

**THE KEY ROLE OF SPECIFIC LANDS IN THE PANAMA CANAL AREA  
IN PRESERVING THE VALUE OF PANAMA'S NATURAL HERITAGE**

A REPORT OF THE PARTNERS IN FLIGHT INTERNATIONAL WORKING GROUP  
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## EXECUTIVE SUMMARY

Panama's diverse natural habitats have worldwide significance by providing a biological link for neotropical migratory birds between North and South America. The biological integrity of Panama's flora and fauna and their respective habitats is crucial to the migration, wintering, and survival of birds throughout the Western Hemisphere, as well as to the maintenance of very rich and diverse resident Panamanian bird populations.

Economic and biological concerns strongly indicate the need to protect critical portions of the Panama Canal's West Bank. These West Bank areas, called here the Atlantic Ecological Zone, the Mid Canal Ecological Zone, and the Pacific Ecological Zone, form a moisture-gradient continuum that, in conjunction with variations in soil type and geology, produce a tremendous habitat diversity supporting an extraordinary array of plant and animals communities. These zones, if managed properly, will continue to maintain the unique biological integrity of the Canal area and will provide an important and increasing contribution to Panama's economic future.

Much of these valuable lands are located on land currently managed by the U.S. Department of Defense (DoD). In an effort to address the significance of these areas to neotropical migratory birds, a meeting of the Partners in Flight International Working Group was held on 14 and 15 March 1996 in Panama City. The Working Group meeting was sponsored by the DoD Partners in Flight Program in support of the Neotropical Migratory Bird Conservation Program.

The primary focus of the Working Group was the importance of the DoD lands in the Panama Canal area for neotropical migratory and resident birds, flora, and other fauna. The Working Group concluded that the zones identified in this document have great economic and conservation potential and that additional Working Group meetings should be conducted to help determine specific sites for conservation and ecotourism.

The Working Group is hopeful that the conclusions formulated in this document, broad as they are, will be utilized by current DoD decision-makers to continue to conserve these valuable areas and eventually be used for ecotourism ventures to stimulate economic potential with low-impact land uses. The Working Group is also optimistic that a dialogue will continue, through the Partners in Flight Program, to provide a forum from which the Autoridad de la Region Interoceanica (ARI) and the Instituto Nacional de Recursos Naturales Renovables (INRENARE) will continue to work with other groups to refine recommendations for the conservation of the Panama Canal area after DoD lands revert to the Republic of Panama.

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Joe Hautzenroder  
DoD Partners in Flight Coordinator, 11 April 1996

## INTRODUCTION

### Background

In 1990, the National Fish and Wildlife Foundation initiated the Neotropical Migratory Bird Conservation Program, a domestic and international initiative for the conservation of neotropical migratory birds. Since then, the program has developed into what is better known as the "Partners in Flight-Aves de las Americas Program" with over 110 Federal and State agencies and nongovernmental organizations throughout North, Central, and South America cooperating in the conservation and management of neotropical migratory birds and their habitat. Neotropical migratory birds are those species whose survival is dependent on international/seasonal migrations. Over 360 such bird species breed in the United States or Canada and migrate south to the tropical regions of Mexico, the Caribbean, Central America, and South America for the winter.

The U.S. Department of Defense (DoD) is one of the key supporters in the Partners in Flight initiative. Millions of hectares of land on hundreds of military installations throughout the Western Hemisphere provide neotropical migratory birds with breeding, stopover and feeding areas. Some of the most valuable and important land for neotropical migratory birds is found on DoD land holdings along the West Bank of the Panama Canal.

The process of identification of habitats, and the evaluation and inventory of flora and fauna of DoD lands in the Panama Canal area began in 1992 by Asociación Nacional para la Conservación de la Naturaleza (ANCON) and The Nature Conservancy (TNC) as part of a project funded by the DoD Legacy Natural Resource Management Program (ANCON and TNC 1995, In preparation a, In preparation b). In 1994, the Smithsonian Tropical Research Institute (STRI), in conjunction with the Smithsonian Migratory Bird Center and Illinois Natural History Survey, initiated a long-term monitoring program for migratory and resident bird populations, also funded by the DoD Legacy Program (Angehr et al. 1996). These Legacy projects have provided much of the information used to generate this report.

In this report, we refer to the three areas under discussion as the Atlantic Ecological Zone, the Mid Canal Ecological Zone, and the Pacific Ecological Zone (Figures 1-3). The term "zone" herein is an ecological term, "an area characterized by distinct physical conditions and populated by communities of certain kinds of organisms" (Morris 1973), and should not be confused with the "zone" of the Former Canal Zone. These zones are located along the West Bank of the Panama Canal. At present, the West Bank is composed of a combination of reverted lands, DoD bases, and Canal operating areas, and the Republic of Panama has not yet decided on the long-term use of these areas. The Atlantic Ecological Zone includes the area northwest of Gatun Lake on the Atlantic slope (Fort Sherman, Piña Range), the Mid Canal Ecological Zone includes the Gatun watershed south of the lake (Balboa West Range,

Empire Range), and the Pacific Ecological Zone includes the area south of the continental divide to the Pacific Ocean (U.S. Ammunition Depot, Howard Air Force Base, Rodman Naval Station, Fort Kobbe).

## Objectives

The objectives of this report are to elaborate on the issues discussed in the Working Group meeting of 14-15 March 1996 and to provide additional information regarding the status and value of these Panama Canal areas to help the DoD prepare for the transfer of these areas to, and associated consultations with, the Republic of Panama in accordance with the 1977 Panama Canal Treaty.

## VALUES OF THE ECOLOGICAL ZONES

### Economic Values

Economists now realize that forests and other natural habitats provide ecological "services" whose value often has not been taken into account or mistakenly has been undervalued when land use decisions are made. Failure to conduct a thorough cost-benefit analysis, which includes the valuation of ecological services, may result in net short- and long-term economic losses to a country if these services are lost through development (Ticknor 1992, Young 1992). Economic valuation is certainly warranted in the case of a biologically rich area such as the West Bank of the Panama Canal. This valuation should include both current and future value, plus the impact if the services are lost or degraded. For the Panama Canal area, the importance of water quality for domestic water supplies and for hydroelectric power, and the monetary value associated with the beauty of forested hills to the owners of homes and businesses, must also be considered. All impacts, not simply economic effects, should be considered. Such a valuation would include identification of the relevant ecological services, an assessment of the economic and social importance of these services, and a quantification of the economic value of the services. As stated by Repetto et al. (1989; cited in Panayotou and Ashton 1992), "A country could exhaust its mineral resources, cut down its forests, erode its soils, pollute its aquifers, and hunt its wildlife and fisheries to extinction, but measured income would not be affected as these assets disappeared." The valuation also should take into account the impact of resource degradation to various groups with vested interests in the land base, including the public sector (government), private sector (business), non-governmental organizations, local people, and the scientific community.

In this section we describe some of the economic values of managing the zones of the West Bank as natural areas, as opposed to converting them to other land uses. This discussion is not meant to be exhaustive, but simply to introduce some of the relevant issues.

## Ecotourism

In PATA (1995), a survey of North American tour operators, rainforest was the chosen ecosystem for 62% of their customers, and 71% identified Central and South America as their preferred destinations. The top five motivations for travel were to: 1) see undisturbed natural areas; 2) learn about nature; 3) visit tropical forests; 4) watch birds; and 5) photograph landscapes and wildlife. The West Bank of the Canal meets all of the above preferences. An advantage of ecotourism is that it typically distributes economic benefits to rural and urban residents, whereas traditional tourism usually benefits only urban areas.

During 1994, approximately 700,400 ecotourists visited Costa Rica, each spending an average of \$85 per day for 1-2 days. Consequently, these foreign visitors brought approximately \$60-100 million to Costa Rica that year alone (ICT 1995; L. Ferrate, Banco Interamericano de Desarrollo, Costa Rica, personal communication). The natural areas on the West Bank of the Panama Canal are more accessible than those of Costa Rica, and are some of the most easily accessible tropical forests in the world, because of the close proximity of airports in Panama City. Therefore, ecotourism in Panama could be developed quickly. The first ecotourist activity to be carried out by a Panamanian company in lands presently managed and under the exclusive control of the DoD will commence during April 1996 by Adventure Panamá (J. Romero, Adventure Panamá, personal communication). There are many opportunities for similar tours in DoD lands now and after these lands revert to the Republic of Panama. In addition, the Canal itself is readily available for increased tourist use, and Lake Gatun, the Chagres River, and adjoining waterways provide excellent sport-fishing.

Sustainable, long-term ecotourism necessitates careful preservation of natural areas and wildlife. Conservation-based ecotourism, such as is done by Costa Rica Expeditions (at Monte Verde, Tortu Guero, and Corcovado) and Maho Bay Tent Camp in the U.S. Virgin Islands, and is planned by Eco-tours de Panamá for the Lake Gatun area (P. LeSar, Eco-tours de Panamá, personal communication), is necessary to ensure the long-term viability of the natural resources, especially birds and other wildlife, that draw tourists from around the world.

All three of the Ecological Zones have exceptional value for the development of ecotourism. In the Atlantic Zone, examples include: 1) Achote Road, one of the premier birding localities in central Panama; 2) two trails located in southern Fort Sherman that offer easy foot travel; 3) the Chagres River, which provides boating, birding, and fishing; 4) Fort San Lorenzo, which provides a picturesque and spectacular historical attraction; and 5) the coast west of Fort Sherman, which contains fringing coral reefs and several small, secluded beaches. The system of gravel roads in the Mid Canal Ecological Zone allows excellent access; Road K-19 in particular provides a very scenic drive. Due to its proximity to Panama City, the potential for ecotourism in the Pacific Ecological Zone is

extremely high, especially for short day trips. In addition, the more open structure of the drier forests in this area typically allows wildlife to be seen more readily.

### Scientific Research

The Panama Canal area, including the Ecological Zones of the West Bank, is of global importance to scientific research. A major factor in attracting scientists to work in the area is the availability of a long-term database for the area, longer than that for virtually any other area in the tropics. The STRI research station on Barro Colorado Island, established in 1924, is today the most intensively studied tropical forest in the world. STRI alone spends more than \$20 million annually in the Republic of Panama, and employs more than 150 Panamanian staff. Approximately two-thirds of STRI's research program focuses on tropical forests and depends on the continued availability of an extensive tropical forest ecosystem in the Canal Area. Additional funds also are spent by more than 400 scientific visitors to STRI each year, and many other projects carried out by researchers affiliated with foreign universities and by local conservation groups. Consequently, the overall economic contribution derived by scientific investigations from all international sources is estimated to exceed \$45 million annually (G. Meier, GEMInternational, personal communication).

The extremely steep rainfall gradient across the isthmus (see below) is another major attraction for scientific researchers, because it offers access to a wide range of environmental conditions within a few hours' drive. A case in point is STRI's tropical forest canopy research program, a flagship project of the United Nations Environment Program. Using a tower construction crane, STRI scientists have been carrying out an intensive program of canopy research in dry forest in Panama City's Metropolitan Park since 1991. With funds provided by Denmark, STRI plans to set up a second crane in wet forest in the Fort Sherman area to provide comparative data on forest function under different rainfall regimes. STRI also eventually plans to establish a canopy crane in dry forest in the current Rodman Naval Station area.

Under the DoD Legacy Resource Management Program, STRI also recently initiated a long-term monitoring program for forests and birds on the West Bank, with sites on both the Atlantic and Pacific slopes (Angehr et al. 1996). Although the initial project period is four years, STRI expects to extend this monitoring program indefinitely if funding can be secured.

### Non-timber Forest Products

Non-timber forest products include nuts, spices, medicinal products, condiments, and cord. Sales of non-timber forest products total several billion U.S. dollars in international trade annually (de Beer 1990; cited in Panayotou and Ashton 1992). Harvesting these products usually differs from harvesting timber by: having shorter harvest cycles and higher monetary value per unit weight; being more labor intensive (thereby supplying more jobs to local people) and generally less destructive ecologically; and

requiring smaller capital investment (Panayotou and Ashton 1992). These products are renewable resources that may be collected on a sustainable basis which, over time, can produce more revenue than timber (Peters et al. 1989). Examples of annual revenues range from \$200 per ha in western Amazonia to \$3,327 for medicinal plants alone in an area of Belize (Godoy and Lubowski 1991; cited in Panayotou and Ashton 1992).

Local people living in communities immediately outside the Canal Area make use of a variety of forest resources. Aguilar and Condit (1995) found that people of the small farming community of Las Pavas, adjacent to the Canal Area, use at least 119 non-cultivated plant species found in nearby forests, including 108 tree species. Uses included construction materials (71 species), fruits for human consumption (40), fibers (13), and medicinal plants (8). Some people from these communities also hunt legally and illegally for subsistence and for market.

Some of this harvest of wild products, particularly hunting, is probably unsustainable over the long term and incompatible with the conservation of biodiversity in the area. However, it is probable that sustainable harvest regimes could be developed for some of these products, and that local people would be able to benefit by the creation of multiple-use "extractive reserves" in parts of the area. One of the major threats to biodiversity in the Canal Area is deforestation due to the use of "slash-and-burn" agricultural systems. Despite its unsustainability, many local people continue to rely on this system because of the lack of alternatives. Conservation of forests in the area in the long-term will depend largely on offering local people some economic stake in its continued preservation. Alternatives include employing local people as ecotourism guides, in reforestation projects (see below), and in industries supporting ecotourism and research activities.

### Biodiversity Prospecting

A multitude of species found in tropical forests produce a tremendous diversity of biochemical compounds, many of which may have significant medicinal (Gupta 1995) or industrial uses. Surveys for such useful compounds are an area of increasing interest for pharmaceutical companies and other industrial firms. Reid et al. (1993) list 21 companies active in plant and other natural product collection and screening. One of the most publicized programs was one initiated by Merck & Co., Ltd. in 1991. Merck provided more than \$1 million to Costa Rica's biodiversity institute, INBio, in return for which INBio is providing chemical extracts from plants, insects, and micro-organisms from protected areas for testing by Merck. Merck also agreed to provide royalties on any commercially useful products discovered. The economic value of biodiversity was a major focus of the United Nations Convention on Biological Diversity signed in Rio de Janeiro in 1992.

Canal Area forests are particularly attractive for such biodiversity prospecting because they offer high biodiversity in close proximity to excellent laboratory facilities. At least two prospecting efforts already

have been initiated in Panama. One, financed by the U.S. National Institutes of Health and carried out in cooperation with the Instituto Nacional de Recursos Naturales Renovables (INRENARE), researchers from the University of Utah, University of Panama, and Gorgas Memorial Laboratory are assaying plant samples collected at the STRI's Barro Colorado Island field station. In another, STRI is working with the Sandoz Corporation and INRENARE on assays of fungi, including those which live on the leaves of tropical forest trees.

### Reforestation and Carbon Sequestration

Given the very limited agricultural production capacity, the susceptibility to erosion of soils of the Canal Area (see below), and the need to provide a reliable water supply for the Canal Watershed, the optimal land-use for the area is likely to be as forest. Much of the area within two kilometers of the former Canal Zone boundary in the central and southern portions of the isthmus has been deforested. Reforestation of this area, such as is proposed by Autoridad de la Region Interoceanica (ARI), would protect the Canal watershed, enhance the biodiversity values of the West Bank, and provide much needed employment. For example, UNTAC (1996) estimates that concessionaires would pay approximately \$147,000 annually to reforest only 3,500 ha and would employ 3,000 temporary employees and 850 permanent employees.

The Republic of Panama recently has passed a law providing financial incentives for reforestation, which has increased interest on the part of both industrial foresters and small investors. STRI, INRENARE, ANCON, and other organizations have carried out extensive field trials of native and exotic tree species for use in the area. Condit et al. (1996) recently provided detailed recommendations for reforestation projects in the Canal watershed, including lists of suitable native and exotic species.

One potential source of funding for reforestation efforts is for "carbon sequestration" projects sponsored by power companies and other utilities. The increase in atmospheric carbon dioxide, produced by the burning of fossil fuels and by deforestation, is recognized as a major contributor to global warming and other detrimental environmental effects. The United Nations Global Warming Convention signed in Rio de Janeiro in 1992 recommends the reduction of emissions of carbon dioxide and other "greenhouse" gases. As an alternative to reducing emissions, some major producers of carbon dioxide such as power companies are looking into the possibility of financing reforestation projects as a means to offset or mitigate their own burning of fossil fuels. Forestry projects in the tropics may be particularly attractive because of the high growth rates and consequent high fixation of carbon that can be achieved with some species. Mitigation efforts could potentially also include funding for conservation programs to forestall additional tropical deforestation.

## Ecological Values

### All Ecological Zones

#### Overview

The unique ecological value of the West Bank of the Canal results from three complementary characteristics:

- 1) the geographic location of the isthmus as the crucial hemispheric connection for North and South America and a funnelling point for the migration of hundreds of species of migratory birds;
- 2) the rainfall gradient across the isthmus from 1,500 mm (60 in) with a 129-day dry season on the Pacific side to more than 3,000 mm (120 in) with a 102-day dry season on the Atlantic side (IGNTG 1988) within only 80 km (50 m); and
- 3) the large, relatively unfragmented blocks of diverse habitats.

The Canal's three Ecological Zones are particularly important for migrating birds because they are the only lowland areas in central Panama allowing a stopover between Chiriqui and Darién, particularly on the Pacific slope. At least 120 species of the 565 species known from the immediate Canal Area are regular migrants that breed in North America. Complete censuses of the plants and animals in these zones have not been carried out, but specific inventories in certain areas indicate the tremendous biodiversity. For example, a total of 1,369 species of vascular plants, 390 birds, 100 mammals, and 90 reptiles are known from Barro Colorado Island alone. The combined total of birds observed on Barro Colorado Island and the Pipeline Road, which approximates the total for the Mid Canal Zone, represents 450 species. The National Audubon Society sponsors annual Christmas Bird Counts, which are 24-hour counts of all birds seen or heard within a 15-mile circle, taken within the time period of 10 days before or after Christmas. The 20-year averages for the bird species observed during these counts for the Atlantic, Mid Canal, and Pacific Zones, which can be used as an index to the relative numbers in these areas, are 342, 277, and 303, respectively. The larger numbers of birds observed in the coastal areas is due to the presence of ocean birds, especially shorebirds (G. Angehr, STRI, personal communication). Throughout other portions of the western hemisphere, Christmas Bird Count stations average only about 80 species per station. Of the 1,850 stations throughout the western hemisphere, the Atlantic Zone typically has the highest number of species each year, and holds the record count (357 species) for all stations for any year (G. LeBaron, National Audubon Society, personal communication).

The Ecological Zones on the West Bank contain some unique habitats not represented in protected areas on the East Bank (e.g., Camino de Cruces National Park, Soberanía National Park), and many of their species are protected by specific laws (Table 1).

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Table 1. Numbers of species protected by the United States Endangered Species Act (US ESA), Panamanian law, and the Convention on the International Trade of Endangered Species (CITES)

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	Atlantic Zone	Mid Canal Zone	Pacific Zone
US ESA	4	4	3
Panama Law	18	10	12
CITES	70	36	34

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#### Large, Undivided, Diverse-habitat Areas

Large, undivided, diverse-habitat areas like these Ecological Zones permit larger populations and greater diversity of animal and plant species than do smaller areas. Bird populations in larger blocks of good habitat are more resistant to local extirpation (MacArthur and Wilson 1967; Robinson et al. 1995; Stouffer and Bierregaard 1995). Substantial evidence exists that reducing the size of a block of forest, or isolating it from adjacent forests (fragmentation) will result in the loss of local biodiversity (Quijano 1992). If a population in a block becomes extinct, due to a drought or other temporary condition, isolation may prevent the species from recolonizing later from other forested areas where it still occurs (Morton 1978, Wright 1985).

One of the best empirical examples of local extirpation due to habitat isolation or fragmentation is found on Barro Colorado Island in the Canal Area. Barro Colorado became isolated from other forests when the Chagres River was dammed to form Lake Gatun in 1913. In one area, only about 500m of water separates the island from the mainland. Detailed study of the island's avifauna began in 1925. Since then, at least 16 birds characteristic of mature forest have become extinct on the island (Willis 1974, Willis and Eisenmann 1979). Another 50 species found in mature forest on the nearby mainland also are absent from the island, and may have disappeared between 1913 and 1925, before detailed records were kept (Karr 1982). (In addition to these birds of mature forest, Barro Colorado has also lost more than 30 species of second-growth forest birds as the forest on the island matured.)

These effects also may be occurring on a wider scale. Several species of birds that formerly occurred in the Canal Area appear to have disappeared from the Canal Area after the 1982-83 El Niño drought (D. Engleman, Panama Audubon Society, personal observation; G. Angehr, STRI, personal observation). Due to local deforestation, these species may have been unable to recolonize in subsequent years from neighboring areas where they still persist.

A major factor in these local extirpations appears to be the reluctance of many mature-forest birds to cross even small non-forest gaps. This is especially true of birds of the dim forest understory which rarely venture into full sunlight. Karr (1982) found that understory birds were much more likely to have become extinct on Barro Colorado than other groups of birds. In contrast, no canopy birds have become extinct on the island, because such birds usually fly freely across open areas. In an experimental study of forest fragmentation in the Brazilian Amazon, Bierregaard et al. (1992) found that a gap of as little as 80 meters could inhibit substantially the frequency of dispersal of many species between a fragment and nearby continuous forest.

Beginning in the 1960s, long-term studies in Soberanía National Park have identified other factors that may be important for the local survival of bird populations. In particular, certain species migrate seasonally between dry and wet sites, or between different vegetation types (Karr and Freemark 1983). Long-term survival of these species may require that they have access to a full range of habitat types. As a case in point, some of the extirpations on Barro Colorado may be due to the fact that the island lacks a stream containing water throughout the dry season, and these birds would not cross the open water surrounding the island to other forests with year-round streams (Karr 1982).

Fragmentation may have even more severe effects on groups of animals such as mammals, reptiles, and amphibians which are less mobile than birds. Fragmentation also may have detrimental effects on plants, especially if it prevents the free movement of pollinators or seed dispersers, or contributes to the extirpation of these pollinators or seed dispersers.

#### Soil Conservation

Preserving the value of the lands on the West Bank of the Canal is dependent on conserving its soils. In general, these soils are fragile and of very limited capacity for agricultural development. Soil categories presented in IGNTG (1988) classify types I-IV as arable (with I having some limitations and IV having severe limitations on plants suitable for cultivation and requiring careful management) and types V-VIII as not arable (with increasingly stringent limitations). Most of the soils in the Mid Canal and Pacific Ecological Zones are in categories VI and VII, with limited amounts in class IV. In the Atlantic Ecological Zone, most soils are classed in categories IV and VIII, with limited of categories III and V (IGNTG 1988).

Much of the Panama Canal area receives heavy rainfall. This occurs in brief, concentrated downpours that have tremendous erosion potential. The actual rate of erosion, however, depends in large part on the nature of the vegetative cover of the soil. Isaza (1986) offered the following figures for the Canal Area for the "C factor" used in calculating erosion rates under different vegetation types: primary forest = 0.00016; secondary forest = 0.001; scrub = 0.003; pasture = 0.0182. These figures indicate that, all other factors being equal, soil loss from pasture will be approximately 100 times greater than from primary forest. In addition, since much of the remaining forest in the Canal Watershed is on steeper slopes, the rate of soil loss could be extreme if these areas were logged. Isaza's figures for the Canal Watershed indicate an average soil loss of 2.4 metric tons/hectare/year from primary forest; 38.4 tons/ha/year from scrub; and 166.8 tons/ha/year from pasture. As stated in Alvarado (1985:8), "erosion rates will vary in direct proportion to the deforestation rate."

Most of the Mid Canal Ecological Zone and much of the Pacific Ecological Zone lie within the Lake Gatun Watershed, therefore serving the critical function of protecting the soils from eroding into the Canal, but only if these areas remain forested.

### Specific Ecological Zones

#### Atlantic Ecological Zone

In the Atlantic Ecological Zone (12,098 ha), the large number of vegetation types, their juxtaposition, and their relatively undisturbed condition support remarkable biological diversity. This zone includes the only remaining sizeable block of Atlantic wet forest in the immediate Canal Area, although similar forests can be found further along the coast to the east and west. This Zone includes large patches of forest as much as 500 years of age totalling approximately 550 ha (ANCON and TNC 1995, In preparation b) and deciduous forest (Figure 1, "Evergreen seasonal tall forest" and "Deciduous forest", respectively), ecosystems that are disappearing throughout Central America. It is possible that much of this deciduous forest is also very old, judging from the height of the trees and the diameters of their crowns (ANCON and TNC 1995, In preparation b). In addition, there are extensive areas of swamp forest on poorly drained soils along the Chagres River and around the Mojinga Swamp, a freshwater wetland. Several mangrove areas occur along the coast. Of particular biological value is the coastal area immediately south of the Ft. Sherman housing area, where most of these different vegetation types occur in close proximity.

#### Mid Canal Ecological Zone

Much of the forest in the Mid Canal Ecological Zone (2,281 ha) is relatively young, although there are some patches of forest possibly more than 500 years of age totalling approximately 360 ha (ANCON and TNC 1995, In preparation a) (Figure 2, "Evergreen seasonal tall forest"). This Zone is extremely

important by providing a biological link between the drier Pacific habitats and the wetter Atlantic habitats, and it contains high biodiversity in its own right. Most of this Zone lies within the Lake Gatun watershed. If these areas remain forested, they will continue to serve the critical function of protecting the soils from eroding into the Canal area.

### Pacific Ecological Zone

The primary conservation value of the Pacific Ecological Zone (6,780 ha) is that its drier forests represent a distinctive and critically endangered forest type within the larger Central American region (Murphy and Lugo 1986) (Figure 3, "Deciduous forest"). Virtually all the dry forests of the entire Pacific Slope of Central America have been cleared for agriculture. Dry forest in the Canal Area is one of the largest remaining patches of dry forest in the region, and is the most significant such forest patch between Darién Province, Panama, and Guanacaste National Park, Costa Rica. In addition, this Zone contains about 28 ha of old growth trees (ANCON and TNC 1995, In preparation a), marsh, which is an endangered habitat type in the area, as well as mangroves and mudflats, all of which support a very wide variety of resident and migratory birds.

### Cultural Values

The Canal Area appears to have supported a fairly dense indigenous population before the arrival of the Spanish in the early 1500s, when it began to be used as a major international trade route. A number of Precolumbian archaeological sites are known on the West Bank. The most significant of these is at Venado Beach, presently in Howard Air Force Base, which is linked to the Conte culture centered in Coclé Province (Sander and Mitchell 1960). Additional excavations were made on Engineer's Hill and other sites approximately 20 years ago, but these areas have not received detailed study. Systematic archaeological surveys of most of the West Bank have not been made, but probably would yield additional Precolumbian sites.

The most significant colonial site on the West Bank is Fort San Lorenzo, situated on a promontory overlooking the mouth of the Chagres River. The first fort was built on this site in the late 1500s, by the command of Phillip II of Spain, to defend the wealth of gold and silver from Peru that crossed the isthmus each year. After an heroic defense by the Spanish garrison, the fort was captured and burned in 1670 by an advance party of the English pirate Henry Morgan. Morgan then went on to sack and destroy Panama City. The fort was destroyed completely by the English Admiral Vernon in 1740, but was rebuilt by the Spanish in 1752.

There were a number of significant colonial-era settlements along the Chagres River trade route. On the West Bank, these included the towns of Chagres, near Fort San Lorenzo (Webster 1971), and Bailamonos Bohio, located in the present Balboa West Range. During the U.S. canal-building era, a

number of towns were established along the construction route, notably Empire on the west side of the Gaillard Cut. With the completion of the canal, these towns were demolished (or drowned) and their inhabitants were relocated. Cooke (1984) considered the Canal Area to be a priority area for salvage archaeology, due to the presence of Precolumbian, colonial, and post-colonial remains and to its proximity to a major urban area.

## CONCLUSIONS

- Economic and biological concerns strongly indicate the need to protect critical portions of the Panama Canal's West Bank. These natural areas have worldwide significance by providing a biological link for neotropical migratory birds between North and South America as well as habitat for some of the world's richest and most diverse resident bird populations.
- It is critical that future decision makers assess the "ecological services" that the forests and other habitats provide.
- The development of ecotourism can be accomplished on a sustainable basis and provides significant revenue and local employment opportunities, but is dependent on the continued preservation of the natural areas delineated in this report.
- The unique attributes of the area are major attractions to scientists worldwide, generating significant revenue and local employment.
- Harvesting of non-timber forest products can be sustainable in the long-term, and can provide local jobs and competitive revenues.
- The Canal Area forests and other associated habitats are particularly attractive for "biodiversity prospecting" due to the multitude of flora and tremendous diversity of biochemical compounds with potential for medical and industrial uses. In addition, significant revenue and local employment can be generated by leases to pharmaceutical companies and other industrial firms, reforestation, and carbon sequestration.
- The unique ecological value of the West Bank of the Canal for migratory and resident birds and other wildlife results from three complementary characteristics: 1) its geographic location and the crucial hemispheric connection and funnelling point for millions of neotropical birds that migrate between North and South America.; 2) its rainfall gradient; and 3) its large, relatively unfragmented blocks of diverse habitats.
- Large undivided forest areas, such as those delineated in this document, permit larger populations and greater diversity of flora and fauna than do smaller areas. In addition, these larger areas are more resistant to local extirpations of associated species. Forest fragmentation adversely affects the long-term survival of bird species sensitive to light and therefore reluctant to cross even small nonforested gaps. Fragmentation may have similar or even more severe effects on less mobile mammals, reptiles, and amphibians.

- Protection of these large Zones is important to permit the survival of many species that otherwise would decline or become extinct in the Canal area.
- The soils on the West Bank of the Canal are relatively fragile, have a very limited capacity for agricultural development, and are subject to severe erosion. Maintenance of these areas as forest will promote soil conservation and protect the Canal from increased siltation.
- The three Ecological Zones encompass the complete range of habitats and wildlife in the Canal area. In addition, individual Zones have unique ecological attributes such as old growth forests and drier deciduous forests that are rare in Central America and warrant protection.
- The Zones include many Precolumbian and historic sites that foster tourism and deserve protection. Fort San Lorenzo, situated on a promontory overlooking the mouth of the Chagres River, is one of the most significant colonial sites on the Canal's West Bank.

## SUMMARY

The undeveloped lands along the West Bank of the Panama Canal are unique and valuable natural and cultural resources for the western hemisphere and for Panama for a variety of reasons, including: 1) providing a biological link between North and South America for neotropical migratory birds; 2) maintaining biodiversity, especially its extremely rich resident and migratory bird populations; 3) preserving water quality and erosion control for the Canal watershed; and 4) developing significant and sustainable revenues from ecotourism, scientific research, non-timber forest products, biodiversity prospecting, reforestation, and carbon sequestration. To manage these zones to achieve all of these potential uses, it is important to consider that the ecological and economic values of these forests are enhanced when forests are maintained in the largest blocks possible, and isolation of forest tracts from one another by roads, agricultural fields, etc. is minimized. Although the entire continuum from wet Atlantic forests to drier Pacific forests are important in maintaining biodiversity, the two extremes are the most critical for biodiversity within this region. Wet forests support high biodiversity and many endemic species. Dry forests in the area include some of the last remaining tracts of that habitat in all of Central America and represent a unique biological community type that is severely threatened regionally. Reduction and fragmentation of forests on the Canal's West Bank could degrade seriously the ecological value of those forests for wildlife. Responsible management of these forests would include retaining the largest tracts possible, with minimal isolation of those tracts from one another. Implementation of these ideas will promote healthy populations of migratory and resident bird populations as well as other fauna and flora.

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