landscape reconfiguration of borrow pits;
- increased water flow on the Aña Cuá branch to maintain a nearly natural state year-round;
- a fish elevator to maintain the gene pool in upstream fish populations;
- ex situ conservation of endemic snails;
- fish regulations to avoid overexploitation of stock aggregations below the dam;
- water monitoring to ensure good water quality in the lake; and
- a program to find, protect, and maintain suitable habitats for the endangered saffron-cowled blackbird. The project shows that even interventions at an advanced stage can contribute substantially to the conservation of natural habitats.

BACKGROUND

The Yacyretá hydroelectric facility is a joint venture between Argentina and Paraguay. It is also among the largest dams in Latin America. The project is based on the exploitation of the hydroelectric potential of the portion of the Paraná River that runs along the border between these countries. At full capacity, the reservoir level will be 83 masl, generating 3,100 MW of electricity.

The civil works include two concrete closure dams, each 40 m high and 5 km long, 60 km of embankment dam, a 56 km trench to cut off foundation seepage, a powerhouse, spillways, and a navigation lock. At 83 masl, the reservoir will cover 1,663 km^2, inundating 574 km^2 of existing river as well as 1,076 km^2 of land, 73% of which will be in Paraguay. The flooded areas include 1,500 ha of cultivated land and 500 ha of urban land.

Over two decades have passed since the project's conception; it has seen not only several sources of financing[7] and a multibillion-dollar budget, but also a change in Bank policies: most importantly, the adoption of OP 4.01 (Environmental Assessment), and OP 4.04 (Natural Habitats), which require an environmental assessment and protection of natural habitats, respectively. When the Bank first became involved, the site of the principal structure had already been selected and established by the Yacyretá Binational Treaty. Experts later considered this site a poor choice. Among other things, it is located on the flood plain of a major river, and it has a high ratio of people displaced and inundated area per Mw produced (19 people and 53 Ha/Mw, respectively). The project objectives were extended to bring it into compliance with the new policies as much as possible, and to offset the impacts caused by the poor site selection. The project's natural habitats and social component took on primary importance.

The aim of this project, Yacyretá II, was specifically to finance the civil works needed to complete the basic permanent structures and the first six generating units, as well as technical assistance for the Resettlement and Environmental Management Plan for operation at 76 masl, a 500 Kv transmission link, and an assessment of private capital participation in EBY. The US$300 million loan became effective on January 13, 1993 and was closed on December 31, 2000.

Operation at full capacity is contingent upon additional infrastructure work and an updated Environmental Management Plan and Resettlement Program.

Aerial view of the main spillway at Yacyretá

NATURAL HABITAT ISSUES

A tributary of the Río de la Plata, the Paraná River is the world's tenth largest river and drains Southern Brazil, Paraguay, Uruguay, and Argentina. The Yacyretá complex is the second hydroelectric project on the Paraná, the first being Itaipu, a joint venture by Brazil and Paraguay. The Yacyretá Dam is located about 400 km downstream from Posadas, Argentina and Encarnación, Paraguay. This portion of the river runs along the border between Argentina and Paraguay, an area where the river branches out, forming a series of three large

[7] World Bank (WB), Inter-American Development Bank (IDB), Entidad Binacional Yacyretá (EBY), Government of Argentina (GOA), and private investors.

islands (Yacyretá, Talavera, Apipe) and several smaller ones (up to 300 total) characterized by white waters. The power plant is on Yacyretá Island which divides the river into two channels, the Aña Cuá and the principal branches where two closure dams and spillways have also been built.

Local flora is associated with the island ecosystems, mainly those of Talavera and Yacyretá Islands. The area flooded so far includes eight habitats types: wetlands, riverine islands, riverine forests, forested savanna, arary forests in flooded areas, dunes, the Apipe rapids, and the river itself. These habitats foster high faunal diversity: 121 bird species, 18 large mammals, and 8 reptile species. Several species with varying degrees of protection are located in the area: 5 species of flora, 17 birds, 12 large mammals, 3 reptiles, and 1 endemic snail. High fish diversity and abundance are also characteristic of the area.

Some 240 km of riparian habitat along the principal branches will be permanently lost, along with some 107,600 ha of terrestrial habitat, mostly forested savanna and wetlands. The western side of Yacyretá Island is of particular concern because it is a high-priority ecoregional area where several endangered species are found, such as arary trees (*Calophyllum brasiliense*). Flooding of the area will clearly permanently displace terrestrial fauna.

The dam precludes fish migrations for the most part and upstream populations are expected to become severely depleted. Downstream, the main concern was the seasonal desiccation of some 22 km of the Aña Cuá branch, which would have a devastating impact on the river and on island wetland ecosystems below the dam. Fisheries would also be impacted.

The hydrological characteristics of the river itself are completely transformed in the area. Essentially, the system is turned into a lake and the flow regime, without adequate measures, is completely modified downstream with the magnitude of peak flows being substantially reduced. Stagnant water and increased aquatic vegetation, especially in the marginal areas of the newly-formed lake, could foster an increase in mosquitoes.

Specific concerns that triggered the Natural Habitats Policy were

- loss of riparian habitats, notably the arary forests;
- loss of riverine habitats, particularly the disappearance of the river islands and rapids;
- the desiccation of the Aña Cuá branch, which would further threaten the remaining river island ecosystems and riparian areas;
- the effects on several endemic and endangered species, such as the saffron-cowled blackbird and the *Aylacostoma* snail; and
- the interruption of fish migrations.

Addressing lost habitat

The major distinction between the types of habitat affected was whether they were located on land or in the river. This guided the approach to deal with the major issues: loss of habitat and threats to populations of special concern.

On land

Because the site had already been selected, the ecological compensation program was designed to match the inundated area with similar protected habitats. It also became critical to improve the environmental conditions of surrounding terrestrial areas that were not flooded, so that they would be suitable for local flora and fauna.

A network of protected areas covering 161,000 ha will be implemented when the dam operates at full capacity (83 masl). The area protected surpasses that of the inundated lands. The network will comprise nine protected areas located in Argentina, and three

in Paraguay (see Table 1 and figure below). The process was speedier and easier in Argentina, because the land was already owned by the government. In Paraguay the land can be managed as a protected area in cooperation with landowners.

Four protected areas have already been established for the conservation of 62,000 ha. This is more than the inundated area at 76 masl. The protected areas include Yacyretá Island in Paraguay; Apipe Island, Galarza, and Santa María Reserve in Argentina. The Yacyretá Island Reserve includes the unflooded portion of Yacyretá Island and Aña Cuá. Preference was given to river island habitats because they are considered high-priority ecoregional areas.

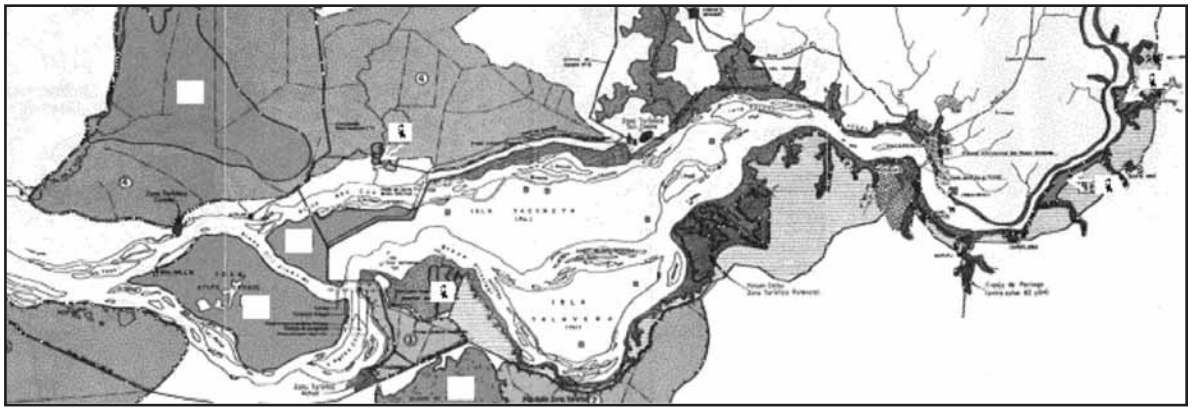
A comanagement agreement between the community-based Fundación Bertoni and the Entidad Binacional Yacyretá assigns responsibilities for the proper management of the Yacyretá Island Reserve. The agreement was finalized in June 2000 and is based on two zones: a restricted use zone that includes arary forests, dunes, and wetlands, and a buffer zone for community use.

Management plans and funding for recurrent costs have been provided for all four of the implemented protected areas. Resources amounting to US$300,000 annually will cover management expenses. These costs have been incorporated into the operating costs of the dam, so that funds remain available throughout the project's lifetime. EBY is likely to contract qualified NGOs to carry out the long-term management of these areas.

Table 1. Protected areas

	HA
Argentina	
Apipe Island*	30,000
Galarza*	20,000
Santa María Reserve*	**3,075
Iberá	10,000
Itatí	30,000
Yaguareté Corá	13,000
Camby Retá	10,000
Teyú Cuaré	78
Campo San Juan	5,700
Paraguay	
Yacyretá Island*	9,000
Refugio Atinguy	100
Yabebyry	30,000
Total	**160,953**

* implemented; ** increased from 2,500 Ha



Major Protected Areas in Argentina and Paraguay, shown in pink and denoted with an "R" (not all PAs in network are shown).

A portion of the revenues earned from electricity sales goes to a special allocation set by EBY. These funds support the protected areas and finance biodiversity programs such as the ex situ conservation of the endangered endemic snail *Aylacostoma sp*.

Borrow pits were restored by softening slopes, creating small reservoirs, reestablishing proper drainage, and using local flora to reforest the area; the footprint of the borrow pits is now minimal. This enabled flora and fauna to eventually recover the use of some 600 ha which would otherwise have been lost (ecologically), despite not being inundated. Recovering these areas was particularly important for bird populations. The restored grounds were incorporated in the network of protected areas.

In river

The hydrological compensation program was designed to minimize changes in the hydrological regime and characteristics of the area. This ensured long-term conservation of river habitat and wetland areas dependent on seasonal flow fluctuations.

A separate spillway on the Aña Cuá branch provides a minimum flow of 1,500 m^3/s year-round. The flow is key to productivity in the area; the amount needed to maintain a near-natural state was based on hydrological and ecological studies. It is worth noting that this flow is equivalent to that of two turbines. Maintaining the Aña Cuá with a nearly natural flow will benefit fish and other aquatic species, as well as riparian habitats.

Water releases through the main and Aña Cuá spillways will be used to maintain seasonal stream flow variation downriver, protect water quality, promote circulation in the lake, control aquatic weeds, avoid fish kills, prevent urban flooding, and facilitate downstream fish passage.

A permanent monitoring program at Yacyretá ensures that the new lake does not turn into an anoxic environment, killing aquatic life. The maintenance program also controls invasive aquatic plants, prevents increases of insects, and monitors water quality. Expenses to prevent pollution from domestic sewerage, industrial waste, and other sources would be financed by future projects through EBY.

Addressing populations of concern

Several endangered species are found in the vicinity of Yacyretá. Moreover, the construction of the dam posed new risks to numerous non-threatened species. These issues called for specific measures.

A fish elevator was installed to compensate for disrupted access to upstream areas. The elevator is not designed to maintain high numbers of fish, but rather to conserve the genetic biodiversity of the area.

A no-fishing zone was declared within the areas located 1 km downriver from the dam to protect the fish stocks concentrating just below it. The unusually high aggregation had made the fish an easy target and vulnerable to overfishing. The regulations still allow for fishing, but not where the fish are concentrated.

A program for the ex situ conservation of an endemic snail is supported by EBY. The snail lived in the rapids and is a previously unknown species, discovered as a result of the environmental studies associated with the project. A local university has been in charge of increasing public awareness of this species as well as the ex situ conservation program. New techniques developed specifically as part of the program have resulted in the successful reproduction of snails in captivity. The program will keep a breeding population until these snails are successfully established in new areas, pos-

sibly downriver where a smaller population of this species is found.

The program for the saffron-cowled blackbird identifies suitable habitats to create a network of protected areas that guarantees the long-term conservation of the bird and its habitat, both in Argentina and Paraguay.

SUCCESSFUL STRATEGIES

Using the shortcomings of the site as leverage to push forward an aggressive, comprehensive, ecological compensation program enabled the project team to carry out more extensive operational adjustments, landscape reconformations, and biodiversity programs, among other measures. Most significantly, they established protected areas which encompass an area larger than that lost to inundation. The project actively involved the community in the management and conservation of these areas.

Prioritization of the protected areas expedited the protection of those habitats considered particularly fragile and unique, in this case, the river islands of Yacyretá and Apipe.

The incorporation of expenses related to conservation in the fixed costs of operating the dam secured funds for the entire lifetime of the project. This provided a long-term solution to one of the most prevalent challenges in conservation: ongoing, sufficient funding. This set an important precedent toward making institutions financially responsible for recurrent environmental costs deriving from services they provide.

The compensation and restoration measures carried out in Yacyretá show that successful outcomes can be achieved even in an adverse situation. Clearly, later interventions in started projects can have substantial positive impacts and generate long-lasting environmental benefits.

Bolivia-Brazil Gas Pipeline Project (GASBOL) Minimizing project footprint

SUMMARY

Extending over 3,000 Km through largely unpopulated areas between Bolivia and Brazil, Gasbol is among the largest gas pipelines in South America. Despite its extension, and overcoming differences between the countries' infrastructure networks, legal structures, and stakeholder agreements, the project's overall footprint is minimal. Because of its length, the route would inevitably traverse sensitive areas. The crossing of natural ecosystems was designed with three criteria in mind: avoiding sensitive ecosystems when possible, reducing the size of impacted areas, and devising techniques that caused minimum disturbances to the landscape and ecosystem functions. This approach set forth numerous innovative measures:

- the pipeline was deviated to avoid sensitive ecosystems,
- the width of the right of way (ROW) was reduced in many transects,
- trees were removed manually,
- 13 rivers were crossed by drilling under the river beds and by other special works,
- wetlands were crossed using a pushing and pulling method during the rainy season;
- steep terrains were avoided by tunneling;
- extensive revegetation was carried out along ROWs, and
- funds were provided by a comprehensive ecological compensation plan to support a total of 13 protected areas.

The project set high social standards for negotiations with indigenous communities and served as the single most important archeological survey in recent years both in Bolivia and Brazil. The pipeline was built in a year and a half; this short timeline was achieved by outstanding management. Gasbol had its own environmental committee, environmental supervision unit, and environmental inspection team. The project had an exemplary environmental assessment (EA) and earned several international awards for its environmental achievements.

BACKGROUND

A new market for Bolivia's reserves of natural gas and an additional source of power for Brazil were the main drivers of what is now the Bolivia–Brazil gas pipeline (GASBOL), one of the most complex projects of its kind in South America. The pipeline extends 3,150 km: 557 km lie in Bolivia, owned by Gas TransBoliviano (GTB), and 2,600 km run through Brazil, managed by Transportadora Brasileira Gasoducto Bolivia–Brasil S.A. (TBG). The pipeline starts in central Bolivia, at Río Grande, running west and then south to Porto Alegre, Brazil. The project includes 18 compression stations and 35 city gates, distributed along 5 states in Brazil: Mato Grosso do Sul, São Paulo, Paraná, Santa Catarina, and Rio Grande do Sul. It has a capacity of 30 million cubic meters per day (MMm^3/d) with an agreed delivery of 16 MMm^3/d.

Gasbol route across Bolivia and Brazil.

The project's binational nature required the team to reconcile different regulatory and legal structures in each country, accommodate to disparate infrastructures, and comply with prior country-specific multistakeholder agreements. The first EA was rejected during routine quality screening, and the environmental achievements detailed in the next sections stem from the efficient and exhaustive nature of the second EA. This investment of time and finance paid off; the new, revised EA subsequently earned the project the International Association of Impact Assessments' Environmental Award (IAIA) in 2001 and the 2001 World Bank Green Award, among others. The project became effective in mid-May 1999 and closed at the end of December 2000. The total project budget was approximately US$2.1 billion, of which the Bank financed US$130 million. The pipeline was inaugurated in February 1999.

NATURAL HABITAT ISSUES

Two-thirds of the pipeline route runs through uninhabited areas and encounters several sensitive ecosystems between Río Grande, Bolivia and Porto Alegre, Brazil. Several national parks, reserves, and ecosystems with legally protected status, as well as high biodiversity hotspots, triggered the Bank's Critical Natural Habitat policy. Aside from the route itself, the ROW had the potential to provide undesired open access to unexploited areas, facilitating illegal activities such as logging and hunting.

Some of the areas to be crossed had traditionally being used by indigenous communities and they were concerned that the gas company would not take full responsibility for the environmental impacts caused by the project,

particularly impacts on sensitive ecosystems. The project would directly impact indigenous lands in Bolivia, because the route went through the Kaa-Iya del Gran Chaco National Park. The Izoceña people, organized as the "Capitania del Alto y Bajo Izozog" (or CABI), were the driving force in creating the Park which is adjacent to their ancestral territory. In Brazil the project affected fewer communities and impacted indigenous lands.

The most sensitive ecosystems crossed by the pipeline were the Gran Chaco forest, Pantanal, Mata Atlântica, and the Aparados da Serra include.

Gran Chaco Forest. Also known as the Chaco, this is an extensive 647,500 km^2 lowland alluvial plain divided among Bolivia, Paraguay, and Argentina. The vegetation is predominantly xerophytic deciduous forests, but also includes semi-evergreen riverine forests, palm woodlands, savannas, halophytic shrubby steppes, grassy steppes, and wetlands. The area is estimated to harbor over 2,300 plant species, 300 birds, and 89 reptiles and amphibians. The more than 100 mammal species include the endangered tapirs, peccaries, guanacos, and jaguars. Within this ecosystem the pipeline crosses the protected areas of Bañados del Izozog and the Kaa-Iya del Gran Chaco.

- The *Kaa-Iya del Gran Chaco National Park and Integrated Management Area* covers 3.4 million hectares. It is one of the largest legally protected national parks in Latin America**.** About 140 km of pipeline cross the northern portion of the park. These lands are traditionally used by several indigenous communities.
- The *Bañados del Izozog* and the *Parapetí River* encompasses 615,882 ha with one-third of the site lying within the Kaa-lya del Gran Chaco National Park. They form the largest and most important wetland in the Santa Cruz Chaco and sustain several riverine communities characteristic of this biogeographic region. Approximately 110 km of pipeline cross this area.

The *Pantanal* is the world's largest wetland (100,000–175,000 km^2 depending on the season) and is shared by Brazil, Paraguay, and Bolivia. Its size is similar to that of Greece. The Bolivian Pantanal covers about 10 percent of the total area, and comprises several zones, two of which, Otuquis and San Matías, became part of the National System of Protected Areas in 1997. Within Bolivia, the pipeline crosses the Pantanal region known as Otuquis. The Brazilian Pantanal is approximately 145,000 km^2 or 80 percent of the Pantanal area; the pipeline passes through the Mato Grosso area.

- The *Otuquis Pantanal Reserve* in Bolivia comprises 1,005,950 ha, of which 903,350 ha are a national park and 102,600 an integrated management area. The pipeline crosses the northern part of the Otuquis Pantanal; the ROW is 30 m wide, including the working space. The area is inhabited by six endangered and nine threatened species, according to IUCN classification.
- The *Mato Grosso Pantanal Reserve* in Brazil comprises 150,000 ha, and is one of the richest wildlife sanctuaries. The vegetation is an exclusively grassy formation, interspersed with brittle ligneous plants and small acaulescent palm trees. It is generally found in the lower areas, which are periodically flooded. Seventy kilometers of pipeline run through this reserve.

The *Mata Atlântica* (Atlantic Forest) is *c*haracterized by dense ombrophyle forest and associated with mixed ombrophyle forest. Brazil's most urbanized and industrialized areas are located within this biome, and thus only about seven percent of the original forest remains in fragmented portions. The Mata Atlântica holds the world record for the greatest diversity of tree species per hectare. The high level of endemism

is partly because the area is isolated from the major South American forest blocks by the savannas and woodlands of the Cerrado region. Forty percent of the 20,000 plant species are endemic; 60 of the 190 reptile species are endemic and 3 threatened with extinction; 55 of the 250 mammal species are endemic. Two-thirds of the primate species are endemic, including the black lion tamarin, one of the world's most highly endangered primates. In all, 29 vertebrate species are critically endangered. Other vulnerable species include tapirs, ocelots, pumas, and the locally endangered blue and yellow macaw. The pipeline crosses isolated patches in four states, affecting around 124 ha, and the Bonito National Park which has elements of Mata Atlântica and lies in the Bodoquena mountain range contiguous to the Pantanal.

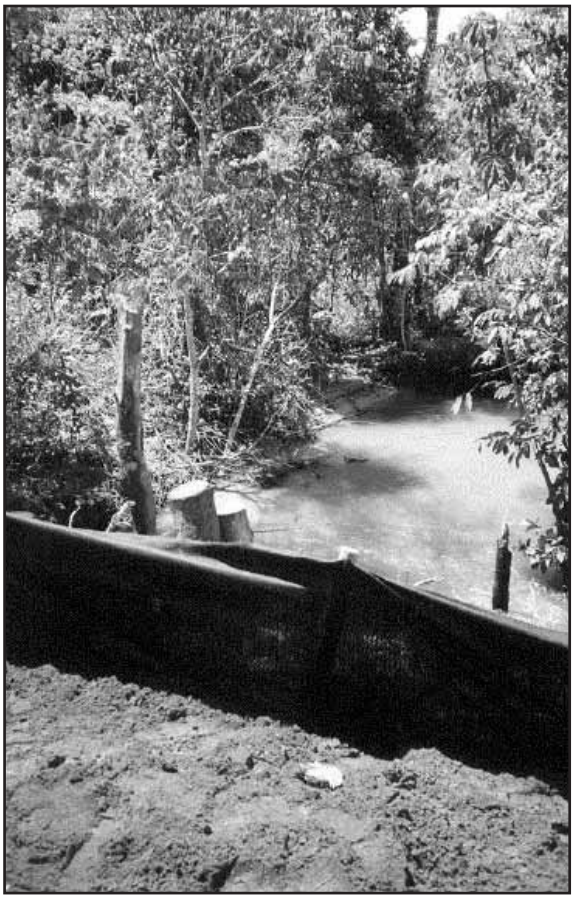
- The *Bonito National Park* is located in the southwest of State of Mato Grosso do Sul. Most of the region's rivers spring from the Bodoquenas mountain range. This is a limestone area which contains a system of waterfalls, rivers and caves. The dominant vegetation is the Cerrado associated with gallery forests and elements of the Mata Atlântica.

The *Aparados da Serra* is located within the Mata Atlântica biome, but has varied floristic formations. There is an area of rocky formations where canyons and cliffs dominate the landscape. Rivers drop into gorges or canyons, many over 700 m high, arriving at the bottom as moist mist. Steep terrains are prone to erosion and unstable slopes, hence their environmental sensitivity. The route passes through the Aparados da Serra National Park. The section affected by the pipeline is characterized predominantly by high-altitude fields with rocky outcrops (*campos de altitude*) and woody savanna (*cerrado gramíneo-lenhoso)*. In the *Mata Atlântica* (Atlantic Forest) and *Aparados da Serra*, the pipeline crosses four sections encompassing 32 hectares of affected vegetation.

Minimizing project footprint

Although one plausible scenario was for the route to avoid all sensitive areas, there is a trade-off between a longer route that required more hectares of ROW and a shorter one that minimized the ROW area but traversed sensitive ecosystems. Despite modifications the route would have to pass through challenging landscapes: large rivers, steep terrains, and wetlands. The design team followed three criteria: 1) avoiding sensitive ecosystems when possible, 2) reducing the size of impacted areas, and 3) devising innovative techniques that caused minimum disturbances to the landscape and ecosystem functions.

1) *Deviations to avoid natural habitats*: The general guidelines of the route for crossing vegetated areas, whether protected or not, specified: i) going around, next to the edge, and avoiding fragmentation, ii) running through the most degraded sections, and iii) crossing parts of lesser extension. For example, in Bolivia the pipeline avoided the Cañón de la Victoria, a hydrological and biological connection between the wetland systems of Otuquis and the Brazilian Pantanal. In Brazil the route went around Tabuleiro National Park. Within the Brazilian Pantanal region, deviations totaled nearly 30 km.; deviations in the State of Santa Catarina to preserve the Mata Atlântica also totaled 30 km. In addition, modifications to the route were made for high-visibility archeological sites.
2) *Reducing ROW width:* In Bolivia, there were almost no access roads to the pipeline so the ROW width was set to 30 meters to allow equipment movement, instead of opening additional, new access roads. In Brazil, however, there were roads near the remaining 2,600 km of the route, so the ROW did not have to double as a road. The ROW was reduced to 20 m, significantly reducing the total area impacted.

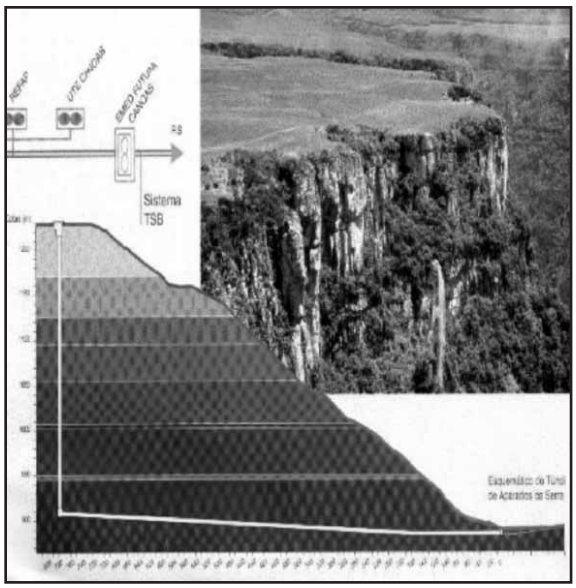


Sheet piling in conventional river crossings

3) *Felling trees manually*, with chainsaws, reduced the impact during vegetation removal. Trees were felled within the ROW to avoid damage to surrounding vegetation, thus preventing the "domino effect."

River crossings were achieved by drilling (directional boring) under the beds of two rivers: the Paraguay and the Itajaí-Açu. The drill hole was enlarged to accomodate the 32" dimension of the Gasbol pipeline. An underwater crossing was effected in 11 other cases. Such subfluvial crossings do not interfere with river flows, and have a reduced impact on the environment and on aquatic vegetation and fauna. The "push-pull" technique was used. For this a floating a preassembled section of pipe is pushed and pulled over a flooded ditch in the river bed. Then the buoys are removed and the concrete-coated pipe sinks into position in the ditch. Temporary mounting platforms are later removed. This technique is very low impact and construction leaves no visible footprint. Of these 13 major crossings of rivers/dams three were located in Bolivia and 10 in Brazil. All smaller crossings were performed with more conventional techniques, but with mitigating action taken to protect waterways from increased sediment load stemming from the civil works.

Protecting steep terrain: To avoid erosion, sediment accumulation, slope instability, and landscape alteration in the steep terrain of the Aparados da Serra in Brazil, it was decided to drill horizontally into the base of the hill for 780 m and then vertically down from the top of the hill 320 m to meet the horizontal tunnel, thus retaining the slopes' integrity with minimal visual impact. The ongoing monitoring program screens for aggregate loss of hill mass by checking the inclination angle of strategically placed stakes. Slope status is checked indirectly by strain gages that are monitored by the Operations Center in Rio de Janeiro.



Crossing the Aparados da Serra, Brazil. The diagram shows the tunnel, measuring 780m in length and 320 in height, which was built to avoid major landscape alterations

Crossing the Pantanal was accomplished by a "push-pull" technique. A preassembled floating section of pipe was pushed and pulled over a flooded ditch. Once in place, the buoys were removed and the concrete-coated pipe sank into position in the ditch. The temporary mounting platforms were removed later. This technique has fewer impacts than conventional ones: it requires less clearing/removal because the only construction space is that needed for the dragshovel to cross the tract of land and that needed for storage of excavated soil. The pipe was assembled off site, so there was no need for working space adjacent to the ditch. With the push and pull technique, construction activities left no visible footprint.

Restoration of impacted areas: In Bolivia, a 13 m strip of the ROW was restored by planting new vegetation once the construction phase was completed. In so doing the effective ROW was narrowed from 30 to 17 m. Reforestation was also carried out in areas designated for support activities and in the affected sections of the Mata Atlântica. In the Pantanal, wetlands were restored to their original configuration and contours.

Shown in sequence, from left to right, top to bottom: the excavated trenches, platforms, pipe sections with floaters, pipes placed in trench, flooded trench, and current view of the ROW in the Pantanal.

Special rules for ROWs: To discourage illegal activities and further impacts, the management of ROWs stipulates that they must not be used as roads, even in Bolivia. Maintenance works must be carried out using helicopters, all-terrain vehicles, existing roads, etc.

Monitoring: Environmentally sensitive areas, including approximately 300 critical areas (river crossings, wetlands, areas with steep slopes, trash disposal sites) are monitored regularly to ensure proper functioning and management. Aerial reconnaissance of the ROW is also conducted. The monitoring includes checking the need for occasional revegetation along the route.

Ecological Compensation Plan

The project provided funds for a total of 13 protected areas, 12 in Brazil and 1 in Bolivia (see Box 2). In Brazil, 0.5 percent of project funds had to be designated for conservation units by law. The 12 protected areas supported by the project in Brazil total over 250,000 ha, are distributed among all 5 states crossed by the pipeline, and were chosen in collaboration with IBAMA (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis). Within Bolivia, the Kaa-Iya del Gran Chaco totals 3.4 million ha. The funds were used for demarcation and signposting, maps, building restoration, construction of support buildings (visitors, research, administrative), Management Plans and the acquisition of land, vehicles, and equipment.

A trust fund for Kaa-Iya del Gran Chaco was established to pay for recurrent costs in perpetuity. The US$1 million fund will provide incremental annual revenues to improve the protection and management of the park.

Box 2 Protected areas supported by Gasbol in Brazil and Bolivia

	Ha
Parque Nacional da Serra da Bodoquena	77,232
Floresta Nacional de Ipanema	5,397
Parque Estadual Albert Loefgreen	174
Parque Nacional Superagui	33,928
Parque Estadual do Cerrado	420
Parque Estadual do Guartelá	799
Parque Estadual de Campinhos	204
Parque Estadual da Serra do Tabuleiro	87,405
Parque Botânico de Morro Baú	750
Parque Nacional de São Joaquim	42,838
Parque Nacional de Aparados da Serra	13,081
Reserva Biológica Estadual Mata Paludosa	113
Parque Nacional Kaa-Iya del Gran Chaco y Area Natural de Manejo Integrado (Bolivia)	3,441,115

Working with indigenous communities

Compensation programs were implemented for indigenous peoples both in Bolivia and Brazil. The Bank's Indigenous Peoples safeguard policy (OD 4.20) was triggered because the route would either cross indigenous lands (in Bolivia) or impact them indirectly (in Brazil the lands would be in the area of influence of the ROW, i.e., 30 km from the ROW). Once again, the project team took up the challenge. They held extensive consultations with the indigenous communities and put together a plan that satisfied the communities' expressed needs.

Bolivia

The Kaa-Iya National Park was established in 1995 and with its Integrated Management Area (IMA) includes the Izoceña, Ayoreode, and Chiquitana indigenous communities as well as part of the Charagua, Pailón, San José de Chiquitos, and Roboré townships in the provinces of Cordillera and Chiquitos, Department of Santa Cruz. One hundred and forty kilometers of the pipeline crosses the park.

Securing traditional land for indigenous people: A land titling program allowed local indigenous peoples to secure title to their lands adjacent to the park. Approximately 1.5 million ha were titled and demarcated. Funds were also provided in Otuqui to facilitate the consolidation of native territories, and in particular provided support for their land claims. The Land Titling Program is the first in Latin America to provide legal title to indigenous peoples' lands.

Coordinated supervision and management plan: To implement Gasbol's Environmental Management Plan within the park an Executive Committee formed by both Gas TransBoliviano and indigenous peoples from the area was created. Management of the park is carried out by the Capitanía del Alto y Bajo Izozog (CABI), an indigenous organization, The Wildlife Conservation Society, and Bolivia's National Protected Areas Agency (SERNAP). A total of US$456,000 from the project's funds were allocated for the Environmental Management Plan of the park itself (published in 2001) and an additional US$1 million was established as a Trust Fund to assist in the management of the park.

Benefits for indigenous communities: The total budget for the Indigenous Peoples Development Plan for Bolivia was US$3.7 million. The benefits included (but were not restricted to) building wells, installing solar panels and radio communications, and the construction/repair of houses and other buildings. The Bank's involvement was crucial in setting the high social and ecological standards that have characterized subsequent negotiations between Kaa-Iya and the energy companies thereafter.

Brazil

A multistakeholder collaborative process was responsible for the Indigenous Peoples

Development Plan (IPDP) in Brazil. The IPDP held consultations in local communities to assess their needs. The result was the investment of US$1 million in land acquisition, ambulances, buses, and construction materials. Facilities such as houses, schools, hospitals, and energy networks were constructed. Agreements were signed with local authorities to ensure the project's sustainability during its operation. While the project constructed the schools and hospitals, the authorities were responsible for finding the teachers and physicians and for replacing materials. Additionally, a total of 22 indigenous towns received 50,000 reais each.

Showing remarkable solidarity, the Terena groups decided to shared their funds with other groups such as the Moreira and Passarinho. Other indigenous groups, such as the Guarani, also shared their funds to help acquire lands for the Morro dos Cavalos and Massiambu *aldeias* (villages). Together, PETROBRAS and TBG bought the first land titled by FUNAI (Fundação Nacional do Indio) in Santa Catarina for the Guarani groups.

The project as an archeological expedition and survey

During preconstruction activities, several significant sites were discovered and multiple artifacts were rescued.. Because the route would run along previously unexplored areas known to have been inhabited by pre-Hispanic cultures, these findings meant there was a high probability of encountering more sites and material of archeological importance once the actual construction began. Both Bolivia and Brazil showed a great interest in the project's archeological potential. In accordance with the Bank's Cultural Property policy (OP 11.03), a full Archeological Heritage Evaluation and Rescue Program was implemented. Taking the route as an archeological transect, and with the joint participation of local universities and project funds, the construction of the pipeline may be considered one of the major archeological surveys of the area.

The archeological activities were divided in two phases: those prior to soil alteration, dealing mainly with prospecting aspects; and those conducted during soil alteration, dealing mostly with the recovery of materials. The evaluation of each site either resulted in a diversion of the pipeline route (and subsequent recovery) for highly significant areas or recovery of materials for those of low significance. The archeological wealth of the area traversed by the pipeline route could not have been foreseen by the development team. Over 16,000 artifacts were recovered and more than 300 sites identified. Local museums, the Museo Arqueológico de Santa Cruz de la Sierra in Bolivia, and the Museu da Universidade de Campo Grande in Brazil exhibit some of the materials recovered and provide information about the cultures and sites identified. A compilation of the archeological findings in Bolivia was published in the book, *Al Este de los Andes, al Sur del Amazonas. Descubrimientos Arquelógicos en los Bosques Secos de los Llanos de Bolivia.* The quantity and quality of the findings changed the perception of human settlements throughout the region, but particularly in the area of the Bañados del Izozog.

SUCCESSFUL STRATEGIES

The following are some of the key elements set forth by the project team that made Gasbol exemplary in its social and environmental achievements:

An environmental management institutional structure of its own meant that Gasbol had its own environmental committee, environmental supervision unit, and environmental inspection team. The large scale of the project required ongoing, accurate monitoring of environmental issues, their follow-up and progress reports. The complexity of this management

need prompted the development of an institutional framework capable of meeting the needs for availability of information and fast response to conflicts. This framework enabled the project to keep actual timelines very close to those scheduled.

The feedback thus facilitated greatly enhanced collaboration and information exchange among stakeholders. This in turn improved the decision-making process between competing alternatives during the design, engineering, implementation, and operational stages.

Taking time for a high-quality EA was a bold decision, because discarding the first EA brought new expenses and cost more time (over a year). The investment in these first stages paid off substantially. It not only proved to be an environmentally successful project, but also set new environmental standards for the whole energy sector in Brazil . The EA also allowed for a better use of engineering resources, because it identified and classified ecosystems according to their need for special construction works. A Strategic Environmental Assessment (SEA)[8] to understand possible synergies with other projects was carried out. The study examined the upstream impacts of oil and gas extraction in Bolivia and the downstream impact of fuel replacement in Brazil.

Fostering the use of innovative techniques to protect the integrity of fragile ecosystems was crucial throughout design and construction. The techniques called for specific timing during the year, highly specialized contractors, and a commitment to keep ecosystem functions unaltered.

Open dialogue with indigenous communities required frequent consultations and flexibility by all parties. The indigenous communities showed great flexibility in terms of their compensation while the project team ensured that those actions were sustainable and long term. The Bank also played a central role in obtaining greater recognition of indigenous communities by local and federal authorities.

Granting civil works and cultural heritage equal priority allowed the project team to transform policy compliance into a full archeological expedition and recovery mission. Prospecting and recovery activities were scheduled side by side with civil works, ensuring that time and resources were evaluated and allocated in an efficient and coordinated manner.

Gasbol is evidence that a complex project can be carried out with high environmental and social standards. It is proof that the technology is available to provide basic infrastructure with minimal costs to natural habitats and that, if the political will exists, harmonious and mutually beneficial relationships can be established with indigenous communities.

[8] An SEA is a study requested by multilateral organizations financing programs involving multipurpose work or large projects with important structural components and their associated projects. The importance that the WB assigns to the SEA lies in its longer-term advantages. This approach surpasses the limitations of the EIAs which are more project specific. The SEA analyses aspects such as implied policies, induced development, cumulative impacts, management capacity, and institutional framework in order to provide a broader context to the environmental assessment process as applied to single projects.

Argentina Flood Protection Project minimizing interference, maximizing benefits

SUMMARY

Crossed by three large rivers, the northeast portion of Argentina is repeatedly flooded. Rather than try to control river flows, the project's approach was to finance improvements to flood defense and preparedness in the entire region. The selection of flood defense structural subprojects was expedited by the regional environmental assessment (REA) which screened and prioritized all alternatives based on strong environmental and economic criteria. Fifty-one subprojects were chosen, all featuring civil works designed for minimum interference with natural flooding processes while still defending economically important infrastructure. The accompanying regional action plan comprised four programs aimed at improving the environmental assessment, management, education, and protection capacities of various institutions in the area. The programs stemmed from the assessment of both cumulative and subproject-specific environmental impacts during the REA. Because water resources are managed mostly by the provinces, the nonstructural components of the project were aimed at strengthening the provinces' role at the national level and achieving the same degree of preparedness among them. Particular areas of focus included: the development and enforcement of flood defense strategies, the maintenance of flood defense installations, early flood warning systems, environmental guidelines for flood-prone areas, and flood emergency plans.

BACKGROUND

The irregular rainfall patterns prevailing in Argentina cause floods and droughts. About one-fourth of the country is repeatedly flooded. This is particularly true for northeastern Argentina, which has three rivers and extensive, low-lying plains. The seven provinces of this area (Entre Ríos, Formosa, Chaco, Corrientes, Misiones, Buenos Aires, and Santa Fe) make up nearly 30 percent of the country. Nearly half of Argentina's population inhabit the latter two provinces, and an additional 12 percent live in the remaining five.

The project is the first phase of a two-stage Flood Protection Program aimed at providing cost-effective flood protection coverage for the most important economic areas, and developing a strategy to cope with recurrent floods. It is based on a river basin-wide assessment carried out with financing from the Flood Rehabilitation Project. As a result of this study each participating province developed a Provincial Master Plan that made recommendations for reducing the effects of recurrent floods.

The structural component of the project supports the priority civil works included in the Master Plans, such as building bridges, drainage channels, embankments, and small flood control works. Secondary civil works will be considered in a future project. The non-structural components target:

- the development of a new institutional framework,
- an early flood warning system with a new hydrometering network,
- the upgrading of flood preparedness, and
- capacity building.

These components particularly support the preparation and implementation of master plans for flood defense systems in areas where flood protection works are not economically or environmentally justified.

The Bank provided US$200 million of the total project costs of US$488 million, 76 percent for structural measures and 24 percent for the remainder, including US$3.6 million exclusively for environmental programs. Approved in December 1996, the project closed in December 2005.

NATURAL HABITAT ISSUES

Three major rivers cross the project area: the Paraná, the Paraguay, and the Uruguay. Flooding is the major regulating force in the ecosystems around these rivers; virtually all ecological events in the floodplains are either positively or negatively related to its extent and regularity. Typical habitats include the Pampas grasslands, Mesopotamia savannah, Paraná forests, Chaco estuaries and forests, and the Paraná River islands and delta.

The Paraná forests in the province of Misiones have the highest level of faunal biodiversity, followed by the Chaco estuaries and forests. Overall, 60 percent of Argentina's birds and more than 50 percent of its amphibians, reptiles, and mammals are found in the floodplains. Floods play a fundamental role in the dispersion of these species along the floodplain corridor. Some 26 percent of mammals, 28 percent of birds, 18 percent of reptiles, and 43 percent of amphibians in the floodplains are considered to be either threatened or subject to some conservation risk.

The Natural Habitats safeguard policy (OP 4.04) applies because the productivity of the entire region is linked to the flood regime, and potentially adverse impacts could result from the number and nature of the civil works proposed throughout the large expanse of territory covered by the project. The project team realized early on that success could only be achieved by carefully selecting the nature and location of the civil works. To both expedite and carry out a thorough evaluation, a Regional Environmental Assessment was conducted.

A Regional Environmental Assessment (REA) for northeast Argentina

The aim of the REA was to protect the integrity of the wetlands and floodplains by minimizing human interference. Its main objectives were to identify the most relevant environmental features of the river basins in order to understand the interaction between natural and manmade systems, and to assess a cumulative impact of the flood protection works. Thus, the REA had three major components:

- an assessment to characterize the region;
- a regional, integrated analysis of the cumulative impacts of the civil works, based on the standard environmental assessments for each subproject; and
- a regional action plan composed of environmental programs that address region-wide weaknesses.

Regional environmental conditions

The regional assessment improved the baseline knowledge of the ecology and dynamics of the riverine and floodplain ecosystems. The following conditions prevail across the region:

- system stability depends on preserving natural interactions between floods and habitats;
- threats to biodiversity include encroachment, illegal hunting, clearing, urban sprawl and infrastructure interfering with natural flood processes, and pollution of small rivers from untreated sewage/industrial effluents;
- populations in riverine areas have adapted to floods; urban and periurban areas are ill-prepared;
- there is deficient water supply, sanitation, and solid waste management;
- there are poor coordination and heterogeneous environmental criteria throughout region;
- there is a lack of systematic procedures.

This characterization of the environmental conditions was used in the selection of environmental criteria for both site selection and site-specific engineering works. A strong participatory approach was promoted throughout the project, with individual project designs being modified after suggestions from local communities and NGOs.

Environmental criteria for civil works

The REA screened subprojects for works that protected economically important infrastructure from floods, did not promote urban expansion in areas of high flood risk, had minimum interference with natural flood processes and had minimum effects on sensitive ecosystems. Wetlands were specifically avoided and no projects were located within critical habitats. The 51 subprojects chosen were those where the civil works did not alter the structure and functioning of floodplain habitats and surrounding wild lands and there was an economic growth rate of at least 12 percent in the area. This economic criterion gave preference to converted lands. Finally, to allow all provinces to participate, the investment in each province was set according to its counterpart funding capacity.

Standard environmental assessments were conducted for each subproject, although their scope was narrow due to the prescreening. Based on the level of their impacts, the individual projects were categorized both before and after mitigation measures, as critical, important, moderate, or minimal. For the most part, only projects with minimal impacts were selected, although some with moderate impacts were included. This in itself was a built-in safeguard that considerably reduced impacts throughout the basin.

The individual projects, although engineered as flood defense works, were incorporated into the urban landscape to

provide open spaces for recreation. For example, the linear park in Concordia along Arroyo Concordia and the squares in the city of Concepción del Uruguay along Las Animas Creek are the result of recovering areas previously lost because of poor drainage in urban creeks.

Cumulative impact issues

Several issues were identified by the REA when the cumulative impacts of all 51 subprojects were assessed:

- works could cause imbalances in water dynamics, and affect community composition, although these impacts are highly localized;
- changes in water residence time will affect productivity, energy transfer and accumulation, but not significantly;
- roads and dikes will alter natural flows;
- considerable deforestation and soil erosion is being caused by unplanned urban development, livestock raising, and agriculture;
- loss of biodiversity in rivers and other water bodies results from effluent discharge;
- existing flood defense works are undermined by poor waste disposal/sanitation services;
- the ecological needs of vertebrate fauna are not met by the current extension of the protected areas;
- there is a lack of awareness of the environment and the consequences of floods throughout the region.

The environmental assessment also recognized the probability that the construction of hydroelectric projects in the upper basins of the rivers has significantly impaired natural ecological resources and processes. However, the REA concluded that, with appropriate mitigating measures, the project would have no regional environmental impacts because of the localized nature of the works which were mostly limited to urban and suburban areas where natural habitats had already been either converted or degraded.

Environmental Programs:
In response to the environmental issues raised by the regional assessment, the REA included a regional action plan. The plan comprises four environmental programs designed to address institutional weaknesses in communities affected by recurrent flooding, further supporting the new institutional framework set forth as part of the project. A total of US$3.6 million was allocated for these programs to improve environmental assessment, management, protection, and education.

The *Program to Strengthen Environmental Assessment Procedures in Key Institutions* is aimed at emergency response coordination subunits, provincial environmental agencies

and natural resource agencies. Its purpose is to improve their environmental capacity for flood protection works and to ensure that environmental assessments explicitly address impacts on floodplains.

The *Program of Technical Assistance for Urban Environmental Management* involves municipalities and NGOs, and addresses the lack of sufficient urban environmental infrastructure and technical solutions to deal specifically with flood-related problems. Decreasing flood impacts in urban settings is a challenging task. All participating localities will develop Urban Area Management Plans which will encourage settlement out of the floodplains and into planned development areas. Flood risk zoning maps are being prepared for all urban sites; new regulations will restrict settlement in flood-prone areas.

For example, the flood risk and land-use maps for the city of Clorinda, Formosa were the basis for determining the urban zoning plan. The plan defines, among others, areas for future development, the route for the Zanjón linear park, and the Itororó natural reserve. The urban management plans show how the environmental programs are tied together to produce the best possible outcome. A further example is the support of this program for pilot projects such as the environmental restoration/improvement of the Avalos-Prosperidad and Rissione lagoons, located in Resistencia, Chaco (under implementation). These natural reservoirs receive the urban drainage of a large watershed with high-density urban areas. Laguna Seca in Corrientes is another urban lagoon targeted for recovery.

Environmental Education and Awareness Programs were established at each of the 51 sites where civil works were located, as well as throughout the provinces involved. This extended the educational program outside the immediate area of influence of the works. The environmental education programs informed people about the importance of floods in natural habitats, the importance of maintaining flood plains, the consequences of creating impervious areas (mainly paving and house building), and better land-use practices. For example, in Santa Fe there is a four-stage program called "Guarding Our Stream" to raise awareness about the ecological role of the Cañada de Gómez creek and the consequences of polluting its waters. The program started with a study to determine the public perception of environmental problems affecting the stream. It then developed interactive workshops to teach residents how to take care of and maintain the stream, and then distributed manuals and videos explaining the canalization that was to be carried out and important environmental features. The final stage was a 20-hour course aimed at teachers in the area. The course highlights the stream as an environmental asset, its importance within the city and its ecological role, as well as guidelines to incorporating this information into natural science classes.

Wetland Protection and Management Program. The region had few protected areas and a lack of effective protection systems. The degradation of wetlands and floodplain ecosystems was extensive, especially around urban areas. At regional level, the project included digital mapping of fauna and flora species which, when layered, will identify critical areas with high biodiversity and areas with populations of species of concern. This mapping provides baseline information for the prioritization of future projects and establishment of conservation areas.

At local level, the program supports initiatives for protection and management of wetlands and other ecosystems. Participating institutions include provincial natural resources agencies, research institutions, municipalities, and NGOs.

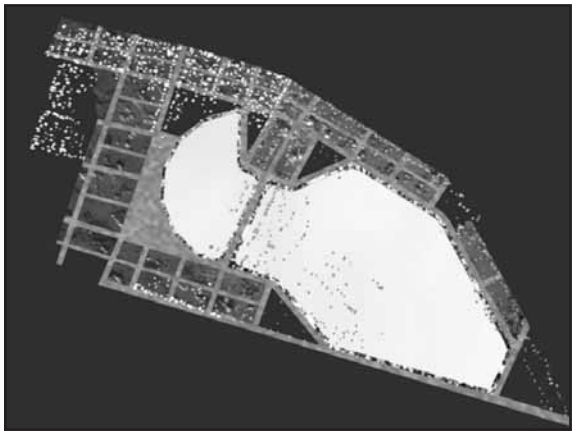
Protected areas will be the result of new legislation, not of mandatory mitigation measures. For example, the pilot plan for the Lagunas del Sur Coastal Park in the city of Formosa aims to prevent further degradation of the creeks and lagoons within the Biosphere Reserve of the Paraguay River's Oca Lagoon.

For this purpose the city has designed a coastal area that will serve as a transition/buffer between urbanized zones and the natural system of lagoons and creeks.

Perhaps one of the most beneficial institutional outcomes of the project are the regional meetings held to show how the environmental programs have been applied across the provinces. These not only promote communication between the different state agencies but also illustrate the different approaches and solutions used to tackle similar problems. In 2002, the First Meeting for Regional Environmental Programs showcased 17 projects from all participating provinces. Similar encounters have taken place since then.

SUCCESSFUL STRATEGIES

A regional approach provided sufficient background information to develop general environmental criteria that would allow an expedient classification and prioritization of potential sites for the project. This approach allowed for site-specific works and an evaluation of their cumulative impact at regional level. It also allowed the identification of areas of high biodiversity, and the distribution of species of concern and habitat types. This is a significant contribution toward increasing the current low percentage of habitat types included in protected areas throughout the country.



Recovery of the Laguna Seca urban lagoon, Corrientes

Minimum interference and effects as a goal translated into strong environmental criteria for civil works. This proved to be a cost-effective way to screen projects and also acted as a safeguard to minimize cumulative impacts on river basins.

Consultations with communities on the planned civil works provided input that resulted in the improvement of individual project designs.

Coordinated environmental programs allowed a multidisciplinary approach to improving existing conditions at the project sites. The works provided immediate defenses against floods; improved conditions, urban plans, environmental assessment, and education will prevent conditions from deteriorating.

One of the most profound changes a project can produce is within a country's regulations and laws that mandate higher environmental safeguards and standards. Within this project regulations and programs at the state and municipal levels ensure, among other things, that:

- the flood risk of an area is assessed prior to construction;
- environmental assessments explicitly address impacts on floodplains;
- urbanization of floodplains is avoided; and
- protected areas where fauna can go in case of flooding are created.

It is significant to note that 15 municipalities in four provinces have taken the initiative to implement regulations and take steps toward flood protection similar to those set forth by the project. This shows that infrastructure projects that are planned to protect natural habitats are an attractive, feasible option, and that well implemented projects can serve as catalysts for new reforms.

Belize Roads and Municipal Drainage Project: protecting mangroves, fostering biodiversity

SUMMARY

Drainage improvement works were needed throughout six cities in Belize. Three important issues stood out during the Environmental Assessment (EA):

- protection of endangered flora;

A small population of cycads was found at one of the sites. Further concerns expressed by the local academic community regarding other related rare plants in the area prompted the project team to launch a nationwide study to assess the distribution and status of all *Zamia* cycad species. When completed, it will constitute a major data base, providing baseline studies and digital maps as a first step toward the long-term conservation of these plants.

- conservation of a lagoon surrounded by mangroves;

At another site, the EA perceived urban sprawl as a major threat to nearby mangroves and a coastal lagoon in nearly pristine condition. The project served as a catalyst for the area's legally protected status which had been pursued by a local NGO and also mediated a co-management agreement between the Forest Department and the NGO. To strengthen the new park the

project provided environmental management and ample technical support to the NGO in the form of training and funds for equipment.

- protocols for chance archeological findings.

Archeological findings were frequently made in towns where no protocols had been defined. The project team included an archeological survey prior to and along with the civil works, and developed protocols and procedures to be used for future archeological findings and monitoring.

BACKGROUND

Heavy rainstorms and low-lying lands make all-weather roads and efficient storm water drainage a priority within Belize's urban infrastructure network. The roads component of the project posed no threats to the environment. It involved improvement of the Burrel Boom Road bypass which connects two highways and reduces travel time to reach the airport from the western region of the country by up to 30 minutes. Traffic can now skirt the city year-round.

The project also aimed to expand the storm-water drainage network to several urban areas that suffer from inadequate land-use planning, which in turn has led to rapid growth and occupation of marginal lands that lack proper infrastructure. The works are mostly remedial actions that will expand and improve existing drainage conveyance systems along waterways and main roads. Six main cities across Belize will benefit: Corozal, Dangriga, and Punta Gorda along the coast; Orange Walk, San Ignacio–Santa Elena, and Benque Viejo del Carmen located inland. An estimated 55,000 inhabitants (ca. 1999) will ultimately benefit from the works to be performed in 27 sites.

Total required funds amount to US$18.4 million, of which 47 percent are for roads and 32 percent for drainage. The remainder supports a road maintenance pilot project (6 percent) and institutional strengthening (15 percent). The US$13 million Bank loan became effective in September 2000 and closed in March 2005.

NATURAL HABITAT ISSUES

Most project cities lie in expanding agricultural areas amidst seasonal swamp forests, lowland moist evergreen seasonal forests, and broadleaf hill forests where project impacts on natural habitats are considered to be low; the works will take place either in land that has been converted to agricultural use or in degraded habitats.

However, two of the cities are located near sensitive areas. Dangriga lies north of mangrove forest (threatened worldwide and protected within Belize under the 1999 Forest Regulation) and a lagoon in nearly pristine condition. Punta Gorda harbors various specimens of the critically endangered cycad, *Zamia picta*. These two circumstances triggered the World Bank safeguard policy on Natural Habitats (OP 4.04).

It was also important to maintain adequate procedures to deal with archeological findings because it was highly likely that these would be encountered in several cities.

Protecting mangroves

The city of Dangriga (pop. 7,390) has widespread drainage problems and nine of the 27 project sites are located here. The improvements to one creek and two canals resulted in the loss of a small area of mangrove forest (along the lower 590 m of John Creek and 3 ha of basin mangrove), with potential indirect impacts on the remaining habitat through induced development. Two canals that drain onto the Gra-Gra Lagoon's banks transport storm-water runoff and untreated sewage into the mangroves. Nevertheless, the Gra-Gra Lagoon has remained a large, nearly pristine

wetland where urban expansion is actually recognized as the greatest threat to its ecological integrity. Because of their nutrient and pollution management capabilities, the ecological functions of wetlands and mangroves are of extreme importance to withstand the current disposal of sewage effluents. Thus, it became clear that in order to preserve their ecosystem functions, it would be highly desirable to protect the mangroves and lagoon; although this was not mandatory according to Bank policies.

Other factors directly impacting the lagoon's functions and its biodiversity include a marina currently being developed within the lagoon itself. Out of concern for the conservation of the lagoon and wetlands, a local community-based NGO, Friends of Gra-Gra, had expressed interest in its management and potential for ecotourism. The NGO was also trying to secure legal recognition for the site as a protected area. This recently-created organization was seeking training and capacity building in order to implement sustainable ecological management techniques.

A new National Park. The Bank's involvement expedited the process of attaining legal protection for the Gra-Gra Lagoon and neighboring wetlands, and sought to have 484 ha declared a National Park. This implies management primarily for ecosystem protection and recreation.[9] The declaration of the Gra-Gra National Park in July 2002 prevents further degradation and encroachment of the mangrove and lagoons, protects a threatened habitat, and secures a safe haven for Morelet's crocodile. The latter is a species of special concern which was being perceived increasingly as a pest, because encroachment into the wetlands made chance encounters more likely.

Co-management of the new national park. Although the land remained government property, the project mediated a Co-management Agreement that involves the local community-based NGO Friends of Gra-Gra and the government, through the Forest Department (Ministry of Natural Resources and the Environment, Commerce and Industry).

Mangroves near Gra-Gra Lagoon

An environmental management plan for the new park Protection of the lagoon and wetlands is further upheld by the funding of an Environmental Management Plan which will include zoning maps with permitted activities and restricted uses, management objectives, and strategy. The Environmental Management Plan is a collaborative effort between Friends of Gra-Gra, the Forest Department, and a consulting team. Within the budget for the EMP, $15,000 were allocated for an Action Plan that will detail immediate infrastructure needs within the park and institutional strengthening for Friends of Gra-Gra. Based on the recommendations in the Action Plan, the project may extend financing to cover demarcation of the park and a trail to facilitate ecotourism activities. The Environmental Management Plan for the Gra-Gra Lagoon National Park will contain a special section on ways to cover recurrent costs, potential threats to the protected area, and the corresponding primary stakeholders involved. This enables the co-managing insti-

[9] Gra-Gra Lagoon National Park is classified under the IUCN Protected Area Management Category II.

tutions to devise strategies for the future that will decrease financial stress and the likelihood of conflict between stakeholders.

Strengthening Friends of Gra-Gra. Considerable effort has gone into building the capacity of Friends of Gra-Gra as co-managers of the Gra-Gra Lagoon National Park. The project team is ensuring that sufficient resources, training, and a solid strategy are available to support them in their new role. $15,000 from the project has been set aside to purchase equipment for the NGO. The "Friends of Gra-Gra Institutional Strengthening Action Plan," designed by the consulting team, will oversee this initial expenditure to ensure that the NGO has all the required equipment to meet its responsibilities, as detailed in the EMP. Through funds and resources facilitated by the project, Friends of Gra-Gra will also receive specific training in areas of their choice, such as ecotourism. The training is provided by the same consulting team that is developing the EMP, so that guidelines and practices are developed within the Park's operational context. Additional funding ($5,000) for Friends of Gra-Gra is in the form of an award granted by the Global Greengrants Fund to train newly appointed park rangers and to purchase basic equipment.

The endangered cycad, Zamia picta

Supporting biodiversity

In Punta Gorda (pop. 5,010), the seasonal swamp forest around the lower course of the South West Lagoon Drain is home to a rare and critically endangered cycad, *Zamia picta.*[10] Cycads overall are one of the world's most threatened groups of plants, largely due to habitat destruction. The area is also home to threatened[11] species of mammals including the Mexican Black Howler monkey, *Alouatta pigra*. The improvements to the lower channel would result in a net clearance of about a hectare of swamp forest, representing approximately seven percent of the 14 ha of forest in the vicinity. The loss of a local swamp forest corridor could pose a significant threat to the population of *Zamia picta*.

A countrywide biodiversity study was initiated following the identification of this small population of an endangered cycad species within the project's area of influence. This discovery initially warned only of potential detrimental effects to the population's long-term survival, but provided no information to quantify the threat. To rectify this, the project team requested a study to assess the status of *Zamia picta*. However, during subsequent

[10] As classified by CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) and IUCN (The World Conservation Union).
[11] As classified by IUCN

meetings with stakeholders, the academic community called the team's attention to other endangered plants near the project area. Acting on this expert advice, the project team expanded the scope of the original assessment and set aside $25,000 to launch a countrywide detailed baseline and distribution study for all *Zamia* species. This is one of the first times the Bank has been directly involved as a major proponent of a countrywide assessment for plant species of special concern. The baseline study of *Zamia* will be followed up by the State Forestry Agency which has experience in recruiting foreign universities to further pursue scientific studies. Works at Punta Gorda continued once expert consultation deemed that the area impacted by the project was not critical to the long-term survival of the *Zamia picta* population.

Archeological recovery

Corozal was built atop an important Mayan settlement and the likelihood of encountering archeological artifacts was very high. Monitoring was deemed necessary in Orange Walk, Benque, and San Ignacio because of the existence of archeological material, and in Santa Elena, Dangriga, and Punta Gorda because of the possibility of encountering such remains.

An archeological team in each city ensured adequate supervision during the beginning of the excavations and/or the cleaning of drains. The teams were each composed of an archeologist and several workers.

Additional surveys were performed in Corozal, the city with the highest likelihood of chance findings. Here the archeological team also stayed the longest (30 days) to conduct test pits, make sketches, take photographs, and document findings.

A protocol for chance findings in Corozal was nonexistent prior to the project, despite their high likelihood throughout the city. In the past, whenever archeological material surfaced, the site would lose its archeological content and documentary value because of inadequate procedures. The new protocol implemented by the project makes an important contribution toward preserving the area's cultural heritage.

SUCCESSFUL STRATEGIES

This project is notable for the team's effort to make valuable, long-lasting contributions when challenges were encountered. Rather than merely solving the presenting problem, the project team addressed the underlying issues. Thus, the flora study was expanded from one species to all those in the genus *Zamia*, and the archeological findings were not only properly documented, but lasting protocols were also established. These actions exemplify the willingness of the project team to provide sound foundations for future follow-up actions.

Stakeholders were involved early in the project.. During joint discussions of the Environmental Assessment and the Environmental Management Plan, the project team:

- identified individual concerns of the participants;
- assessed their existing capacity to deal with environmental management and conservation issues; and
- established collaboration teams with stakeholders to address specific issues.

The project team also remained open to concerns emerging later in the project, as in the case of threatened flora or the need to increase the NGO's management capacity.

Taking advantage of local interest paid off in at least two critical aspects. It involved the

academic community, resulting in a better informed decision-making process; and it involved and strengthened a local NGO to take an active role in the new park's management. Thus, the project gained access to expert advice and facilitated the human resources which the State Forestry Agency lacked.

The three net contributions of the project—the new national park, the nationwide biodiversity study, and the archeological findings protocol—are usually the subjects of conservation or cultural grants. In this case, they were the outcome of drainage works, an unusual source of funding which shows the versatility of infrastructure projects and their potential to have a positive impact on the environment.

Cartagena Water Supply, Sewerage and Environmental Clean-Up Project: Reclaiming Ciénaga de La Virgen

SUMMARY

The rehabilitation and expansion of the water supply and sewerage network of the city of Cartagena implied selecting a site for the final disposal of the city's wastewaters, and restoring Ciénaga[12] de La Virgen. Strict environmental criteria combined with hydrological models and high-end technology demonstrated that the best option was to transfer wastewater discharges from Ciénaga de La Virgen and Cartagena Bay to a submarine outfall. This choice not only served infrastructure needs; it also lowered pollution within the ciénaga; the first of a series of actions geared toward its restoration and conservation.

Site selection covered four main areas: i) it was first decided that city sewage should receive preliminary treatment instead of raw disposal; ii) disposal would be transferred from semi-closed water bodies (Ciénaga de la Virgen and Cartagena Bay) to the open Caribbean coast; iii) hydrological models were used to select the best location for the submarine outfall off the coast; and iv) a close monitoring system was devised for the operational phase. An expert panel guided the feasibility studies and selection process. Environmental impacts were assessed for all alternatives during each step of the process, thus ensuring high environmental standards throughout the design phase.

[12] A coastal lagoon surrounded by mangroves and wetlands.

The Environmental Assessment required a cumulative impact assessment which showed that the main threats and problems in the ciénaga were: a) illegal occupation of urban spaces; b) loss of biodiversity; c) destruction of mangroves; d) filling of wetland ecosystems; and e) unsanitary conditions. To address these issues, in addition to clean-up activities, the ciénaga was legally established as a protected area and a Recovery, Conservation and Environmental Management Plan (RCEMP) has been prepared and is currently under implementation. The legal framework and recommendations must include financial instruments to guarantee the funds to operate, manage, and guard the protected area, an ecological restoration plan, a zoning plan, an environmental education program, and guidelines for sustainable use of the ciénaga's resources which include fisheries and mangroves.

BACKGROUND

The current state of the Ciénaga de La Virgen–Juan Polo system in Cartagena is the cumulative result of high population densities, land filling activities along the margins, resource overexploitation, and an apathetic community. The ciénagas, Cartagena Bay, and the city canals have been highly polluted by the direct discharge of up to 145,000 m^3/day of wastewater, of which 60 percent was directed to Ciénaga de La Virgen (also called de Tesca), 30 percent to Cartagena Bay, and 10 percent to the city water courses. The natural assimilation capacity of these water bodies had been largely overrun and their degradation had been a long-standing problem.

The main components of the Cartagena Water Supply, Sewerage and Environmental Clean-up Project include: 1) expansion of the water supply system; 2) expansion of the sewerage system in the ciénaga basin; 3) construction of the main wastewater conveyance system; 4) construction of wastewater treatment installation; 5) construction of a submarine outfall; and 6) industrial wastewater discharge control. These activities will improve sanitary conditions in the poorest neighborhoods by expanding coverage to some of these areas, directly benefiting about 80,000 people and bringing the total coverage to about 90 percent.

It should be noted that the submarine outfall will be implemented in two phases, the first extending from 2005 to 2015 and the second from 2015 to 2025. The first phase is to be constructed under the project, as described above. The second phase, not included in the present case study, comprises the addition of an aerated flow-equalization basin at the Paraíso pumping station site, an additional transfer pumping station to convey wastewater to the equalization basin.

The funds needed totaled US$117 million, US$85 million of was provided by the Bank. A total of US$3.3 million were allocated for the Environmental and Social Component. The project started in July 1999 and closed in June 2005.

The Environmental Assessment for the project was innovative. It incorporated cumulative impacts, the first time an analysis of this type was performed in Colombia. The analysis included all ongoing and planned projects related to the city's sanitation conditions, the conservation of wetlands and other ecosystems, and the expansion of the urban perimeter. Thus, a number of important projects were included: 1) sewerage expansion and improvement in the Cartagena Bay sewerage network; 2) a new outlet (Bocana) for Ciénaga de La Virgen; 3) a national highway around the southern perimeter of Ciénaga de La Virgen; 4) an expansion of the city airport which would directly impact some wetland areas; and 5) private tourism development plans in the northern area of Cartagena. The social dynamics in and around the ciénaga were also included.

The EA was carried out in close interaction with the municipality of Cartagena, which

Aerial view of Ciénaga de la Virgen and Juan Polo.

was preparing a new land-use plan. Such collaboration was crucial, because this allowed the outfall site, treatment facility, conveyance systems, and protected areas to be included in preliminary versions of the new land-use plan. The broad-view approach of the EA optimized resource allocation and prevented future conflicts by identifying key stakeholders and bringing together not only those directly involved with the project but those involved with the Ciénaga de la Virgen as a whole. This established the conditions for a much more comprehensive approach to the recovery portion of the ciénaga.

NATURAL HABITAT ISSUES

The EA identified the potential for the submarine outfall to have numerous negative environmental impacts, if handled inadequately. The impacts could be extensive, because the area of influence extends to Ciénaga de la Virgen, the coastal plains, and the coastal marine environment. The cumulative impact assessment identified the following main threats and problems to the ciénaga: a) illegal occupation of urban spaces; b) loss of biodiversity; c) destruction of mangroves; d) filling of wetland ecosystems; and e) public health issues. Throughout the wetlands, mangroves constitute the dominant type of vegetation; they are considered endangered worldwide. The ciénaga also provides an essential habitat for migratory and resident birds, fish, and other fauna, thus playing an important role in local biodiversity. The potential negative impacts of the submarine outfall and the threat to mangroves and biodiversity in Ciénaga de la Virgen triggered the Natural Habitats safeguard policy.

SELECTING THE SITE FOR FINAL DISPOSAL

Recognizing the potential for adverse impacts on the neighboring aquatic environments, the District of Cartagena called on the Bank's experience for technical guidance. The Bank put together a panel of five experts in wastewater management, design and construction of ocean outfalls, water quality and oceanographic modeling, environmental impact assessment, and private sector participation. The panel oversaw the feasibility studies and design process; it provided advice, reviewed technical reports, and participated in public consultation meetings. Multiple alternatives were evaluated in each step of the process, from a technical, economic, environmental, and social perspective.

Water treatment prior to disposal was selected instead of the current practice of discharging raw sewage. The options examined included preliminary, primary, secondary, and advanced water treatments. Preliminary treatment was selected for the initial phase until 2015, when the water treatment plant will be upgraded. The treatment plant will remove 99 percent of suspended solids, 30 percent of oil and greases, and 75 percent of nonsuspended particles. The facilities include six rotary screens (1.5 mm clearance) followed by two vortex-type grit chambers. Treating the water will abate direct fecal pollution in the marine environment, thereby minimizing the footprint of the project during its operational stage.

Four main final disposal sites were assessed in combination with different levels of water treatment. The sites were a) Cartagena Bay, b) Ciénaga de la Virgen, c) the Caribbean Sea, and d) reuse and irrigation. The Caribbean Sea was the best option because current efforts are

Alternative locations for the submarine outfall.

focused on improving water quality in both Cartagena Bay and the ciénaga. Reuse and irrigation was expensive but, more importantly, inoperative during the rainy season (seven months of the year). The Caribbean Sea with preliminary treatment was considered the best environmental, economic, and technical option.

Location of the submarine outfall was determined by the steepness of the continental slope. The least expensive location was that closest to the coast. Depth was site specific, dependant on dilution rates around the outfall at each of the four options off the Caribbean coast: a) La Boquilla, b) Punta Canoas, c) off Ciénaga de la Virgen, and d)Tierra Bomba Island. The selection criteria explicitly stated that sensitive ecosystems (such as coral reefs) should be avoided and that the site should impact the fewest habitats and their quality. Based on the combined results of costs, environmental criteria, and a hydrodynamics model, the optimal site was Punta Canoas.

A *hydrodynamics mathematical model* was used to evaluate the technical merits of the alternative sites for the submarine outfall in Cartagena. First, intensive current measuring efforts were carried out for over two years across the front area of Cartagena. The measurements were the input for the hydrodynamic and water quality mathematical model which was then subject to a fatal flaw analysis The model incorporated the direction and velocity of ocean currents to estimate dilution and dispersal rates of the different effluent components. One of the criteria by which the site was chosen, was the resulting combination of high dilution rates and smaller size of the maximum dispersal area. The final location ensures dilution levels higher than 1:300 at the outfall exit and minimizes the area directly impacted around the outfall.

Fatal flaw analysis ensures that the outfall meets minimum environmental standards even in the worst conditions. The analysis was conducted for all four sites evaluated. The analysis estimates the concentration of coliforms, solids, and other parameters under simultaneous adverse conditions for wind, current, speed, direction, coliform concentrations, and low bacteria decay rates. Because Colombia has no water quality standards for domestic sewage discharges through ocean outfalls, the project adopted the existing water quality standards which limit total and fecal coliforms in surface waters with potential recreational uses. The standards for total coliforms are 1,000 and 5,000 for primary and secondary contact, respectively; standards for fecal colifoms are 200 and 1,000, respectively. These conditions are to be met in all recreational beaches under outfall operation at the end of the design period (2025). Outfall sites failing to meet the adopted standards were not considered further.

The final design of the submarine outfall is located off Punta Canoas, runs 20.85 km on land, 2.85 km and down to a 20 m depth in the sea. The effluent is let out through a diffuser 500 m length with 27 double-mouthed elevated pipes for a total of 54 discharge ports. The multiple pipe diffuser lessens the intensity of direct fecal pollution.

Water quality-related monitoring/maintenance programs have been implemented to control and keep track of water quality. The monitoring is essential to monitor the quantity of nutrients and pollutants entering the system, and the system's ability to recycle them. Water samples from around the submarine outfall are constantly monitored and tested to ensure not only that the level of total coliforms and overall water quality stays within designed low levels but also that coliform exceedence does not spread beyond predicted areas. Close monitoring of the marine environment enables a timely response if ocean conditions change.

Improved water and wastewater management will be achieved by developing an Unaccounted-for Water Reduction Plan and an Industrial Wastewater Discharge Control Program. The latter will have a considerable positive impact on the water quality of the receiving bodies. The program will:

- identify key sources of industrial pollution;
- establish a system to regulate and audit the discharge of industrial waters;
- define strategies to control small dispersed sources (such as gas stations); and
- provide technical assistance in the selection and design of pretreatment processes.

The engineering design of the submarine outfall in Cartagena, Colombia avoided sensitive marine environments and caused the least disturbance in the surrounding water quality through adequate location and use of water treatment prior to disposal into the sea. The selection of the outfall toward the Caribbean Sea allows the effluent disposed of in Ciénaga de la Virgen and Bahía de Cartagena to be transferred, thus preventing further degradation of both areas and allowing restoration programs to take place while still ensuring that minimum water quality standards are met and environmental and health risks are kept low. In all, the project represents an enormous and successful effort to improve the sanitary conditions and water quality of city and surrounding water bodies, as well as improved management of both water and wastewater with higher environmental standards.

Rescuing Ciénaga de La Virgen

Despite its degraded state, the ciénaga is still an important ecosystem for local biodiversity and small-scale fisheries. The ciénaga itself, which received the majority of the raw sewage, is composed of 2,250 ha of water and 950 ha of wetlands; Juan Polo, a smaller ciénaga of 80 ha, lies to the north. The cumulative impact assessment identified the main threats to the ecosystem and the results were incorporated in the Recovery, Conservation and Environmental Management Plan (RCEMP) for Ciénaga de La Virgen.

Reversing degradation. The civil works of the project itself and others planned (such as Bocana) helped to stop and reverse some of the damage by:

- stopping the disposal of effluents directly into the wetlands,
- improving or re-establishing flow among water bodies and waterways, thereby avoiding the isolation of particular areas and restoring past habitat fragmentation; and
- constituting physical barriers that will prevent future urban sprawl into the wetlands.

The transfer of the wastewater discharge from Ciénaga de la Virgen to the submarine outfall, along with an environmental management plan to restore and conserve this ecosystem, constitute the first steps toward reclaiming the ciénaga as a unique asset within the urban landscape of Cartagena.

Protecting the ciénaga: Despite its importance, and because of its degraded condition, the ciénaga was perceived as a neglected, bad-smelling area, with several sites posing sanitary concerns. It had not been legally established as a protected area and also lacked a restoration or environmental management plan. The latter was needed to complement the clean-up benefits of removing the discharges to the lagoon. The Bank served as a catalyst for protecting this area. The legal establishment of Ciénaga de La Virgen as a protected area includes a Recovery, Conservation and Environmental Management Plan (RCEMP) as part of the same package. Recommendations to secure funds that will finance the operation and management of the protected area will be included as part of its legal framework.

The Recovery, Conservation and Environmental Management Plan (RCEMP) for Ciénaga de La Virgen ensures restoration and sustainable use after the project is completed. The RCEMP is based on the results of the cumulative impact assessment and covers five main areas: (i) ecological restoration, (ii) environmental education, (iii) zoning and management, (iv) sustainable use of mangroves, and (v) institutional strengthening. The RCEMP is being drafted by Conservation International, a renowned NGO with ample experience in projects related to the ciénaga.

The ecological restoration plan starts with the identification and prioritization of actions needed to further halt the degradation of wetlands, such as: mapping areas with high rates of urban sprawl or where solid waste is being dumped directly into waterways, identifying the magnitude of nonpoint sources, locating and controlling invasive species, and stopping overfishing. The variety of issues and the wide range of agencies involved in these activities go beyond those affected by the project directly. To address this, the project team has channeled Bank funds and resources into a far-reaching program that concerns project participants and actively involves other parties who have either contributed historically to the degradation of the wetland or will carry out activities related to the ciénaga.

An urban asset: high potential for tourism, increased land value, increased water quality, decreased health issues.

Environmental education program development is included in the RCEMP. The program would target schools around the ciénaga, promote awareness and a participatory approach to wetland management, and increase awareness of problems affecting the ciénaga.

One of the most beneficial aspects of the RCEMP is that it provides a framework for environmental activities deriving from other projects to be incorporated in a coordinated plan for the ciénaga, so that human, financial, and logistical resources are optimized by avoiding redundant tasks and interference between various activities.

SUCCESSFUL STRATEGIES

The establishment of a multidisciplinary expert panel to oversee the entire design and site selection process ensured high standards throughout the process. In response to the District of Cartagena's request for technical guidance the project team not only included engineering

and modeling experts but extended the expert advice to areas such as environmental impacts and private sector participation, providing a well-rounded approach throughout the feasibility and design phases.

An integral approach to the ciénaga incorporated the concerns of all stakeholders from the city to the surrounding neighborhoods: fishermen, tourists, and conservation groups. The project successfully addressed issues such as health problems, and environmental and engineering challenges. More importantly, its modular design allows different phases to be added as demands on the system increase.

Evaluation of the ciénaga across projects meant going from a project-based impacts and potential benefits perspective to an inclusive all-projects approach. This ensured that past, current, and future activities were considered, and provided a better view of threats to the ciénaga and needs for its management and restoration. It also drastically increased local and government awareness. It changed the perception that the wetland was a detrimental landscape feature with low esthetic value that posed a sanitary risk, to a new view of the wetland as an environmental asset with high ecological and aesthetic value that can provide multiple amenities. The project's direct benefits include higher land values due to the expansion of water services, improved sanitary conditions as a result of the clean-up activities, and incorporation of the protected areas into the city's new zoning plan. For the other projects, the wetland will now represent a scenic road, a tourist attraction, and a source of economically sustainable activities.

The Cartagena Water Supply, Sewerage and Environmental Clean-Up Project demonstrates that making habitat restoration part of the project's ultimate goals puts forward a strong statement about the level of commitment to and importance of restoring a degraded ecosystem. The project shows that the cascading effect of changing the perception of a previously degraded landscape to an economic, aesthetic and ecological asset can result in improved practices and higher standards across sectors and stakeholders.

Honduras Road Reconstruction and Improvement Project: safeguarding an endemic biodiversity hotspot

SUMMARY

The project sought to rehabilitate or upgrade main and rural roads throughout Honduras. Because all works were to be within the existing roads' right-of-way, environmental impacts were expected to be minimal. However, standard environmental screening of the project found that one of the roads to be upgraded ran through the Aguan Valley, a known habitat of the endangered, endemic Honduran emerald hummingbird, *Amazilia luciae*. A subsequent study to assess the hummingbird's habitat showed that dry thorn forest was essential not only for the hummingbird's survival but also for at least 11 endemic plant species, all either threatened or endangered; this fact placed the dry thorn forest at the top of Honduran ecosystems with high endemic biodiversity. The 3,300 ha of remaining thorn forest lies mostly within privately owned lands. Interviews showed that landholders intended to convert the rest of their land to cattle ranching as soon as it was financially possible. Upgrading the road would increase land values, consequently favoring an increase in the deforestation rate upon road completion. The impending land conversion and the rich endemic biodiversity called for an Action Plan to conserve the dry thorn forest in the Aguan Valley. The Conservation Action Plan was designed to ensure that adequate environmental measures were in place before road construction began. Some of the plan's key components include securing habitat, development guidelines, environmental education, and endangered species monitoring.

Much progress was made in increasing government and local awareness of the uniqueness of this area and the Honduran Government ultimately transferred the funds to upgrade a different road.. Bank efforts resulted in the much needed CAP for this area and in the inclusion of the dry thorn forest in the Biodiversity in Priority Areas Project (funded by GEF), thereby making its conservation a national priority. The project set aside US$200,000 to support CAP-related activities and played a vital role in raising national awareness of this previously-neglected area.

BACKGROUND

The goal of the project was the reconstruction of 262 km of main roads, the replacement of bridges, and the improvement of 100 km of rural roads. The population at large and some of the country's poorest rural communities will benefit.

The total cost of the project is US$106.8 million, of which the Bank is lending US$66.5 million, with 19 percent of the project finances allocated to rural roads, bridges, and a pilot project for road maintenance. The remaining budget (81 percent) is allocated to the reconstruction of five main roads:

- Tegucigalpa–Danli: rehabilitation of 84 km with an average daily traffic (adt) of 2,500 vehicles;
- Jícaro Galán–El Amatillo: rehabilitation of 40.2 km with an adt of 2,600 vehicles;
- Santa Rita–Yoro (El Negrito–Portillo de Chancaya section): reconstruction of 46.5 km with an adt of 1,734 vehicles.
- Río Dulce–El Porvenir: improvement (upgrading from gravel to asphalt) of 46.5 km. with an adt of 624 vehicles.
- San Lorenzo–Olanchito: upgrading and widening of an unpaved section of 45 km of the main road, with an adt of 456 vehicles.

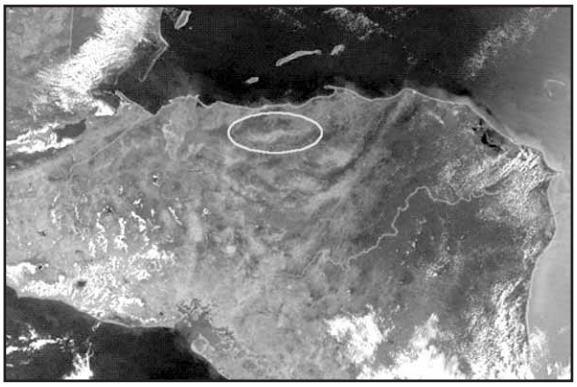
The project started in November 2000 and is scheduled to close in March 2006.

NATURAL HABITAT ISSUES

The majority of the roads traverse pine and other forested areas as well as agricultural areas along their routes, but the works are within the existing roads' right-of-way, and the average daily traffic on most roads is already around 2,000 vehicles. The ecological impacts stemming from the works on the first four main roads are minimal and they have only a small resettlement component.

However, the San Lorenzo–Olanchito road is an unpaved section of 45 km that runs through the upper Aguan River Valley. The road has an approximate area of influence of 150 km^2, and within it lie several patches of dry thorn forest. The Aguan Valley, particularly the thorn forest patches upriver from Olanchito, are the only areas known to harbor the endemic, critically endangered Honduran emerald hummingbird, *Amazilia luciae.* In fact, the emerald hummingbird is the only bird endemic to Honduras and the most endangered bird in Central America. Field visits confirmed that most of the thorn forest lies within private lands; the main land uses in the area are cattle ranching and agriculture. Although trees are usually not cut down, the understory is either heavily grazed or converted to more productive pastures and/or crops. Road improvements would increase land values, thereby facilitating and encouraging land clearance in the area. The main concern was the risk that the remaining dry thorn forest would be cleared, thus directly affecting the Honduran emerald hummingbird.

Through the use of a precautionary approach, provisions were made in the Credit Agreement to ensure that adequate studies were carried out and conservation measures were implemented as needed. A Habitat Study was required. If supported by the study's findings, a Conservation Action Plan would also be required.



Aguan Valley in Honduras

Honduran Emerald Hummingbird Habitat Study

The participating federal agencies, academic institutions, NGOs, and consultants designed a comprehensive habitat study with three major components. The first would fill biological information gaps; the second would target socioeconomically driven land-use changes; and the third would identify and prioritize subsequent conservation actions. Specifically, the objectives of the study were to:

- determine the status of the Honduran emerald hummingbird and its habitat, and especially the relevance of the San Lorenzo–Olanchito portion of the Aguan River Valley as natural habitat for the hummingbird and/or other threatened biodiversity;
- assess the likely indirect impacts of the proposed road upgrade, with emphasis on potential land-use changes and habitat loss; and
- identify proper follow-up conservation measures to ensure the survival of the Honduran emerald hummingbird and/or other threatened flora or fauna in the Aguan River Valley and/or other valleys with suitable habitat.

Because there was no consulting firm in Honduras with the expertise needed, project participants put together a multidisciplinary expert team to carry out the study. The team, which included a botanist, ornithologist, environmental lawyer, economist, and field assistants, surveyed the Aguan Valley and other dry Atlantic slope valleys (around Santa Barbara, Cofradía, and Cortes). The results of the study were conclusive:

Only two areas harbor the Honduran emerald hummingbird: the San Lorenzo–Olanchito portion of the Aguan Valley, and San Esteban, Olancho.

The San Lorenzo–Olanchito area is critical to the survival of endemic species. The study noted at least 11 endemic plant species, 9 of them exclusive to the Aguan Valley, all threatened or endangered. This makes the Aguan Valley the region with the highest endemism in Honduras and the *only* viable habitat for all these endemic species. Furthermore, this specific portion of the Aguan River Valley, which comprises 96 percent of the habitat of the Honduran emerald hummingbird, is essential for this bird's long-term survival.

The understory of the dry thorn forest is a year-round food resource for the hummingbird. Particularly in undisturbed areas, there are always flowers within the thorn forest understory. The flowers of the *pie de niño* are a staple food year-round; the more abundant they are, the higher hummingbird densities are. Throughout cattle forest areas the pie de niño has been replaced by pasture.

Land conversion throughout the valley was favored by local landholders. Interviews revealed that financial constraints restricted efforts to clear dry thorn forest and replace it with pasture.

Road improvement would encourage and facilitate deforestation throughout the area. The available remaining habitat was estimated at 3,300 ha, only 11 percent of that existing in 1938. It was estimated that deforestation rates

would increase by a factor of four after the highway was paved, if no conservation measures were in place. At this rate, the remaining thorn forest in the Aguan Valley could be irreversibly damaged within two years and gone within five years unless conservation measures succeed in effectively protecting a substantial proportion of the remaining forest (at least 3,000 ha). Road paving would facilitate deforestation mainly by increasing land values, thereby expediting ranchers' access to capital for land clearing, and facilitating the rapid transport of milk from ranches to processing plants, increasing the profitability of ranching (and of pasture expansion).

The essential information provided by the study determined the course of action that was to be followed. The amount of endemic biodiversity and its threatened/endangered status qualified the dry thorn forest in the San Lorenzo–Olanchito area as a Critical Natural Habitat under the Bank's Natural Habitats policy (OP 4.04). The study showed that the area was a previously unknown high-priority conservation spot—the only viable habitat where the endemic plants and hummingbird could survive in the long term.

A Conservation Action Plan for the Biodiversity of the Dry Thorn Forest

It was clear that measures much stronger than those anticipated in the Environmental Assessment were needed. The estimated deforestation rates made a compelling case for ensuring that sufficient conservation measures were in place before any work on the road was allowed, so that this ecosystem remained secured despite increased deforestation pressure. The habitat study made evident the need for a CAP even in the absence of any road work.

CAP cornerstones

The habitat study established that 3,000 ha would be adequate to ensure the long-term survival of the threatened biodiversity in the Aguan Valley, namely the emerald hummingbird and endemic plants. To ensure a high probability of success, the CAP required that key legal, institutional, and funding commitments be in place prior to bidding the civil works.

Dry thorn forest, photo George Ledec

Secure strict protection of 489 ha of dry thorn forest controlled by the Honduran Air Force. This is a high-quality area of vital importance as a core conservation site. The parcel will remain the property of the Air Force but a legal agreement will guarantee permanent habitat protection.

Acquire additional private lands for strict conservation to build a network of core areas around the Air Force parcel, and on the other side of the Aguan River where adequate habitat with hummingbirds is also found. Suitable parcels and potential sellers have been identified in the area; land prices are still under negotiation.

Establish conservation easements to protect areas remaining in private ownership. Easements have worked in other parts of Honduras, making it a feasible, low-risk option. Because most of the dry thorn forest is within private lands, this would constitute the main mechanism for preserving the natural habitat. Because conservation easements refer to precise parcels, negotiations can only be initiated upon com-

pletion of the land tenure cadastral study for the Aguan Valley.

Conservation incentives for landholders such as assistance with demarcation and other protection management costs, registered secured land titles, and protection against squatters must be in place in order to make easements an attractive offer. Meetings with landowners have taken place to consider the type of benefits that could be granted in exchange for designating a portion of their land for conservation.

Establish an ecological and compliance monitoring program. This would include routine verification of monitoring indicators and targets, mapping and census of species populations, periodic habitat quality evaluations, and monitoring of the extent of landholder compliance with easement agreements.

Expanding the boundaries of the Pico Bonito National Park to incorporate most or all of the remaining thorn forest in the Aguan Valley, with the Air Force and acquired parcels among the park's strict protection core zone and the remaining private lands within the buffer zone.

The CAP also included other supporting measures which did not have to be fully implemented before bidding began on the civil works for the road. These activities included:

A two-year environmental education program, with a total cost of approximately US$34,000. The focus of the program is on the biodiversity of the Aguan Valley and other CAP components such as advantages of conservation easements, and elements of ecotourism.

Promoting ecotourism as a complementary economic activity in the Aguan Valley. Sustainable alternative economic activities such as ecotourism are part of the development guidelines for the area. These guidelines will prevent detrimental land uses or levels of intensity that pose a threat to the dry thorn forest. Ecotourism in particular could further encourage conservation of this habitat and residents of the San Lorenzo–Olanchito area could provide accommodations for visitors and/or guided tours.

CAP implementation

Ultimately, the preparation of an adequate CAP took longer than was estimated and the Honduran Government decided to transfer the funds allocated for the San Lorenzo–Olanchito road, to another road located in a nonsensitive area (San Pedro Sula–Tegucigalpa). The government made a commitment to continue the conservation efforts in the Aguan Valley and set aside US$200,000 for this purpose from the credit. Despite the complexity of the CAP and the transfer of funds to a different road, there has been considerable good will to implement it on the part of SOPTRAVI,[13] other Honduran Government agencies, and NGOs. Progress in CAP implementation is evidenced by these latest achievements:

The Air Force parcel has been secured. The legal agreement has been negotiated, the Air Force has relocated its personnel to a different site, and a small building within the parcel has been demolished. The Air Force remains in charge of this area and actively enforces both its boundaries and use for conservation. The legal agreement is in the process of being passed by the Honduran Congress.

The Honduran Emerald Reserve project led by the American Bird Conservancy is raising funds for a locally owned and managed reserve. Partners include the World Bank, Fundación Pico Bonito, SOPTRAVI, and Conservation International.

Conservation easements are being negotiated to secure land to the south of the Air Force parcel. This comprises the best preserved area around

[13] Secretaría de Obras Públicas, Transporte y Vivienda (Honduran Ministry of Housing, Transport and Public Works)

the Air Force parcel and would help secure a large, continuous patch of dry thorn forest.

An environmental education program in Arenal is being implemented to raise awareness among the community and help secure land on the opposite side of the river. The environmental education and conservation efforts are led by the Programa Hondureño de Educación Comunitaria (Honduran Program for Community Education).

The Bank played a pivotal role by raising awareness about this habitat, putting together a detailed habitat study and a conservation action plan, and including the dry thorn forest in the gap analysis of the project for the Rationalization of the Protected Areas System of Honduras, part of the Biodiversity in Priority Areas Project (PROBAP), funded by the GEF. As a result, conservation of this ecosystem is now a national high priority. PROBAP finances, among other things:

- management plans for the globally important protected areas;
- demarcation of core and buffer zones;
- construction of visitors' centers in the Atlantic zone;
- staff recruitment; and
- construction of park ranger facilities.

SUCCESSFUL STRATEGIES

Following the precautionary approach paid off in the short term, because the Habitat Study showed the dry thorn ecosystem to be a unique stronghold of endemic biodiversity.

Binding studies to the Credit Agreement enabled the World Bank's Natural Habitats policy to act as the de facto conservation statute, overriding national environmental standards that would have allowed road paving without adequate studies and measures in place.

Structuring a multidisciplinary approach addressed ecological concerns and the socioeconomic response of the local community. Furthermore, putting together a group of experts started a collaboration process among the stakeholders. The Bank's ability to act as a facilitator among stakeholders, other resource management projects, and international organizations demonstrates the wealth of resources it can bring into a project, whether financial, human, or logistical.

Ensuring timely conservation measures was essential throughout the project. The site was promptly recognized as a potential critical habitat, the habitat study and CAP were aptly timed prior to bidding the civil works, and when improvement works were transferred to an alternative road, funds were set aside to support CAP implementation. Moreover, to ensure continuing support by the government, the project team enabled the inclusion of the dry thorn forest in PROBAP's priority biodiversity areas.

The project exemplifies how the Bank can successfully act as a catalyst for conservation actions that benefit previously unknown high biodiversity areas. Although the population status of endemic species in the Aguan Valley remains precarious, the Bank's involvement opened a window of opportunity to safeguard the dry thorn forest. Opening these windows of conservation opportunities and securing conservation measures can help redefine the relationship between infrastructure projects and natural habitats today.

Bogotá, Colombia: Santa Fe I Water and Sewerage Project: restoring ecosystem services in an urban landscape

SUMMARY

To rehabilitate and expand the water supply and sewerage network of Bogotá and surrounding municipalities, the city undertook the restoration of wetlands, waterways, and ecosystem services. Innovative architectural and engineering designs were used to improve water quality and reconnect previously isolated water bodies while blending project works into the urban landscape. The water supply network was both rehabilitated and expanded. Civil works were shaped into recreational/educational areas: linear parks border canals, playgrounds contain canal overflows, and community spaces camouflage storage tanks. Environmental displays were placed throughout these public areas. This urban landscaping approach completely overturned the public perception of canals and wetlands from one of dumps overrun by raw sewerage to one of environmental assets. The public's awareness of the benefits and importance of conserving wetlands was dramatically improved. Institutional reforms included:

- establishing a new environmental department within Bogotá's public Aqueduct and Sewer Company (EAAB),
- acquiring new equipment and software that will keep track of neighboring water sources; and
- developing a water quality monitoring system.

The combined effects of civil works, institutional restructuring, and public awareness have thus resulted in a renewed drive to conserve and restore the approximately 500 ha of urban wetlands remaining in the city. The Bank recognized the project's collective environmental achievements by granting it the 2003 Green Award.

BACKGROUND

The city of Bogotá and surrounding municipalities hold one-third of the nation's industries. According to estimates, the population within the city will reach 10 million by 2010. Accordingly, EEAB's goals are to increase water supply from 91 percent to 94 percent and sanitation service levels from 83 percent to 90 percent by 2010. The city's water network was in pressing need of rehabilitation and expansion: the water production capacity was limited to about 65 percent of the nominal capacity. The main constraints were in the Tibito system: the Tibito treatment plant had a capacity of 11 m3/s but supplied only 4 m3/s. Civil works included—but were not limited to—the rehabilitation and/or construction of 2,220 km of sewage interceptors, sewage collectors, distribution mains, and storm-water drains, ultimately supplying 180,000 connections for water service and 200,000 for sewerage service.

Besides civil works, the project anticipated the implementation of the Unaccounted-For Water (UFW) reduction program, as well as the establishment and maintenance of an Environmental Department within EAAB. The project's environmental component, 1.6 percent of project cost, had a specific budget line item for wetland conservation in the Bogotá area. Upon project completion, water quality was expected to improve significantly (although still below proposed levels) in several sections of the Bogotá River. The project was approved in November 1995 and is expected to be closed by December 2004. The total project cost was US$414.2 million, of which the Bank provided 35 percent (US$145 million).

NATURAL HABITAT ISSUES

Bogotá is located in central Colombia, within the upper basin of the Bogotá River. The river receives all of the city's sewage and storm water and carries them down to its confluence with the Magdalena River. Other rivers also cross the city: the Torca, Salitre, Fucha, and Tunjuelo. Thirteen wetlands within the capital district are associated with these rivers. However, the project works are located in the lower areas of the north and west of the city, and thus influence only seven wetlands: La Conejera, Juan Amarillo, Torca, Jaboque, Santa María del Lago, El Burro, and La Vaca. Despite the lower number of wetlands affected by the project, they encompass 84 percent of the 530 ha of remaining urban wetlands in Bogotá. Several of the wetlands harbor threatened and endemic species.

Since 1994 all wetlands within the capital have been considered natural reserves. The project works involved 7 of the 13 urban wetlands, several of which are the habitat of endemic and threatened species. These facts triggered the Critical Natural Habitats policy. Although these wetlands are protected, they have been degraded by illegal settlement, extraction of resources, wastewater disposal, and lost connectivity between water bodies. The environmental agency (DAMA) and the regional agency (CAR) were key in establishing the strategy that guided the entire project, the focus for civil works and restoration measures was to reestablish ecosystem functions and maintain the existing biodiversity.

Restoring Habitats

Environmental screening identified the lack of treatment of storm water and sanitary sewage prior to their discharge into the river, urban canals, and adjacent wetlands. This had signifi-

Torca Canal, after improvement of flow capacity and landscaping. Green slopes and fences around paths and bike trails on both sides of the canal significantly increased adjacent property values.

cantly lowered the water quality throughout surface waters, creating sanitary and flooding risks as well as poor environmental conditions. Nutrient and waste input had exceeded the recycling capacity of river beds and wetlands; eutrophication prevailed in most areas. Furthermore, while some areas had increased flood risk, others were desiccating. Lower canals drained neighboring wetlands, and land refilling had isolated some wetlands from the rivers and canals. To restore the rivers and wetlands, the civil works needed a design that would improve water quality and reestablish lost connectivity by improving flow throughout water bodies and waterways.

Water quality: The new Torca sewage system carries wastewaters past the confluence of the Salitre and Bogotá Rivers, effectively improving sanitary conditions and water quality on the first 32 km of the latter. This measure also benefited those wetlands affected by raw sewage: Los Cementerios, Torca, Juan Amarillo, Jaboque, El Burro, and La Vaca. Interceptors strategically located throughout the city also separated storm water and sewage, improving the water quality on the Torca, Guaymaral, Salitre, Jaboque, and Tintal canals. The Tibito treatment plant was brought to full capacity, which translated into a nearly threefold increase in the volume of treated water; capacity increased from 4 m3/s to 11 m3/s. The above actions will lower pollutants discharged to the water bodies, decrease nutrient loads, and lower the biological oxygen demand in the system. Water and sediment quality will improve and bioaccumulation of pollutants will decrease. The improvement of sanitation levels has also had a beneficial effect on storm-water canals throughout the city. Currently, improvements in the operation of the Salitre water treatment plant are being sought; these would make a significant difference to the quality of the effluent.

Reestablishing connectivity: Extensive excavation was needed to restore lost flow capacity in canals and rivers. Bottom deposits originated from surface runoff, domestic and industrial sewerage, and soil in the river bed. Toxic sludge was removed from the Torca, Guaymaral, Salitre, and Jaboque canals. Additional excavation was needed for multiple water canals throughout the city and in specific wetlands to reconform lost or deteriorated water bodies. This was the case in the Juan Amarillo wetland where the reconformation of one of the lagoons (35 ha) required dredging over 2 million m3 of sediments. Overall, the works improved the canals and lakes within the Chicid-La Ramada irrigation district which provides water to 60 percent of the aquatic ecosystems located

A typical canal, prior to the project, that posed a high sanitary risk, had poor environmental conditions and low aesthetic value.

Jaboque Wetland, the second largest wetland in Bogotá. Linear parks prevent future encroachment into the wetland.

southeast of Bogotá's savanna. The network of drainage canals restored the lost connectivity among rivers and wetlands throughout the city. The canals improved the drainage basins of Salitre, Jaboque, Tintal, Tunjuelo, Torca, and Fucha.

Sludge and excavation material disposal: Toxic sludge was placed in confined landfills located either in abandoned portions of the canals where wide trenches could be built, or in selected sites where dikes were built to guarantee the protection of adjacent water bodies. The excavated material was usually recycled by filling in lower suburban zones prone to flooding, making them suitable for future urbanization. At Tintal, 700,000 m3 of the excavated material was also used to cover the Gibraltar sanitary landfill. Throughout all canals, excavated material was used to cover toxic sludge in trenches and dikes. Once the final layer of excavated material was in place, the surface was leveled with a three-percent slope to drain toward the canals, and pasture and native bushes were planted.

Best practices during construction included:

- Adequately treating and disposing of sludge in controlled sites;
- incorporating sheet piling, 15 m in depth, along interceptor construction sites to protect the drainage of neighboring wetlands;
- scheduling construction activities to avoid disturbances to bird populations during feeding and reproduction periods;
- keeping an inventory of all large trees to be removed in order to identify bird eggs and nests and minimize impacts;
- requiring contractors to establish environmental units and implement public awareness programs during construction; recognizing the different levels of environmental quality in each wetland, construction activities (lake/lagoon reconformation, reconnecting wetlands to canals) were established the regional agency CAR, based on individual needs.

Ecosystem services in an urban landscape

The wetlands in Bogotá are essential for the city's long-term development. The Juan Amarillo wetland alone retains 40 percent of the city's storm waters. Without it, approximately 50 percent of the city would flood during winter. Other ecosystem services include sediment retention, aquifer replenishment, nutrient recycling, and habitat provision for endemic,

Playground along the Salitre contains overflows and serves as natural permeable area.

resident, and migratory species. It was therefore important that the transition between natural and urban landscapes be functional while maintaining wetlands' integrity. Innovative architectural design was key to achieving this goal.

Wetlands and rivers were delimited by bordering these areas with linear parks. Bike routes, walking trails, and passive recreational areas run along rivers and canals, serving multiple functions. The canals and paths serve as physical barriers that prevent encroachment into the wetlands and serve as urban spaces where the public can enjoy the aesthetic values of the landscape. Live barriers in the form of bushes and trees, as well as fences, also serve to maintain the paths for pedestrian, cycling, and skating use only. The Paseo Río Salitre is the largest urban environmental corridor in Latin America, providing a continuous public space that connects the Cerros Orientales (eastern hills in the San Rafael Ecological Park), where the water drains from the mountains, to the rivers, canals, and wetlands that cross the city. The Paseo consists of 43 km of trails, 37 km of cycling routes, and 228 ha of recovered wetlands in Juan Amarillo. It is the single most important landscape component that has helped change public perception of the sewerage system.

Protection against floods is provided by playgrounds strategically located in lower, flood-prone areas of high and medium density. If flows exceed the design capacity of the canals, the parks become active as natural permeable areas, preventing the flooding of residential areas

Community parks disguise structural components, such as the water storage tanks. El Volador tank has a key technical function within the water supply network, yet it also serves a social function as a community space. The site, formerly an abandoned quarry, was subjected to geomorphological stabilization techniques; the volume and height of the tank provide structure to the park: sport courts with a scenic view of the park and city were built on the top of the tank, its outside walls showcase a mural, and the lower grounds house a playground, walking trails, an open air auditorium, green areas, and an environmental management public area.

Side and top view of the Tanque El Volador Community Park. The water storage tank is a key structure in the water supply network.

Converting slopes along rivers and canals to pasture land and using native species for reforestation, turned formerly unused, unsafe muddy edges into visually appealing green areas. The green cover makes the borders less vulnerable to erosion caused by flooding and surface runoff, and it reduces the sediment load on the waterways.

The series of urban recreational areas associated with the drainage canals and wetlands effectively protect sensitive ecosystems against illegal settlement and resource exploitation. They do so while increasing the aesthetic value of the sewage system and changing the perception of adjacent canals from a nuisance and sanitary risk to a recreational and environmental asset that has increased property values.

Conservation of wetlands and water sources

The wetlands spread across the city and are highly visible, making it relatively easy to raise public awareness about their status or conservation needs. Water sources, although they

surround the city, are out of public view so the public are less aware of their status so different strategies are needed to keep track of these natural habitats. The Bank ensured that financial resources were allocated separately for the conservation and management of wetlands and water sources. Despite the water supply and sewerage network's wide range of environmental impacts on the surrounding natural resources, EAAB—the management agency—lacked an environmental department to address and assess these problems. The project team helped the agency restructure its internal organization to add an Environmental Department to address and follow up on all pertinent issues.

Wetlands

Demarcation of wetlands does not, in itself, ensure the proper conservation of these ecosystems in the future. In fact, the different wetlands have varying ecological values. La Conejera, Juan Amarillo, Torca, Jaboque, and Santa María del Lago still support a high biodiversity of vertebrates (98 species in Conejera), particularly birds (42 species in Juan Amarillo), and invertebrates (26 species in Conejera). Several species are endemic, and some are threatened (e.g., a threatened mouse in Jaboque). Of all the wetlands, the Santa María del Lago wetland has the best water quality and La Vaca is rated with the lowest ecological value . with only a few remnant populations of birds, being mostly grassland. This heterogeneity throughout the systems called for specific studies on wetlands and management needs.

The ecological value of the different wetlands was assessed with the help of Conservation International (CI), a well-established NGO in the area with broad experience in conservation and management. With project funds, CI carried out the most extensive compilation to date of information and research specific to the wetlands of Bogotá. The result was a large-format book coordinated by CI and Bogotá's public Aqueduct and Sewer Company (EAAB) and funded by the Bank and other agencies. The book, "Los Humedales de Bogotá y la Sabana" (The Wetlands of Bogotá and the Savanna), includes the best collection of social and biological scientific knowledge as well as environmental management regarding these wetlands. The publication also serves as an assessment of cumulative impacts, and has become an invaluable reference tool for the public, management agencies, and NGOs.

Management Plans financed by project funds are being developed for Jaboque and La Conejera. NGOs play an important role in this process, coordinating efforts with EAAB. The Association for Social and Environmental Development (Asociación para el Desarrollo Social y Ambiental, ADESSA) is being funded to produce an Integrated Community Management Plan for the Recovery and Protection of the Jaboque Wetland, and the Fundación Humedal La Conejera was granted project funds to develop a plan to rehabilitate aquatic habitats within La Conejera wetland, protect endangered species, and strengthen the rational use of the wetland by the local community. The implementation of the environmental management plans for La Conejera and Jaboque will strengthen the protected areas and improve the health of the ecosystems associated with high mountain wetlands.

Public education and environmental awareness campaigns were carried out by EEAB during the project to increase the public's acceptance and appreciation of the importance of restoring ecosystem services as part of the city's water supply and sewage network. The project team also funded Fundación Alma, which is carrying out a 15-month-long participatory environmental and educational program for the Juan Amarillo wetland. In addition, educational displays explaining the recreational, economic, and ecological value of the wetlands have been posted at different sites throughout the linear parks and playgrounds.

Assigning the management plans and public education campaigns to different NGOs distributes the workload between different organizations, ensures that the wetlands receive adequate attention, makes better use of human resources, and creates a network of NGOs that can support and assist one another during document preparation.

Water sources

The low water quality in rivers and canals placed a higher demand on water sources, because 70 percent of the water consumed in the city must be of high quality for residential use. Additional threats to water sources were posed by illegal connections to the water supply system and by undetected leaks that increased demand.

Institutional strengthening: As part of this component the project team helped EAAB develop a comprehensive permanent program to reduce Unaccounted-for-Water (UFW) from 42 percent to 25 percent. The main causes were illegal connections, inaccurate consumer records, software tampering, and faulty meters. The rest was primarily caused by leaks in the distribution system and residential connections.

Capacity building: Although the project's engineering works were aimed at restoring the ecosystem functions of urban wetlands and bringing the water supply and sewerage network to full capacity, the project's institutional capacity building portion focused on the long-term strategic incorporation of ecosystems that provide water to the city (such as moorlands, wetlands, and mountain lakes). The water company will optimize the usage of water resources and infrastructure by enhancing its capability to assess and project the status of water sources for the city. These studies will provide reference points to keep city water usage within the limits of adjoining ecosystems' carrying capacity.

The water quality monitoring program has not yet been developed, although its goal is the design and implementation of an IT management system to monitor and verify organic matter and suspended solids entering and leaving the city's wastewater system. This would greatly enhance the water company's ability to track and manage water quality.

SUCCESSFUL STRATEGIES

The following strategies were key to maintaining high environmental standards throughout the project:

Architectural and engineering designs were aimed at restoring ecosystem services and reversing the degradation of natural habitats. By reestablishing lost connectivity among the various waterways and wetlands, reducing nutrient loads, and reconforming lost lakes and lagoons, the civil works greatly restored the ecosystems' flow capacity, as well as their capacity for nutrient assimilation and flood protection.

Involving NGOs throughout project: Different NGOs made important contributions at different project stages: CI compiled the latest information available on the wetlands; Fundación Alma launched an educational campaign; and ADESSA and Fundación La Conejera are currently developing management plans. This has fostered community involvement and leveraged resources in addition to those of EAAB and government agencies.

Scheduling construction activities according to natural population activities proved vital to protect the bird population from the harmful effects of disturbing the nesting season and nesting habitat.

Using urban landscaping for technical, ecological, recreational, and economic purposes. The case of Bogotá is unique in the extent to which landscaping was incorporated into project works. Going beyond requirements mandated by Bank policies or national guidelines, the proj-

ect funds and resources were used in a highly efficient manner to make the project footprint nonexistent. The project team made sure that no area used by the project was left without a landscape designed for specific activities. This included reforestation, recreational areas, playgrounds, and community spaces, and resulted in increased aesthetic value, public appreciation, and property values.

The environmental achievements of the Santa Fe I Water Supply and Sewerage Project were recognized by the Bank, which granted the 2003 Green Award to the project. This recognition demonstrates that infrastructure projects in Latin America can provide services and serve social functions while restoring natural habitats and increasing public appreciation for the services and goods that ecosystems provide.

Tocantins Sustainable Regional Development Project: conservation as desired land use

SUMMARY

This statewide project for sustainable development builds on a thorough assessment and mapping of natural resources, followed by strict zoning based on resource availability and the communities' interests, to select the 6,000 km of municipal roads to be improved. A key difference of the approach is the primary designation of conservation areas at state level as part of the zoning scheme. Roads are selected as a network, taking into account conservation priority areas. This is radically different from the classic road-by-road approach to environmental assessments and conservation. The project takes the best examples of outstanding land-use planning and includes large conservation areas as a desirable asset within the zoning plan. From a socioeconomic planning standpoint, innovation lies in strong community involvement; land use is matched with existing natural resources as well as the economic interests of communities and of local and state governments. In its final form, the road network will foster suitable economic activities and avoid conservation areas. The baseline studies will provide essential reference data to evaluate goals in the future and monitor resources.

BACKGROUND

The state of Tocantins, Brazil, has included the road network in a regional development project based on land management and ecological-economic zoning (EEZ) Recognizing that it is more than just a road improvement

project, Under the road portion of this project, about 6,000 km of municipal roads will be selected in a participatory manner and improved to all-weather conditions. Bridges and culverts will be (re)constructed and 120 km of high priority state feeder roads linking the main municipal networks to the state's primary transport network will be improved. More importantly, the environmental management portion will strengthen the state's land management by financing regional ecological-economic zoning, specific studies on sensitive ecosystems and biomes in need of protection, surface and ground water resources, and soil characteristics. The information provided by these studies will help match land use to existing resources. In turn, to match economic interests to resources, an extensive participatory process will involve the local civil society in the definition and monitoring of municipal and regional development agendas.

The project's EEZ relies on the recently completed agroecological zoning (AEZ), carried out under the State Highway Management Project. The AEZ consists of a set of maps that characterize the existing potential and restrictions for the use of the land. It represents an invaluable tool to carry out the EEZ, which seeks to reconcile the demands of economic development with the requirements for ecological conservation and optimal resource use. Table 1 below lists various examples of the thematic maps that are part of the agroecological and ecological-economic zoning.

The project's total required financing is US$100 million, of which the Bank is providing US$60 million. The ratio of works to environmental budgets is among the highest within the transport sector, with US$12.7 million devoted to environmental management, US$7.7 million to participatory planning and development, and the rest to rural transport improvement. The project has been active since December 2003 and is scheduled to close by the end of December 2009. The entire package will ultimately benefit the nearly 400,000 people living in the eastern half of the state of Tocantins (130,000 km^2), equivalent to one-third of the state's total population.

Table 1. Maps within the AEZ and EEZ

Agroecological Zoning	Ecological-Economic Zoning
Geological	State map
Geomorphological	Administrative regions
Pedology	Hydroelectric potential
Climate	Road network
Annual precipitation	Potential land use
Annual temperature	Conservation/limited use
Soil erosion	Tourist attractions
Topography	Digital atlas
Watersheds and basins	Geographical database
Potential flora	Ecological-economic
Land use/Land cover	
Agroecological	

The sustainable regional development project was conceived in coordination with the Natural Resources Policy Project under the Pilot Program to Conserve the Brazilian Rainforest and a proposed Rural Poverty Reduction Project.

NATURAL HABITAT ISSUES

The project benefits four regions in the eastern half of the state: Bico de Papagaio to the North, Goiatins-Pedro Afonso to the Northeast, Jalapão to the East, and Arrais, Dianópolis, Natividade, and Taguatinga to the Southeast. There are three dominant biomes, each facing different threats from inadequate land-use practices:

- The tropical rain forest (*floresta ombrofila aberta*), located in the transition zone between the humid plains of eastern Amazonia and the high plains of the Center-West cerrados.

Threats: The forest has been cleared in many areas and faces intense land conflicts. A key concern is soil degradation caused by unsustainable production, alteration of hydrological regimes, and clearing of remaining forests, including gallery forests. Despite this, it is still a source of extractive products such as babaçu nuts.

- The *cerrado* (particularly the cerrado savanna) dominates most of the central-eastern half of the state.

Threats: It used mostly for ranching. Lately it is also being used for agriculture, although this usually requires soil correction, suitable land forms, and sometimes irrigation.

- The gallery forests are found within the cerrados and isolated deciduous forest areas throughout the southeast.
  Threats: Clearing of the remaining patches of gallery forests is the most pressing threat.

Just as the degraded areas are of concern, so are the unique ecosystems found in the state. Several protected areas and indigenous lands are located in the project area. Eleven more conservation units have been proposed, six of which will be part of this project. Although there are no foreseen road improvement activities in these areas, some paving activities may occur in other potentially sensitive areas (as defined by the zoning) and thus the Natural Habitats Safeguard Policy (OP 4.04) applies to the project.

Matching land use and natural resources to local interests

Further degradation of natural habitats and unsustainable production are expected to halt through the improved land-use management. The project's ecological-economic zones are supported by a road network selected through a participatory process.

State road in Tocantins

The road network in context: Continuing its regional approach, the state will prioritize areas and select where road improvement is needed the most. The EEZ process has been designed around five goals:

- avoid critical habitats;
- match type and amount of natural resources to economic activities and levels of use;
- improve land-use and water resources management and monitoring;
- improve the institutional framework for environmental conservation; and
- prioritize municipal agendas, taking into consideration the communities' expectations.

The following are key actions related to these goals.

Avoiding critical habitats: The chapadas in Jalapão are a sand-dune landscape unique in the Brazilian cerrado which is home to rare and threatened Brazilian fauna. There are two integrated protection areas in the Jalapão region: the Ecological Station and Jalapão Park (875,000 ha total), and one restricted use area, the APA[14] do Jalapão (300,000 ha). No road improvement activities can take place in the

[14] APA: Environmentally Protected Areas

integrated protection areas and no activities are foreseen within the restricted use area. Together, these areas contain all environmentally sensitive habitats within the Jalapão region and protect about 30 percent of it. The road improvement activities also avoid all indigenous lands.

Safeguarding natural habitats: If a road section to be improved is located close to or through an area with a potentially fragile ecosystem, additional studies will be carried out so that the indirect impacts can be estimated and appropriate mitigation measures can be defined. These measures may involve land- and water-use restrictions, establishment of additional protected areas or modification of the project design and/or alignment, among others. The studies must be reviewed and approved by the Bank before the bidding of the corresponding road improvement activities is launched.

Matching resources to economic activities is similar to an auditing exercise on a region's natural resources, where the type of economic activities are matched to the type and quality of the resources available and to the intensity of development that a given area can sustain. This is particularly important with respect to hydrological resources, which often determine the sustainability of the level at which development (e.g., agriculture or population density) should be set. The EEZ for Tocantins is innovative because it incorporates hydrological and geological resources; it strengthens land-use and water resources monitoring, and guides future development programs.

Improved land-use and water management will result from compliance with the zoning scheme by ensuring that development will remain in accordance with the carrying capacity of local resources. Unplanned development can cause habitat fragmentation or increased settlement in wildlands. A poor choice of the sites to be developed would translate into a high environmental cost for a short-lived production area. For example, the northern region of Tocantins, at the point of transition to the Amazon biome and denser rain forest, is better suited to perennial crops. The sandy and dry region of Jalapão is thinly populated and has low potential for ranching or agriculture, making it more suitable for fruit production, ecosystem protection, and tourism. The southeast portion of the state is prone to soil erosion and the soil is not very fertile; thus, the area is better suited for ranching and limited agriculture in short rotations.

Incorporating communities' expectations into municipal agendas turns a traditionally top-down decision-making process into a grassroots process, greatly increasing the acceptance and chances of success. Highlights of this process are detailed below.

Roads with a plan: to serve local interests

Social data compiled for the EEZ will include location of human activities and living areas, heritage, cultural and archeological resources, and existing infrastructure.

The selection of state roads will be based on those that the municipalities and local communities perceive as the most important socially and economically. Other criteria are:

- the number of municipal roads connected to the regional road;
- the economic potential of adjacent zones; and
- the potential to attract traffic from other parts of the road network.

Public hearings will be held after the selection of each road section to address impacts on daily life and discuss measures to mitigate the potential adverse effects.

The main municipal networks will be defined by local development forums and the state

road administration in accordance with environmental criteria and socioeconomic relevance. When reviewed by the corresponding agencies, roads providing access to areas unsuitable for sustainable development will be eliminated.

Small-scale zoning will follow the municipal agendas drawn up in conjunction with the communities, ensuring that land management and economic development follow the interests of the local population as well. By involving the community, the state hopes to avoid land-use conflicts and illegal activities within conservation areas in the future.

Table 2. Proposed Conservation Units

Conservation Units	HA
Encontro das Águas	2,700
Barreira Branca	10,000
Serra do Bom Despacho	34,000
Serra das Caldas	52,000
Rio Palmeiras	56,000
Serra da Cangalha	59,000
Serra Grande	62,000
Ribeirão Tranqueira	71,000
Serra dos Arraios	102,000
Serra do Mumbuca	146,000
Água Morna	322,000
Total	**916,700**

Conservation as a specific land use

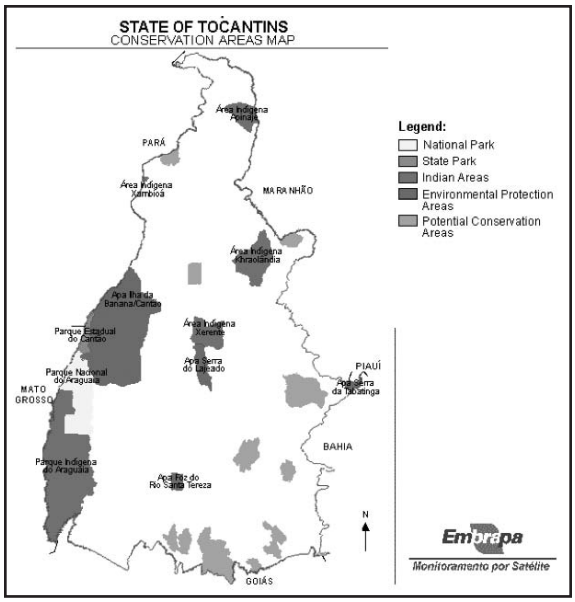
The current land-related conflicts in the state stem from inadequate use of natural habitats: unsustainable production, soil erosion, unplanned clearing and limited supervision of conservation areas with subsequent illegal settlement, hunting, and fishing. Recognizing the need to secure land unaffected by clearing and other land-use changes, the state government set a short-term goal of protecting at least 10 percent of the state territory to preserve biodiversity, protect ecosystems, and promote the conservation of natural resources. Currently the state as a whole has 2,750,000 ha within 11 conservation units and an additional 857,000 ha under federal jurisdiction.

The regional approach of the AEZ and the EEZ facilitated the identification of further areas that need protection, with the added advantage that it allowed for larger expanses of land to be considered for conservation purposes rather than what would be typical under a road-by-road approach.

Conservation as a primary land use: Within the EEZ, areas devoted to economic growth lie outside critical habitats. A set of criteria to ensure that the decision-making process will comply with the recommended land use, is being developed. The system of protected areas is aimed at rehabilitating and preserving sensitive ecosystems.

Increasing protected areas: One of the outcomes of the AEZ was the identification of areas that should be protected. Eleven potential new conservation units totaling 917,000 ha are currently under evaluation (see Table 2); the six deemed most urgent will be implemented under the project, adding some 214,000 to 762,000 ha (5–20 percent) to the current system. This portion of the project is carried out in coordination with the *Programa Nacional de Biodiversidade* funded by the GEF. It is also worth noting that in this case the conservation units are desirable, not a compensatory or mandatory measure according to Bank policies.

Conserving biodiversity hotspots Despite the cerrados' importance for biodiversity conservation, few existing conservation units are located within this biome. Several of the largest conservation units proposed are located in the cerrados as well as within the gallery forests, another biome in great need of protection.



Map of current and potential conservation areas in Tocantins

Increasing community and government awareness of conservation areas: Although the project does not have a public education campaign, it draws the attention of state and federal agencies to those areas deemed important for conservation. At the community level, the hearings and forums will raise awareness within the community not only of those areas that the community wants to conserve, but also of those that other communities want to protect and those identified as important during the zoning.

SUCCESSFUL STRATEGIES

The regional approach was essential to the project. Many of its components, although desirable and positive at a smaller scale, would not show the same results if carried out in an isolated manner. The regional approach is vital to homogenize the zoning methodology, data collection, and road selection process that will ultimately still allow small-scale dynamics to guide local actions throughout the entire state.

The project is proactive in nature. It has three levels of protection against unwanted changes in land use within natural habitats. The first two are the zoning plan, and the enforcement of boundaries in the protected areas, and the third level of protection is that offered by the community. Since the municipal agendas and preferred economic activities will be drawn up in conjunction with the communities, zone uses are expected to enjoy strong local support.

Optimal improvement of the road network. Designating areas in advance for specific economic activities means that financial and infrastructure resources can be allocated to best serve current needs. The road network thus becomes the backbone to support state and municipal agendas.

Steering municipal agendas through local forums guarantees an open dialogue between government agencies and the communities. The transparency and participatory nature of the process will minimize future conflicts among users regarding the nature of projects or development of economic activities within each zone. This promotes urban growth toward areas that will have a complete infrastructure network and reduces illegal resource exploitation within the designated conservation areas.

Birds in Tocantins, Photo: Tocantins Government

The Tocantins Sustainable Regional Development Project is one of the best examples of how lessons learned in other projects can be successfully applied to best address infrastructure and natural habitat conservation needs. It goes beyond compliance with local environmental laws and Bank policies, creating new regulations and bringing net benefits to the natural habitats. Its statewide approach allows for optimal allocation of resources to foster economic growth. Equally important, it allows statewide identification and prioritization of those natural resources that need to be protected.

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