United States
Department of
Agriculture

Forest Service

**International Institute
of Tropical Forestry**

General Technical
Report IITF-25

The San Lorenzo Protected Area:

A Summary of Cultural and Natural Resources

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Cover photo: *Fort Sherman, begun in 1911, remained heavily fortified until shortly after World War II to protect the northwest entrance to the Panama Canal. The treaties negotiated between the United States and Panama in 1977 returned 7,000 military and civilian buildings in the Canal Zone to the Panamanian Government. Today, Sherman is a major 20th century historic site with World War I batteries, an airstrip, lighthouse, officers' quarters, barracks, docks, warehouses, recreational facilities, and a chapel.*

Photo courtesy of Gerald P. Bauer.

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April 2004

International Institute of Tropical Forestry
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Abstract

The 12 000-ha San Lorenzo Protected Area (SLPA), located at the northwestern entrance to the Panama Canal, is currently part of the Mesoamerican corridor of protected areas extending from Guatemala to the Colombian border. The SLPA contains two forts built for similar protective functions: Fort San Lorenzo at the mouth of the Chagres River, first initiated by the Spanish in 1597 to protect the "Camino de las Cruces," the gold route over the isthmus; and Fort Sherman, started in 1911 to protect the northern entrance to the Panama Canal, the 20th century's "royal corridor" through Panama. Both forts successfully fulfilled their military objectives, and Fort Sherman simultaneously protected the area's natural resources during the 20th century. This report highlights the SLPA's setting as a major crossroads, and briefly describes pre-Columbian activities, the Spanish conquest, the legacy of fortune seekers and the Chagres River including pirates and shipwrecks, the building of the Panama railroad, the efforts of France and the United States on the Panama Canal, and early agricultural activities. It also mentions the military history of Forts San Lorenzo and Sherman, and current knowledge on the geology, soils, flora, fauna, marine resources, ecological research, and proposed conservation of the SLPA, including ecotourism. Relevant environmental legislation is outlined along with the major functions of all entities that are cooperating with programs on the SLPA. Also included is a chronology of major historical events related to the SLPA.

Keywords: Cultural resources, fauna, flora, Panama, protected area.

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Background Information

Introduction

The 12 000-ha area known as the San Lorenzo Protected Area (SLPA) encompasses both Fort San Lorenzo and Fort Sherman. The SLPA was initially part of the Canal Zone (renamed the Canal Area after 1977), a 16-km wide strip of land ceded by Panama to the United States in 1903 for building and protecting the Panama Canal. Construction of the military base of Fort Sherman began in 1911 to defend the northern, or Caribbean, entrance to the Panama Canal (fig. 1). By 1918, Fort San Lorenzo and the coastal strip between the Chagres and Piña Rivers west of the original Canal Zone were added by accord with the Panamanian Government.

The SLPA extends 24 km at its longest dimension from Toro Point to the town of Escobal, and nearly 11 km at its widest dimension from the southeastern corner of Limón Bay to the beaches northeast of the town of Piña. The SLPA is bordered on the north by the Caribbean Sea and on the east by Limón Bay, the northernmost part of the Panama Canal, Gatún Locks, and Gatún Lake. The Piña River, roughly parallel and west of the Chagres River, bounds the northwestern part of the SLPA. The western boundary of the SLPA is demarcated arbitrarily by a line from near the Piña River south for 8 km and then southeast for another 8 km. The major points (headlands) along the coast, traveling counterclockwise from the southwestern corner of Limón Bay, are: Limón, Pulpit, Shelter, Toro, Naranjitos, Iglesias, and Fort San Lorenzo (fig. 1). Named beaches include: Shimmey (or Playa La Flor), south of Shelter Point; Devil's, west of Fort Sherman; and Hidden (or Tortuguilla), north of Fort San Lorenzo. A large, grassy field occupies the area around Gatún Dam. The major colonial sites are Fort San Lorenzo, remnants of the colonial north coast trail, and the Gatún trenches. Historical sites from the late 19th and early 20th centuries include the French Canal, the Fort Sherman complex, numerous World War I batteries, and the Gatún Locks and Dam. The major long-term research site containing the canopy crane of the Smithsonian Tropical Research Institute (STRI) is situated in tall forest on a ridge above the Chagres River.

The Smithsonian crane, installed in September 1997, ascends 55 m vertically and extends 54 m laterally through the canopy, allowing scientists to study biodiversity and phenology. The elevated perch has been described by some visitors as "the perfect set-up," and "the best seat in the house."

Photo courtesy of Gerald P. Bauer.

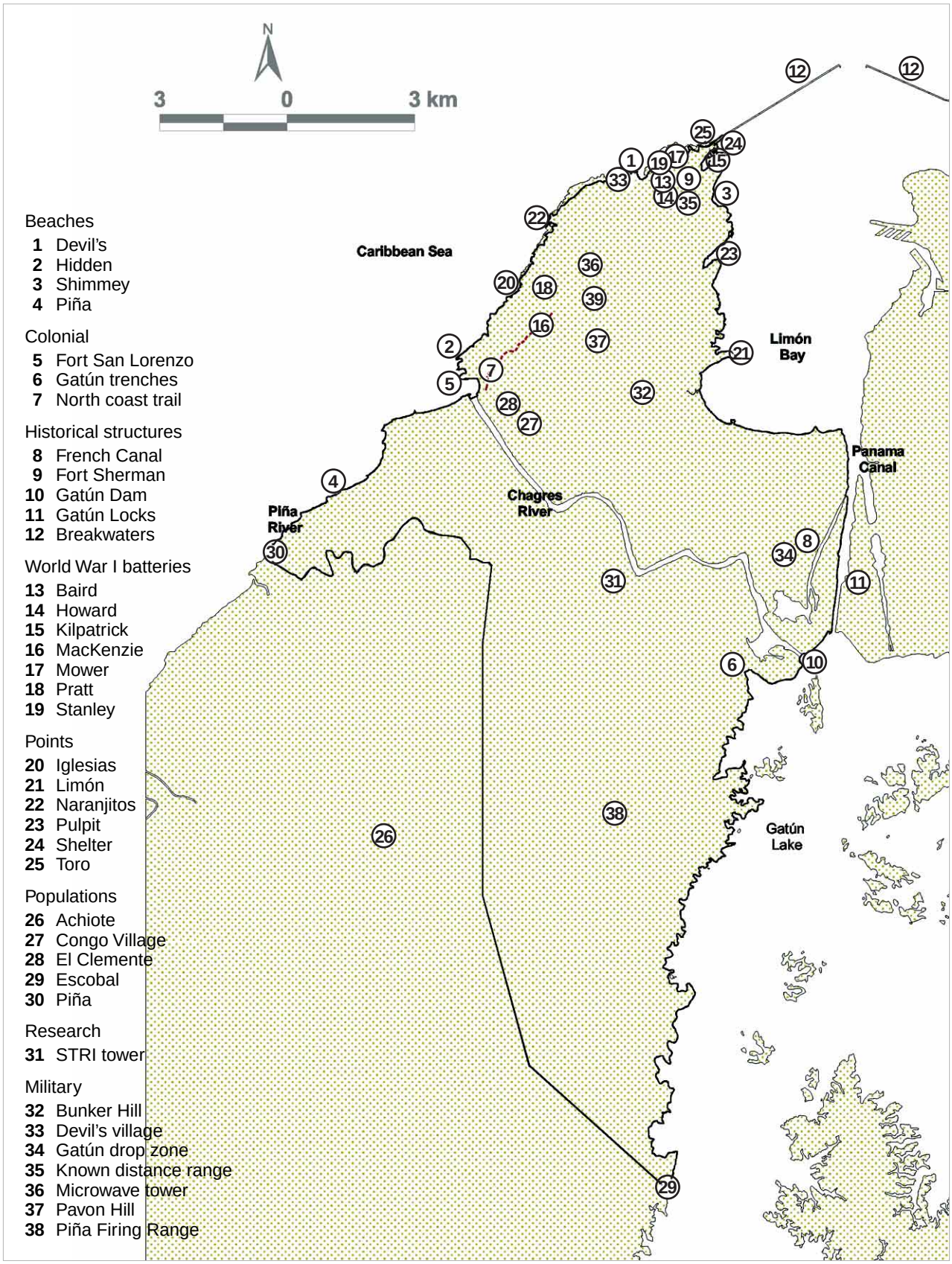


Figure 1—Locations in the San Lorenzo Protected Area.

Although heavily impacted in some areas by past agricultural and military activities, the SLPA contains large areas of mature secondary forests that may be readily enjoyed from numerous roads and trails. With Panama's increasing population growth and urban expansion—especially along the canal—the SLPA is seen as an oasis where forests and wildlife still abound. In fact, it would be difficult to identify a comparable area elsewhere in Central America. This rare combination of natural resources and accessibility is due to past military protection from timber harvest and hunting. Careful planning and management of the natural resources of the SLPA could generate local employment and provide residents and visitors with numerous opportunities for recreation and ecotourism. Continual surveillance and monitoring of the natural resources of the SLPA are imperative if it is to be used on a sustained basis.

Objectives

The main purpose of this report is to provide baseline information and important references on the natural resources and history of the SLPA. Naturalists, ecotourists, and wildlife researchers are the intended audience. The major topics include

- Administrative details, including entities involved with past and current management
- A description of the geology, physiography, soils, and climate
- A summary of past human influence from pre-Columbian times to the 20th century
- An overview of Fort Sherman's infrastructure, facilities, and past military history
- A classification of the major vegetation types
- Lists of flora and fauna
- A summary of ongoing research activities
- A review of management opportunities, educational programs, environmental issues, and ecotourism potential

Legal and Administrative Details

The Spooner Act of 1902 authorized the President of the United States to negotiate a treaty with Colombia for a strip of land across Panama—at that time a province of Colombia—in order to build a canal. The Act also authorized the purchase of the rights and property from the French after their initial attempts to build a canal failed (Goethals 1915, Gold 1999, McGovern 1998). Panama, after declaring its independence from Colombia, enacted the Hay-Bunau-Varilla Treaty of November 18, 1903, granting the United States rights to the Panama Canal in perpetuity (Gold 1999). The original treaty included all land within 8 km of the canal. The "Depopulation Order" of December 5, 1912, removed all persons from the Canal Zone, remunerating those with valid titles. At this time, the old settlements of Tortuguilla Point, Fort San Lorenzo, and Chagres were outside of the Zone.

To better defend the canal, the United States requested that the Canal Zone be extended west of Fort Sherman to include the mouth of the Chagres River (Pereira Jiménez 1964). In June 1916, the request was granted, and this area was also depopulated. Former Chagres residents were moved 13 km southwestward along the coast to New Chagres on the Lagarto River. Thus by 1916, all land north of the Chagres River had been included in the Canal Zone. Finally, in July 1918, a strip of land between the Chagres and Piña Rivers along the Caribbean Coast was added to the Canal Zone as a result of another request (Pereira Jiménez 1964). According to the Torrijos-Carter Treaty enacted in 1977, all property and operations of the Canal Zone would revert to Panamanian control by the year 2000. For the SLPA, areas not used for military training reverted in 1979; the remaining areas of the SLPA, including the Piña Firing Range and the Fort Sherman complex with surrounding forests, were returned on June 30, 1999.

The framework under which Panamanian national agencies function is established by law and their objectives are outlined in their charters. Some of the legal basis for management of the SLPA was previously summarized in the management plan for Portobelo National Park (Agencia Española de Cooperación Internacional and others 1992), and is outlined in this report (appendix A contains the Spanish and English meanings of acronyms used in the text and cited literature; appendix B contains a list of entities involved with the SLPA, their acronyms, and their major objectives and functions; and appendix C provides a chronology of events that influenced the SLPA). Although San Lorenzo is currently being called a "protected area," the term as such does not appear as one of the 17 categories listed in the "national system of protected wildlands, or areas" (INRENARE 1994). The SLPA contains both "protection forest" and "protected coastal landscape"

and, in 2001, during the process of developing the first management plan, was being considered for classification as a national park.

The historic ruins of San Lorenzo, at the mouth of the Chagres River, were designated for protection by Law 61 of 1908 by the Panamanian Government (Republic of Panama 1979). Law 9 of 1976, regulating historic sites in Panama City and Portobelo, also created Portobelo National Park. In 1986, Law 21 created the National Institute for Renewable Natural Resources (INRENARE). The responsibilities of the Institute included the planning, organization, coordination, regulation, and development of policies for the benefit, conservation, and use of renewable natural resources. Responsibilities for the conservation of Portobelo National Park were relegated to INRENARE and the Panamanian Tourism Institute (IPAT). In 1992, IPAT delegated these responsibilities to the National Institute of Culture (INAC) by virtue of Law 14 of 1982, which dictates measures regarding the custody, conservation, and administration of Panama's historic legacy sites. The same law also prohibits several activities such as fishing, hunting, mineral exploitation, removing or destroying flora, and untethered animals. Construction is limited to buildings required for administration or surveillance, and camping is confined to designated sites. Permits for the collection and study of flora and fauna are limited to recognized scientific or educational institutions. Removal of specimens that dramatically alter the appearance of sites, or of species that are rare or endangered, is also prohibited.

In 1991, INRENARE cooperated with the Food and Agricultural Organization of the United Nations (FAO), 29 international organizations, and more than 50 national institutions including nongovernment organizations, private sector groups, and communities, in the development of Panama's tropical forest action plan (Agencia Española de Cooperación Internacional and others 1992). This collaborative venture demonstrated the government's support of the action plan as a strategic instrument for managing renewable natural resources, and for orienting external cooperation.

Panama's Law 5 of 1993 created the Authority of the Interoceanic Region (ARI) as an autonomous entity whose main responsibility is the protection, beneficial use, and administration of reverted Canal Area properties (Feraud 1999, Panamá 1993). Among the specific functions are regional economic development, the optimum use of existing resources, collaboration with public and private institutions on environmental protection, the adoption of a general land use plan, and coordination with INRENARE on the sustainable use of resources within the Canal Area.

Panama's Law 1 of 1994 established forestry legislation that prohibited several activities in national reserves such as the unauthorized cutting and destruction of trees, unapproved Earth movement by heavy equipment, illegal construction, the disturbance of the "ecological balance" of an area, and the setting of forest fires (Feraud 1999). Panama's Law 8 of 1994 was devised to promote tourism by providing tax incentives and benefits for tourism projects (Lieberknecht and others 1999). Among the provisions of the law are tax exemptions on materials, vehicles, equipment, and real estate; exoneration from income tax on a creditor's interest in hotel investments; and real estate depreciation. ARI is the main vehicle for promoting tourism ventures in reverted areas. Law 30 of 1994 specifies the requirements for environmental impact studies.

Panama's Law 24 of 1995 established wildlife legislation that included sanctions for hunting or capturing threatened or endangered species or those protected by closed seasons (Feraud 1999, Panamá 1995). Removing eggs from nests, draining or diverting waterways for purposes of fishing, and trading or trafficking wildlife without permission were also prohibited, as was the pollution of water bodies.

Law 19 of 1997 mandated that the Panama Canal Authority (ACP) shall approve policies, programs, and projects—both public and private—that may affect the watershed, and called for an interinstitutional commission to coordinate the activities of government and nongovernment organizations (Panamá 1997a). Law 21 of 1997 approved a regional plan for the use, conservation, and development of the interoceanic region (the area encompassed by both the canal watershed and the Canal Area), declaring the SLPA as a protection forest and protected landscape (Panamá 1997b). Specific mention was made for conservation of the natural environment, including areas with high biodiversity, the historic ruins at Fort San Lorenzo, the mangroves of Limón Bay, and areas with severe limitations for

use such as wetlands; e.g., the Mojinga Swamp, lowland drainage areas into Limón Bay, and the Chagres floodplain.

The National Environmental Authority (ANAM), created by Law 41 of 1998 (Panamá 1998), replaced INRENARE as the natural resource agency for Panama. ANAM, a national authority, has greater powers and responsibilities than the former INRENARE with regard to the environment, among them the formulation of national policy, the promotion of projects, the evaluation of environmental impact statements, research (including inventories of natural resources), education, and the management of a database. ANAM also regulates the national system of all existing legally established protected areas, giving priority to ecosystems with high diversity and productivity such as corals, estuaries, and wetlands. The same law allows third party management of protected areas and the development of public service concessions for tourism.

Other decrees, resolutions, and directives cited in the plan for the management of Portobelo National Park (Agencia Española de Cooperación Internacional and others 1992), as well as more recent directives, also apply to the protection and conservation of the SLPA's natural resources:

- Decree 44 of 1967 regulates slash-and-burn activities in rural areas.
- Executive Decree 15 of 1981 regulates fishing and lobster (*Panaliris argus*) trapping.
- Resolution DIR 003–86 of 1986 regulates hunting and the purchase or sale of wildlife species, dead or alive.
- Resolution 012–87 of 1987 regulates construction in national parks and equivalent reserves.
- Resolution 024–90 of 1990 regulates the raising of wild animals.
- Resolution 91–36 of 1991 regulates mineral concessions and requires environmental impact statements.
- Resolution DG 006–91 of 1991 authorizes agency officials to confiscate arms and vehicles of persons violating hunting regulations.
- Resolution DG 007–91 of 1991 authorizes agency officials to confiscate tools used to illegally cut trees or forests.
- Executive Decree 4 of 1992 regulates shrimp fishing and specifies measures for the conservation of marine turtles.
- Resolution JD–010–94 of 1994 creates a system of protected areas with defined use categories.
- Executive Directive No. 327 of 1998 adopts a focus including tourism, conservation, and research as a strategy for the development of the tourist industry and conservation of national heritage and cultural resources.
- Resolution No. 36 of 1999 approves a national environmental strategy with measures that public and private sectors and citizens should adopt for conservation, use, and management of natural resources.

In June 1999, ARI, ANAM, and IPAT officials signed an interinstitutional agreement for the management and integral use of the SLPA, indicating the respective rights and responsibilities of each agency. On November 2000, INAC, by addendum, also signed the agreement.

Brief Historical Perspective

The history of Panama, particularly that of the SLPA, is rich and exciting. Spanning about 10,000 years of human activity, Panama served first as a crossroads for Indian migrations east and west, and later as a crossroads north and south for World trade. Columbus discovered Panama's north coast in 1502, and by 1513, the Pacific Ocean (called the South Sea) had been sighted. Conquest followed discovery and early exploration. Soon, the "Camino Real," and an alternative wet season route, "Camino de las Cruces," or the Las Cruces Trail, were developed over the isthmus to transport Peru's gold treasures back to Spain. Caribbean pirates, among them Francis Drake and Henry Morgan, plundered Spanish ships and coastal installations from the middle of the 16th to the middle of the 18th century**.** Panama's independence from Spain in 1821 was followed by California's gold rush of 1849, stimulating a renewed interest in transisthmus passage. Panama's railroad, built in 1855, served westward migration in the United States before the completion of the U.S transcontinental railroad in 1869. The French attempt to build a sea-level canal during the 1880s was followed by Panamanian independence from Colombia in 1903, and the successful U.S. effort to build and open the Panama Canal at the outbreak of World War I in 1914.

The construction of Fort Sherman was started in 1911 as part of a Caribbean defensive strategy to protect the Panama Canal. Defensive batteries were

soon mounted along the coast. At the peak of World War II, the U.S. stationed more than 68,000 troops in 100 military installations in Panama, mainly in the Canal Zone. In 1951, Fort Sherman was designated the Army's center for "jungle warfare training." In the 1960s and 1970s, political pressure, nationalism, social unrest, and the impossibility of defending the canal against modern missiles or sabotage led to the conclusion that Panama had the most to gain by defending its own vital interests in the canal. Subsequently, in 1977, the return of the Canal Zone was negotiated in treaties between Omar Torrijos and Jimmy Carter. During the remainder of the 20th century, the Panama Canal and its facilities have reverted to the Panamanian Government.

Geology, Soils, and Coastal Features

Major Formations

A concise general geological description of the SLPA (McCullough and others 1956) follows:

> The principal study area [the SLPA] is underlain by a series of nearly flat-lying sedimentary formations ranging in age from Middle Miocene to Recent. The uplands are composed of consolidated sedimentary rocks tilted at low angles to the northwest; the lowlands are underlain in most places by unconsolidated clays and silts. The bedrock formations have been fractured and faulted on a large scale, so that adjacent blocks are upraised and depressed relative to one another. The upland areas are upthrown and slightly tilted fault blocks, while the lowland units are down dropped blocks covered by more recent sediment.

Three major geological formations, all sedimentary, occur on the SLPA (Ministerio de Comercio e Industrias 1998) (fig. 2):

- The Chagres formation (56 percent), consisting of massive fine-grained sandstone, is of Upper Pliocene origin.
- The Gatún formation (21 percent), made up of sandstone, shales, tuffs, conglomerates, and loams, are of middle Miocene origin.
- The Río Hato formation (23 percent), including conglomerates, sandstone, shale, tuffs, nonconsolidated sandstone, and pumice, are of recent origin.

All are mainly interbedded sandstone, siltstone, and shale, with variable portions of shell sand and tuff.

Faulting is evident in the abrupt topographic contrast between upland and lowland areas and their linear boundaries—the straight, narrow stream valleys (fig. 3) and their alignment on opposite sides of divides (McCullough and others 1956). Faulting, probably during the middle or late Pliocene or Pleistocene, has been the main control for the topographic units. Each of the three upland areas—the Fort Sherman uplands, the Mindi Hills, and the Piña-Escobal highlands (fig. 4)—is a separate fault block, uplifted with respect to the lowlands, and offset with relation to one another. All upland blocks were tilted northwestward during uplift.

The Río Hato formation underlies all areas < 6 m in elevation, including the Chagres-Mojinga-Gatún and the Limón Bay Lowlands (McCullough and others 1956). The sediments, often called muck, contain a large amount of organic matter, and are usually saturated with water. In some instances, the formation may be 60 m deep (Jones 1950). Much of the deposit was formed under brackish coastal swamps, where Chagres River sediments were incorporated. The Limón Bay Lowlands contain abundant coral fragments.

The Chagres formation lies above and grades into the Toro limestone (McCullough and others 1956), constituting the most widely exposed bedrock unit within the SLPA. The deposit is marine and probably accumulated rapidly in deep water.

The Toro member, of Lower Pliocene origin, overlies the Gatún formation (McCullough and others 1956), and is a coarse limestone containing interbedded coquina (organic remains comprised of an accumulation of large shell fragments). The formation is from 90 to 150 m deep (Jones 1950), thinning to the southwest. The upper 30 to 60 m are exposed along the east and southeast sides of the Fort Sherman uplands, and the full thickness along the highlands west of Gatún Lake; smaller patches cap the Mindi Hills. Where exposed the coquina provide a look into the past of the SLPA region. The SLPA also has numerous small caves in the upland areas and at least one stretch of a small underground stream in the hills above Providencia on Achiote Road (S11) (fig. 3). The caves and subterranean streams have not

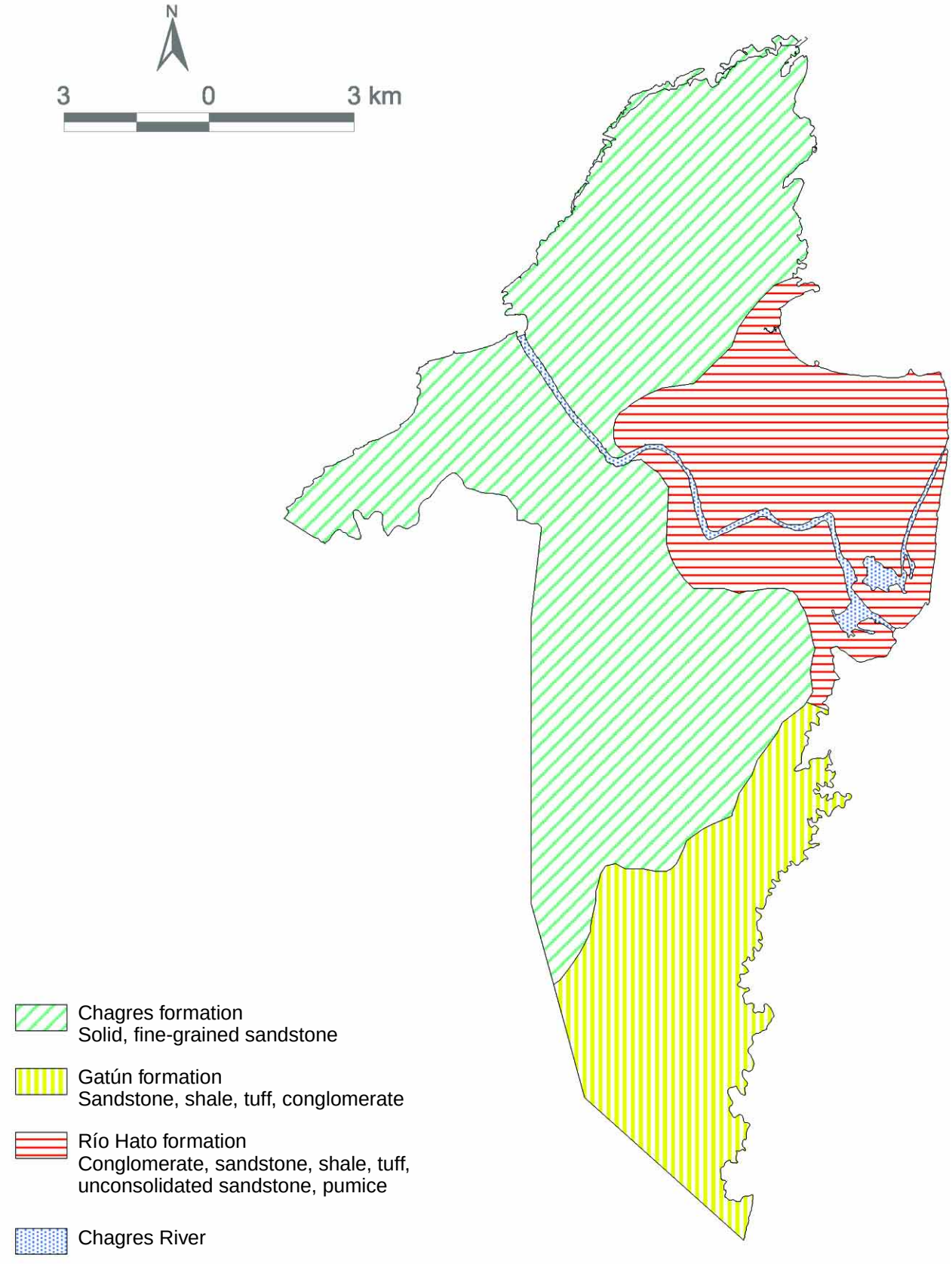


Figure 2—Major geological formations in the San Lorenzo Protected Area (República de Panamá 1998).

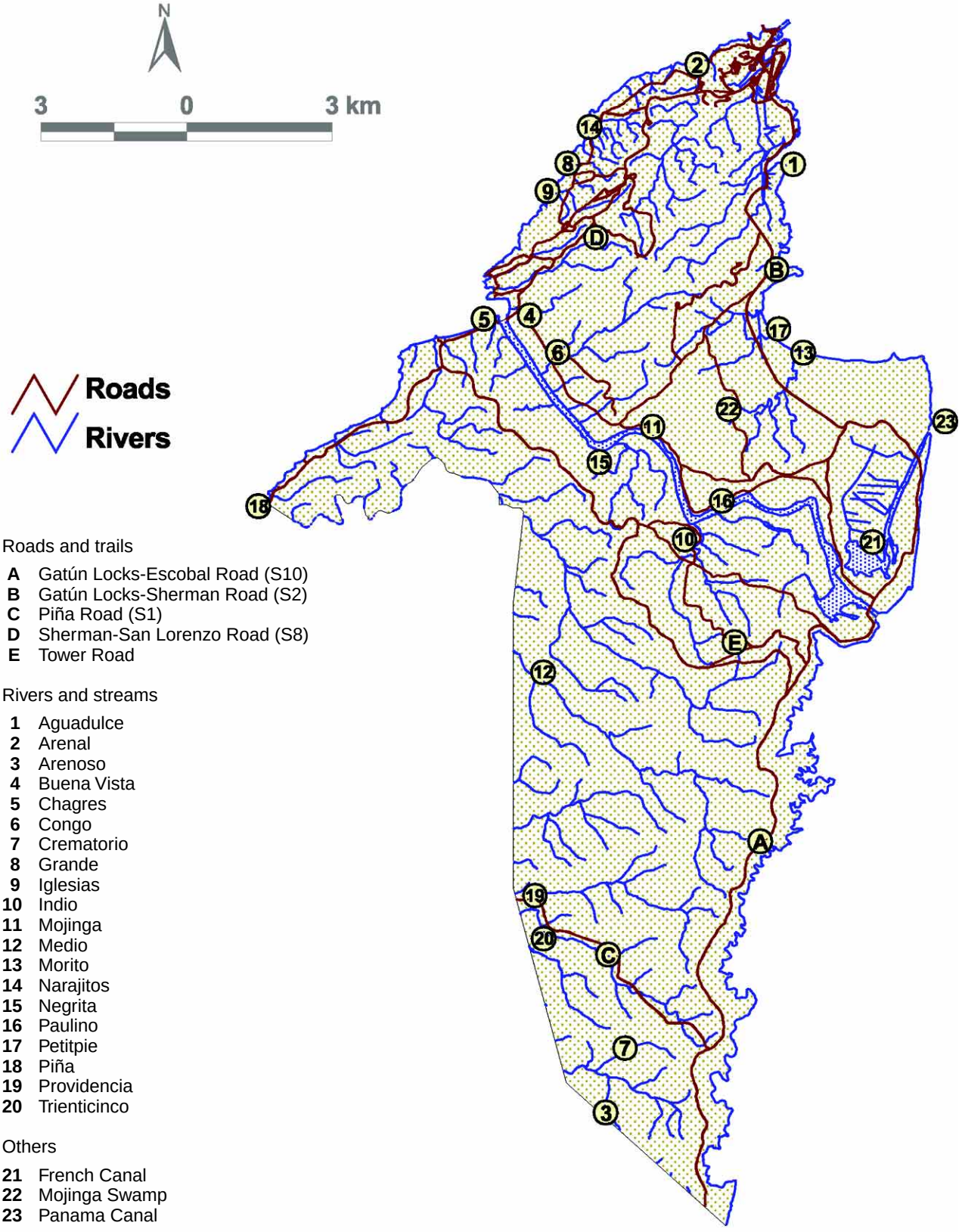


Figure 3—Roads and rivers in the San Lorenzo Protected Area.

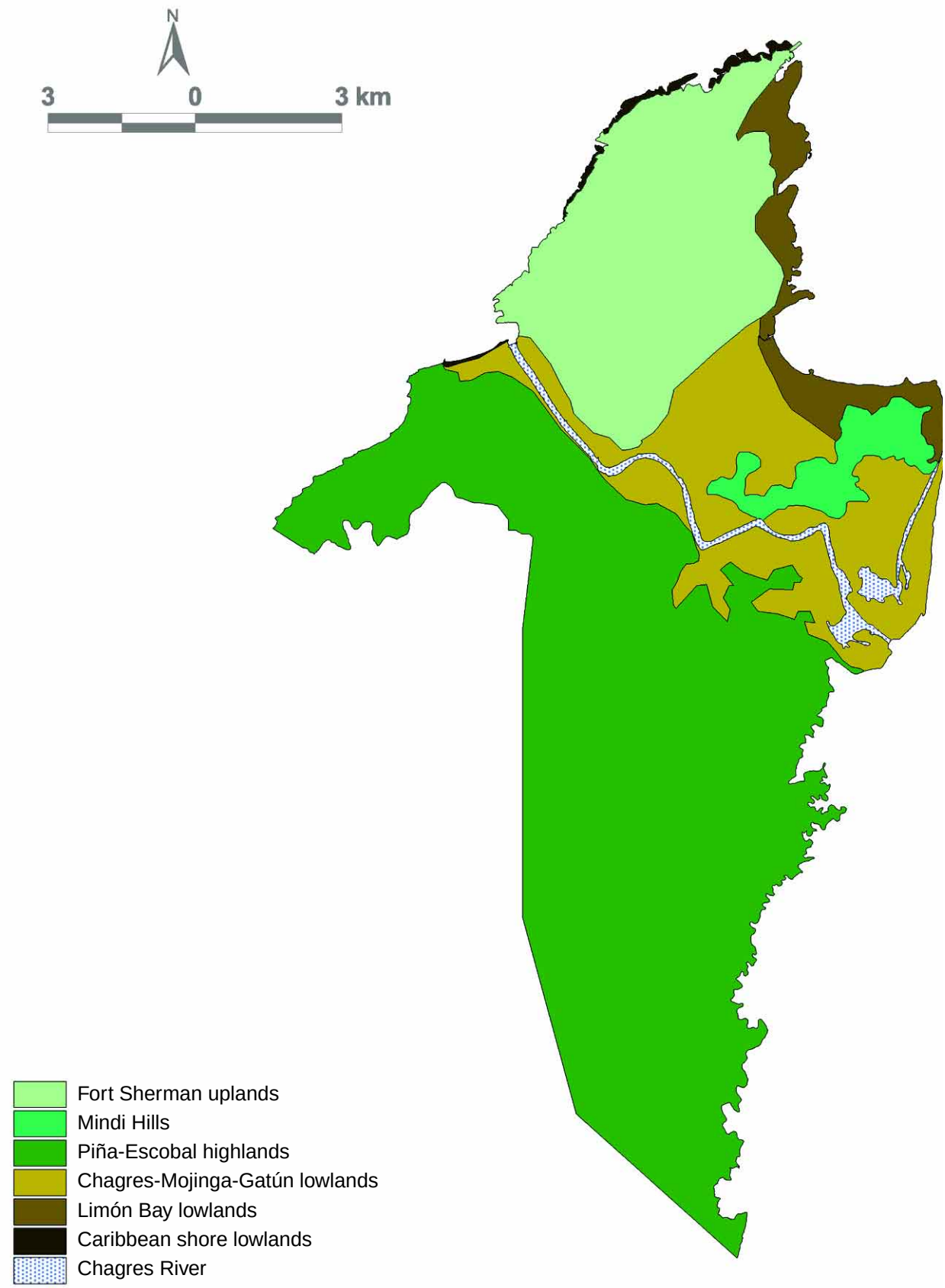


Figure 4—Major physiographic features of the San Lorenzo Protected Area (McCullough and others 1956).

been explored, and pose many unanswered questions regarding their total number, location, size, extent, and resident fauna and flora.

The Gatún formation contains the oldest rocks exposed in the SLPA (McCullough and others 1956). The total depth is > 400 m, and perhaps as much as 900 m. All of the Mindi Hills—the scarp along the western shore of Gatún Lake—and the hills just west of Gatún Dam, are part of the formation. The formation is apparently a shallow-water, coastal marine deposit, with the addition of volcanic fragments.

Sea level during the past 10,000 years, particularly between 9,350 and 6,550 years before the present, rose by nearly 50 m (Jaén Suárez 1981). Panama at the beginning of this warming event would have had an additional 100 000 km^2, situated mainly in the Gulfs of Panama and Chiriquí. The dramatic loss of land area had a lasting impact on natural resources. As the climate became more humid, forest cover, including mangroves, expanded onto herb and grasslands, and the country's megafauna (giant sloth and mastodon) disappeared. The human occupants dependent on these animals were also an agent in their elimination (Jaén Suárez 1981).

Major Soil Types

About 1910, the earliest reconnaissance of soils in the vicinity of the SLPA was undertaken to assess agricultural possibilities (Bennett 1912). Among the common soils encountered were Gatún clay and Chagres silt loam. Gatún clay, weathered from underlying sedimentary rocks, contains about 80 percent clay and 18 percent silt with other fractions (Bennett 1929). Chagres silt loam is alluvial and contains about 50 percent silt, 25 percent clay, and 20 percent very fine sand, with other fractions. Other soils found in limited areas include saturated marsh soils, mangrove soils, and dredge fill southwest of the Gatún Locks. Narrow strips of loose, fine sand are found at river and stream mouths along the Caribbean Coast between Toro Point and the mouth of the Chagres River (Bennett 1929).

Shoreline and Reefs

The marine shorelines of the SLPA include nearly 15 km of the Caribbean Sea from Piña to Toro Point, about 12 km of Limón Bay from Shelter Point south to the canal entrance, and another 4.5 km along the Gatún Locks. Freshwater shorelines extend for about 20 km along Gatún Lake.

Much of the SLPA shoreline from Fort Sherman west towards Piña is covered by coastal lowland, a stretch of land characterized by forested headlands interspersed with cove beaches (McCullough and others 1956). Wave-cut cliffs characterize the shoreline where upland ridges reach the sea; seaward of the ridges, a rock bench merges into a fringing reef. Sandy beaches occur where upland valleys reach the sea. The landward edges of the valleys, in turn, merge into the floodplains of streams. The largest area of coastal lowland on the SLPA extends for 1.5 km southwest from the mouth of the Chagres River. At one time, many of these beaches probably served as turtle nesting sites. The secluded nature of these coastal lowlands offers the visitor precious moments of respite from a busy World.

Reef flats border most of the Caribbean shore. The longest segment along the coastline of the SLPA stretches for nearly 2.5 km from Devil's Beach to Naranjitos Point, rising nearly 20 m and forming Brujas Island (McCullough and others 1956). Caribbean barrier reefs, paralleling the coast, have developed under conditions of strong winds, heavy rainfalls, and high sedimentation. Nearly 50 ha of coral platforms are situated along the SLPA coast in four areas—Fort Sherman, Isla Brujas, Punta Naranjitos, and Punta Iglesia. Reefs growing along the shore of the SLPA are characterized by a high diversity of algae and contain about one-half of the coral species reported for the Caribbean shore of Panama (Guzmán and Holst 1994). The absence of some species of corals may be a result of the generally shallow nature of the reefs as well as a century of environmental impact caused by sedimentation and occasional oil spills. Relatively diverse coral populations, however, have survived at Punta Naranjitos and San Lorenzo.

Physiography

Hydrological System

The SLPA has numerous permanent and intermittent streams, some with waterfalls. About one-half of the area's average 3000 mm of annual rainfall is intercepted and evaporated directly back into the atmosphere, or is absorbed by trees and later transpired (GEA Consultores, S.A. and Louis Berger International, Inc. 1999). The remainder escapes to the ocean by means of streams and rivers. Seasonal variation in rainfall produces greater average flows during the wet season, although heavy downpours at any time will cause high runoff. The steep slopes of the SLPA produce many intermittent waterfalls during rainstorms, the most notable being conveniently located along the Gatún Locks-Escobal Road (S10) just above Gatún Lake. The most spectacular waterfall, which is about 20 m high, is a 4-hour hike from Gatún Dam along the Tiger Trail.

The major rivers or creeks that drain the SLPA area flow into the Caribbean Sea or Limón Bay (fig. 3). The main drainage lines are to the northwest and west, with some smaller streams flowing northeast into Limón Bay or southwest into the Chagres (McCullough and others 1956). Direct drainage from the scarps bordering Gatún Lake is limited to a narrow strip of land east of the Gatún Locks-Escobal Road (S10).

The Chagres, the largest river flowing through the SLPA, separates the area into a northeastern one-third containing Fort Sherman, and a southwestern two-thirds containing the Piña Range (fig. 3). The Indio and Negrita Rivers and Paulino Creek flow into the Chagres from the south, and the Mojinga, Congo, and Buena Vista Rivers enter from the northeast. Numerous rivers or streams also enter directly into the Caribbean Sea, the largest of which are the Iglesias, Grande, Naranjitos, and Arenal. The Aguadulce and Petitpie Rivers and Morito Creek are the major watercourses that flow into Limón Bay. The Piña, Medio, Treinticinco, and Providencia Rivers, and the Crematorio and Arenosa Creeks, are tributaries that flow out of the SLPA to the west, and ultimately into the Caribbean Sea. The Mojinga Swamp, located north of the Chagres, drains into the Chagres via the Mojinga River and into Limón Bay via Morito Creek.

Topography

Two principal topographic features, dissected upland blocks and flat alluvial lowlands, characterize the SLPA (McCullough and others 1956) (fig. 4). The upland blocks are

- The Fort Sherman uplands, located north of the Chagres River and west of Limón Bay, with the highest point at 111 m
- The Mindi Hills, low and rounded, situated between the Chagres River and Limón Bay. Surrounded by the Chagres-Mojinga-Gatún Lowlands, they extend nearly 5 km northeast to southwest, and are about 1.5 km wide. Their high point is 88 m
- The Piña-Escobal highlands, the most rugged of the upland areas, located south of the Chagres between Gatún Lake and the Caribbean Sea. Their highest point is 198 m.

All upland areas range from moderately hilly to rugged (McCullough and others 1956). Elevations along the narrow ridges generally decline from easterly high points toward the west and northwest. Valleys between the ridges are narrow and steep, and slopes of 45° or more are common. Larger streams have small floodplains along their lower reaches. Where these ridges and valleys reach the Caribbean Sea, they terminate in a series of cliff headlands and cove beaches.

Three lowland areas are recognized (McCullough and others 1956) (fig. 4)

- The Chagres-Mojinga-Gatún Lowlands are the largest. They extend along the Chagres from its mouth to Gatún Lake, and encompass the Mojinga Swamp and surrounding lands between the Fort Sherman uplands and the Mindi Hills
- The Limón Bay Lowlands, next in size, lie east of the Fort Sherman uplands, south of Toro Point, and north of the Mindi Hills. The Gatún Locks-Sherman Road (S2) arbitrarily separates the Chagres-Mojinga-Gatún Lowlands from the Limón Bay Lowlands
- The Caribbean shore lowlands, the smallest area, range from Toro Point to the Chagres River. These lowlands are a discontinuous strip situated between the sea and the 20-m contour.

The lowlands are flat, poorly drained, and little altered by erosion. Water commonly covers considerable areas.

Climate

General

Lying south of the Caribbean hurricane belt, Panama has a tropical humid climate characterized by a wet season from May to November and a dry season from December through April (Bennett 1929, Boyer and others 1980). The wet season, governed by the position of the Inter-Tropical Convergence Zone, has uniform temperatures, high humidity, gentle breezes, and frequent, heavy, convectional downpours. Heavy rainfalls are often accompanied by thunder, lightening, and occasionally, by high winds. During a normal year, the entire country receives an average of 3000 mm of rainfall. A pronounced rainfall gradient, however, exists across the isthmus between the Caribbean and Pacific shorelines. Mean annual rainfall along the Caribbean is about 3000 mm/year, whereas the Pacific receives about one-half that amount (Bennet 1929, Tosi 1971). Panama's Caribbean entrance to the canal, despite its greater rainfall, receives an average of nearly one-half hour more of sunshine per day than the Pacific entrance to the canal.

Rainfall and Temperature

Climatic data for the SLPA are available from two stations, Gatún Locks (9° 16′ N, 79° 55′ W), and Coco Solo (9° 22′ N, 79° 53′ W). Processed data from the Gatún station include: rainfall, recorded from 1905 to 1998; intense rainfalls, estimated from data collected between 1908 and 1941; evaporation; and wind direction and velocity. Data from Coco Solo include wind direction and velocity, and average relative humidity. Mean temperature was also recorded from 1976 to 1978, 1981 to 1982, and from 1984 to 1995.

Rainfall and temperature from the different stations have been combined in a climatic diagram (fig. 5). The mean annual rainfall is 3022 mm/year and is notably seasonal. January to April, the dry season, has mean monthly rainfalls between 42 and 125 mm/month. May through December, the wet season, has rainfalls between 285 to 500 mm/month. The driest and wettest months are March with 42 mm, and November with 500 mm. Temperature is remarkably consistent throughout the year, ranging from 26.8 °C in September to 27.7 °C in April and May.

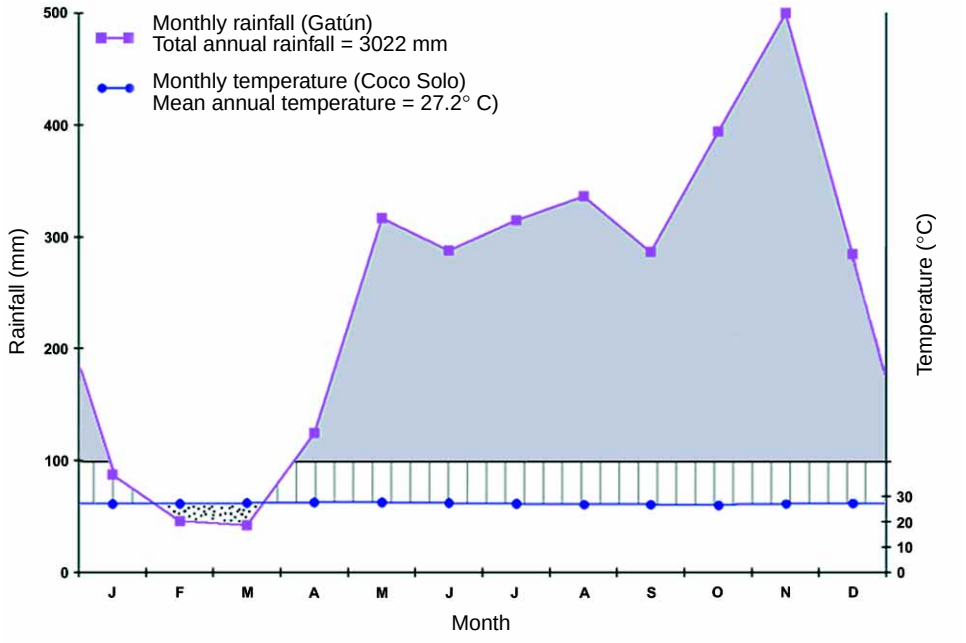


Figure 5—Climatic diagram for the San Lorenzo Protected Area (Gatún, 9° 16′ N, 79° 55′ W, elevation 25 m; and Coco Solo, 9° 22′ N, 79° 53′ W, elevation 5 m) (Walter 1973).

Relative Humidity, Evaporation, and Wind

Relative humidity averages 75 percent for the entire year, ranging in the low 70s during the dry season, and in the mid- to high-70s during the remainder of the year. Mean annual evaporation is 1040 mm and mean annual evapotranspiration is 1535 mm (GEA Consultores, S.A. and Louis Berger International, Inc. 1999).

Wind velocity averages 16 km/hour during the entire year. From December to April, the mean wind velocity ranges between 19 and 24 km/hour; the remainder of the year, it ranges between 10 and 14 km/hour. Wind direction at the Gatún station is predominantly from the north, and at the Coco Solo station, predominantly from the north-northeast (GEA Consultores, S.A. and Louis Berger International, Inc. 1999). The dry season along the Caribbean Coast is characterized by strong winds, locally called "northers," that may average nearly 50 km/hour, and occasionally up to 90 km/hour (Bennett 1929). Although not of hurricane force, winds of this velocity—whether associated with dry season winds or thunderstorms—can snap or uproot large trees, create forest openings, and stimulate regeneration of the forest.

Variation in Weather and Climate

Although mean climatic data are useful for characterizing average conditions, extreme values are often critical to the survival of the flora and fauna of a region. During the 1982–83 El Niño event, nearby Barro Colorado Island received 25 percent less-than-average rainfall because of an extended dry season (Leigh and others 1990); consequently, many components of the semievergreen forest suffered high mortality. Moreover, heavy rainfalls at Gatún are not common (GEA Consultores, S.A. and Louis Berger International, Inc. 1999). Rainfall rates of 150 mm/hour for 5 minutes, or 130 mm/hour for 10 minutes, or 65 mm/hour during an entire hour, average once per year. Similarly, rates of 230 mm/hour for 5 minutes, 200 mm/hour for 10 minutes, or 125 mm/hour for an entire hour, are estimated to average once per 100 years. Heavy rainfalls may precipitate local landslides or cause soil erosion.

During the last part of the glacial period, from 20,000 to about 11,000 years B.P., the climate in central Panama was cooler and drier than now (Piperno and others 1991). Consequently, lowland and upland taxa grew together in lowland forests as species assemblages not seen today. Future changes in the climate of the SLPA are a matter of speculation, but could occur. If the carbon dioxide concentration of the atmosphere continues to increase, temperature will probably increase as well, and rainfall patterns may change (Condit 1998). Seasonal patterns of rainfall would then become critical, particularly if dry seasons were pronounced.

Human Influence

Pre-Columbian Activities

Several Indian groups used Panama as a gateway between Central and South America (Organization of American States 1971) (appendix C). The discovery of projectile points used by "paleoindians" near Madden Dam, about 50 km east of the SLPA, demonstrates that hunters of large mammals (megafauna) occupied Panama about 9,000 B.C. (Bird and Cooke 1977, Jaén Suárez 1981). Until 3,000 B.C., these nomadic groups of two or three families probably camped temporarily, collecting fruit, and killing game before moving on.

Cores drilled in the Gatún Lake basin by the Panama Canal Company during the early 1960s have provided a long series of sediment dates used to interpret changes in climate, vegetation, and human activities, including agriculture (Bartlett and Barghoorn 1973, Cooke and others 1996). The dates were largely substantiated by phytolithic (phytolyths are microscopic pieces of silica formed within the cells of living plants) analyses (Piperno 1985). Hunter-gatherers were present in the Chagres Valley between 9,200 and 7,000 years ago, when rainforest covered the area. Maize pollen has been found in freshwater sediments and peat deposited after 7,000 years ago, some of which appeared to be associated with agriculture (Bartlett and others 1969). After this period, sea-level changes altered the habitat, first to mangrove, and later to freshwater (Cooke and others 1996). Between 2,900 and 2,050 B.C., humans cut and burned the forest, and planted crops. The increasing human presence on the landscape can be seen in the virtual disappearance of tree pollen, even that of early secondary species.

The origin and greater use of domesticated plants in Central America took place in the period between 7,000 and 500 years B.C. (Helms 1975). Agriculture

probably progressed in stages, passing from a period dominated by hunting and gathering between 5,000 and 3,000 years B.C., to one characterized by the intensification of fruit tree and tuber culture between 3,000 and 500 years B.C. (Jaén Suárez 1981).

During the earliest stages of nomadic activities, the population of Panama was probably limited to about 2,000 individuals, rising gradually to about 250,000 to 500,000 by A.D. 1500 (Jaén Suárez 1981). At the time of the arrival of Europeans, Panama's fertile land, numerous watersheds, and abundant wildlife constituted the subsistence resources for at least 60 Indian chiefdoms (Helms 1979). Three groups related to the Chibchas of Colombia—the Cuna, the Chocó, and the Guaymí—were prevalent then, and are still found today (Diagram Group 1985). Because of introduced diseases, war, and the indiscriminate use of Indians as a source of labor in mines and agriculture, only about 10,000 of the original inhabitants of Panama survived the Spanish conquest (Bennett 1968, Jaén Suárez 1981, Villegas 1917).

Thirty-two archaeological sites dating to the Late Ceramic Period (A.D. 600 to 1600) have been documented on the Petaquilla mining concession about 75 km southwest of the SLPA (Griggs 1998). One site appears to represent not only the late Ceramic, but also the Early Ceramic period (3,000 to 900 B.C.). Other cultural resources on the concession include a quartz mine, probably prehistoric, and three gold placer mine sites. A 1953 National Geographic exploration along the Río Indio, about 20 km west of SLPA, reported stories of aboriginal gold ornaments and uncovered potsherds at various sites (Stirling 1953).

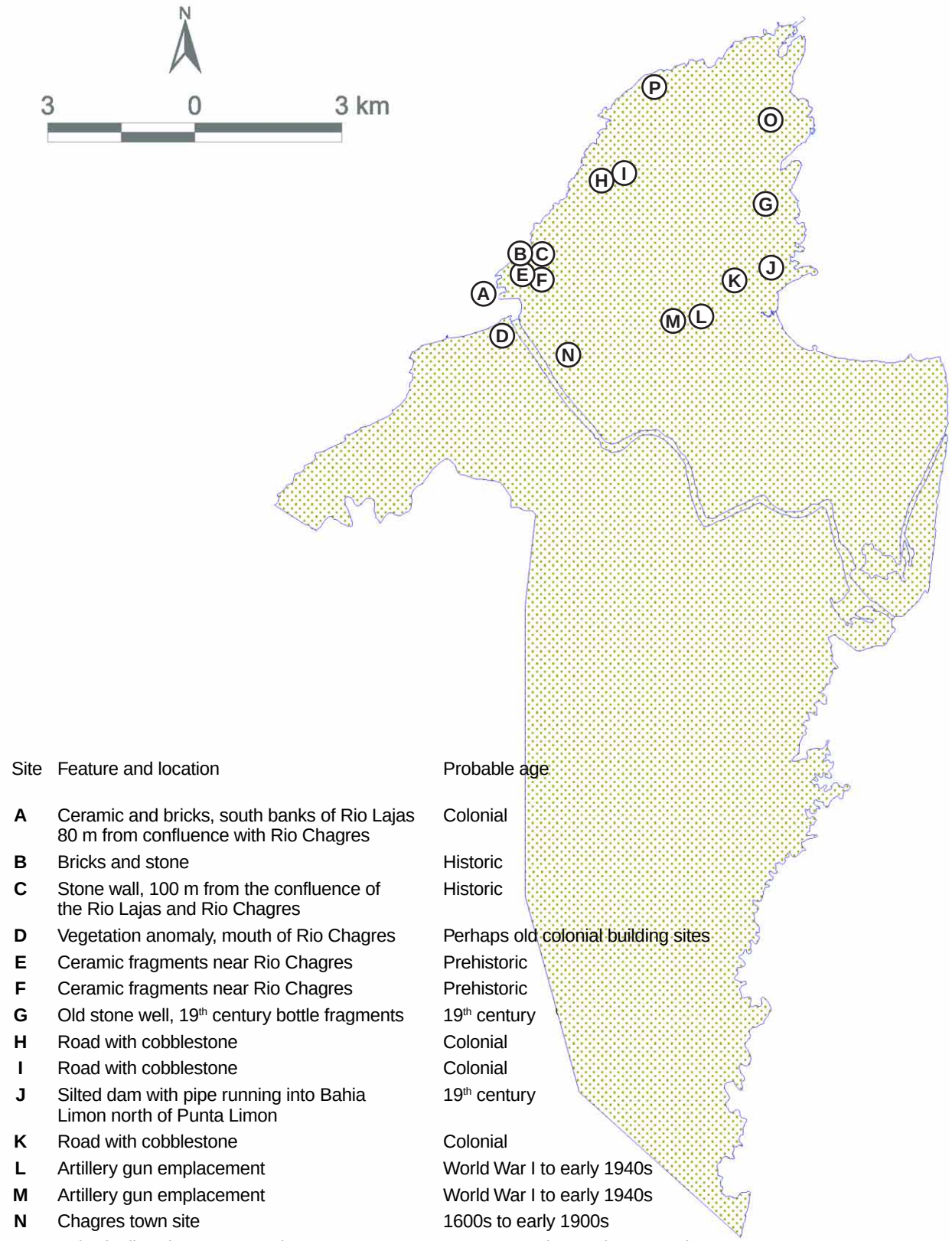
During a 1979 archaeological survey of the SLPA, very few prehistoric artifacts were found (Gaber 1987) (fig. 6). Much of the survey area is in the floodplain of the Chagres River, which, before the construction of the Gatún Dam, could be covered by as much as 14 m of water during the wet season probably burying any evidence of earlier occupation (Gaber 1987). A more recent reconnaissance showed potential for new finds at Fort San Lorenzo, particularly for excavations at the town site enclosed within the fort from 1680 to 1742 (Deagan 1993); moreover, the coastal waters off San Lorenzo contain shipwrecks and portions of the fort and cannons that have eroded into the sea. The shipwrecks provide an opportunity for underwater research and have attracted proposals for exploration and salvage (Colonial Panama 2000, Deagan 1993).

Spanish Conquest

Panama's Caribbean shoreline, centered along the coast of the SLPA, is steeped in the legacy of the fourth voyage of Columbus. In 1502, Columbus discovered the Chagres River, calling it "lagartos" after alligators seen on the banks. Columbus also established the Caribbean settlement Nombre de Dios, about 70 km to the northeast of the SLPA, then visited Portobelo, about 40 km to the northeast of the SLPA, and before returning to Spain, abandoned his caravel Gallega at the mouth of the Belén River, about 100 km to the west of the SLPA (Keith and others 1990). Goethals (1915) called Columbus "the practical founder of the Panama Canal enterprise, for he was the first to propose a water highway from Europe to Asia, by the Atlantic Ocean."

The waters off of Nombre de Díos and Portobelo became the resting place for at least 30 vessels between 1503 and 1818 (Colonial Panama 2000). Numerous barges and ships were also lost in or near the Chagres River, as follows: several flat-bottomed boats transporting treasure from Panama to Portobelo sunk in 1619 in the Chagres; five of Henry Morgan's ships lost in 1670 on reefs at the mouth of the Chagres; the merchant ship Chaperon sunk in 1681, and two Spanish vessels lost at the mouth of the Chagres during Admiral Vernon's attack in 1740. In 1681, an unidentified treasure galleon of Captain Antonio de Lima sank on the reef near Punta de Brujas, and the ship La Boticaria was lost near the Isla de Naranjos.

In 1513, native informants directed Balboa across the isthmus where, from a viewpoint on a ridge, he became the first European to see the Pacific Ocean (Helms 1975). In 1519, the local seat of government was moved to Panama City, which was linked by trail to Nombre de Dios. As early as 1523, Charles V of Spain ordered Cortes to search for a passage across the isthmus (Arosmena 1961); later, the King directed the Governor of Panama to explore the area south of the Chagres River for a site to cut a canal to the South Sea (Pacific Ocean). In 1532, Pizarro conquered Peru and Panama became the portage between the Pacific and Atlantic Oceans (Haring 1918). In 1534, the Las Cruces Trail from Panama City to the mouth of the



Site	Feature and location	Probable age
A	Ceramic and bricks, south banks of Rio Lajas 80 m from confluence with Rio Chagres	Colonial
B	Bricks and stone	Historic
C	Stone wall, 100 m from the confluence of the Rio Lajas and Rio Chagres	Historic
D	Vegetation anomaly, mouth of Rio Chagres	Perhaps old colonial building sites
E	Ceramic fragments near Rio Chagres	Prehistoric
F	Ceramic fragments near Rio Chagres	Prehistoric
G	Old stone well, 19th century bottle fragments	19th century
H	Road with cobblestone	Colonial
I	Road with cobblestone	Colonial
J	Silted dam with pipe running into Bahia Limon north of Punta Limon	19th century
K	Road with cobblestone	Colonial
L	Artillery gun emplacement	World War I to early 1940s
M	Artillery gun emplacement	World War I to early 1940s
N	Chagres town site	1600s to early 1900s
O	Pair of railroad ore cars, 0.5 km west-northwest of Punta Pulpit	1880s, French Canal construction
P	Heavily eroded ceramic sherds	Uncertain

Figure 6—Archaeological sites in the San Lorenzo Protected Area (Gaber 1987).

Chagres River was first established; consequently, Philip II of Spain foresaw the need for a fort at the Chagres mouth to protect Spain's gold route over the isthmus. These were the beginnings of Spanish influence in Panama, one of the few areas in the Caribbean Lowlands they effectively controlled during the colonial period (Helms 1975).

Fort San Lorenzo was constructed in several stages (Deagan 1993). In 1587 and 1588, trenches were dug to guard the river mouth with cannon. In 1595, a platform and tower were constructed about 8 m above sea level on the side of a cliff**.** In 1597, the Spanish contracted the Italian engineer Antonelli to construct a water level battery to defend the Chagres River at San Lorenzo. For the next 40 years, the battery was attacked, burned, fell into disrepair, and rebuilt. Nothing remains of the battery today (Manucy and Gagliano 1958).

In the 1680s, Fort San Lorenzo was constructed in its current location at 25 m above sea level on a cliff at the mouth of the Chagres River (Deagan 1993; Zapatero 1985a, 1985b). The walls of the fort on the landward side were protected by a 10-m wide dry moat with a drawbridge. The fort had a parade ground and several enclosed cells designed for the confinement of prisoners and the storage of equipment and supplies. In 1748, the Spanish abandoned the Chagres route over the isthmus, preferring travel around the tip of South America at Cape Horn. From that time until the late 19th century, the Colombian Government, of which Panama was then a part, used the fort as a prison.

Eleven sites associated mainly with colonial and 18th century military activities were found during several reconnaissance trips through the SLPA in 1979 (Gaber 1987) (fig. 6). The most important site was Fort San Lorenzo and the surrounding terrain, including the shores of the Chagres River, where an indigenous settlement once existed. Gold, silver, and other goods were shipped from Peru to Panama City, carried by mule on the Las Cruces Trail where it crosses the Chagres, and by boat to Fort San Lorenzo. Mule trains with as many as 500 animals were reported (Manucy and Gagliano 1958).

About 1750, as part of the efforts to fortify Panama, the Spanish excavated six trenches totaling 700 m in length on Gatún Hill on the west bank of the Chagres (Albright 1971, Manucy and Gagliano 1958, Webster 1971). Each of the trenches, the longest of which is 260 m, measures about 1 m wide and 1.2 m deep. Fort Gatún, now flooded by Gatún Lake, was situated at the confluence of the Chagres and Gatún Rivers, about 120 m vertically and 1.6 km horizontally from the trenches. The purpose for the extensive and well-constructed trenches is uncertain; however, the construction is military, with a firing step and broad Earth parapet held with stone. The strategic location on Gatún Hill provides a clear view of both the Chagres River and Limón Bay. In 1719, French pirates sacked Fort San Lorenzo and then traveled along the Mojinga Swamp shoreline to Limón Bay, a route that would have passed below the trenches. Perhaps the trenches were intended for the defense of Fort Gatún should Fort San Lorenzo fall to invaders. Another possibility is that the trenches were built as a last means of defense to which river inhabitants could escape in case of attack.

Fortune Seekers: Pirates and the Gold Rush

The "Spanish Main" originally referred to the South American Coast between Panama and the Gulf of Paria (Roberts 1940). Later, however, it was expanded to include the adjacent lands and waters of Central America and the Caribbean, areas visited and traversed by Spanish galleons after finding gold in the New World. The discovery of Peru's gold led to the use of the "Camino Real" in Panama—the route by which all merchandise had to pass when crossing the isthmus (Manucy and Gagliano 1958, Minter 1948, Peterson 1975). Two routes, however, actually existed in Panama. The "Camino Real," used during the dry season, was located between Panama City and Nombre de Dios. The "Camino de las Cruces," two-thirds of which was the Chagres River, was used during the wet season. The Cruces Trail went from Panama City through the river settlement of Cruces, down the Chagres River past Gatún Hill to Fort San Lorenzo, and then onto Portobelo via the Caribbean Sea. Construction of the Panama Canal flooded much of the town of Cruces and portions of the "Camino Real."

Pirates began attacking Panama's Coast around 1560. In 1571, Sir Francis Drake entered the Chagres River and sacked Cruces, plundering barges on route (Mason 1942, Peterson 1975). In 1573, with the help of escaped African slaves known as Cimarrons (Minter 1948), Drake robbed a mule train laden with treasure bound for Nombre de Dios. His other

ventures included attacks on Nombre de Dios, Cartegena, the west coast of South America from Peru to Panama, and circumnavigation of the globe from 1577 to 1580. In 1594, Drake returned from England to again attack Spanish settlements in the Caribbean. In 1596, he burned Nombre de Dios, and Portobelo superceded it as the Atlantic port-o-call. Drake died later that year and was buried at sea, where his remains lie somewhere in the shallow waters off Portobelo—an appropriate place for a buccaneer who, as a young man, gained fame for his Caribbean exploits against the Spanish.

Perhaps the most famous of Caribbean adventurers was Sir Henry Morgan—buccaneer, admiral, and Lieutenant Governor of Jamaica (Bennett 1915, Earle 1981, Forbes 1948, Lindsay 1951, Peterson 1975, Roberts 1940). Born in Pencarn, Wales, around 1635, Morgan may have first sailed as a seaman in search of wealth and adventure, although some suggest that he sold himself as a bond slave in Barbados. Using Port Royal, Jamaica, as a base, his early plundering included Puerto Príncipe, Cuba, and Portobelo, Panama. In 1670, Morgan ordered the attack that left Fort San Lorenzo in ruins. In 1671, after a forced march across the isthmus with about 1,200 men, Morgan sacked and burned Panama City, the "greatest mart for gold and silver in the whole world" (Minter 1948).

Once back at San Lorenzo, Morgan deceived his own men, loading his ships and returning to Jamaica with the bulk of the stolen goods (Minter 1948). Morgan was soon deported to England, where he was confined for his Panamanian exploits after England and Spain signed the Treaty of the Americas. Bribing his way to freedom, Morgan was subsequently appointed Lieutenant Governor of Jamaica, for which he received the customary honor of knighthood. Morgan's remaining years were spent in Jamaica, where he died in August of 1688. During an earthquake 4 years later, his grave, located on a point along the harbor, went "into the sea, to the sharks . . . while the earth opened as though the devil himself had come to claim his own at last" (Lindsay 1951). Between 1739 and 1742, Admiral Vernon attacked San Lorenzo, burning the town of Chagres but not destroying the fort (Deagan 1993). In the late 1700s, piracy waned (Helms 1975) and the legacy of the buccaneers came to a close.

The 1848 discovery of gold at Sutter's mill in California caused "gold fever" and a rush from the U.S. Eastern seaboard west via several major routes. The first route was 4800 km across the North American plains by wagon train; the second was by ship to the mouth of Nicaragua's San Juan River, then northwest by boat to Lake Nicaragua, then to the Pacific Coast port of Corinto by stagecoach, then on to California by ship. Another route was a 25 000-km trip by ship around Cape Horn. The last alternative was over the Isthmus of Panama. The trip included a canoe ride beginning at the mouth of the Chagres, known then as "Yankee Town," followed by an overland trek by mule or foot south to Panama City on the Pacific Coast, then north to the U.S. west coast by ship.

The gold rush attracted reckless, impatient fortune seekers not accustomed to hardships. Gamblers, murderers, speculators, cheap politicians, and prostitutes were in the majority along the Panama Canal route (Perez-Venero 1978). Chagres in those days was a "no man's land," an uncomfortable place with frequent culture clashes, all kinds of vices, and people from the lowest social stratum (Periera Jiménez 1964). All this was happening without protest on anybody's part—a veritable American "wild-west" atmosphere. Travel on the Chagres to Panama City was just as bad—too few boats, mules, or horses for transport, exorbitant prices, no guarantees for anything. Everybody traveled at their own risk.

The gold rush and the need for an efficient East-West mail route in the United States stimulated the construction of the Panama railroad (Grigore 1997, Kemble 1943). Between 1848 and 1869, nearly 600,000 passengers—along with $710 million of treasure shipments—traversed Panama (Kemble 1943). During the construction of the railroad between 1850 and 1855, more than 6,000 people died from cholera, dysentery, malaria, yellow fever, smallpox, and other maladies. An often quoted, though grossly inflated estimate for deaths while building the railroad is that one man died for every tie placed along the 75-km track (Grigore 1997, McCullough 1977). Maps of the railroad route indicate that its closest approach to the SLPA may have been in the vicinity of the Gatún Locks (Mack 1944, Otis 1867).

African and West Indian Heritage

The rapid decline of the Indians early in the colonial period due to Spanish colonization and Indian enslavement was not immediately matched by an increase of Europeans and Africans, the latter first forcibly imported in the 16th century as slaves. Labor was still scarce in the mid-19th century. Between 1850 and 1950, as many as 200,000 West Indians emigrated to Panama in search of employment and a better life (Bennett 1915, Conniff 1983, Wood 1915) in four major movements: from 1850 to 1855, during the construction of the Panama railroad; from 1880 to 1889, for the unsuccessful French canal; from 1904 to 1914, during the construction of the U.S. canal; and, from 1940 to 1942, for the proposed development of an additional set of canal locks. The latter work was never completed.

Many West Indians who stayed in Panama after the construction of the canal faced difficult times (Lewis 1980). They were no longer protected by British law nor were their children British citizens. The canal government could not offer West Indians citizenship nor were they permitted to reside in the Canal Zone; moreover, the Panamanian Government did not offer them citizenship because of the language barrier. Regardless, many West Indians continued to live in Panama after the work on the canal was finished; today their children are an integral part of Panama's cultural diversity. The valiant efforts of West Indians were later recognized in statements such as "the remarkable economic development which Panama has made in a half century of republican life, was due to the contributions which have come from many sources, not the least of which is that substantially rendered by the people from the West Indies whose offspring are now fully participating in the life of our country without let or hindrance" (Lewis 1980).

The descendants of African slaves brought to Panama during the colonial period now celebrate their freedom during the Congo festivities held every year from late January until Ash Wednesday (Cheville 1977). Scattered in small towns such as Achiote, Escobal, and Piña near the SLPA, and along the Caribbean Coast around Colon, Congo groups meet in their own private retreats (el palenque) to sing, dance, prepare special meals, and enact a folk drama. The dance celebrates the flight and settlement of escaped slaves (cimarrones). The cimarrones successfully waged guerrilla war from jungle communities, forcing the Spanish to negotiate a peace treaty. During carnival season, minikingdoms of Congos exist alongside the civil community. The Congo queen, María de Merced, and her surrogate husband, Juan, temporarily reign over the kingdoms, sharing the responsibilities for the fiesta, including visits between various Congo groups.

Photo courtesy of Gerald P. Bauer.

Descendants of African slaves brought to Panama during the colonial period commemorate their freedom during the Congo festivities held from late January until Ash Wednesday. Group members meet in their own private retreat (el palenque) to sing, dance, prepare special meals, and enact a folk drama.

The Panama Canal: France and the United States

Soon after discovery by the Europeans, Panama was recognized as an important crossroads linking two oceans and two continents. Panama was the first European settlement offering convenient access to the western coasts of Central and South America; indeed, Simón Bolivar suggested the country as a potential World capital should one ever be created (Pan American Union 1955). Bolivar saw Panama "situated as it is in the center of the world, looking in one direction towards Africa and Europe, and equidistant from America's two extremities," as a capital of peace (Collin 1990). Access across the isthmus, began as an Indian trail, was followed by a Spanish cobble road soon after the discovery of the Pacific Ocean, a railroad in 1855, and finally a canal in 1914. Even before Panama's independence from Spain, Panamanians had developed what some intellectuals described as a "transit" personality (Perez-Venero 1978).

In 1821, Panama declared its independence from Spain along with the rest of Central America, and joined the Republic of Greater Colombia (Colombia and Venezuela), which had already achieved independence from Spain in 1819. Panama briefly seceded from Colombia in 1830, and again for 13 months in the early 1840s. From 1850 to 1902, at least 53 revolutions, rebellions, insurrections, riots, and other outbreaks in Panama indicated that the Colombian Government, centered in Bogotá, was incapable of controlling the isthmus (Roberts 1940, Speller 1972). Finally, in 1903, Panama achieved independence from Colombia.

The idea of constructing a canal across the isthmus, first conceived by the Spanish in colonial times, was resurrected by the French in January of 1880 (Arosemena 1961, Haring 1918, Villegas 1917). Promoted by an energetic Ferdinand de Lesseps, a key player in the construction of the Suez Canal, the effort fell apart in May 1889, after countless engineering failures, health problems, and the financial "crash" of the worthless stock of the French Canal Company. After building docks, living quarters, hospitals and offices, and excavating an estimated 50 million m^3 of soil—an amount equivalent to two-thirds of that removed for the Suez Canal—de Lesseps found his dream conquered by the Panamanian jungle. Today, quiet backwaters are the surviving remnants of the proposed sea-level canal.

For many years, the Chagres River was the center of debate in the proposed sea-level canal. Seasonally high rainfall in its headwaters caused flooding of the Gatún Lowlands and of the Chagres flood plains in the SLPA. The final decision to build a canal with locks mandated the construction of a dam on the Chagres and the formation of Gatún Lake.

Few passengers aboard the cargo ships and cruisers that rise and fall 25 m while riding through the locks know much about the canal's past. The manifest destiny philosophy of the United States, the dynamic character of Teddy Roosevelt (McDowell 1958), the French attempt to salvage everything possible from the sea-level canal fiasco, and Panama's independence from Colombia, are all woven into the intriguing history of the Panama Canal—the eighth wonder of the World (McCullough 1977). During that history, 200 million m^3 of soil were excavated, three locks measuring 33 by 300 m were built, the World's largest Earth dam was constructed, Gatún Lake was created, dreadful tropical diseases were conquered, and a pathway across the isthmus was opened—the dream first conceived by the Spanish 400 years earlier. The canal, built at a cost of $387 million, today provides safe passage to 14,000 ships per year (Simons 1999); unfortunately, 25,000 human lives were lost to disease during the combined French and U.S. efforts.

Agricultural Activities: A Forgotten Past

Before World War I, migratory farming was one of the major causes of forest loss on the SLPA (McCullough and others 1956). Numerous small farms and some larger ones were operating near Toro Point (fig. 1) and in the watersheds of the Arenal and Aguadulce Rivers (fig. 3). By 1912, no undisturbed forest remained below 30 m in elevation between the Arenal River Valley east to Limón Bay and south to Limón Point.

Along the Caribbean Coast, there was one settlement at the mouth of the Naranjitos River, and another named San José near the beginning of the road to Pavon (McCullough and others 1956). A trail ran from the mouth of the Chagres through San José to Shimmey Beach about 0.8 km east of the current highway. Lateral trails, where squatters practiced migratory agriculture, extended from the main trail to

Naranjitos Point and Battery Pratt. Agriculture along the coastal fringe between the Chagres and Piña Rivers, including the farms in the valley of the Piña River, was abandoned in 1918.

Several small populations existed along the Chagres River in 1912, the most famous being the 16th century town of Chagres, which was near Fort San Lorenzo (McCullough and others 1956, Periera Jiménez 1964). In 1916, the town had 96 houses and 400 to 500 inhabitants. It was during the California gold rush, however, when Chagres served as a terminus for both people and freight, that the town had its greatest population. Given the continual demand for food and forest products at that time, it is unlikely that any forest within 2 or 3 km of the town escaped cutting.

Around 1912, a very fertile strip of land below the Gatún Dam was cultivated in coconuts and bananas (Bennett 1912). Other farms were located near the Indio River, and at several locations along the Chagres River below Gatún, including the prosperous San Andreas hacienda near the bend in the river. Agricultural crops, coconut plantations, and pasture surrounded the hacienda. At that time, the steamship Chagres (gross tonnage of 5,288), owned by a subsidiary of the United Fruit Company, transported bananas from the lower Chagres River to ports in the United States (Adams 1914). Panama disease caused by a *Fusarium* fungus, however, was so common within the region that most farmers expected no more than 5 years of production before outbreaks (Bennett 1929). The cultivation of crops such as corn, sugar cane, para grass, rice, and numerous vegetables was considered possible if protection from flooding and adequate drainage were provided. Among the common tropical fruits were mangos, avocados, plantains, papayas, star apples, soursops, oranges, limes, pineapples, breadfruit, and sapotes. It is highly unlikely that, before 1912, any suitable agricultural land within the region remained uncleared.

After World War I, the banana industry expanded in the Canal Zone, particularly in the hills around Gatún Lake (McCullough and others 1956). The largest plantings, about 600 ha, were just north of Escobal. Other large plantings were situated in the headwaters of the Piña River, along the Gatún Locks-Escobal Road (S10), and in the Mindi Hills and lowlands to the south and east. A new policy was adopted within the Canal Zone in 1921 allowing the lease of small tracts of land for agriculture (Jaén Suárez 1981, McCullough and others 1956). Farms were established in the Mindi Hills and the lowlands to the east. This policy was altered in 1935 when, as a prewar safety measure, no new lands were leased, and existing licenses could not be sold or transferred. Moreover, when license holders died or moved off the land, their property reverted to forest. By the start of World War II, most of the land leased for banana plantations had been abandoned.

Surrounding Communities Today

The 1990 population of Colon province, including four "corregimientos" (Spanish territorial units, the jurisdiction of a mayor appointed by the king) that encompass the SLPA, averaged from 10 to 30 persons/km^2 (República de Panamá 1991). At the same time, the total population of the communities nearest the SLPA was 775 persons. By 2000, the total population of these communities had more than tripled to 2,378 persons. Achiote had 365 persons, Escobal 1,653, and Piña 360. Away from the immediate boundary of the SLPA, the greatest number of persons live to the east along the canal, and in and around the city of Colon; lands along the Caribbean shore only a few kilometers to the west remain sparsely settled.

The current impact of these communities on the SLPA involves clandestine timber cutting and hunting, illegal extraction of plant materials, some harvest of fuelwood, freshwater and marine fishing, and coffee production under the forest canopy. The latter—a type of agroforestry widespread in the Tropics—protects the soil, recycles nutrients, and provides habitat for numerous species of animals (Perfecto and others 1996, Wunderle and Waide 1993). Subsistence crops such as bananas and tubers are often grown with the coffee. Coffee shade often supports high densities of bird species, especially migrants, whose habitat requirements are likely to be less stringent than resident species.

Several programs have been initiated with the local communities. The Natura Foundation (Fundación Natura) is working through the Panamanian Centre for Research and Social Action (CEASPA) to improve the production of coffee crops, to plant native tree species, and to introduce an iguana-breeding program. CEASPA is also involved in environmental awareness activities for community leaders and schoolchildren.

Through an interinstitutional agreement, ARI, ANAM, and IPAT cooperated to hire 15 Colon residents to work as park guards to protect the SLPA. Training for the guards included first aid, patrolling techniques, plant and animal identification, map reading, and interaction with visitors.

Fort Sherman

The Panama Canal was built when the battleship was the major strategic weapon and being a great power implied being a naval power (Morris 1994). The canal's opening on August 15, 1914, was only 1 week after the outbreak of World War I. The defensive structures, training programs, and protective measures implemented at Fort Sherman reflected immediate military concerns. During the 20th century, as weapons and delivery systems modernized and international relations improved, past concerns about belligerent nations were refocused on terrorism, natural disasters, and environmental protection.

The two major military facilities on the SLPA were the Fort Sherman complex north of the Chagres River and the Piña Firing Range south of the Chagres (Jungle Expert 2000) (fig. 1). The Fort Sherman complex had artillery batteries and anti-aircraft gun emplacements, both obsolete by the mid-1940s. The Piña Range had small arms firing ranges, a mortar maneuver course, a live fire village, and a demolitions range. The white drop zone and other areas along Gatún Lake were used for airborne insertions and small boat operations. The Chagres River was also used for small boat and tactical riverine operations. In the later years, Fort Sherman was mainly used to lodge troops stationed on the Caribbean side of the canal, making it an ideal site for jungle warfare training.

Battery Stanley, built between 1912 and 1916, was named for Major General David Sloane Stanley. The battery contained a single 14-inch rifle with a range of 24,000 yards, as well as underground rooms for ammunition storage, plotting, and communications. The battery was abandoned after World War II.

Photo courtesy of Gerald P. Bauer.

Military History

On November 5, 1903, the first permanent U.S. military force was stationed in the Canal Zone to support Panama's quest for independence. In 1909, the U.S. Secretary of War requested plans for the defense of the canal that included the building and maintenance of Fort Sherman, which was named in honor of renowned Civil War commander William Tecumseh Sherman (Morris 1994). The first troops arrived in October, 1911 (Jungle Expert 2000), when construction began at Toro Point (Bryan 1941, McCullough and others 1956). From this time until shortly after World War II, Fort Sherman remained heavily fortified to protect the Panama Canal, including the Atlantic port of Cristóbal and the Gatún Locks.

Between 1912 and 1924, seven batteries (Baird, Howard, Kilpatrick, MacKenzie, Mower, Pratt, and Stanley), named after Civil War commanders, were constructed at Fort Sherman along its northern shoreline (Morris 1994) (table 1). Each had a defensive wall, rotary cannon, and bunkers for the storage of munitions and communications equipment. The batteries operated originally through soldiers stationed at observation points, some located at a considerable distance. The use of aircraft carriers during World War II, as witnessed by the attack on Pearl Harbor, made these defensive structures obsolete (McGovern 1998). Following the war, the large coastal defensive weapons were dismantled. The battery sites, however, remain in relatively good condition as relics of earlier military era.

Starting in 1943, Fort Sherman was used as a military training site for the Pacific Theater because of its rugged terrain, notably that of the Piña Range (Jungle Expert 2000). At the peak of World War II, the United States had 60,000 troops in Panama, many stationed at Fort Sherman. Moreover, at that time, several security measures were adopted to protect the canal, among them

- Implementing a mobile force among air and submarine bases as part of a Caribbean network
- Constructing torpedo nets in harbors
- Implementing anti-aircraft defenses to avert sabotage of Gatún Dam
- Posting guards at the locks and on board ships as they traversed the canal.

In 1953, the U.S. Army designated Fort Sherman as the Jungle Warfare Training Center, later called the Jungle Operations Training Center, "to keep the art of jungle warfare alive in the Army." The first trainees were from Panama, but training for outside units was initiated in 1957. The center normally ran 10 training cycles of 3 weeks duration each year. Training increased during the Vietnam War, graduating 1,700 students in 1961 and 9,145 in 1967. A normal training cycle for the Jungle Warfare Course involved individual soldier, small unit, and company skills (Jungle Expert 2000, McDowell 1978). Once the small unit was proficient in jungle operations, field training moved to company, and occasionally to battalion level exercises.

In the mid-1970s, Fort Sherman was designated as the training area for the U.S. Army School of the Americas Jungle Operations Training Center based at Fort Gulick (Jungle Expert 2000). Training programs involved instruction on battalion level techniques of jungle survival and operations for units from the continental United States. In 1976, the fort also became the home of the local army's Noncommissioned Officer's Academy (De Mena 1995). Other training programs offered through the 1990s included the Engineer's Jungle Warfare Course, which gave greater emphasis to demolitions and mobility operations, and the Air Crew Survival Course, which emphasized basic survival, escape, and evasion techniques.

The U.S. presence within the Canal Zone was a source of contention during much of the 20th century. In 1964, the flag riots related to sovereignty of the Panama Canal resulted in 21 deaths and more than 450 wounded (Graffenreid and Wheaton 1976). Subsequently, a series of meetings, some bilateral and others involving international entities such as the OAS and the United Nations, gradually resulted in mutual agreement between Panama and the United States. The treaties negotiated between Jimmy Carter and Omar Torrijos in 1977 abolished the Canal Zone and gave the permanent right to the United States, jointly with Panama, to defend the canal's neutrality (Morris 1994). The treaties also provided for the gradual return of 7,000 military and civilian buildings to Panama. Fort Sherman, the oldest—and one of the largest—Army installations in Panama, remained a defensive site until June 30, 1999.

Table 1—Major fortifications built at Fort Sherman through World War II

Battery name	Construction dates	Namesake[a]	Equipment or other details	Dates scrapped
Baird	1912–15	Brigadier General Absalom Baird	Four 12-inch mortars (M 1912) on model 1896 M III mounts; traverse 360°; range of 17,900 yards	1943
Howard	1912–15	Major General Oliver O. Howard	Details same as Baird	1943
Kilpatrick	1913–16	Major General Hugh Judson Kilpatrick	Two 6-inch rifles model (M 1908, M II) on disappearing carriage model (DC 1905 M II); traverse 170°; range of 14,500 yards	1946
MacKenzie	1916–23	Major General Alexander MacKenzie	Same equipment as Pratt; field command post for jungle warfare training	
Mower	1912–15	Major General Joseph Anthony Mower	Single 14-inch rifle model (M1910) on DC M 1910 disappearing carriage mount; traverse 170°; range of 24,000 yards; underground ammunition storage, plotting room, and communications system	Between 1946–48
Pratt	1916–23	Brigadier General Sedgwick Pratt	Two 12-inch rifles on barbette mounts model (BC M 1917); traverse 360°; range 30,000 yards; casemated in 1942; concrete tunnel, magazines, and plotting rooms; covered with about 30 feet of soil; is well protected; designated in 1965 as alternate command post for Headquarters U.S. Southern Command	
Stanley	1912–16	Major General David Sloane Stanley	Details virtually the same as Mower	Between 1946–48
Tortuguilla Point, Naranjitos Point, Fort Sherman	1939		Four 155-mm guns on Panama mounts at each site	After World War II
Fort San Lorenzo, Tortuguilla Point	1939		Two 75-mm guns at each site, the former on pedestal mounts and the latter on temporary emplacements	After World War II
Fort Sherman	1939		Four 75-mm guns on temporary emplacements	After World War II

[a] Prominent military figures from the U.S. Civil War.
Source: Gardner and Carpenter (1965), McGovern (1998).

Infrastructure

The infrastructure evident today at Fort Sherman evolved over the course of the 20th century. The earliest housing was made of wood, later replaced by concrete (De Mena 1996). The initial access to the base was by boat or ferry across Limón Bay, and then by aircraft or train to Fort Sherman. Over time, many obsolete structures were removed or abandoned.

The first structures visible to visitors as they enter the canal from the Caribbean are the breakwaters at the entrance to Limón Bay. They were completed by 1916 using rock quarried at Portobelo on the Caribbean side (Abbot 1913) or at Sosa Hill on the Pacific side (Rosseau 1915), along with spoils derived from the Culebra Cut (McGovern 1998) and materials excavated from the Colon harbor (Comber 1915). Extending 3.5 km into the Caribbean from Toro Point on the west, and 3.3 km from Coco Solo Point on the east, the breakwaters protect vessels entering the canal, notably from the winter "northers" that blow from November to April (Rousseau 1915). In addition to reducing heavy wave action, breakers help control sediment deposition at the canal entrance (St. George 1985). Spoils from the Culebra Cut were also used to build Gatún Dam and to furnish landfill for the port of Balboa (McGovern 1998). In the past, passengers entering the canal were greeted by the lighthouse at Toro Point, a relic from the French era. Built in 1893, the lighthouse once had a Fresnel lens capable of casting a beam of light > 30 km to the horizon.

Today, the fort contains seven three-story buildings, three two-story buildings, and 67 homes, with accommodations for 300 people; all the buildings were previously used as barracks, officers quarters, or residences. Other facilities, developed in response to local needs or military requisites, include a cafeteria, chapel, craft shop, gymnasium, library, movie theater, recreational facilities, an airstrip, boat houses, bulk fuel storage facilities, docks, and warehouses (De Mena 1996; GEA Consultores, S.A. and Louis Berger International, Inc. 1999). These facilities are now available for administrative offices, interpretative centers, visitors' accommodations, storage areas, and other purposes.

Fort Sherman's communication tower has been well maintained and remains functional. Of the seven World War I batteries, Mower and Stanley, which are overgrown with vegetation, require the most attention. The three observation towers, each made of reinforced concrete, have staircases to canopy-level platforms.

Transportation System

The SLPA has numerous natural and constructed corridors, the latter being associated with the area's military past (fig. 3). The Chagres River, navigable for 13 km through riparian forest between Gatún Dam and Fort San Lorenzo, is the largest of these corridors. The lower stretches of other small rivers are also navigable, but only for short distances in small boats. Most of the SLPA shoreline, from Piña to Fort Sherman along the Caribbean Sea, and from Gatún Dam to Escobal along Gatún Lake, is accessible by boat.

SLPA's transportation system was developed in stages. Initially, Fort Sherman was serviced by ferry from Cristóbal (De Mena 1996). Among the earliest works to be developed were a railroad from Fort Sherman to batteries MacKenzie and Pratt, and a road from battery MacKenzie to Tortuguilla Point, both in 1921. The railroads no longer exist.

Much of the SLPA transportation system was constructed between 1939 and 1943 for the defense of the canal during World War II. In 1942, the 13-km Gatún Locks-Sherman Road (S2) was completed. Today, the road extends for 18 km from Fort Sherman to Escobal, running along the eastern boundary of the SLPA, passing the Gatún Locks and dam about midway. The Sherman-San Lorenzo Road (S8) parallels the Caribbean Sea for 6 km, ending at the mouth of the Chagres River. The 15-km Piña Road (S1), about 1 to 2 km distant from the Chagres River over most of its course, connects the Caribbean town of Piña with the Gatún Locks-Escobal Road (S10) at a point about 2 km southwest of the Gatún Dam. All but the Sherman-San Lorenzo Road (S8) and the Piña Road (S1) are paved. In addition to these major roads, there are numerous secondary roads, jeep trails, speciality roads (to batteries, docks, military facilities, and research sites), and hiking trails that provide access to the forests, scenic vistas, and waterfalls of the SLPA.

In the past, the Fort Sherman landing strip, nearly 1000 m in length, was crucial for defense of the canal and for training. Today, the airstrip can be used for emergencies or to facilitate the visits of important guests. A helicopter-landing pad is located near the STRI canopy crane. Boat ramps are also available for shoreline patrol and recreation.

Terrestrial Flora

General

Much of the forest within the SLPA is secondary (McCullough and others 1956). First impacts to the forest may date as far back as the 1540s, when riverboats traversed two-thirds of the "Camino de las Cruces" on the Chagres River. Other disturbances were associated with the construction of the transisthmus railroad, both French and U.S. efforts to build the Panama Canal, and all subsistence and plantation farming north and south of the Chagres River abandoned between 1912 and the mid-1940s. In the Fort Sherman uplands, all forest within a couple of kilometers of the fort near old Chagres, within the firing range, and along the major highways, railroad routes, and batteries, is secondary. McCullough and others (1956) summarize well the nature of SLPA forests when they note that "the forests have been cut or profoundly disturbed in various degrees at many different places and at many different times during the past century. Accordingly, tracts developing replacement forest (usually called 'secondary growth') are present in all parts of the area."

The greatest tract of mature forest in the Fort Sherman uplands is located in the most rugged terrain—the area northeast of Pavon Peak southward toward the Chagres River. South of the Chagres River, much of the forest land is relatively undisturbed. The major exception is the impacted vegetation growing within the Piña Firing Range.

By the mid-1980s, known flora in Panama, including Pteridophytes, numbered more than 8,100 species in 195 families with more than one-quarter in the 5 most common families—Orchidaceae, Leguminosae, Rubiaceae, Graminae, and Compositae (D'Arcy 1987, Woodson and Schery 1943–1980). By the early 1990s, the total number of angiosperms, gymnosperms, ferns, and fern-allies was estimated at nearly 9,400 (Correa and Valdespino 1998, Hampshire 1989). A recent survey of the SLPA's flora and fauna was based on a rapid ecological assessment of habitats and species (Asociación Nacional para la Conservación de la Naturaleza and The Nature Conservancy 1996). Although such assessments may help characterize a region, restrictions on time and access lead to underestimates of species. According to the assessment, Fort Sherman contains at least 450 plant species and the Piña Range at least 300 (table 2). Subsequent research on only 4.96 ha of tall evergreen seasonal forest revealed about 200 tree species of at least 1 cm in diameter (table 3) (Condit and others 2004). Future taxonomic field studies will certainly augment the plant list for the SLPA.

On nearby Barro Colorado Island, peaks in flowering occur during the dry season, and in July (Croat 1969). The first peak is largely due to trees and vines, and partly to shrubs and small trees; the second peak results from the flowering of small trees, shrubs, and herbs. Although the SLPA flora has not been studied in the same detail as that on Barro Colorado Island, a surge in flowering during the dry season is evident.

Table 2—Plant species in the San Lorenzo Protected Area

Family	English name	Scientific name	Vegetation type[a] 1	2	3	4	5	6	7	8	9	10	11	12
Dicotiledoneas														
Acanthaceae	Acanthus	*Aphelandra sinclairiana*		x	x		x							
Anacardiaceae	Sumac	*Anacardium exelsum*	x	x	x	x	x		x					x
		Mangifera indica					x							
		Spondias mombin	x	x	x	x	x	x	x					
		S. radlkoferi	x											
		Tapirira guianensis	x											
Annonaceae	Custard apple	*Annona acuminata*	x	x	x	x	x							
		A. glabra							x					
		A. purpurea						x						
		A. spraguei	x	x	x		x		x					
		Desmopsis panamensis	x	x	x	x	x		x	x				
		Guatteria amplifolia	x	x										
		G. dumetorum	x	x	x	x			x					
		Oxandra longipetala								x				
		Xylopia aromatica	x											
		X. frutescens		x	x									
		X. macrantha	x	x	x	x	x		x					
Apocynaceae	Dogbane	*Aspidosperma cruenta*			x									
		A. megalocarpon	x			x								
		Lacmellea panamensis	x	x	x	x			x					
		Odontadenia puncticulosa							x					
		Malouetia guatemalensis								x				
		Rhabdadenia biflora									x			
		Stemmadenia grandiflora				x								
		Tabernaemontana arborea	x	x	x	x		x	x					
		Thevetia ahouai			x									
Araliaceae	Ginseng	*Dendropanax arboreus*	x	x	x	x								
		Didymopanax morototoni		x	x									
Asteraceae	Aster	*Lycoseris latifolia*						x						
		Mikania leiostachya							x					
		Wedelia trilobata							x					
Bignoniaceae	Trumpet-creeper	*Amphitecna latifolia*								x				
		Jacaranda copaia	x	x	x									
		Macfadyena unguis-cati	x						x	x				
		Parmentiera cereifera					x	x						
		Phryganocydia corymbosa		x										
		Pithecoctenium crucigerum			x									
		Tabebuia rosea	x	x		x	x		x	x				
Bixaceae	Red-flower pincushion	*Cochlospermum vitifolium*			x									

continued

Table 2—Plant species in the San Lorenzo Protected Area (continued)

Family	English name	Scientific name	Vegetation type[a] 1	2	3	4	5	6	7	8	9	10	11	12
Dicotiledoneas (cont.)														
Bombacaceae	Kapok-tree	*Bombacopsis quinata*		x	x	x	x	x		x				
		Cavanillesia platanifolia	x			x								
		Ceiba pentandra	x											
		Ochroma pyramidale		x										
		Pachira aquatica							x					
		Pseudobombax septenatum	x	x		x	x	x		x				
		Quararibea asterolepis	x			x								
		Q. pterocalyx				x								
Boraginaceae	Borago	*Cordia alliodora*		x	x		x							
		C. bicolor	x	x	x		x							
		C. lasiocalyx	x											
		C. panamensis					x							
Burseraceae	Frankincense	*Buresra simaruba*				x	x	x						
		Protium costaricense		x	x									
		P. pnamense	x	x	x	x	x			x				
		P. tenuifolium		x	x									
		Tetragastris panamensis	x	x	x									
		Trattinnickia aspera	x	x	x									
Buxaceae	Boxwood	*Buxus citrifolia*						x						
Cactaceae	Cactus	*Epiphyllum phyllanthus*				x					x			
Capparidaceae	Caper	*Capparis frondosa*	x	x	x	x	x		x					
		C. odoratissima						x						
Cecropiaceae	Cecropia	*Cecropia insignis*	x		x									
		C. longipes				x								
		C. obtusifolia		x	x	x	x		x		x	x		
		C. peltata		x	x			x	x		x			x
		Pourouma guianensis	x	x	x									
Chrysobalanaceae	Cocoa-plum	*Hirtella americana*		x	x									
		H. racemosa	x	x										
		H. triandra	x	x	x	x	x			x				
		Licania hypoleuca		x										
		Maranthes panamensis	x	x	x									
Clusiaceae	Mangosteen	*Calophyllum longifolium*	x	x	x	x								
		Marila laxiflora	x	x										
		Rheedia edulis	x	x	x									
		Symphonia globulifera	x	x					x	x				
		Tovomita longifolia	x	x										
		T. stylosa	x	x						x				
Combretaceae	Indian almond	*Bucida buceras*							x		x			
		Combretum decandrum				x	x							
		Conocarpus erectus									x			
		Laguncularia racemosa									x			
		Terminalia amazonia	x	x	x									

continued

Table 2—Plant species in the San Lorenzo Protected Area (continued)

Family	English name	Scientific name	Vegetation type[a] 1	2	3	4	5	6	7	8	9	10	11	12
Dicotiledoneas (cont.)														
Connaraceae	Connarus	*Rourea glabra*		x										
Convolvulaceae	Morning-glory	*Ipomoea pes-caprae*								x				
		Maripa panamensis	x	x	x	x		x	x					
Dilleniaceae	Dillenia	*Davilla nitida*				x								
		Doliocarpus dentatus		x	x									
		D. major	x		x	x	x		x					
		D. olivaceus	x			x	x							
		Tetracera volubilis							x					
Ebenaceae	Ebony	*Diospyros artanthifolia*		x										
Elaeocarpaceae	Elaeocarpus	*Mutingia calabura*									x			
		Sloanea ternifolia	x		x	x								
Erythroxylaceae	Coca	*Erythroxylum macrophyllum*	x		x									
		E. panamense		x	x									
Euphorbiaceae	Spurge	*Acalypha diversifolia*	x	x	x	x	x							
		Adelia triloba				x								
		Alchornea costaricensis	x	x										
		A. latifolia		x										
		Croton billbergianus	x	x		x	x							
		C. hirtus			x									
		Drypetes standleyi	x											
		Hura crepitans	x	x		x	x	x						
		Hyeronima laxiflora	x	x	x									
		Mabea occidentalis			x									
		Margaritaria nobilis			x				x					
		Omphalea diandra										x		
		Pera arborea		x										
		Sapium caudatum	x	x		x	x							
Fabaceae	Bean	*Acacia melanoceras*							x	x				
		Adenopodia polystachya					x							
		Albizia adinocephala				x								
		Andira inermis	x	x	x				x					
		Dipteryx panamensis			x									
		Erythrina costaricensis				x								
		E. fusca		x					x				x	x
		Flemingia strobilifera						x						
		Inga cocleensis	x	x										
		I. fagifolia	x	x	x	x								
		I. goldmanii	x	x	x	x			x					
		I. hayesii	x											
		I. marginata		x										
		I. multijuga						x	x					
		I. mucuna				x								
		I. pauciflora				x								

continued

Table 2—Plant species in the San Lorenzo Protected Area (continued)

Family	English name	Scientific name	Vegetation type[a]											
			1	2	3	4	5	6	7	8	9	10	11	12
Dicotiledoneas (cont.)														
Fabaceae	Bean (cont.)	*I. quaternata*	x	x	x		x							
		I. sapindoides	x											
		I. spectabilis	x											
		I. umbellifera		x										
		Lonchocarpus pentaphyllus	x		x									
		Machaerium kegelii				x								
		M. seemannii		x			x							
		Mucuna rostrata								x				
		Pithecellobium macradenium	x	x										
		P. rufescens			x	x	x	x						
		Prioria copaifera							x	x				
		Pterocarpus offininalis							x	x			x	
		P. rohrii	x											
		Swartzia simplex	x	x	x	x	x	x						
		Tachigali versicolor	x	x	x	x								
Flacourtiaceae	Flacourtia	*Casearia arborea*		x			x							
		C. commersoniana	x				x							
		C. guianensis	x				x							
		C. sylvestris			x	x	x							
		Hasseltia floribunda	x	x	x	x			x					
		Laetia thamnia		x	x		x							
		Lindackeria laurina	x	x		x			x					
		Ryania speciosa	x	x										
		Tetrathylacium johansenii	x	x		x	x							
		Xylosma oligandra			x									
		Zuelania guidonia		x	x		x	x	x		x			
Gesneriaceae	Gesneriad	*Drymonia serrulata*							x					
Hippocrateaceae	Hipocratea	*Hippocratea volubilis*	x	x	x	x	x		x					
		Prionostemma asperum	x		x				x					
Lacistemaceae	Lacistema	*Lacistema aggregatum*	x	x	x	x	x							
Lauraceae	Laurel	*Beilschmiedia pendula*	x			x								
		Nectandra globosa			x									
		Ocotea cernua			x									
		O. skutchii	x											
		Persea americana		x										
		Phoebe cinnamomifolia			x	x	x							
Lecythidaceae	Brazil-nut	*Grias cauliflora*							x	x				
		Gustavia superba	x	x	x	x	x	x	x					
Loganiaceae	Logania	*Strychnos panamensis*	x	x	x	x	x							
		S. toxifera		x										
Malpighiaceae	Barbados cherry	*Hiraea grandifolia*	x	x		x								
		H. reclinata		x	x	x	x	x	x					
		Malpighia romeroana					x							

continued

Table 2—Plant species in the San Lorenzo Protected Area (continued)

Family	English name	Scientific name	Vegetation type[a] 1	2	3	4	5	6	7	8	9	10	11	12
Dicotiledoneas (cont.)														
Malvaceae	Mallow	*Hibiscus pernambucensis*						x	x			x		
Marcgraviaceae	Shingle plant	*Marcgravia nepenthoides*	x											
		Souroubea sympetala	x	x										
Melastomataceae	Melastome	*Conostegia cinnamonea*		x	x									
		Miconia affinis		x										
		M. argentea		x	x		x	x	x	x				
		M. hondurensis		x	x									
		M. impetiolaris					x							
		M. nervosa		x										
		Mouriri myrtilloides		x	x		x							
		Ossaea quinquenervia					x							
		Triolena hirsuta	x											
Meliaceae	Mahogany	*Carapa guianensis*							x					
		Cedrela odorata	x	x		x								
		Guarea grandifolia	x	x					x					
		G. guidonia		x	x	x								
		Trichilia pleeana		x		x	x							
		T. tuberculata	x	x	x	x	x	x	x					
Menispermaceae	Moonseed	*Abuta racemosa*	x	x	x		x							
Monimiaceae	Monima	*Siparuna pauciflora*	x	x	x									
Moraceae	Mulberry	*Brosimum alicastrum*	x	x	x	x	x							
		B. guianense			x									
		B. utile	x											
		Castilla elastica	x	x	x	x								
		Ficus citrifolia			x			x						
		F. costaricana				x			x					
		F. insipida	x	x	x		x	x	x					
		F. maxima	x											
		F. nymphaeifolia		x	x									
		F. obtusifolia		x										
		F. popenoei							x		x			
		F. tonduzii	x	x										
		F. yoponensis	x	x										
		Maquira costaricana	x	x	x	x								
		Olmedia aspera	x	x	x	x	x							
		Perebea xanthochyma	x	x	x	x								
		Poulsenia armata	x	x	x	x			x					
		Pseudolmedia spuria	x	x	x		x							
		Sorocea affinis	x	x	x	x	x							
		Trophis racemosa	x	x	x	x			x					
Myristicaceae	Nutmeg	*Virola elongata*		x										
		V. sebifera	x	x	x		x			x				
		V. surinamensis	x	x	x	x			x					

continued

Table 2—Plant species in the San Lorenzo Protected Area (continued)

Family	English name	Scientific name	Vegetation type[a]											
			1	2	3	4	5	6	7	8	9	10	11	12
Dicotiledoneas (cont.)														
Myrsinaceae	Myrsine	*Stylogyne standleyi*	x	x	x				x					
Myrtaceae	Myrtle	*Aulomyrcia zetekiana*	x	x	x									
		Calycolpus warscewiczianus		x										
		Eugenia acapulcensis						x						
		E. coloradensis		x		x	x		x					
		E. galalonensis			x	x								
		E. nesiotica		x										
		E. venezuelensis			x		x		x					
		Myrcia fosteri			x									
		M. gatunensis		x			x							
Nyctaginaceae	Four o'clock	*Guapira standleyana*		x		x								
		Neea amplifolia	x	x	x									
		Pisonia aculeata		x		x								
Nymphaeaceae	Water lily	*Nymphaea blanda*								x				
Ochnaceae	Ochna	*Cespedesia macrophylla*	x	x										
		Ouratea lucens	x	x	x	x	x		x	x				
Olacaceae	Olax	*Heisteria concinna*	x	x	x	x	x							
		H. costaricensis	x											
		H. cyanocarpa	x	x	x	x			x					
Onagraceae	Evening primrose	*Ludwigia octovalvis*							x					
Passifloraceae	Passion-flower	*Passiflora vitifolia*			x									
Phytolaccaceae	Pokeweed	*Petiveria alliacea*		x										
Piperaceae	Pepper	*Peperomia macrostachya*			x									
		Piper aequale		x										
		P. arboreum		x										
		P. carrilloanum	x	x										
		P. cordulatum	x	x	x			x	x					
		P. culebranum		x										
		P. darienense	x	x										
		P. grande	x											
		P. hispidum										x		
		P. marginatum										x		
		P. pubistipulum	x											
		P. reticulatum	x	x		x	x	x	x					
Polygonaceae	Buckwheat	*Coccoloba acapulcensis*		x		x								
		C. coronata						x						
		C. obovata	x											
		C. manzanillensis		x	x		x			x				
		C. parimensis	x	x	x									
		Triplaris cumingiana		x		x	x							

continued

Table 2—Plant species in the San Lorenzo Protected Area (continued)

Family	English name	Scientific name	Vegetation type[a] 1	2	3	4	5	6	7	8	9	10	11	12
Dicotiledoneas (cont.)														
Rhamnaceae	Buckthorn	*Gouania lupuloides*			x									
Rhizophoraceae	Red mangrove	*Cassipourea elliptica*	x	x	x				x	x				
		Rhizophora mangle									x			
Rubiaceae	Madder	*Alibertia edulis*					x		x	x				
		Alseis blackiana					x							
		Amaioua corymbosa	x	x										
		Calycophyllum candidissimum				x	x	x						
		Cephaelis elata		x										
		Cosmibuena skinneri	x			x								
		Coussarea curvigemmia				x	x							
		Chomelia spinosa									x			
		Faramea luteovirens	x	x	x	x	x	x						
		F. occidentalis	x	x		x	x							
		Genipa americana		x	x	x	x							
		Guettarda foliacea		x				x						
		Guettarda macrosperma			x		x							
		Hamelia patens							x					
		Hoffmannia vesciculifera	x											
		Macrocnemum glabrescens		x	x	x			x					
		Palicourea guianensis		x	x		x							
		Pentagonia macrophylla	x	x	x	x			x					
		Posoqueria latifolia	x	x		x			x	x				
		Psychotria acuminata			x		x							
		P. chagrensis	x	x	x				x					
		P. furcata	x	x	x									
		P. grandis	x											
		P. horizontalis	x	x	x	x	x							
		P. limonensis	x	x	x	x	x			x				
		P. marginata		x			x		x					
		P. pittieri		x	x									
		P. psychotriifolia		x										
		P. suerrensis	x	x										
		Randia armata	x	x	x	x	x	x		x				
		Rudgea isthmensis	x											
		R. pitteri	x	x										
		Uncaria tomentosa				x			x	x		x		
Rutaceae	Rue	*Citrus aurantifolia*					x							
		C. limon				x								
		Zanthoxylum belizense	x											
		Z. procerum		x		x	x							
Sapindaceae	Soapberry	*Allophylus psilospermus*	x			x	x							
		Cupania cinerea	x		x		x							
		C. rufescens		x	x									
		C. scrobiculata	x	x		x								
		C. sylvatica	x	x	x									

continued

Table 2—Plant species in the San Lorenzo Protected Area (continued)

Family	English name	Scientific name	Vegetation type[a] 1	2	3	4	5	6	7	8	9	10	11	12
Dicotiledoneas (cont.)														
Sapindaceae	Soapberry (cont.)	*Matayba apetala*	x											
		Paullinia bracteosa	x	x	x	x			x					
		P. fibrigera		x	x		x		x					
		P. glomerulosa		x			x							
		P. pinnata					x							
		P. pterocarpa	x		x		x							
		P. rugosa	x											
		P. turbacensis				x	x							
		Serjania mexicana					x							
		Talisia nervosa	x	x	x	x								
		T. princeps	x	x	x	x	x		x					
Sapotaceae	Sapodilla	*Chrysophyllum argenteum*	x	x	x	x	x		x					
		C. cainito		x	x		x							
		Cynodendron panamense			x									
		Manilkara bidentata	x	x	x	x	x							
		M. chicle		x										
		M. zapota		x										
		Pouteria stipitata				x								
		P. unilocularis	x	x	x	x	x							
Simaroubaceae	Quassia	*Picramnia latifolia*	x	x	x		x		x					
		Quassia amara	x	x										
		Simarouba amara	x	x	x									
Solanaceae	Potato	*Cestrum latifolium*										x		
		C. megalophyllum	x		x	x								
		Solanum arboreum		x										
Sterculiaceae	Cacao	*Guazuma ulmifolia*	x	x	x	x		x						
		Herrania purpurea	x	x	x	x								
		Sterculia apetala		x	x		x			x				
Tiliaceae	Linden	*Apeiba aspera*	x	x	x	x								
		A. tibourbou				x	x							
		Luehea seemannii	x	x	x	x	x							
		Trichospermum galeotti		x	x									
Ulmaceae	Elm	*Trema micrantha*							x					
Urticaceae	Nettle	*Myriocarpa longipes*	x			x								
Verbenaceae	Verbena	*Aegiphila panamensis*		x										
		Avicennia germinans									x			
		Petrea aspera	x	x	x									
		P. volubilis	x		x	x	x							
Violaceae	Violet	*Hybanthus prunifolius*			x									
		Rinorea sylvatica		x										
Vochysiaceae	Vouchysia	*Vochysia ferruginea*	x	x	x									

continued

Table 2—Plant species in the San Lorenzo Protected Area (continued)

Family	English name	Scientific name	Vegetation type[a]											
			1	2	3	4	5	6	7	8	9	10	11	12
Monocotiledoneas														
Alismataceae	Water-plantain	*Echinodorus bracteatus*								x				
Araceae	Arum	*Anthurium acutangulum*	x						x					
		A. bakeri		x	x									
		A. brownii									x			
		A. clavigerum	x	x	x	x	x	x	x	x	x			
		A. ochranthum		x										
		A. salviniae	x	x		x								
		A. scandens		x					x					
		Dieffenbachia longispatha		x	x	x	x		x	x				
		D. oerstedii	x											
		Monstera dilacerata		x	x	x								
		M. dubia		x	x	x	x		x					
		Montrichardia arborescens							x	x	x			
		Philodendron aurantiifolium			x									
		P. grandipes	x	x										
		P. radiatum	x	x	x				x	x	x			
		P. scandens		x	x									
		Raphia taedigera											x	
		Spathiphyllum friedrichsthalii								x				
		S. phryniifolium							x					
Arecaceae	Palm	*Astrocaryum standleyanum*	x	x	x	x	x		x	x				
		Bactris barronis			x	x								
		B. coloniata	x	x	x	x	x							
		B. coloradonis	x	x	x		x							
		B. major		x			x		x	x		x		
		Chamaedorea tepejilote	x	x		x								
		Desmoncus isthmius	x	x	x	x	x	x	x	x				
		Elaeis oleifera	x						x	x	x			
		Geonoma cuneata	x	x										
		G. deversa		x										
		G. interrupta	x	x										
		G. procumbens		x	x									
		Manicaria saccifera							x					
		Oenocarpus mapora	x		x				x	x				
		Raphia taedigera							x	x				
		Scheelea zonensis		x	x	x	x							
		Socratea durissima	x	x										
		Synechanthus warscewiczianus	x	x	x									
Bromeliaceae	Bromeliad	*Aechmea magdalenae*		x	x		x	x						
		Tillandsia bulbosa						x			x			
Commelinaceae	Spiderwort	*Commelina erecta*		x	x	x								
Costaceae	Costus	*Costus laevis*		x		x			x	x				
		C. pulverulentus		x										

continued

Table 2—Plant species in the San Lorenzo Protected Area (continued)

Family	English name	Scientific name	Vegetation type[a] 1	2	3	4	5	6	7	8	9	10	11	12
Monocotiledoneas (cont.)														
Cyclanthaceae	Panama hat palm	*Carludovica drudei*	x											
		C. palmata	x	x	x	x	x							
		Cyclanthus bipartitus	x	x	x				x	x				
		Dicranopygium harlingii				x								
Cyperaceae	Sedge	*Cyperus giganteus*								x			x	
		Eleocharis fistulosa												x
		Mapania assimilis	x											
		Scleria eggersiana								x				
Haemodoraceae	Bloodwort	*Xiphidium coeruleum*					x							
Heliconiaceae	Heliconia	*Heliconia irrasa*	x	x										
		H. longiflora		x										
		H. metallica	x											
		H. vaginalis		x	x				x					
Maranthaceae	Prayer-plant	*Calathea inocephala*		x		x	x							
		C. insignis		x										
		C. lutea	x											
		Maranta arundinacea						x						
		Pleiostachya pruinosa	x	x	x	x			x					
		Stromanthe jacquinii	x	x	x			x		x				
Orchidaceae	Orchid	*Aspasia principissa*		x		x		x	x	x				
		Brassavola nodosa						x	x	x	x			
		Caularthron bilamellatum		x				x		x				
		Chysis aurea		x										
		Dimerandra emarginata		x							x			
		Epidendron difforme									x			
		E. nocturnum	x								x			
		E. rigidum	x						x					
		E. schlechterianum		x										
		Maxillaria uncata	x	x										
		Oncidium ampliatum		x					x					
		Palmorchis powellii			x		x							
		Pleurothallis verecunda		x										
		Trichocentrum capistratum		x										
		Vanilla planifolia		x										
Poaceae	Grass	*Brachiaria mutica*												x
		Chusquea simpliciflora		x	x			x						
		Gynerium sagittatum							x	x		x	x	x
		Panicum maximum								x			x	x
		Pharus latifolius		x	x									
		Saccharum spontaneum										x	x	x
		Streptochaeta sodiroana	x	x						x				
Smilacaceae	Catbriar	*Smilax mollis*			x									
		S. panamensis					x							

continued

Table 2—Plant species in the San Lorenzo Protected Area (continued)

Family	English name	Scientific name	Vegetation type[a]											
			1	2	3	4	5	6	7	8	9	10	11	12
Monocotiledoneas (cont.)														
Typhaceae	Cat-tail	*Typha domingensis*								x			x	
Zingiberaceae	Ginger	*Dimerocostus strobilaceus*					x							
		Renealmia alpinia	x	x	x									
		R. cernua		x					x					
Cone-bearing plants														
Cycadaceae	Cycad	*Zamia acuminata*				x	x							
		Z. fairchildiana				x								
Ferns														
Adiantaceae	Maidenhair	*Adiantum fruticosum*		x										
		A. lucidum	x	x	x	x	x		x					
		A. lunulatum						x						
Cyatheaceae	Tree fern	*Cyathea petiolulata*	x	x	x									
Parkeriaceae	Ceratopteris	*Ceratopteris pteridoides*								x				
Polypodiaceae	Polypody	*Campyloneurum latum*	x		x	x			x		x			
		Dicranoglossum panamense		x	x				x					
		Pecluma pectinata							x					
Pteridaceae	March fern	*Acrostichum aureum*							x	x	x			
		A. danaeifolium											x	
		Pteris polita								x				
Schizaeaceae	Curly-grass	*Lygodium radiatum*		x										
		L. venustum		x	x									
Tectariaceae	Tectaria	*Cyclopeltis semicordata*				x	x							
		Tectaria incisa				x	x							
Theltpteridaceae	Thelypteris	*Thelypteris serrata*								x				
Vittariaceae	Vittaria	*Anetium citrifolium*		x	x									

[a] 1 = Evergreen seasonal tall forest; 2 = evergreen seasonal mixed forest (includes coastal mixed vegetation); 3 = evergreen seasonal low forest; 4 = semideciduous mixed forest; 5 = semideciduous low forest; 6 = deciduous forest; 7 = flooded cativo forest; 8 = flooded palm forest; 9 = mangrove swamp forest; 10 = flooded shrubland; 11 = marsh (flooded herbaceous land); 12 = seminatural (seminatural flooded grassland). List derived from a rapid ecological assessment of the San Lorenzo Protected Area.

Source: ANCON and TNC (1996).

Table 3—Additional tree species recorded in tall seasonal evergreen forest at the San Lorenzo Protected Area[a]

Family	English name	Scientific name
Annonaceae	Custard apple	*Cremastosperma panamense* *Cymbopetalum lanugipetalum* *Unonopsis panamensis* *Xylopia macrantha*
Arecaceae	Palm	*Euterpe precatoria* *Geonoma congesta* *Socratea exorrhiza*
Bignoniaceae	Bignonia	*Jacaranda copaia*
Burseraceae	Bursera	*Protium glabrum*
Caricaceae	Pawpaw	*Jacaratia spinosa*
Cecropiaceae	Cecropia	*Pourouma bicolor*
Celastraceae	Bittersweet	*Crossopetalum parviflorum* *Maytenus schippii*
Chrysobalanaceae	Coco plum	*Licania hypoleuca*
Clusiaceae	Mangosteen	*Garcinia madruno* *Tovomita longifolia* *T. stylosa* *Vismia baccifera* *V. macrophylla*
Cyatheaceae	Tree fern	*Cnemidaria petiolata*
Elaeocarpaceae	Elaeocarpus	*Sloanea meianthera*
Erythroxylaceae	Coca	*Erythroxylum citrifolium*
Euphorbiaceae	Spurge	*Phyllanthus acuminatus* *Tetrorchidium gorgonae*
Fabaceae	Pea	*Lonchocarpus latifolius* *Ormosia croatii* *Pterocarpus rohrii*
Flacourtiaceae	Flacourtia	*Laetia procera* *Lozania pittieri*
Humiriaceae		*Humiriastrum diguense* *Vantanea depleta*
Icacinaceae	Icacina	*Discophora guianensis*
Lauraceae	Laurel	*Nectandra purpurea* *Ocotea dendrodaphne* *O. ira* *O. puberula* *O. whitei*
Lecythidaceae	Brazil-nut	*Gustavia fosteri*
Malvaceae	Mallow	*Hampea appendiculata*
Melatomataceae	Melastome	*Clidemia densiflora* *Conostegia bracteata* *Leandra granatensis* *Miconia elata*

continued

Table 3—Additional tree species recorded in tall seasonal evergreen forest at the San Lorenzo Protected Areaa (continued)

Family	English name	Scientific name
Melatomataceae (continued)	Melastome	*M. ligulata* *M. minutiflora* *M. nervosa* *M. prasina* *M. serrulata* *M. simplex* *Mouriri myrtilloides*
Mimosaceae	Mimosa	*Abarema barbouriana* *Inga nobilis* *I. pezizifera* *I. sertulifera*
Monimiaceae	Monima	*Mollinedia darienensis*
Myristicaceae	Nutmeg	*Virola multiflora*
Myrsinaceae	Myrsine	*Ardisia bartlettii* *A. fendleri* *A.guianensis*
Myrtaceae	Myrtle	*Chamguava schippii* *Myrcia gatunensis* *M. zetekiana*
Nyctaginaceae	Four o'clock	*Neea delicatula*
Ochnaceae	Ochna	*Cespedesia macrophylla*
Olacaceae	Olax	*Heisteria acuminata*
Piperaceae	Pepper	*Piper angustum* *P. colonense*
Polygonaceae	Buckwheat	*Coccoloba ascendens*
Quiinaceae		*Quiina schippii*
Rubiaceae	Madder	*Faramea multiflora* *Posoqueria latifolia* *Psychotria deflexa* *P. elata* *P. poeppigiana* *Tocoyena pittieri*
Rutaceae	Rue	*Zanthoxylum juniperinum*
Sabiaceae	Sabia	*Meliosma glabrata*
Sapotaceae	Sapodilla	*Pouteria reticulata*
Staphyleaceae	Bladdernut	*Turpinia occidentalis*
Sterculiaceae	Cacao	*Herrania pulcherium* *Theobroma bernoullii*
Theophrastaceae	Theophrasta	*Clavija costaricana*
Tiliaceae	Linden	*Mortoniodendron anisophyllum*

[a] More than 200 tree species reaching at least 1.0 cm in diameter were recorded on 4.96 ha surrounding the Smithsonian crane. The 84 listed species (Condit and others 2004) were not tallied in the rapid ecological assessment included in table 2 (ANCON and TNC 1996).

Life Zones and Major Forest Types

The seasonally dry forests of the Pacific shore and the rainforests of the Caribbean slopes are separated by central highlands and considerable distances in most of Central America (McCullough and others 1956). In general, coastal forests grade into cooler, higher elevation forests in mountainous interiors. In Panama, however, because of the low and narrow Continental Divide, forests intergrade directly at low elevations.

The SLPA has three life zones (Holdridge 1967, Tosi 1971): tropical moist forest (55 percent), separated into two areas—the west bank of Limón Bay including Fort Sherman and the west shore of Gatún Lake; tropical premontane wet forest (40 percent), which lies between the Caribbean Sea and the northwest shores of Gatún Lake; and tropical wet forest (5 percent) in two areas—the northwestern corner and isolated along the west-central border of the SLPA (fig. 7). Within Panama, these same life zones represent about two-thirds of the country, as follows: tropical moist forest, 32.4 percent; tropical premontane wet forest, 20.1 percent; and tropical wet forest, 14.4 percent (Tosi 1971).

Several moisture gradients exist within the SLPA. The first is rainfall, ranging from northeast to south central, in accordance with the ecological life zones. The other gradients are: topographic, ranging from valley bottoms to ridgetops; and geologic and edaphic, ranging from saturated alluvial soils to better drained sandstones and conglomerates. These gradients provide a diversity of habitats, and combined with past disturbance of varying degrees, produce several different vegetation types.

Twelve terrestrial vegetation types have been recognized on the SLPA (fig. 8) (Asociación Nacional para la

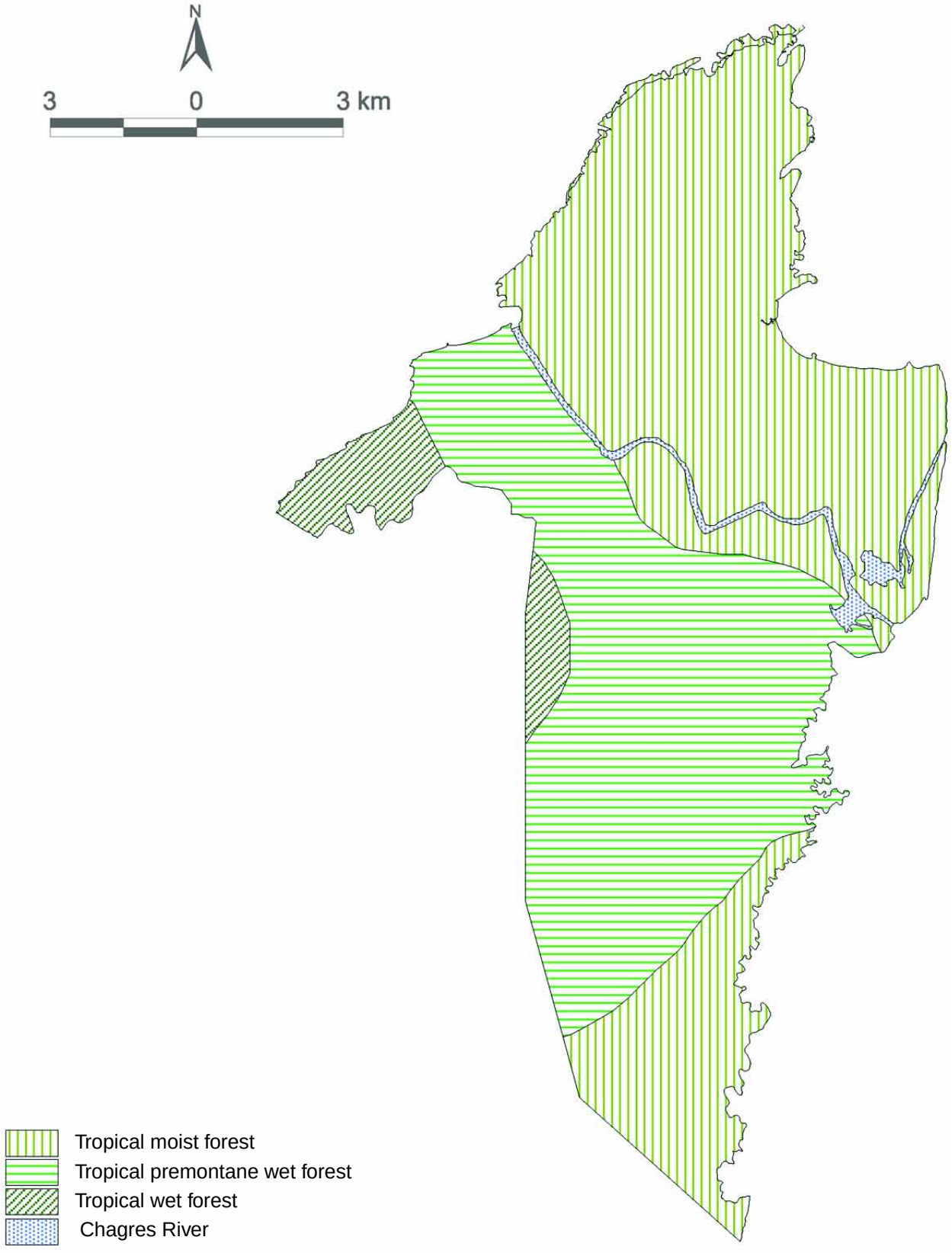


Figure 7—Life zones in the San Lorenzo Protected Area (Tosi 1971).

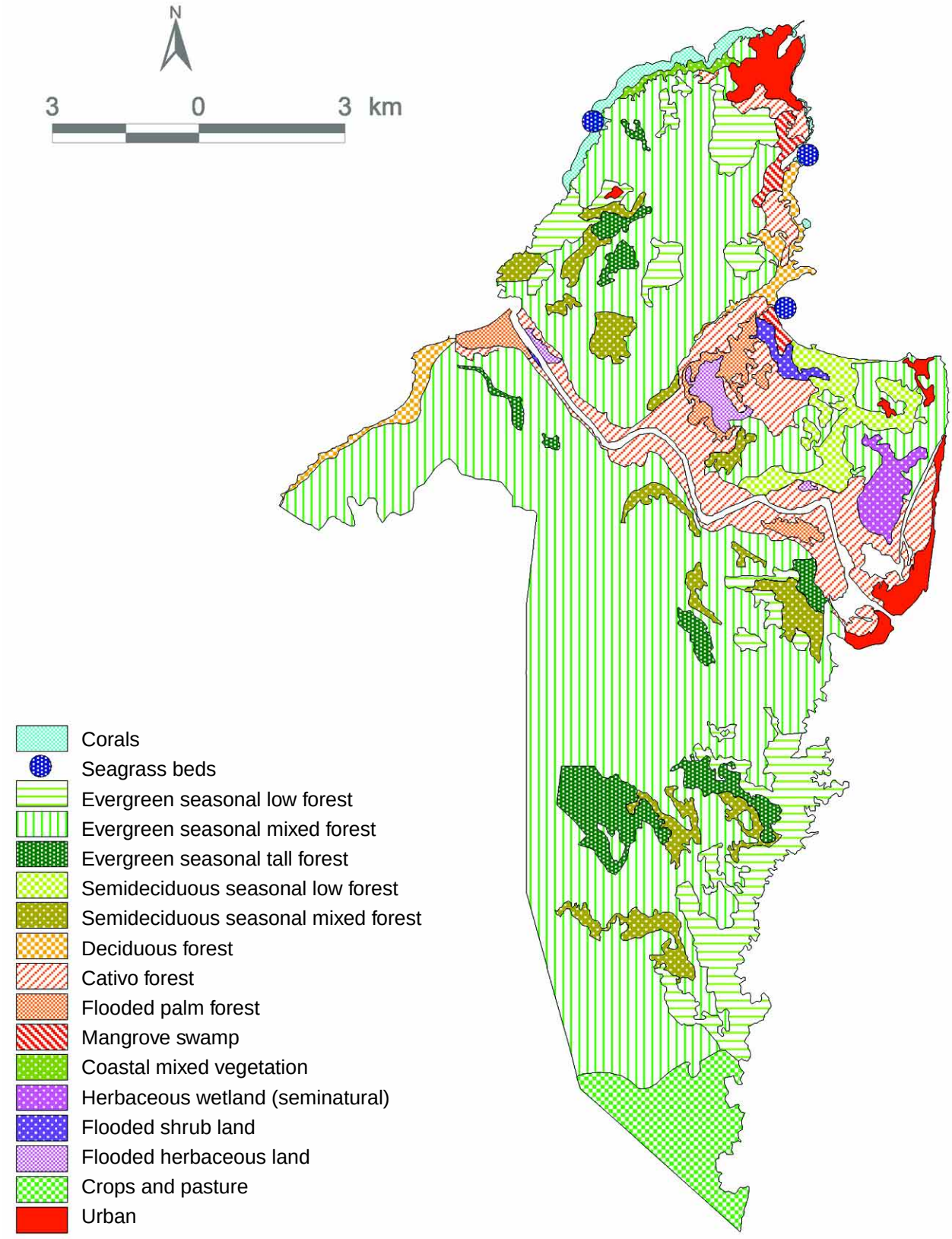


Figure 8—Vegetation types in the San Lorenzo Protected Area (Asociación Nacional para la Conservación de la Naturaleza and The Nature Conservancy 1996, McCullough and others 1956, URBIO S.A. 1999).

Conservación de la Naturaleza and The Nature Conservancy 1996, URBIO S.A. 1999). Of these, six are forest types, as follows: evergreen seasonal forest, semideciduous seasonal forest, deciduous forest, flooded cativo forest, flooded palm forest, and mangrove swamp. The first two types have been divided into subtypes based on stand age and the degree of past disturbance. Evergreen seasonal forest, with tall, mixed (includes coastal mixed vegetation) and low subtypes, occupies 61 percent of the SLPA. Semideciduous seasonal forest, with mixed and low subtypes, covers another 11 percent, and deciduous forest, only 2 percent. Flooded vegetation types occupy 21 percent of the SLPA, including three forest (cativo, 15 percent; palm, 3 percent; and mangrove, 1 percent) and three nonforest vegetation types [flooded shrubland, marsh (flooded herbaceous land), and herbaceous wetland—seminatural, 2 percent]. Urban areas and cultivated lands (crops and pasture) cover the remaining 5 percent of the SLPA.

Evergreen seasonal forest—In the evergreen seasonal forest, very few trees lose their leaves during the dry season; however, flower and fruit production are prominent at that time. Three types of evergreen forest are recognized based on tree height: tall, occupying 3 percent of the SLPA; mixed, covering 50 percent; and low, occupying 8 percent of the SLPA.

Evergreen seasonal tall forest is characterized by trees with spreading crowns, several reaching 30 to 40 m in height and some emerging at 50 m (Asociación Nacional para la Conservación de la Naturaleza and The Nature Conservancy 1996). The forest has three or four strata with dominant trees attaining 50 cm in diameter at breast height or 1.3 m above the ground. Common trees include wild espavé (*Anacardium excelsum*), sangre (*Virola surinamensis*), peinecillo (*Apeiba aspera*), chuchupata (*Guarea grandifolia*), sigua negra (*Guatteria dumetorum*), and sigua colorado (*Ocotea skutchii*).

Evergreen seasonal mixed forest, the most common forest type, is characterized by trees of variable crown width, and a greater diversity in terms of structure, tree height, and species composition than the tall forest. The canopy reaches 25 to 35 m and is characterized by verbá (*Brosimum* sp.), guácimo colorado (*Luehea seemannii*), jobo (*Spondias mombin*), cabeza de negrito (*Guazuma ulmifolia*), *Vatairea* sp., olivo (*Sapium caudatum*), and tachuelo (*Zanthoxylum procerum*).

Evergreen seasonal low forest ranges between 10 and 20 m tall, with occasional emergents up to 30 m. The trees, mainly pioneers, have small crowns. The dominant species include guácimo colorado, almácigo (*Bursera simaruba*), jobo, and sangre**.** The low forest is the result of major disturbances within the past 100 years.

Semideciduous seasonal forest—In semi-deciduous seasonal forest, the limited availability of water causes from 25 to 75 percent of the trees to lose their leaves during the dry season, a 2-month period of < 100 mm of rainfall. Semideciduous forest is closely tied to geology, topography, and soil type, which together enhance drainage and provide drier conditions. Two types, mixed and low semideciduous seasonal forest, are recognized.

Semideciduous seasonal mixed forest contains a mixture of wide- and small-crowned trees. Total height ranges from 25 to 35 m. The most common species in Fort Sherman are guácimo colorado**,** alfaje (*Trichilia tuberculata*), verbá, nuno (*Hura crepitans*), jobo, and palo cuadrado (*Macrocnemum glabrescens*). In addition, cuipo (*Cavanillesia platanifolia*) grows in the Piña Range. The mixed forest is disturbed vegetation where the tallest trees are pioneers, probably 150 years old. Without further disturbance, slower growing species will eventually dominate the forest.

The semideciduous seasonal low forest has small-crowned trees and an average height of 10 to 20 m, with occasional emergents to 30 m tall. The forest is comprised of few species, including pioneers in the canopy. The common species are jobo, laurel (*Cordia alliodora*), and madroño (*Calycophyllum candidissimum*), with barrigón (*Pseudobombax septenatum*) as an emergent. The low forest owes its origin to major disturbance.

Deciduous forest—The deciduous forest, limited by available moisture, grows on limestone outcrops with good drainage. From 75 to 100 percent of the dominant tree species, among them barrigón and cedro espinoso (*Bombacopsis quinata*), lose their leaves during the dry season.

Very large trees are occasionally encountered in the aforementioned forest types. The family Bombacaeae, for example, has cuipo, cedro espinoso, and ceiba (*Ceiba pentandra*), which are notable because of their size. These species are often assumed to be very old,

but large size is not always an indicator of longevity, since growth rates depend on species and site characteristics. Since tropical tree species do not produce annual rings, a ring count does not help in determining their age.

Flooded forest types—Cativo, palm, and mangrove are the main flooded forest types, along with small areas of bloodwood swamp. Cativo forest, dominated by cativo (*Prioria copaifera*), develops on poorly drained lowland soils, including dredge spoils, that are subject to frequent, temporary flooding after rainstorms. The forest is common in the coastal fringe along the Gatún Locks-Sherman Road (S2), and along the Chagres River. Cativo trees vary in height depending on past disturbance and the influence of brackish water, and commonly reach 30 m or more in height and 0.6 to 1.2 m in diameter (McCullough and others 1956). The understory is dominated by cativo regeneration, but other species such as the chunga (*Astrocaryum standleyanum*) and wild pigeon plum (*Ouratea guatemalensis*) are also present. The only other common species that attains large size is the fig (*Ficus glabrata*).

Palm forest, dominated by the large-leafed rafia palm (*Raphia taedigera*), occupies 3 percent of the SLPA. Rafia swamps are common in the backwaters along the Chagres River (McCullough and others 1956), where seasonal flooding occurs for longer periods than in the cativo forest. Rafia dominates swamps for long periods, forming uniformly spaced clumps of different sizes that allow little herbaceous vegetation to grow underneath (Devall and Kiester 1987; Urquhart 1997, 1999). Small trees and shrubs of *Grias cauliflora*, however, grow in drier areas along with the palm. Other typical associates are maquenque (*Oenocarpus mapora*), uña de gato (*Uncaria tomentosa*), and garrapato (*Hirtella triandra*). Raphia's neotropical distribution is limited to five disjunct populations ranging from Nicaragua to Brazil; two areas are reported for Panama, Bocas del Toro, and the SLPA. Unfortunately, the populations

Bloodwood (Pterocarpus officinalis) *forest grows in the wetlands near Fort Sherman. The species is confined mainly to temporarily flooded coastal wetlands and stream banks from the Gulf of Campache in Mexico south to Ecuador, and to the mouth of the Amazon River in Brazil. Bloodwood is also found in the West Indies.*

Photo courtesy of Gerald P. Bauer.

Photo courtesy of Gerald P. Bauer.

The Chagres River, "the river that has seen more gold than all the other rivers of the world combined," is 193 km long and drains 4.2 percent of Panama. Boasting a 500-year history of adventure, the Chagres is also called the World's most valuable river because it feeds the locks that operate the canal and provides Panamanians with hydropower, drinking water, and recreational fishing.

in Bocas del Toro are being replaced by subsistence crops, highlighting the need to protect the species in the SLPA.

Mangrove swamps, dominated by red, black, and white mangroves, grow along the coast in salt and brackish waters. Tree occurrence and heights, often to 20 m or more, are influenced by the tides. The red mangrove (*Rhizophora mangle*) forms an impenetrable thicket with its stilt roots, mainly on lands between low and mean tide levels. Red mangrove seed germinates inside a conical fruit and forms a long, heavy, narrow first root which, when reaching about 30 cm in length, drops into the water, where it attaches to the substrate and grows. Black mangrove (*Avicennia nitida*) is most abundant inland along the coast on lands flooded at mean and high tides. A dense growth of pencil-like projections (pneumatophores) used for respiration are common below black mangrove trees. The white mangrove (*Laguncularia racemosa*) commonly occupies the most shallowly flooded areas. Because Caribbean tides only average about 30 cm, the white mangrove is the most common, comprising about 95 percent of the SLPA mangroves. Mangrove woodlands are breeding grounds for numerous species of fish and birds. Mangroves, all dense woods, have been regularly harvested for fence posts and fuelwood; moreover, the bark of all mangroves is a source of tannin, traditionally used for tanning leather.

Bloodwood (*Pterocarpus officinalis*) is confined mainly to coastal wetlands and stream banks where heavy rainfalls cause temporary flooding (Weaver 2000). Bloodwood, reaching 40 m tall and 60 to 90 cm in diameter, is easily identified by its long, narrow, sinuous buttresses, very light wood, and the dark-red latex that exudes from cuts. Bloodwood swamps, commonly mixed with ferns in standing water that reflects the canopy, are among the most "photogenic" of all forest associations. One readily accessible area of bloodwood is situated in the wetlands bordering Fort Sherman.

Monkey-cap palm (*Manicaria saccifera*) sometimes develops on the landward side of white mangrove swamps either in dense or scattered stands (Bailey 1933, McCullough and others 1956). In the area of the Aguadulce River, monkey-cap palm grows in association with stunted cativo and bloodwood trees.

Flooded nonforest types—Three nonforested vegetation types, flooded shrubland, marsh, and seminatural flooded grassland, are recognized within the SLPA. Flooded shrubland, containing majagua (*Hibiscus pernambucensis*) and caña brava (*Bactris major*), grows on periodically flooded soils. Marsh, with soils covered by as much as 1.5 m of water in the deepest parts during the wet season, is dominated by the southern cattail (*Typha domingensis*).

Seminatural flooded grassland, created by human disturbance, was originally covered by marsh. These areas, however, were partially drained and regularly cut for parachute practice, and in the 1920s and 1930s, Guinea grass (*Panicum maximum*) and Para grass (*Panicum purpurescens*) were planted for pasture (McCullough and others 1956). Paja de esterilla (*Eleocharis fistulosa*), wild sugar cane (*Saccharum spontaneum*), and wild cane (*Gynerium sagittatum*) have invaded these areas, along with a few dispersed trees such as the trumpet tree (*Cecropia peltata*) and palo santo (*Erythrina fuscata*).

Other Vegetation (Ferns, Cane, and Lianas)

The mangrove fern (*Acrostichum aureum*) can be seen along the Gatún Locks-Sherman Road (S2). The fern occurs throughout the Tropics, mainly in coastal strand vegetation, where it grows in brackish or saltwater on alluvial banks of estuaries, along ditches, and occasionally in fresh water above sea level (Lellinger 1989, Tryon and Tryon 1982). The pantropical distribution of mangrove fern is due to airborne spores as well as vegetative propagation after long-range dispersal of rhizome fragments by ocean currents or flooded river waters. The mangrove fern does not have the salt-secreting glands of mangroves and instead accumulates salts in its tissues, rendering them incombustible. Having discovered this fire-retardant quality, Central American Indians used the mangrove fern to thatch the areas around hearths within their huts (Janzen and others 1983).

The giant cane (*Gynerium sagittatum*) occupies grounds that were disturbed by road building (McCullough and others 1956). Small in total area, the vegetation type is confined to roadsides.

Nearly one-half of the trees > 15 cm in diameter on nearby Barro Colorado Island have lianas growing in their crowns (Gentry 1991). A thorough investigation of the SLPA forests may reveal a similar abundance in older stands. Among the families with the greatest number of climbing plants in the neotropics are the milkweed (Asclepidaceae), morning glory (Convolvulaceae), legume (Leguminosae), sunflower (Asteraceae), aroid (Araceae), and bignonia (Bignoniaceae) families. Lianas compete with host trees for light, water, and nutrients, and may contribute to higher mortality rates for their hosts (Putz and Mooney 1991). At the same time, climbers are important to forest animals as food and as a structural component of the habitat.

Medicinal Plants

Knowledge of the medicinal and hallucinatory values of forest vegetation and how to prepare and administer plant extracts, is a tradition that has been passed down for centuries. Recent surveys highlight the continuing importance of medicinal plants in traditional folk medicine. One review carried out in 21 Latin American countries showed that 270 species in 82 families were highly regarded for their medicinal properties (Gupta 1995). More than 400 plant species in Panama are used in folkloric medicine (Zapata 1998); moreover, in the provinces of Panama and Colón alone, more than 80 species are used (Sasaki 1996). One example is achiote (*Bixa orellana*), an attractive shrub reaching 10 m in height. Achiote seeds, long used by the Indians as a source of red dye for body decoration, are also prepared in a tea that is purportedly used as a stimulant and diuretic, and to alleviate stomach aches, hemorrhaging, and cardiac illnesses. Achiote is also used as an aphrodisiac, laxative, and even as an insecticide. Achiote has also loaned its name to a community near the SLPA.

Terrestrial Fauna

The most recent attempts to summarize existing information on the wildlife of the SLPA are presented in the "Ecological Survey of the U.S. Department of Defense Lands in Panama" (Asociación Nacional para la Conservación de la Naturaleza and The Nature Conservancy 1996) and "Characterización Ambiental de Sitio para el Área de Sherman-San Lorenzo" (GEA Consultores, S.A. and Louis Berger International, Inc. 1999). The combined tallies, although based on several studies, are not as complete as the wildlife inventory for nearby Barro Colorado Island where recurrent surveys span three-quarters of a century. Valuable regional references for certain species include field guides to the mammals (Emmons and Feer 1997, Reid 1997), Costa Rica's herpetofauna (Savage and Villa 1986), the herpetofauna of Barro Colorado Island (Rand and Myers 1990), and Costa Rica's natural history (Janzen 1983).

Mammals

Panama has more than 230 species of mammals; bats and rodents comprise about one-half of the total (Handley 1966; Méndez 1970, 1993). Eighty-one species of mammals, or 35 percent of the total for Panama, have been recorded within the SLPA during several surveys (Asociación Nacional para la Conservación de la Naturaleza and The Nature Conservancy 1996, Fleming 1970, Fleming and others 1972, Smythe 1995) (table 4). Bats are the most common group with 41 species, followed by rodents with 17, and carnivores with 9. The remaining 14 species include 6 other major groups. Nine of the species are listed as threatened on the Convention on International Trade in Endangered Species (CITES) red list, and 19 on the country list for Panama. Rothschild's porcupine is the only mammal reported as endemic to Panama (Emmons 1997; GEA Consultores, S.A. and Louis Berger International, Inc. 1999).

Tropical bats feed on a variety of foods, including fruit, nectar, insects, terrestrial vertebrates, fish, and the blood of warm-bodied animals (McNab 1971). Studies at three different sites in Costa Rica and Panama, including the SLPA, showed that about 30 species may be found at or near ground level (Fleming and others 1972).

Table 4—Mammal species in the San Lorenzo Protected Area

Order and Family	English name	Scientific name	Locale[a]		Class[b]	
			P	S	E	P
Artiodactyla – deer, peccaries						
Cervidae	Brocket deer	*Mazama americana*		S		P
	White-tailed deer	*Odocoileus virginianus*		S		P
Tayassuidae	Collared peccary	*Tayassu tajacu*		S		P
Carnivora – carnivores (cats, raccoons, weasels)						
Felidae	Ocelot	*Felis pardalis*		S	I	P
	Margay	*F. weidii*		S	I	
	Jaguarundi	*F. yagouaroundi*		S	I	P
Procyonidae	Coati	*Nasua narica*	P	S		P
	Kinkajou	*Potos flavus*		S		
	Crab-eating raccoon	*Proycon cancrivorous*		S		
	Northern raccoon	*P. lotor*	P	S		P
Mustelidae	Tayra	*Eira barbara*	P			
	Southern river otter	*Lontra longicauda*		S	I	P

continued

Table 4—Mammal species in the San Lorenzo Protected Area (continued)

Order and Family	English name	Scientific name	Locale[a] P	Locale[a] S	Class[b] E	Class[b] P
Chiroptera – bats						
Emballonuridae	Chestnut sac-winged bat	*Cormura brevirostris*		S		
	White-lined sac-winged bat	*Saccopteryx bilineata*		S		
Molossidae	Mastiff bat	*Molossus mollosus*		S		
Mormoopidae	Parnell's mustached bat	*Pteronotus parnellii*	P	S		
Natalidae	Funnel-eared bat	*Natalus stramineus*	P	S		
Noctilionidae	Great bulldog bat (Fishing bat)	*Noctilio leporinus*	P			
Phyllostomidae	Jamaican fruit-eating bat	*Artibeus jamaicensis*	P	S		
	Great fruit-eating bat	*A. lituratus*	P	S		
	Pygmy fruit-eating bat	*A. phaeotis*	P	S		
	Watson's fruit-eating bat	*A. watsoni*		S		
	Allen's short-tailed bat	*Carollia castanea*	P	S		
	Seba's short-tailed bat	*C. perspicillata*	P	S		
	Wrinkle-faced bat	*Centurio senex*	P	S		
	Big-eyed bat	*Chiroderma trinitatum*	P	S		
	Shaggy-haired bat	*C. villosum*	P	S		
	Wooly false bat	*Chrotopterus auritus*	P			
	Common vampire bat	*Desmodus rotundus*	P	S		
	Long-tongued bat	*Glossophaga commissarisi*		S		
	Pallas' long-tongued bat	*G. soricina*		S		
	Dark long-tongued bat	*Lichonycteris obscura*		S		
	Spear-nosed long-tongued bat	*Lonchophylla robusta*	P	S		
	Sword-nosed bat	*Lonchorhina aurita*		S		
	Macconnell's bat	*Mesophylla macconnelli*		S		
	Little big-eared bat	*Micronycteris brachyotis*	P			
	Little big-eared bat	*M. daviesi*		S		
	Little big-eared bat	*M. hirsuta*	P			
	Little big-eared bat	*M. megalotis*		S		
	Little big-eared bat	*M. minuta*		S		
	Little big-eared bat	*M. sylvestris*	P			
	Spear-nosed bat	*Phyllostomus hastatus*		S		
	Heller's broad-nosed bat	*Platyrrhinus helleri*	P	S		
	Spix's round-eared bat	*Tonatia bidens*		S		
	D'orbigny's round-eared bat	*T. silvicola*	P	S		
	Fringe-lipped bat	*Trachops cirrhosus*		S		
	Tent-making bat	*Uroderma bilobatum*		S		
	Yellow-eared bat	*Vampyressa nymphaea*		S		
	Little yellow-eared bat	*V. pusilla*	P	S		
	Great stripe-faced bat	*Vampyrodes caraccioli*		S		
Thryopteridae	Sucker-footed bat	*Thyroptera tricolor*		S		
Vespertilionidae	Little brown bat	*Myotis nigricans*		S		
	Black-winged little yellow bat	*Rhogeessa tumida*		S		

continued

Table 4—Mammal species in the San Lorenzo Protected Area (continued)

Order and Family	English name	Scientific name	Locale[a]		Class[b]	
			P	S	E	P
Didelphimorphia – opposums						
Didelphidae	Southern opposum	*Didelphis marsupialis*	P	S		
	Robinson's mouse opposum	*Marmosa robinsoni*		S		
	Common gray-four-eyed opposum	*Philander opossum*		S		
Lagomorpha – rabbits						
Leporidae	Brazilian rabbit (tapiti)	*Sylvilagus brasilensis*		S		
Primates – primates (monkeys)						
Callitrichidae	Titi monkey	*Saguinus oedipus geoffroyi*	P	S	I	P
Cebidae	Howler monkey	*Alouatta palliata*	P		I	P
	Night monkey	*Aotus lemurinus*		S	II	P
	Capuchin monkey	*Cebus capucinus*	P	S	II	P
Rodentia – rodents (paca, agouti, rats, mice, porcupines, squirrels)						
Agoutidae	Paca	*Agouti paca*		S		P
Dasyproctidae	Agouti	*Dasyprocta punctata*	P	S		P
Echimyidae	Rufous tree rat	*Diplomys labilis*		S		
	Armored rat	*Hoplomys gymnurus*		S		
	Tome's spiny rat	*Proechimys semispinosus*	P	S		
Erthizontidae	Rothschild's porcupine	*Coendou rothschildi*[c]		S		
Hydrochaeridae	Capybara	*Hydrochaeris hydrochaeris*		S		
Muridae	Rice rat	*Oryzomys alfaroi*		S		
	Rice rat	*O. bicolor*		S		
	Rice rat	*O. caliginosus*		S		
	Rice rat	*O. capito*	P	S		
	Cotton rat	*Sigmodon hispidus*		S		
	Naked tail climbing rat	*Tylomys microtinus*		S		
	Cane mouse	*Zygodontomys brevicauda*		S		
Sciuridae	Red-tailed squirrel	*Sciurus granatensis*	P	S		
Heteromyidae	Pocket mouse	*Heteromys desmarestianus*	P	S		
Xenartha – anteaters, sloths, armadillos						
Bradypodidae	Three-toed sloth	*Bradypus variegatus*		S	II	
Dasypodidae	Nine-banded armadillo	*Dasypus novemcinctus*	P	S		P
Megalonychidae	Two-toed sloth	*Choloepus hoffmani*		S		
Myrmecophagidae	Northern tamandua	*Tamandua mexicana*		S		P

[a] P = Piña; S = Fort Sherman.
[b] E = protected by the U.S. Endangered Species Act CITES rankings: I = species threatened with extinction. Trade in wild specimens of taxa or population is essentially prohibited with few exceptions. II = species not threatened with extinction but may become so unless trade is controlled or monitored; P = protected by Panamanian law.
[c] Endemic species.
Source: ANCON and TNC (1996); Fleming (1970); Fleming and others (1972); GEA Consultores and Louis Berger International, Inc. (1999); Smythe and others (1995).

Birds

Panama has about 930 known species of birds (Ridgely and Gwynne 1989, Stiles and Skutch 1989), of which 75 percent are residents and 14 percent are regular migrants (Karr 1985). Of the remainder, 6 percent are occasional visitors, 1 percent are pelagic (common over open ocean), and another 4 percent or so are considered nonconfirmed sightings.

The SLPA has at least 57 bird families and about 435 species, or 47 percent of Panama's total (Tejera 1995) (table 5). The habitats occupied by the bird species of the SLPA are: forested areas, 44 percent; forest edges, 18 percent; aquatic areas, 14 percent; open areas, 12 percent; secondary sites, 7 percent; and generalists, seen in a variety of habitats, 5 percent. About 74 percent of the species in the SLPA are residents, and 4 percent vagrants (rare or accidental occurrence). The remainder consists of migrants, as follows: winter migrants to the SLPA, 15 percent; migrants passing through to other countries, 6 percent; and migrants to areas elsewhere in Panama, 1 percent. The 5 most common families of birds in the SLPA contain 158 species, or 36 percent of the total, as follows: Tyrannidae (tyrant flycatchers), 61; Thraupinae (tanagers), 27; Parulidae (wood-warblers), 25; Acciptridae (hawks, eagles, and kites), 23; and Formicaridae (antbirds), 22. Most common among the wintering migrants are the aquatic sandpipers and phalaropes (Scolopacidae), and forest and forest-edge dwelling wood-warblers (Parulidae).

Determining the origins of Panama´s avifauna, with groups being derived from both north and south of the Miocene break in the Central American isthmus, is a difficult zoogeographical problem (Howell 1969). The major part of the avifauna, about 40 percent, emerged from South America (Karr 1985); of the remainder, about 10 percent are North American, 12 percent from the Old World, and 5 percent pantropical. The remaining 32 percent, mainly associated with freshwater or marine environments, are difficult to classify; however, current information about particular bird species—their morphological descriptions, status, relative abundance (rare to abundant), habitats, habits, and range—have been concisely summarized (Ridgely and Gwynne 1989).

Table 5—Bird species in the San Lorenzo Protected Area

Family and English name	Scientific name	Locale[a]		Habitat[b]	Status[c]	Class[d]	
		P	S			E	P
Tinamidae – tinamous							
Great tinamou	*Tinamus major*	x	x	F	R		P
Little tinamou	*Crypturellus soui*	x	x	E	R		P
Pelecanidae – pelicans							
Brown pelican	*Pelecanus occidentalis*	x	x	A	R		
Phalacrocoracidae – cormorants							
Olivaceous cormorant	*Phalacrocorax brasilianus*	x	x	A	R		
Anhingidae – darters							
Anhinga	*Anhinga anhinga*	x	x	A	R		
Fregatidae – frigatebirds							
Magnificent frigatebird	*Fregata magnificens*	x	x	A	R		
Ardeidae – herons							
Rufescent tiger-heron	*Tigrisoma lineatum*	x	x	F	R		
Great blue heron	*Ardea herodias*	x	x	A	R		
Great egret	*Casmerodius albus*	x	x	A	R		

continued

Table 5—Bird species in the San Lorenzo Protected Area (continued)

Family and English name	Scientific name	Locale[a]		Habitat[b]	Status[c]	Class[d]	
		P	S			E	P
Ardeidae – herons (cont.)							
Snowy egret	*Egretta thula*	x	x	A	R		
Little blue heron	*E. caerulea*	x	x	A	R		
Tricolored heron	*E. tricolor*	x	x	A	R		
Cattle egret	*Bubulcus ibis*	x	x	A	R		
Green heron	*Butorides virescens*	x	x	A	MW		
Striated heron	*B. striatus*	x	x	A	R		
Agami heron	*Agamia agami*	x	x	F	R		
Black-crowned night-heron	*Nycticorax nycticorax*		x	A	R		
Yellow-crowned night-heron	*Nyctanassa violacea*		x	A	R		
Boat-billed heron	*Cochlearius cochlearius*	x	x	F	R		
Threskiornithidae – ibises and spoonbills							
White ibis	*Eudocimus albus*		x	A	R		
Anatidae – ducks, geese, and swans							
Blue-winged teal	*Anas discors*	x	x	A	MW		
Cathartidae – vultures							
Black vulture	*Coragyps atratus*	x	x	G	R		
Turkey vulture	*Cathartes aura*	x	x	G	R		
King vulture	*Sarcoramphus papa*	x	x	F	R		
Acciptridae – hawks, eagles, and kites							
Osprey	*Pandion haliaetus*	x	x	A	MW	II	
Gray-headed kite	*Leptodon cayanensis*	x	x	F	R	II	
Hook-billed kite	*Chondrohierax uncinatus*	x	x	F	R	II	
American swallow-tailed kite	*Elanoides forficatus*	x	x	F	R	II	
Double-toothed kite	*Harpagus bidentatus*	x	x	F	R	II	
Mississippi kite	*Ictinia mississippiensis*	x	x	F	MP	II	
Plumbeous kite	*I. plumbea*	x	x	F	MB	II	
Bicolored hawk	*Accipiter bicolor*	x		F	R	II	
Crane hawk	*Geronspiza caerulescens*	x	x	F	R		
Plumbeous hawk	*Leucopternis plumbea*	x		F	R	II	
Semiplumbeous hawk	*L. semiplumbea*	x	x	F	R	II	
Barred hawk	*L. princeps*	x		F	V		
White hawk	*L. albicollis*	x	x	F	R	II	
Common black-hawk	*Buteogallus anthracinus*	x	x	E	R	II	
Great black-hawk	*B. urubitinga*	x	x	F	R	II	
Gray hawk	*Buteo nitidus*	x	x	E	R	II	
Roadside hawk	*B. magnirostris*	x		E	R	II	
Broad-winged hawk	*B. platypterus*	x	x	F	MW	II	
Short-tailed hawk	*B. brachyurus*	x		G	R	II	
Swainson's hawk	*B. swainsonii*	x	x	O	MP	II	
Zone-tailed hawk	*B. albonotatus*	x	x	O	R	II	
Crested eagle	*Morphnus guianensis*	x		F	R		
Harpy eagle	*Harpia harpyja*		x	F	R		
Black hawk-eagle	*Spizaetus tyrannus*	x	x	F	R	II	

continued

Table 5—Bird species in the San Lorenzo Protected Area (continued)

Family and English name	Scientific name	Locale[a]		Habitat[b]	Status[c]	Class[d]	
		P	S			E	P
Falconidae – falcons and caracaras							
Red-throated caracara	*Daptrius americana*	x		F	R		
Crested caracara	*Polyborus plancus*	x	x	O	R		
Yellow-headed caracara	*Milvago chimachima*	x	x	O	R	II	
Laughing falcon	*Herpetotheres cachinnans*	x		G	R	II	
Barred forest-falcon	*Micrastur ruficollis*	x	x	F	R	II	
Slaty-backed forest-falcon	*M. mirandollei*	x	x	F	R	II	
Collared forest-falcon	*M. semitorquatus*	x	x	F	R	II	
Bat falcon	*Falco rufigularis*	x	x	E	R	II	
Peregrine falcon	*F. peregrinus*	x	x	O	MW	I	
Cracidae – curassows, guans, and chachalacas							
Gray-headed chachalaca	*Ortalis cinereiceps*	x	x	E	R		P
Crested guan	*Penelope purpurascens*	x	x	F	R		P
Great currasow	*Crax rubra*	x	x	F	R		P
Phasianidae – pheasants, grouse, turkeys, and quail							
Marbled wood-quail	*Odontophorus gujanensis*	x	x	F	R		P
Rallidae – rails, gallinules, and coots							
White-throated crake	*Laterallus albigularis*	x	x	A	R		
Gray-necked wood-rail	*Aramides cajanea*	x	x	F	R		
Rufous-necked wood-rail	*A. axillaris*		x	A	R		
Uniform crake	*Amaurolimnas concolor*	x		F	R		
Colombian crake	*Neocrex colombianus*	x		A	V		
Spotted rail	*Pardirallus maculatus*		x	A	V		
Purple gallinule	*Porphyrula martinica*	x	x	A	R		
Common moorhen	*Gallinula chloropus*	x	x	A	MW		
Eurypygidae – sunbitterns							
Sunbittern	*Eurypyga helias*	x	x	F	R		
Aramidae – limpkins							
Limpkin	*Aramus guarana*	x	x	A	R		
Charadriidae – plovers and lapwinds							
Black-bellied plover	*Pluvialis squatarola*		x	A	MW		
Collared plover	*Charadrius collaris*	x	x	A	R		
Wilson's plover	*C. wilsonia*		x	A	MW		
Semipalmated plover	*C. semipalmatus*		x	A	MW		
Jacanidae – jacanas							
Wattled Jacana	*Jacana jacana*	x	x	A	R		
Scolopacidae – sandpipers and phalaropes							
Greater yellowlegs	*Tringa melanoleuca*		x	A	MW		
Lesser yellowlegs	*T. flavipes*		x	A	MW		
Solitary sandpiper	*T. solitaria*	x	x	A	MW		

continued

Table 5—Bird species in the San Lorenzo Protected Area (continued)

Family and English name	Scientific name	Locale[a]		Habitat[b]	Status[c]	Class[d]	
		P	S			E	P
Scolopacidae – sandpipers and phalaropes (cont.)							
Willet	*Catoptrophorus semipalmatus*		x	A	MW		
Wandering tattler	*Heteroscelus incanus*	x		A	V		
Spotted sandpiper	*Actitis macularia*	x	x	A	MW		
Whimbrel	*Numenius phaeopus*		x	A	MW		
Long-billed curlew	*N. americanus*		x	O	V		
Ruddy turnstone	*Arenaria interpres*		x	A	MW		
Red knot	*Calidris canutus*		x	A	MW		
Sanderling	*C. alba*		x	A	MW		
Semipalmated sandpiper	*C. pusilla*		x	A	MW		
Western sandpiper	*C. mauri*		x	A	MW		
Least sandpiper	*C. minutilla*		x	A	MW		
Pectoral sandpiper	*C. melanotos*		x	O	MP		
Buff-breasted sandpiper	*Tryngites subruficollis*		x	O	MP		
Short-billed dowitcher	*Limnodromus griseus*		x	A	MW		
Common snipe	*Gallinago gallinago*		x	O	MW		
Wilson's phalarope	*Phalaropus tricolor*	x		A	MP		
Laridae – skuas, gulls, terns, and skimmers							
Laughing gull	*Larus atricilla*	x	x	A	R		
Bonaparte's gull	*L. philadelphia*	x		A	V		
Gull-billed tern	*Sterna nilotica*		x	A	R		
Royal tern	*S. maxima*		x	A	R		
Sandwich tern	*S. sandvicensis*	x	x	A	R		
Common tern	*S. hirundo*		x	A	MW		
Black tern	*Chlidonias niger*		x	A	MW		
Brown noddy	*Anous stolidus*		x	A	V		
Black skimmer	*Rynchops niger*		x	A	MW		
Columbidae – pigeons and doves							
Rock dove	*Columba livia*		x	O	R		P
Pale-vented pigeon	*C. cayennensis*	x	x	E	R		P
Scaled pigeon	*C. speciosa*	x	x	F	R		P
Short-billed pigeon	*C. nigrirostris*	x	x	F	R		P
Ruddy ground-dove	*Columbina talpacoti*	x	x	O	R		
White-tipped dove	*Leptotila verreauxi*	x	x	E	R		
Gray-chested dove	*L. cassinii*	x	x	F	R		
Olive-backed quail-dove	*Geotrygon veraguensis*	x	x	F	R		
Violaceous quail-dove	*G. violacea*	x	x	F	R	II	
Ruddy quail-dove	*G. montana*	x	x	F	R		
Psittacidae – parrots							
Orange-chinned parakeet	*Brotogeris jugularis*	x	x	G	R	II	
Brown-hooded parrot	*Pionopsitta haematotis*	x	x	F	R	II	
Blue-headed parrot	*Pionus menstruus*	x	x	F	R	II	
Red-lored amazon	*Amazona autumnalis*	x	x	F	R	II	
Mealy amazon	*A. farinosa*	x	x	F	R	II	

continued

Table 5—Bird species in the San Lorenzo Protected Area (continued)

Family and English name	Scientific name	Locale[a] P	Locale[a] S	Habitat[b]	Status[c]	Class[d] E	Class[d] P
Cuculidae – cuckoos							
Black-billed cuckoo	*Coccyzus erythropthalmus*	x	x	F	MP		
Yellow-billed cuckoo	*C. americanus*	x	x	F	MP		
Squirrel cuckoo	*Piaya cayana*	x	x	G	R		
Little cuckoo	*P. minuta*	x		E	R		
Striped cuckoo	*Tapera naevia*	x	x	O	R		
Pheasant cuckoo	*Dromococcyx phasianellus*	x	x	F	R		
Rufous-vented ground-cuckoo	*Neomorphus geoffroyi*	x		F	R		
Greater ani	*Crotophaga major*	x	x	A	R		
Smooth-billed ani	*C. ani*	x	x	S	R		
Strigidae – owls							
Vermiculated screech-owl	*Otus guatemalae*	x	x	F	R	II	
Tropical screech-owl	*O. choliba*	x	x	O	R	II	
Crested owl	*Lophostrix cristata*	x	x	F	R		
Spectacled owl	*Pulsatrix perspicillata*	x	x	O	R	II	
Mottled owl	*Ciccaba virgata*	x	x	E	R	II	
Black-and-white owl	*C. nigrolineata*	x	x	E	R	II	
Caprimulgidae – nightjars							
Short-tailed nighthawk	*Lurocalis semitorquatus*	x	x	F	R		
Lesser nighthawk	*Chordeiles acutipennis*	x	x	G	R		
Common nighthawk	*C. minor*	x	x	G	MW		
Pauraque	*Nyctidromus albicollis*	x	x	O	R		
Ocellated poorwill	*Nyctiphrynus ocellatus*	x		F	V		
Nyctibiidae – potoos							
Great potoo	*Nyctibius grandis*	x	x	F	R		
Common potoo	*N. griseus*	x	x	E	R		
Apodidae – swifts							
White-collared swift	*Stroptoprocne zonaris*	x	x	G	R		
Chimney swift	*Chaetura pelagica*	x	x	G	MP		
Short-tailed swift	*C. brachyura*	x	x	G	R		
Band-rumped swift	*C. spinicauda*	x	x	G	R		
Lesser swallow-tailed swift	*Panyptila cayennensis*	x	x	G	R		
Trochilidae – hummingbirds							
Rufous-breasted hermit	*Glaucis hirsuta*	x	x	F	R	II	
Band-tailed barbthroat	*Threnetes ruckeri*	x	x	F	R	II	
Green hermit	*Phaethornis guy*	x		F	R		
Long-tailed hermit	*P. superciliosus*	x	x	F	R	II	
Little hermit	*P. longuemareus*	x	x	F	R	II	
White-tipped sicklebill	*Eutoxeres aquila*	x		F	R		
White-necked jacobin	*Florisuga mellivora*	x	x	E	R	II	
Green-breasted mango	*Anthracothorax prevostii*		x	O	V		
Black-throated mango	*A. nigricollis*	x	x	O	R	II	
Rufous-crested coquette	*Lophornis delattrei*	x	x	E	R	II	
Violet-crowned woodnymph	*Thalurania colombica*	x	x	F	R	II	

continued

Table 5—Bird species in the San Lorenzo Protected Area (continued)

Family and English name	Scientific name	Locale[a] P	Locale[a] S	Habitat[b]	Status[c]	Class[d] E	Class[d] P
Trochilidae – hummingbirds (cont.)							
Violet-bellied hummingbird	*Damophila julie*	x	x	F	R	II	
Sapphire-throated hummingbird	*Lepidopyga coeruleogularis*	x	x	S	R	II	
Blue-chested hummingbird	*Amazilia amabilis*	x	x	F	R	II	
Rufous-tailed hummingbird	*A. tzacatl*	x	x	S	R	II	
White-vented plumeleteer	*Chalybura buffoni*	x	x	F	R	II	
Bronze-tailed plumeleteer	*C. urochrysia*	x	x	F	R	II	
Purple-crowned fairy	*Heliothryx barroti*	x	x	F	R	II	
Trogonidae – trogons							
White-tailed trogon	*Trogon viridis*	x	x	F	R		
Violaceous trogon	*T. violaceus*	x	x	F	R		
Black-throated trogon	*T. rufus*	x	x	F	R		
Black-tailed trogon	*T. melanurus*	x	x	F	R		
Slaty-tailed trogon	*T. massena*	x	x	F	R		
Momotidae – motmots							
Blue-crowned motmot	*Momotus momota*	x	x	E	R		
Rufous motmot	*Baryphthengus martii*	x	x	F	R		
Broad-billed motmot	*Electron platyrhynchum*	x	x	F	R		
Alcedinidae – kingfishers							
Ringed kingfisher	*Ceryle torquata*	x	x	A	R		
Belted kingfisher	*C. alcyon*	x	x	A	MW		
Green kingfisher	*Chloroceryle americana*	x	x	A	R		
Amazon kingfisher	*C. amazona*	x	x	A	R		
Green-and-rufous kingfisher	*C. inda*	x	x	F	R		
American pygmy kingfisher	*C. aenea*	x	x	F	R		
Bucconidae – puffbirds							
White-necked puffbird	*Notharcus macrorhynchus*	x	x	E	R		
Black-breasted puffbird	*N. pectoralis*	x	x	F	R		
Pied puffbird	*N. tectus*	x	x	F	R		
White-whiskered puffbird	*Malacoptila panamensis*	x	x	F	R		
Gray-cheeked nunlet	*Nonnula ruficapilla*	x		F	R		
White-fronted nunbird	*Monasa morphoeus*	x		F	V		
Galbulidae – jacamars							
Great jacamar	*Jacamerops aurea*	x		F	R		
Capitonidae – barbets							
Spot-crowned barbet	*Capito maculicoronatus*	x		F	R		
Ramphastidae – toucons							
Collared aracari	*Pteroglossus torquatus*	x	x	F	R		
Yellow-eared toucanet	*Selenidera spectabilis*	x		F	R		
Keel-billed toucan	*Ramphastos sulfuratus*	x	x	F	R	II	
Chestnut-mandibled toucan	*R. swainsonii*	x	x	F	R		

continued

Table 5—Bird species in the San Lorenzo Protected Area (continued)

Family and English name	Scientific name	Locale[a]		Habitat[b]	Status[c]	Class[d]	
		P	S			E	P
Picidae – woodpeckers							
Olivaceous piculet	*Picumnus olivaceus*	x	x	E	R		
Black-cheeked woodpecker	*Melanerpes pucherani*	x	x	F	R		
Red-crowned woodpecker	*M. rubricapillus*	x	x	O	R		
Yellow-bellied sapsucker	*Sphyrapicus varius*	x		F	MW		
Cinnamon woodpecker	*Celeus loricatus*	x	x	F	R		
Lineated woodpecker	*Dryocopus lineatus*	x	x	E	R		
Crimson-crested woodpecker	*Campephilus melanoleucos*	x	x	F	R		
Furnariidae – overbirds							
Slaty spinetail	*Synallaxis brachyura*	x		O	V		
Buff-throated foliage-gleaner	*Automolus ochrolaemus*	x	x	F	R		
Plain xenops	*Xenops minutus*	x	x	F	R		
Tawny-throated leaftosser	*Sclerurus mexicanus*	x	x	F	R		
Scaly-throated leaftosser	*S. guatemalensis*	x	x	F	R		
Dendrocolaptidae – woodcreepers							
Plain-brown woodcreeper	*Dendrocincla fuliginosa*	x	x	F	R		
Ruddy woodcreeper	*D. homochroa*	x	x	F	R		
Long-tailed woodcreeper	*Deconychura longicauda*	x	x	F	R		
Wedge-billed woodcreeper	*Glyphorynchus spirurus*	x	x	F	R		
Barred woodcreeper	*Dendrocolaptes certhia*	x	x	F	R		
Straight-billed woodcreeper	*Xiphorhynchus picus*		x	F	R		
Buff-throated woodcreeper	*X. guttatus*	x	x	F	R		
Black-striped woodcreeper	*X. lachrymosus*	x	x	F	R		
Formicariidae – antbirds							
Fasciated antshrike	*Cymbilaimus lineatus*	x	x	E	R		
Great antshrike	*Taraba major*	x	x	S	R		
Barred antshrike	*Thamnophilus doliatus*	x	x	S	R		
Slaty antshrike	*T. atrinucha*	x	x	F	R		
Spot-crowned antvireo	*Dysithamnus puncticeps*	x	x	F	R		
Pygmy antwren	*Myrmotherula brachyura*	x	x	F	R		
Streaked antwren	*M. surinamensis*	x	x	E	R		
Checker-throated antwren	*M. fulviventris*	x	x	F	R		
White-flanked antwren	*M. axillaris*	x	x	F	R		
Dot-winged antwren	*Microrhopias quixensis*	x	x	F	R		
Dusky antbird	*Cercomacra tyrannina*	x	x	E	R		
Bare-crowned antbird	*Gymnocichla nudiceps*	x		S	R		
White-bellied antbird	*Myrmeciza longipes*	x	x	E	R		
Chestnut-backed antbird	*M. exsul*	x	x	F	R		
Dull-mantled antbird	*M. laemosticta*	x		F	R		
Immaculate antbird	*M. immaculata*	x		F	R		
Spotted antbird	*Hylophylax naevioides*	x	x	F	R		
Bicolored antbird	*Gymnopithys leucaspis*	x	x	F	R		
Ocellated antbird	*Phaenostictus mcleannani*	x	x	F	R		
Black-faced antthrush	*Formicarius analis*	x	x	F	R		
Black-crowned antpitta	*Pittasoma michleri*	x		F	R		
Spectacled antpitta	*Hylopezus perspicallatus*	x	x	F	R		

continued

Table 5—Bird species in the San Lorenzo Protected Area (continued)

Family and English name	Scientific name	Locale[a]		Habitat[b]	Status[c]	Class[d]	
		P	S			E	P
Tyrannidae – tyrant-flycatchers							
Paltry tyrannulet	*Zimmerius vilissimus*	x	x	E	R		
Brown-capped tyrannulet	*Ornithion bruneicapillum*	x	x	F	R		
Southern beardless-tyrannulet	*Camptostoma obsoletum*	x	x	E	R		
Yellow-crowned tyrannulet	*Tyrannulus elatus*	x	x	E	R		
Forest elaenia	*Myiopagis gaimardii*	x	x	F	R		
Greenish elaenia	*M. viridicata*	x		E	R		
Yellow-bellied elaenia	*Elaenia flavogaster*	x	x	S	R		
Lesser elaenia	*E. chiriquensis*	x	x	S	R		
Olive-striped flycatcher	*Mionectes olivaceus*	x	x	F	R		
Ochre-bellied flycatcher	*M. oleaginea*	x	x	F	R		
Sepia-capped flycatcher	*Leptopogon amaurocephalus*	x		F	R		
Yellow tyrannulet	*Capsiempis flaveola*	x	x	O	R		
Yellow-green tyrannulet	*Phylloscartes flavovirens*	x		E	R		
Black-capped pygmy-tyrant	*Myiornis atricapillus*	x	x	E	R		
Southern bentbill	*Oncostoma olivaceum*	x	x	F	R		
Slate-headed tody-flycatcher	*Todirostrum sylvia*	x		S	R		
Common tody-flycatcher	*T. cinereum*	x	x	S	R		
Black-headed tody-flycatcher	*T. nigriceps*	x	x	E	R		
Brownish flycatcher	*Cnipodectes subbrunneus*	x	x	F	R		
Olivaceous flatbill	*Rhynchocyclus olivaceus*	x	x	F	R		
Yellow-olive flycatcher	*Tolmomyias sulphurescens*	x	x	E	R		
Yellow-margined flycatcher	*T. assimilis*	x	x	F	R		
Golden-crowned spadebill	*Platyrinchus coronatus*	x	x	F	R		
Northern royal flycatcher	*Onychorhynchus coronatus*	x	x	F	R		
Ruddy-tailed flycatcher	*Terenotriccus erythrurus*	x	x	F	R		
Sulphur-rumped flycatcher	*Myiobius barbatus*	x	x	F	R		
Black-tailed flycatcher	*M. atricaudus*	x		E	R		
Olive-sided flycatcher	*Contopus borealis*	x	x	F	MP		
Western wood-pewee	*C. sordidulus*	x	x	F	MP		
Eastern wood-pewee	*C. virens*	x	x	F	MP		
Tropical pewee	*C. cinereus*	x	x	S	R		
Yellow-bellied flycatcher	*Empidonax flaviventris*	x		F	MP		
Acadian flycatcher	*E. virescens*	x	x	F	MW		
Alder flycatcher	*E. alnorum*	x		S	MP		
Vermilion flycatcher	*Pyrocephalus rubinus*	x	x	O	V		
Long-tailed tyrant	*Colonia colonus*	x	x	F	R		
Bright-rumped attila	*Attila spadiceus*	x	x	F	R		
Speckled mourner	*Laniocera rufescens*	x	x	F	R		
Rufous mourner	*Rhytipterna holerythra*	x	x	F	R		
Sirystes	*Sirystes sibilator*	x		F	R		
Dusky-capped flycatcher	*Myiarchus tuberculifer*	x	x	F	R		
Panama flycatcher	*M. panamensis*	x	x	S	R		
Great crested flycatcher	*M. crinitus*	x	x	F	MW		
Lesser kiskadee	*Philohydor lictor*	x	x	A	R		
Great kiskadee	*Pitangus sulphuratus*	x	x	O	R		
Boat-billed flycatcher	*Megarynchus pitangua*	x	x	S	R		
Rusty-margined flycatcher	*Myiozetetes cayanensis*	x	x	S	R		
Social flycatcher	*M. similis*	x	x	O	R		
Gray-capped flycatcher	*M. granadensis*	x	x	S	R		

continued

Table 5—Bird species in the San Lorenzo Protected Area (continued)

Family and English name	Scientific name	Locale[a] P	Locale[a] S	Habitat[b]	Status[c]	Class[d] E	Class[d] P
Tyrannidae – tyrant-flycatchers (cont.)							
White-ringed flycatcher	*Conopias albovittata*	x	x	F	R		
Streaked flycatcher	*Myiodynastes maculatus*	x	x	O	R		
Sulphur-bellied flycatcher	*M. luteiventris*	x	x	E	MP		
Piratic flycatcher	*Legatus leucophaius*	x	x	E	MB		
Tropical kingbird	*Tyrannus melancholicus*	x	x	O	R		
Eastern kingbird	*T. tyrannus*	x	x	E	MP		
Gray kingbird	*T. dominicensis*	x	x	O	MW		
Fork-tailed flycatcher	*T. savana*	x	x	O	R		
Cinnamon becard	*Pachyramphus cinnamomeus*	x		E	R		
White-winged becard	*P. polychopterus*	x	x	E	R		
Masked tityra	*Tityra semifasciata*	x	x	E	R		
Black-crowned tityra	*T. inquisitor*	x	x	E	R		
Cotingidae – cotingas							
Rufous piha	*Lipaugus unirufus*	x	x	F	R		
Blue cotinga	*Cotinga nattererii*	x	x	F	R		
Purple-throated fruitcrow	*Querula purpurata*	x	x	F	R		
Pipridae – manakins							
Thrushlike mourner	*Schiffornis turdinus*	x	x	F	R		
Golden-collared manakin	*Manacus vitellinus*	x	x	E	R		
Blue-crowned manakin	*Pipra coronata*	x	x	F	R		
Red-capped manakin	*P. mentalis*	x	x	F	R		
Hirundinidae – swallows							
Purple martin	*Progne subis*	x	x	G	MP		
Gray-breasted martin	*P. chalybea*	x	x	G	R		
Brown-chested martin	*Phaeoprogne tapera*		x	G	MW		
Tree swallow	*Tachycineta bicolor*		x	G	MW		
Mangrove swallow	*T. albilinea*	x	x	A	R		
Blue-and-white swallow	*Notiochelidon cyanoleuca*	x	x	G	MW		
White-thighed swallow	*N. tibialis*	x	x	F	R		
Northern rough-winged swallow	*Stelgidopteryx serripennis*	x	x	G	MW		
Southern rough-winged swallow	*S. ruficollis*	x	x	G	R		
Bank swallow	*Riparia riparia*	x	x	G	MW		
Cliff swallow	*Hirundo pyrrhonota*	x	x	G	MP		
Barn swallow	*H. rustica*	x	x	G	MW		
Corvidae – jays, magpies, and crows							
Black-chested jay	*Cyanocorax affinis*	x	x	F	R		
Troglodytidae – wrens							
White-headed wren	*Campylorhynchus albobrunneus*	x		F	R		
Black-bellied wren	*Thryothorus fasciatoventris*	x	x	E	R		
Bay wren	*T. nigricapillus*	x	x	E	R		
Stripe-breasted wren	*T. thoracicus*	x	x	F	R		
Rufous-and-white wren	*T. rufalbus*		x	E	R		
Buff-breasted wren	*T. leucotis*	x	x	E	R		

continued

Table 5—Bird species in the San Lorenzo Protected Area (continued)

Family and English name	Scientific name	Locale[a] P	Locale[a] S	Habitat[b]	Status[c]	Class[d] E	Class[d] P
Troglodytidae – wrens (cont.)							
Plain wren	*T. modestus*	x	x	O	R		
House wren	*Troglodytes aedon*	x	x	O	R		
White-breasted wood-wren	*Henicorhina leucosticta*	x	x	F	R		
Southern nightingale-wren	*Microcerculus marginatus*	x	x	F	R		
Song wren	*Cyphorhinus phaeocephalus*	x	x	F	R		
Sylviinae – warblers, kinglets, and gnatcatchers							
Tawny-faced gnatwren	*Microbates cinereiventris*	x	x	F	R		
Long-billed gnatwren	*Ramphocaenus melanurus*	x	x	E	R		
Tropical gnatcatcher	*Polioptila plumbea*	x	x	F	R		
Turdinae – solitares and thrushes							
Veery	*Catharus fuscescens*	x	x	F	MP		
Gray-cheeked thrush	*C. minimus*	x	x	F	MP		
Swainson's thrush	*C. ustulatus*	x	x	F	MP		
Wood thrush	*Hylocichla mustelina*	x	x	F	MW		
Clay-colored robin	*Turdus grayi*	x	x	O	R		
Mimidae – mockingbirds and thrashers							
Gray catbird	*Dumetella carolinensis*	x	x	S	MW		
Tropical mockingbird	*Mimus gilvus*	x	x	O	R		
Motacillidae – pipits and wagtails							
Yellowish pipit	*Anthus lutescens*	x		O	R		
Vireonidae – vireos							
Solitary vireo	*Vireo solitarius*		x	E	MW		
Yellow-throated vireo	*V. flavifrons*	x	x	F	MW		
Red-eyed vireo	*V. olivaceus*	x	x	F	MP		
Yellow-green vireo	*V. flavoviridis*	x	x	E	MB		
Black-whiskered vireo	*V. altiloquus*	x	x	S	V		
Scrub greenlet	*Hylophilus flavipes*	x	x	S	R		
Tawny-crowned greenlet	*H. ochraceiceps*	x	x	F	R		
Golden-fronted greenlet	*H. aurantiifrons*	x	x	E	R		
Lesser greenlet	*H. decurtatus*	x	x	F	R		
Green shrike-vireo	*Vireolanius pulchellus*	x	x	F	R		
Parulinae – wood-warblers							
Golden-winged warbler	*Vermivora chrysoptera*	x	x	E	MW		
Tennessee warbler	*V. peregrina*	x	x	E	MW		
Northern parula	*Parula americana*		x	E	MW		
Yellow warbler	*Dendroica petechia*	x	x	S	MW		
Chestnut-sided warbler	*D. pensylvanica*	x	x	F	MW		
Magnolia warbler	*D. magnolia*	x	x	F	MW		
Cape May warbler	*D. tigrina*	x	x	E	MW		
Black-throated blue warbler	*D. caerulescens*	x	x	F	V		
Black-throated green warbler	*D. virens*	x		F	MP		

continued

Table 5—Bird species in the San Lorenzo Protected Area (continued)

Family and English name	Scientific name	Locale[a] P	Locale[a] S	Habitat[b]	Status[c]	Class[d] E	Class[d] P
Parulinae – wood-warblers (cont.)							
Blackburnian warbler	*D. fusca*	x	x	F	MP		
Yellow-throated warbler	*D. dominica*	x		E	V		
Bay-breasted warbler	*D. castanea*	x	x	F	MW		
Cerulean warbler	*D. cerulea*	x	x	F	MP		
Black-and-white warbler	*Mniotilta varia*	x	x	F	MW		
American redstart	*Setophaga ruticilla*	x	x	F	MW		
Prothonotary warbler	*Protonotaria citrea*	x	x	E	MW		
Worm-eating warbler	*Helmitheros vermivorus*	x	x	F	MW		
Ovenbird	*Seiurus aurocapillus*	x	x	F	MW		
Northern waterthrush	*S. noveboracensis*	x	x	E	MW		
Louisiana waterthrush	*S. motacilla*	x	x	F	MW		
Kentucky warbler	*Oporornis formosus*	x	x	F	MW		
Mourning warbler	*O. philadelphia*	x	x	S	MW		
Hooded warbler	*Wilsonia citrina*	x		F	MW		
Canada warbler	*W. canadensis*	x	x	F	MP		
Rufous-capped warbler	*Basileuterus rufifrons*	x	x	E	R		
Buff-rumped warbler	*Phaeothlypis fulvicauda*	x		F	R		
Coerebinae – bananaquits							
Bananaquit	*Coereba flaveola*	x	x	S	R		
Thraupinae – tanagers							
Plain-colored tanager	*Tangara inornata*	x	x	E	R		
Bay-headed tanager	*T. gyrola*	x	x	F	R		
Golden-hooded tanager	*T. larvata*	x	x	E	R		
Scarlet-thighed dacnis	*Dacnis venusta*	x	x	F	R		
Blue dacnis	*D. cayana*	x	x	F	R		
Green honeycreeper	*Chlorophanes spiza*	x	x	F	R		
Shining honeycreeper	*Cyanerpes lucidus*	x	x	F	R		
Red-legged honeycreeper	*C. cyaneus*	x	x	E	R		
Yellow-crowned euphonia	*Euphonia luteicapilla*	x	x	S	R		
Thick-billed euphonia	*E. laniirostris*	x	x	E	R		
Fulvous-vented euphonia	*E. fulvicrissa*	x	x	F	R		
White-vented euphonia	*E. minuta*	x	x	F	R		
Blue-gray tanager	*Thraupis episcopus*	x	x	O	R		
Palm tanager	*T. palmarum*	x	x	O	R		
Olive tanager	*Chlorothraupis carmioli*	x	x	F	R		
Gray-headed tanager	*Eucometis penicillata*	x	x	F	R		
Sulphur-rumped tanager	*Heterospingus rubrifrons*	x	x	F	R		
White-shouldered tanager	*Tachyphonus luctuosus*	x	x	E	R		
Tawny-crested tanager	*T. delatrii*	x	x	F	R		
White-lined tanager	*T. rufus*	x	x	O	R		
Red-throated ant-tanager	*Habia fuscicauda*	x	x	E	R		
Summer tanager	*Piranga rubra*	x	x	E	MW		
Scarlet tanager	*P. olivacea*	x	x	F	MW		
Crimson-backed tanager	*Ramphocelus dimidiatus*	x	x	S	R		
Flame-rumped tanager	*R. flammigerus*	x	x	S	R		
Rosy thrush-tanager	*Rhodinocichla rosea*	x	x	E	R		
Dusky-faced tanager	*Mitrospingus cassinii*	x	x	E	R		

continued

Table 5—Bird species in the San Lorenzo Protected Area (continued)

Family and English name	Scientific name	Locale[a] P	Locale[a] S	Habitat[b]	Status[c]	Class[d] E	Class[d] P
Cardinalinae – cardinals and grosbeaks							
Streaked saltator	*Saltator albicollis*	x	x	S	R		
Buff-throated saltator	*S. maximus*	x	x	E	R		
Black-headed saltator	*S. atriceps*	x		S	R		
Slate-colored grosbeak	*S. grossus*	x	x	F	R		
Rose-breasted grosbeak	*Pheucticus ludovicianus*	x	x	E	MW		
Blue-black grosbeak	*Cyanocompsa cyanoides*	x	x	E	R		
Blue grosbeak	*Guiraca caerulea*	x	x	S	MW		
Indigo bunting	*Passerina cyanea*		x	S	MW		
Dickcissel	*Spiza americana*	x	x	O	MP		
Emberizinae – emberizine finches							
Orange-billed sparrow	*Arremon aurantiirostris*	x	x	E	R		
Black-striped sparrow	*Arremenops conirostris*	x	x	O	R		
Blue-black grassquit	*Volatinia jacarina*	x	x	O	R		
Slate-colored seedeater	*Sporophila schistacea*	x	x	E	R		
Variable seedeater	*S. americana*	x	x	O	R		
Yellow-bellied seedeater	*S. nigricollis*	x	x	O	R		
Ruddy-breasted seedeater	*S. minuta*	x	x	O	R		
Lesser seed-finch	*Oryzoborus angolensis*	x	x	O	R		
Saffron finch	*Sicalis flaveola*	x	x	O	R		
Icterinae – orioles and blackbirds							
Bobolink	*Dolichonyx oryzivorus*	x	x	O	MP		
Red-breasted blackbird	*Sturnella militaris*	x	x	O	R		
Eastern meadowlark	*S. magna*	x	x	O	R		
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*	x		O	V		
Great-tailed grackle	*Cassidix mexicanus*	x	x	O	R		
Shiny cowbird	*Molothrus bonariensis*	x	x	O	R		
Giant cowbird	*Scaphidura oryzivora*	x	x	O	R		
Orchard oriole	*Icterus spurius*	x	x	S	MW		
Yellow-backed oriole	*I. chrysater*	x	x	E	R		
Yellow-tailed oriole	*I. mesomelas*	x	x	E	R		
Baltimore oriole	*I. galbula*	x	x	E	MW		
Yellow-billed cacique	*Amblycercus holosericeus*	x	x	O	R		
Scarlet-rumped cacique	*Cacicus uropygialis*	x	x	F	R		
Yellow-rumped cacique	*C. cela*	x	x	E	R		
Crested oropendola	*Psarocolius decumanus*	x	x	E	R		
Chestnut-headed oropendola	*P. wagleri*	x	x	E	R		
Montezuma oropendola	*P. Montezuma*	x		E	V		
Fringillidae – finches							
Lesser goldfinch	*Spinus psaltria*	x	x	S	R		

[a] P = Piña; S = Fort Sherman.
[b] A = Aquatic; E = edge; F = forest; G = general; O = open; S = secondary.
[c] MB = Migrant from elsewhere in Panama; MP = migrant passing through Panama; MW = winter migrant in Panama; R = resident; V = vagrant.
[d] E = Protected by the U.S. Endangered Species Act CITES rankings: I = species threatened with extinction. Trade in wild specimens of taxa or population are essentially prohibited with few exceptions. II = species not threatened with extinction but may become so unless trade is controlled or monitored; P = protected by Panamanian law.
Table compiled by George R. Angehr and W. Douglas Robinson of the Smithsonian Tropical Research Institute.

Photo courtesy of Gerald P. Bauer.

The green iguana (Iguana iguana)*, predominantly a vegetarian, may grow to 1.8 m long. The iguana lives at elevations < 1000 m, favoring wooded areas near water. Long favored in the diets of Panama's indigenous peoples and rural populations, the iguana is also a popular item in the pet trade.*

Reptiles and Amphibians

Panama has 228 species of reptiles (10 percent endemic) including 127 snakes, 81 lizards and iguanas, 15 marine and freshwater turtles, 3 worm lizards, a crocodile, and a caiman. Of the 228 species, the SLPA contains 34 reptiles, or 15 percent of Panama's total (table 6). Among those identified so far are 15 species of iguanas and lizards, 12 snakes, 4 geckos, 2 turtles, and 1 caiman (Ibáñez 1991, Ibáñez and others 1995). The lizard *Norops lionotus* is endemic to Panama.

Panama also has about 170 species of amphibians (16 percent endemic) including 141 frogs and toads, 21 salamanders, and 8 cecilias. The SLPA has 36 species of amphibians, or 21 percent of Panama's total (table 6). Of those recorded so far, there are 34 frogs and toads, and 2 are salamanders. The salamander *Bolitoglossa cuna* is endemic to Panama. Among the more noteworthy amphibians are the colorful poison dart frogs (Savage 1968).

The data on reptiles and amphibians for the SLPA is derived from two separate evaluations—the rapid ecological assessment and an independent herpetological study (table 6). Sampling in the herpetological study was limited to five two-day periods throughout the year (Ibáñez and others 1995). The major sites were along the Gatún Locks-Sherman Road (S2), in Mojinga Swamp, cativo forest, mangroves, secondary forest, and in the vicinity of Gatún Dam.

Table 6—Reptile and amphibian species in the San Lorenzo Protected Area

Group and Family	English name	Scientific name	Locale[a]		Class[b]	
			P	S	E	P
REPTILES						
Snakes						
Boidae	Boa constrictor	*Boa constrictor*	P	S	II	P
	Annulated tree boa	*Corallus annulatus*		S	II	
Culubridae	Black racer	*Chironius carinatus*	P	S		
	Large scaled black tree snake	*C. grandisquamis*	P	S		
	Mexican milk snake	*Leptodeira annulata*	P	S		
	Parrot snake	*Leptophis ahaetulla*	P			
		Liophis epinephalus	P			
	Mexican vine snake	*Oxybelis aeneus*	P			
	Green vine snake	*O. brevirostris*	P			
		Siphlophis cervinus	P			
Elapidae	Central American coral snake	*Micrurus nigrocinctus*	P			
Viperidae	Fer de lance	*Bothrops asper*	P			

continued

Table 6—Reptile and amphibian species in the San Lorenzo Protected Area (continued)

Group and Family	English name	Scientific name	Locale[a]		Class[b]	
			P	S	E	P
REPTILES (cont.)						
Geckos						
Gekkonidae	Yellow-headed gecko	*Gonatodes albogularis*	P	S		
	Common house gecko	*Hemidactylus frenatus*	P			
	Litter gecko	*Lepidoblepharis xanthostigma*	P	S		
	Turnip-tailed gecko	*Thecadactylus rapicauda*	P			
Iguanas and lizards						
Corytophnidae	Brown basilisk	*Basiliscus basiliscus*	P	S		
	Helmeted basilisk	*Corytophanes cristatus*	P			
Gymnophtalmidae		*Leposoma rugiceps*		S		
Iguanidae	Black iguana	*Ctenosaura similis*		S		P
	Green iguana	*Iguana iguana*	P	S	II	P
Polychrotidae	Giant green anole	*Dactyloa frenata*	P	S		
		Norops auratus	P	S		
	Green tree anole	*N. biporcatus*	P			
	Pug-nosed anole	*N. capito*	P			
	Slender brown anole	*N. limifrons*	P	S		
		N. lionotus[c]		S		
		N. tropidogaster	P	S		
Scincidae	Bronze-backed skink	*Mabuya unimarginata*	P	S		
Teiidae	Jungle runner	*Ameiva ameiva*	P	S		
	Central American ameiva	*A. festiva*	P	S		
	Delicate ameiva	*A. leptophrys*	P	S		
Turtles						
Emydidae	Slider	*Trachemys scripta*	P			
Kinosternidae	White-lipped mud turtle	*Kinosternon leucostomum*	P			
Crocodilians						
Alligatoridae	Spectacled caiman	*Caiman crocodilus*		S	E	P
AMPHIBIANS						
Toads and frogs						
Bufonidae	Marine toad	*Bufo marinus*	P	S		
	Leaf litter frog	*B. typhonius*	P	S		
Centrolenidae		*Centrolenella spinosa*	P	S		
	Glass frog	*Hyalinobatrachium fleischmanni*		S		
Dendrobatidae	Rocket frog	*Colostethus nubicola*	P	S		
		C. talamancae	P	S		
	Poison dart frog	*Dendrobates auratus*	P	S		

continued

Table 6—Reptile and amphibian species in the San Lorenzo Protected Area (continued)

Group and Family	English name	Scientific name	Locale[a]		Class[b]	
			P	S	E	P
AMPHIBIANS (cont.)						
Toads and frogs (cont.)						
Hylidae	Red-eyed leaf frog	*Agalychnis callidryas*	P	S		
	Emerald-eyed tree frog	*Hyla crepitans*	P			
	Hourglass tree frog	*H. ebraccata*		S		
	Yellow tree frog	*H. microcephala*		S		
		H. phlebodes		S		
	Tree frog	*H. rufitela*	P	S		
	Veined tree frog	*Phrynohyas venulosa*	P	S		
	Tree frog	*Scinax boulengeri*		S		
	Tree frog	*S. rostrata*		S		
		S. rubra		S		
	Tree frog	*S. staufferi*		S		
		Smilisca sila		S		
Leptodactylidae	Slim-fingered rain frog	*Eleutherodactylus crassidigitus*	P	S		
	Tink frog	*E. diastema*	P	S		
	Common rain frog	*E. fitzingeri*	P	S		
	Fort Randolph robber frog	*E. gaigeae*	P			
		E. raniformis	P			
		E. ridens	P	S		
	Banded robber frog	*E. taeniatus*		S		
		Leptodactylus insularum		S		
	White-lipped frog	*L. labialis*	P	S		
	Sabinal frog	*L. melanonotus*		S		
	South American bullfrog	*L. pentadactylus*	P	S		
		L. poecilochilus		S		
	Tungara frog	*Physalaemus pustulosus*	P	S		
Ranidae	Rainforest frog	*Rana vaillanti*		S		
	Brilliant forest frog	*R. warszewitschii*	P			
Salamanders						
Plethodontidae		*Bolitoglossa cuna*[c]	P	S		
		Oedipina parvipes		S		

[a] P = Piña; S = Fort Sherman.

[b] E = Protected by the U.S. Endangered Species Act CITES rankings: II = species not threatened with extinction but may become so unless trade is controlled or monitored; P = protected by Panamanian law.

[c] Endemic species.

Source: ANCON and TNC (1996); GEA Consultores and Louis Berger International, Inc. (1999); Ibanez and others (1995); personal observations.

Freshwater Fish

At least 42 species of freshwater fish live in some part of the Chagres River watershed or in small streams near Toro Point. The Chagres watershed includes Gatún Lake, streams on Barro Colorado Island, and and minor tributaries within the SLPA (Hildebrand 1938, Zaret and Paine 1973) (table 7). Most fishes of eastern and central Panama are of South American origin (Hildebrand 1938). Two large families, the characins (family Characinidae) and the mailed catfish (family Loricaridae) are from South America. The migrations of these families to the Chagres watershed appears to have been from the western Atlantic slope of Colombia to the Pacific slope of eastern and central Panama by means of the Atrato, Tuira, Bayano, and other rivers, and then to neighboring coastal streams of the Chagres.

The Chagres River is 193 km long; the Chagres watershed with its numerous tributaries drains 3262 km^2 (Jaén Suárez 1981), or 4.2 percent of Panama. Gatún Lake, created in 1914, covers 423 km^2; the dam forming the lake measures over 30 m high and spans 2.4 km. Gatún Lake, extending 37 km between the Gatún Locks and the Culebra Cut, borders the SLPA. Madden and Alajuela Dams, built in 1936, are smaller reservoirs that are situated above Gatún Lake within the Chagres watershed. The regimen of the Chagres varies considerably during the year, with the greatest flows during the wet season. Unlike the period before the construction of the canal and the reservoirs, barriers to fish migration exist at the dam sites. Since the beginning of work on the canal, fish species have been introduced into the reservoirs and possibly elsewhere within the watershed.

Freshwater fish were deliberately introduced into the Chagres watershed (including Gatún Lake) on four occasions, as follows: guppies (*Lebistes reticulatus*) from Barbados for mosquito control around 1910; 450 large mouth bass (*Micropterus salmoides*), 1,000 catfish (species unknown), and 800 sunfish (*Lepomis* sp.) in 1917 for sport fishing; 2,250 large mouth bass, 500 bluegills (*Lepomis macrorochirus*), and 500 crappies (*Pomoxis sp.*) in 1925, also for sport fishing (Hildebrand 1938); and peacock bass (*Cichla ocellaris*) in 1967, again for sport fishing (Zaret and Paine 1973). Of these, only the peacock bass survived. Recently, the culture of tilapia (*Tilapia* sp.) was introduced to local communities through artificial fish

Table 7—Freshwater fish in the San Lorenzo Protected Area, Gatún Lake, and the Chagres watershed

Family[a] and species	Locality			
	BCI	CR	GL	TP
Atherinidae (silverside)				
Melaniris chagresi			X	
Characidae (characins)				
Astyanax ruberrimus		X	X	
Brycon chagrensis		X	X	
B. petrosus		X		
Bryconamericus emperador	X		X	
Compsura gorgonae	X		X	
Creagrutus notropoides		X		
Hoplias microlepis			X	
Hyphessobrycon panamensis		X	X	
Pseudocheirodon affinis		X	X	
Roeboides guatemalensis		X	X	
Cichlidae (cichlids)				
Aequidens coeruleopunctatus		X	X	
Cichla ocellaris[b]			X	
Cichlasoma maculicauda		X	X	
Geophagus crassilabris			X	
Neetroplus panamensis		X	X	
Cyprinodontidae (killifishes or toothcarps)				
Rivulus brunneus	X			
R. montium		X		
Gobiidae (gobies)				
Awaous tajasica				X
Dormitator maculatus				X
Eleotris isthmensis				X
E. pisonis			X	X
Gobiomorus dormitor	X		X	
G. maculatus			X	
Guavina guavina				X
Leptophilypnus fluviatilis			X	

continued

Table 7—Freshwater fish in the San Lorenzo Protected Area, Gatún Lake, and the Chagres watershed (continued)

Family[a] and species	Locality			
	BCI	CR	GL	TP
Gymnotidae (naked-back knifefishes)				
Hypopomus brevirostris		X		
Loricariidae (suckermouth armored catfishes)				
Ancistrus chagresi		X		
Chaetostoma fischeri		X		
Loricaria uracantha		X		
Plecostomus plecostomus panamensis		X	X	
Mugilidae (mullets)				
Agonostomus macracanthus		X		
A. monticola				X
Joturus pichardi		X		
Pimelodidae (long-whiskered catfishes)				
Pimelodella chagresi		X		
Rhamdia wagneri	X			
Poeciliidae (live bearers, or viviparous top-minnows)				
Brachyrhaphis cascajalensis	X	X	X	X
B. episcopi	X		X	
Gambusia nicaraguensis[b]			X	X
Mollienisia sphenops				X
Poecilia mexicana			X	
Poeciliopsis pittieri		X		

BCI = Barro Colorado Island; CR = Chagres watershed; GL = Gatún Lake; TP = Toro Point (Fort Sherman).
[a] Source of common family names: Nelson (1984).
[b] Introduced species.
Source: Hildebrand (1938), Labrut (1993), Zaret and Paine (1973).

ponds and floating cages suspended in Gatún Lake. Inevitably, some of the fish escaped and have reproduced successfully.

Fish species occurrence and abundance vary according to habitat; e.g., fast-flowing, shallow headwaters; lake shorelines or deep water; lowland river waters; or estuaries. Moreover, native species and food chains may be influenced by the introduction of exotic species. Peacock bass, native to the Amazon River and its tributaries, is renowned for its taste and as a good fighter. It is also a predator of other fish, and by 1973 had caused a major impact on other species, effectively eliminating *Astanax ruberrimus*, *Roeboides guatemalensis*, *Aequidens coeruleopunctatus*, *Gobiomorus dormitor*, *Gambusia nicaraguensis*, and *Poecilia mexicana*, and drastically reducing *Melaniris chagresi* (table 7). In contrast, *Cichlasoma maculicauda* increased. Peacock bass also had secondary impacts on zooplankton and bird species, and a resurgence of local mosquito populations may also have occurred (Zaret and Paine 1973). Further sampling in Gatún Lake could determine if a new equilibrium has been established.

Select Marine Flora and Fauna

Although the freshwater and marine environments are a critical part of the natural resource base of the SLPA, detailed information on freshwater and marine algae and invertebrates, and Caribbean fishes, is beyond the scope of this report. Published species lists and guides for identification of reef corals, sponges, algae, and other organisms found along the SLPA coast are available (Gammill 1997; GEA Consultores, S.A. and Louis Berger International, Inc. 1999; Guzmán and Holst 1994; Humann 1992, 1993; Littler and others 1989; Selfton and Webster 1986; Wood 1983). Species lists and guides for identification of Caribbean fish may be found in several publications (Ackerman 1951, Humann 1994, Meek and Hildebrand 1923, Randall 1968, Stokes 1980). The following is a general discussion of coral reefs, sea-grass communities, and sea turtles.

Coral Reefs

Mean tidal variation at Cristóbal (and presumably the SLPA) is only 0.56 m (GEA Consultores, S.A. and Louis Berger International, Inc. 1999). The barrier reefs that parallel the coast have developed under

conditions of strong winds, heavy rainfalls, high sedimentation (Guzmán and Holst 1994), and minor tidal variation. They range in age from 3,000 to 7,000 years old.

Thirteen coral platforms varying in size from 4 to 23 ha were found during a survey of the Caribbean Coast between Punto Muerto and the Chagres River (Guzmán and Holst 1994). Nearly 50 ha of coral reef were located along the SLPA coast in four areas designated as Fort Sherman, Isla Brujas, Punta Naranjitos, and Punta Iglesia (fig. 8).

During the Spanish conquest and colonization, and later during the construction of the canal by French and American companies, coral, sand, and sediments were mined, mainly in and around Portobelo and Limón Bay. The coastal waters off of the SLPA, including Fort San Lorenzo, may also have been harvested to some extent for the same purpose. Coral reefs once covered Limón Bay; today, these reefs, highly contaminated with fecal matter, have died (Guzmán and Holst 1994). The highlights of the survey of Caribbean reefs between Punto Muerto and the Chagres River follow:

- The algae are diverse, with more than 80 percent of the central region dominated by macroalgae and only 6 percent by live coral.
- The corals recorded within the survey region represent 53 percent of the species reported for the Caribbean shore of Panama and include the principal reef forming species.
- The only natural population of *Acropora cervicornis* is found in a 12-m^2 patch in front of the entrance to Fort Sherman.
- The only population of the soft coral *Pseudopterogorgia acerosa* is located a few meters south of the entrance to Fort Sherman.
- Relatively diverse populations of corals are still found at Punta Naranjitos and San Lorenzo.

The absence of coral species within the survey region that are common elsewhere along the Caribbean shore may be due to several factors (Guzmán and Holst 1994):

- Reefs in the survey region do not extend to depths > 10 to 15 m, whereas elsewhere reefs extend to depths of 40 m
- A century of environmental impact has profoundly disturbed the corals within the survey region
- Currently, the corals are under stress due to sedimentation, dredging, and oil spills.

The relatively low amount of coral and high amount of algae clearly shows the effect of long-term disturbance. Past exploitation and operations related to the construction and maintenance of the canal have had a negative impact on Caribbean corals. Unfortunately, the coral reefs of the SLPA cannot compete with reefs elsewhere in the Caribbean, so tourism focused on diving is not feasible (GEA Consultores, S.A. and Louis Berger International, Inc. 1999).

Sea-Grass Communities

Sea-grass communities containing four species of grass—*Thalassia testudinum*, *Siringodium filiforme*, and *Halodule wrightii* in shallow waters, *and Halophila decipiens* in deeper waters with less light—grow commonly in association with calcareous algae in lagoons between the reef crests and the mangroves (GEA Consultores, S.A. and Louis Berge International, Inc. 1999; Marshall 1994). These communities—two in Limón Bay and one at Punta Brujas—stabilize the beaches and the reefs, help collect sediment, support a variety of decopod crustaceans (Heck 1977), and serve as breeding grounds and foraging areas for many fish species. Other organisms, among them sea anemones, sponges, tunicates, shrimp, crabs, lobster, and sea conch, also abound in sea-grass communities.

Sea-grass communities are sensitive to urban development, deforestation, and coastal dredging, all of which increase coastal sedimentation (Marshall 1994). Sea-grass is also grazed by the West Indian manatee (*Trichechus manatus*), previously hunted for its meat, oil, and hides, and now considered threatened. Manatee, recorded in the Chagres River before the construction of the canal, were reintroduced into the river in 1964, and later escaped into Gatún Lake and the canal (Schad and others 1981). Viable wild populations still survive west of the SLPA in Bocas del Toro (Mou and Chen 1990). It has been suggested that canal dredge spoils could be deposited in the shallows of Limón Bay and planted to sea-grass to increase the populations of commercially important fish species (Marshall 1994). If the areas were large enough, manatee might also survive part of the year in Limón Bay.

Sea Turtles

Sea turtles, with a fossil record of at least 200 million years, are represented today by only eight species in two genera (Lutz and Musick 1996, Márquez 1990). Fishermen in the coastal town of Piña, at the western end of the SLPA, recall that in the past, four sea turtle species—loggerhead (*Caretta caretta*), green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), and leatherback (*Dermochelys coriacea*)—were seen occasionally. Aerial searches from 1981 to 1983 provided evidence of leatherback tracks between the Penisula de Valiente (Bocas del Toro) and west of the Chagres River (Meylan and Meylan 1984). Other turtles may also use these beaches, but no other species have been confirmed (GEA Consultores, S.A. and Louis Berger International, Inc. 1999).

Adapted to life in the ocean, sea turtles are tied to the land only for reproduction. The high commercial value of sea turtles for meat, eggs, oil, leather, shell ornaments and jewelry, cultural and ceremonial uses, and other products, has made these animals the targets of sailors, fishermen, and coastal dwellers for centuries. Sailors of Columbus' era welcomed fresh turtle meat as a pleasant change from a regular diet of hardtack and salt pork. Recent hazards to sea turtles include pollution, beach invasion for housing or recreational uses, sand extraction, poaching, and entanglement in fishing nets. Although all sea turtles provide meat and eggs, commercial values vary among species. The green sea turtle is pursued for its meat, the hawksbill for its shiny tortoise shell, and the leatherback for its oil. The loggerhead is the least commercially valuable of the sea turtle species previously sighted near Piña. Sea turtles, all listed as threatened or endangered, are no longer recorded on the beaches of the SLPA.

Classified Species

A number of animal species recorded on the SLPA are considered to be threatened or endangered according to the U.S. Endangered Species Act, and are protected by Panamanian law, or laws in both countries, as follows:

- 17 mammals: 9 endangered, 16 protected by Panama (table 4)
- 64 birds: 54 endangered, 10 protected by Panama (table 5)
- 5 reptiles and amphibians: 4 endangered, 3 protected by Panama (table 6)

The mammals include six carnivora (three cats, coati, raccoon, and river otter), four primates (monkeys), two rodentia (paca and agouti), and three xerartha (armadillo, sloth, and anteater). The major bird families include 20 Acciptridae (hawks, eagles, and kites), 7 Faconidae (falcons and caracaras), 3 Cracidae (curassows, guans, and chachalacas), 5 Columbidae (pigeons and doves), and 15 Trochilidae (hummingbirds). The reptiles include two Biodae (snakes), two Iguanidae (iguanas), and one Alligatoridae (caiman).

Additional classifications of threatened species, including those of the Nature Conservancy and the U.S. Fish and Wildlife Service, are mentioned in the Ecological Survey of the U.S. Department of Defense lands in Panama (Asociación Nacional para la Conservación de la Naturaleza and The Nature Conservancy 1996), or as part of a Central American survey (Unión Internacional para la Naturaleza 1999).

Health Concerns

Panama is notorious for the loss of lives from disease during its colonization and settlement periods, and later during the building of the transisthmus railroad and the French and American canals (Hardy 1939). The major disease vectors in the Panama Canal Basin are mosquitoes (Diptera, Culicidae), phlebotomine sandflies (Diptera, Psycholidae), triatomine bugs (Hemiptera, Reduviidae), biting midges (Diptera, Ceratopugonidae), blackflies (Diptera, Simuliidae), and tabanids (Diptera, Tabanidae) (Adames 1998).

Numerous diseases have been reported for the canal basin. Malaria, with main symptoms of chills and sweating, is perhaps the best known of the maladies. Malaria is caused by parasitic protozoans such as *Plasmodium vivax*, *P. falciparum*, *P. malaridae*, and *P. ovale*, which are transmitted by three species of mosquitoes, *Anopholes albimanus*, *A. punctimacula*, and *A. pseudopuntipennis*. Yellow fever, a virus causing jaundice, vomiting, and hemorrhaging, is transmitted by wild mosquitoes, among them *Haemagagus janthinomys*, *H. equimus*, *H. lucifer*, *Sabethes chloropterus*, *Anophales neivai*, and *Aedes aegypti* from Africa. Monkeys are also infected by yellow fever.

Dengue, or breakbone fever, often epidemic, is characterized by severe pains in the muscles and joints. Dengue is caused by a virus transmitted by the *A. aegyptii* mosquito. Venezuelan equine encephalomelitis, another virus, is spread by mosquitoes, including *Culex occosa*, *C. erraticus*, and *Masonia dyari*. The San Louis encephalitis, common throughout the Western Hemisphere, is spread by *M. dyari* and eight other mosquito species. Leishmaniasis, a skin and mucous membrane disease, is caused by a protozoan in the genus *Leichmania*. Five species of the mosquito genus *Lutzomia* are responsible for its spread. Other lesser known maladies are Chagres fever, Chagres disease, and Punta Toro virus, the latter first detected in the SLPA.

Some of the aforementioned disease vectors have either been identified in the SLPA or are suspected to exist there (GEA Consultores, S.A. and Louis Berger International, Inc. 1999), but the risk of contracting these diseases is low if appropriate precautions are taken.

Research Activities

Permanent Forest Monitoring Plots

Barro Colorado Island (BCI) in Gatún Lake is < 6 km from the SLPA. BCI, gradually formed after the Chagres River was dammed in 1910, has been a biological reserve since 1923. With an irregular shoreline of 48 km, the island covers 1565 ha and reaches an elevation of 145 m above the surrounding lake and 170 m above sea level. The first laboratory on BCI was established in 1924 when visiting scientists initiated their research. In 1940, BCI was dedicated as a natural monument, and placed under the administration of the Smithsonian Tropical Research Institute (STRI) in 1946.

The wealth of studies conducted by STRI on the flora (Croat 1978) and fauna of BCI, much of it based on monitoring, is relevant to the management of the SLPA. More than 500 vertebrate species have been identified on BCI: 60 bats, 384 birds, 30 frogs, 22 lizards, and 40 snakes. As part of the Canal Treaty of 1977, the relationship between STRI and Panama was relegated to a status similar to those of international missions.

In 1986, a nature trail was designed on BCI for the public as a means of promoting education and appreciation for tropical ecosystems (Wong and Ventocilla 1995); today, BCI receives about 2,300 day-visitors annually. BCI has residences, dorms, dining and conference halls, and modern laboratories where local scientists and guests continue their research in what is one of the best studied tropical forests in the World.

In addition to research on BCI, STRI scientists currently maintain a 4.96-ha permanent monitoring plot at the crane site in the SLPA. All trees at least 1 cm in diameter surrounding the crane have been permanently tagged and measured (Condit and others 2004). Tree diameters and heights were recorded to determine the current structure of the forest. Future remeasurement of all trees will provide insights into forest dynamics, including ingrowth and mortality rates, and changes in species composition due to normal tree mortality or climatic events such as wind storms or prolonged droughts. Similar data collected in other tropical forests allow comparisons of structure and dynamics throughout the World.

STRI Crane

For decades, lack of access to treetops has limited research in tropical forests. Several millions of species remain unknown; recent estimates indicate that > 90 percent of the World's species are undescribed arthropods (mainly insects, spiders, and mites) living in tropical forests (Wright and Colley 1996). To gain insights into the species composition and dynamics of canopy flora and fauna, STRI, in collaboration with the United Nations Environment Programme (UNEP), mounted a crane in the evergreen seasonal tall forest of the SLPA (fig. 1). The new crane permits canopy comparisons with data from the World's first erected canopy crane located in the dry forest of Metropolitan Nature Park near Panama City.

The STRI crane, ascending 55 m vertically and 54 m laterally through the canopy, allows scientists riding in a gondola to reach 0.92 ha of forest at virtually any height. Safe and easy to use, even for heavy equipment, the crane allows researchers to return repeatedly to any sampling point. This innovative work from cranes, underway at only 12 sites

worldwide, has already provided estimates of canopy biodiversity and biotic interactions and yielded data on canopy rainfall, temperature, and microclimate. The effects of environmental variables on plant performance, physiological responses to increases in atmospheric carbon, and the effects of ultraviolet radiation on the upper canopy are also being determined (Allen 1996, Joyce 1991, Wright and Colley 1996).

Researchers on the SLPA site are conducting an inventory of vascular epiphytes and mapping their distributions, and determining the impact of canopy herbivores on trees, epiphytes, and lianas. Herbivorous arthropods are collected in traps and trays at different heights to determine the vertical distribution and abundance of each species. The role of avifauna in controlling herbivory on canopy trees is revealed by wrapping wire mesh bird exclosures around branches and leaves. The phenology (climatic effects on annual plant and animal phenomena) of canopy trees and plant-pollinator interactions are also being monitored to show possible relationships between insect seasonality and flowering patterns. Another study evaluates the capacity of trees to assimilate atmospheric reactive nitrogen—specifically, how assimilation varies in relation to tree species and height of leaves above the ground.

The information collected on biodiversity, climate change, ozone layer depletion, and forest monitoring will ultimately provide an informed basis for environmental management and policymaking (Wright and Colley 1996). Specifically, the UNEP will use these research results to support its Convention on Biological Diversity, the United Nations Framework Convention on Climate Change, the Vienna Convention for the Protection of the Ozone Layer, the Intergovernmental Panel on Forests, and the Forest Principles outlined in Agenda 21.

Management Activities

Major Partners of the SLPA

Playing a crucial cooperative role, the Panamanian Centre for Research and Social Action (CEASPA) works with seven Panamanian, five foreign, and three international entities to develop social and environmental programs at the SLPA (appendix B). CEASPA's four major Panamanian cooperators are the Interoceanic Regional Authority (ARI), the National Environmental Authority (ANAM), the National Institute of Culture (INAC), and the Panamanian Tourism Institute (IPAT). While CEASPA is implementing a project involving community participation, the major cooperators are seeking a consensus for the best use of the reverted SLPA lands. Other Panamanian entities involved with the SLPA include the Natura Foundation (Fundación Natura), the Panama Audubon Society, and the Panama Canal Authority (ACP).

The foreign entities involved with activities on the SLPA are the Smithsonian Tropical Research Institute (STRI), the U.S. Agency for International Development (USAID), the U.S. Department of Agriculture, Forest Service (USFS), the U.S. National Fish and Wildlife Foundation, and the U.S. Peace Corps. International entities include the Global Environment Facility (GEF), the World Bank, and the World Monument Fund (WMF).

In 1979, Fort San Lorenzo was nominated as a World Heritage site (Organización de las Naciones Unidas para la Educación, la Ciéncia y la Cultura 1980; Republic of Panama 1979). In 1980, UNESCO declared Fort San Lorenzo a magnificent example of 17th- and 18th-century military architecture built in defense of trans-Atlantic trade. Subsequently, a 5-ha area encompassing the fort at the mouth of the Chagres River was designated a World Heritage site.

Among the potential projects with a major role for the SLPA is the Mesoamerican Biological Corridor, previously named the Paseo Pantera (Carr and others 1994, Coates 1997, World Bank 1998). The corridor is an ambitious proposal designed to unite protected

Photo courtesy of Gerald P. Bauer.

Fort San Lorenzo began as a water level battery in 1597. The fort was built later 25 m above sea level on a cliff overlooking the mouth of the Chagres River, and was protected landward by a dry moat and drawbridge. In 1980, United Nations Organization for Education, Science and Culture declared Fort San Lorenzo a World Heritage site.

areas throughout Central America by ecological land bridges so that the habitat necessary for migration of the wildlife in the region can be protected (Carr and others 1994). Project areas range from Mexico's Yucatan Peninsula to Panama's Darién region along the Colombian border. The goals of the international program are to promote regional peace and maintain biological diversity through sustainable economic activities such as ecotourism and agroforestry (Illueca 1997). In preliminary talks, all Central American countries agreed to protect their national heritages, adopt sustainable development programs, use natural resources optimally, control pollution, and reestablish ecological equilibrium. The SLPA is part of the corridor; its location on the Caribbean side of the isthmus, where 70 percent of Panama's remaining forests are situated, adds significantly to the regional system. Moreover, the relative proximity of the SLPA to other protected areas near and along the Panama Canal; i.e., Barro Colorado Island; Portobelo, Chagres, Soberanía, and Altos de Campana National Parks; and Metropolitan Natural Park, make it part of a mostly forested transisthmus corridor from the Caribbean Sea to the Pacific Ocean. If the Islas Taboga and Urabá Wildlife Refuges are included, the corridor extends another 15 km southwest into the Pacific Ocean.

Table 8—The San Lorenzo Protected Area: biodiversity summary[a]

Biodiversity element	Estimated values	
	Flora	
	ha	*%*
Life zones		
Tropical moist forest	6 480	54
Tropical wet forest	360	3
Tropical premontane wet forest	5 160	43
Total	12 000	100
Vegetation types		
Evergreen seasonal forest		
Tall	360	3
Mixed	6 000	50
Low	960	8
Semideciduous seasonal forest		
Mixed	840	7
Low	480	4
Deciduous forest	240	2
Flooded forest		
Cativo	1 800	15
Palm forest	360	3
Mangrove woodland	120	1
Flooded nonforest lands	240	2
Flooded shrubland	____	____[b]
Marsh	____	____[b]
Seminatural grassland	____	____[b]
Urban, agriculture, infrastructure	600	5
Total	12 000	100
	Fauna[c]	
	no.	*%*
Animal species		
Amphibians	36	21
Reptiles[d]	35	15
Birds	435	47
Mammals[d]	81	35
Total	587	37
Protected by Panamanian law	30	5
Classified by CITES	66	11

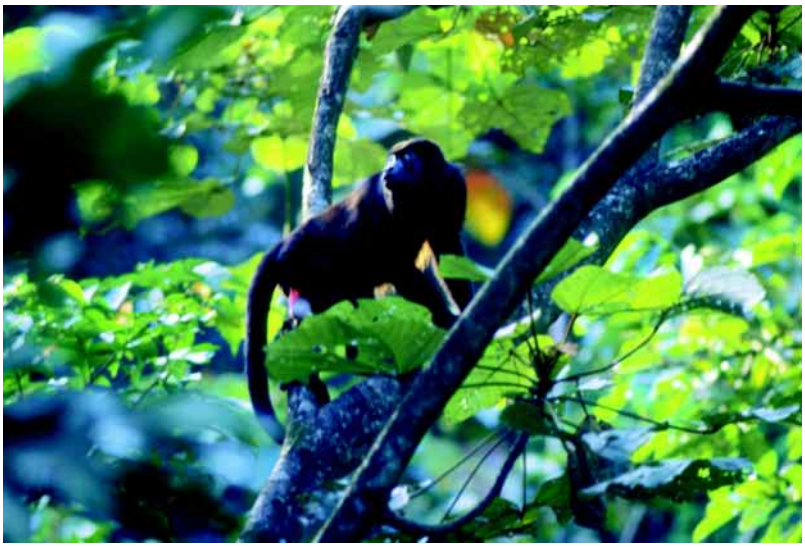
[a] Total area estimated at 12 000 ha; all values rounded.
[b] Minor vegetation types.
[c] Proportion of Panama's fauna in the San Lorenzo Protected Area.
[d] Each group has one endemic species.

Ecotourist's Paradise

The SLPA contains 3 ecological life zones, 12 vegetation types, and at least 500 species of higher plants (table 8). Nearly 590 species of vertebrates have been identified within the SLPA, including 36 species of amphibians, 35 reptiles, 435 birds, 81 mammals; moreover, the Chagres watershed and SLPA streams contain 42 species of freshwater fish. Much of the fauna and flora of the SLPA are easily seen from roadsides and trails.

The SLPA also has a variety of attractive scenery and is readily accessible by car from Panama City. The picturesque historical and cultural attractions of the SLPA highlight Panama as the crossroads between two continents and two oceans. The legacy of Spanish gold and Fort San Lorenzo, pirates, shipwrecks, the first "intercontinental railroad," the French attempt at a the sea-level canal, and the building of the Panama Canal, Gatún Locks, and Fort Sherman, are all interwoven into the history of the SLPA.

Tourists will find both terrestrial and aquatic activities, including hiking along roads or trails, wildlife photography, bird watching, canoeing on the Chagres, kayaking, and fresh or saltwater fishing. The Caribbean shore, particularly west of Fort Sherman, offers quiet beaches, swimming, scuba diving, and snorkeling. The sandy coves and wooded ridges bordering the Caribbean shore provide glimpses of passing vessels and views of the city of Colón across Limón Bay. Along the Gatún Locks-Sherman Road (S2), the principal thoroughfare of the SLPA, wetland forests (mangrove, Pterocarpus, and cativo swamps) and typical flora (mangrove ferns, large trees, and heliconias) are readily visible from vehicles. Monkeys, sloths, and anteaters are often seen, as are several species of birds, lizards, and butterflies, including the iridescent blue morpho (*Morpho peleides*). At Fort Sherman, viewing the architecture of the residences, administration buildings, and World War I batteries provides insights into military life during the 20th century. Hikers venturing along gravel roads and trails into the interior encounter panoramas from rugged highpoints and occasional views of waterfalls, small caves, and some of the more timid fauna of the SLPA. A short distance away, the Panama Canal and Gatún Locks, traversed by ships from all over the World, add to a memorable experience.



*Mantled howler monkeys (*Alouatta palliata*), noted for their noisy exchanges along territorial boundaries, are arboreal and diurnal. Usually roaming in small groups, they range from forest lowlands to 1,500 m in elevation from eastern Mexico to Panama, and western South America from Colombia to Peru. They can successfully survive in fragmented forest.*

Morpho butterflies (Morpho peleides)*, which range from Mexico to Colombia, are common in San Lorenzo along streams, trails, and roads. Morphos are spectacular in flight, their iridescent blue wings glittering in the forest, as well as adept at avoiding capture. Morphos remain among the favorite butterflies for sale in mounted displays.*

The keel-billed toucan (Ramphastos sulfuratus)*, ranging from Mexico to Venezuela and common in forest and second-growth woodland on the Caribbean slope of Panama, often perches in small groups high in trees.*

Photos courtesy of Gerald P. Bauer.

The SLPA is listed as one of the most important areas in Panama for bird species (Angehr and Jordán 1998). The Panama Audubon Society counted 357 bird species in the SLPA during one 24-hour period, a record among society counts in the Western Hemisphere (Jukofsky 1999). Five convenient hiking, sightseeing, and bird watching areas are recommended along the 50 km of paved roads in the SLPA (Edwards and Loftin 1971). At the first area, the Gatún Locks-Sherman Road (S2), which parallels the western shore of Limón Bay, 27 bird species have been listed, among them pigeons and doves, parrots, trogons, toucans, flycatchers, honeycreepers, caciques, and tanagers. At the second of these areas, on the Sherman-San Lorenzo Road (S8) paralleling the Caribbean shoreline, 41 species have been noted, including hawks, pigeons and doves, parrots, hummingbirds, toucans, woodpeckers, antbirds, jays, wrens, honeycreepers, tanagers, and others. At the third site, Fort San Lorenzo, a promontory above the Chagres River, 13 species have been recorded, among them terns, parakeets, flycatchers, elaenia, martins, swallows, and robins. At the fourth site, on the Achiote Road (S11) inside the Atlantic lowland forest, at least 65 species have been observed including tinamou, vultures, hawks, pigeons and doves, parrots, hummingbirds, trogons, toucans, woodpeckers, flycatchers, wrens, euphonia, tanagers, and saltators. Ten of these forest bird species are found nowhere else in the canal area. At the last site, the mouth of the Chagres River, 24 species have been seen, among them pelicans, frigatebirds, heron, terns, doves, martins, swallows, tanagers, seedeaters, and grassquits. All of these five sites are located within a few minutes of each other and are readily accessible by car.

Panama is well known for its fresh and saltwater fishing (D'Croz and others 1994, Labrut 1993). Fishing sites in and around the SLPA include Gatún Lake, the Chagres River below the dam, Limón Bay, and the Caribbean Sea between the mouth of the Chagres and Isla Grande east of Portobelo. Boat ramps are available on Gatún Lake, at Fort Sherman, and at the mouth of the Chagres.

Gatún Lake, where peacock bass, snook (*Centropomus undecimalis*), tarpon (*Megalops atlanticus*), and crevalle jack (*Caranx hippos*) are available throughout the year, is the favorite fresh-water fishing destination near the SLPA. Peacock bass is the most common species; the remaining three are relatively rare. Peacock bass and snook respond to live bait or lures. Tarpon, usually caught with live bait, are prized for food and sport. Sometimes reaching 50 kg in weight, tarpon are known to swarm Caribbean rivers to consume figs falling from riverbank trees (Stirling 1953). Snook, tarpon, and crevalle jack are also caught in the Chagres River along with snapper (*Lutjanus* spp.). In the Chagres, snook are available in December and January, and tarpon in February and March; snapper and crevalle jack are caught throughout the year.

Snapper and crevalle jack are also caught in Limón Bay, along with barracuda (*Sphyraena barracuda*). All species are available the entire year but in limited quantities. The Atlantic Coast has barracuda, snapper, snook, and crevalle jack, along with kingfish (*Scomberomorus cavalla*). Snook are available in December and January, and kingfish from January through March. The remaining species are caught throughout the year.

In the open ocean, fishing for many species is seasonal. Among the favorites are black marlin (*Makaira indica*), Atlantic blue marlin (*Makaira nigricans*), colorado snapper (*Lutjanus colorado*) and snappers in general, bonitos (*Sarda sarda*), yellowfin tuna (*Thunnus albacares*), amberjack (*Seriola dumerili*), dolphin (*Coryphaena hippurus*), jacks (*Caranx* spp., and other genera), ladyfish (*Elops sauris*), and several species of sharks, among them the dogfish (*Mustelus canis*) and smalltooth sawfish (*Pristis pectinata*).

Environmental Issues

One of the many conclusions reached in the Chagres River biography by Periera Jiménez (1964) was: "There was prosperity each time that the isthmus was used as a trail to go from one sea to another. Each time that this function of our country (Panama) was abandoned, there was misery and disharmony. To understand this conclusion is to know the utmost mission of our republic situated as it is between two hemispheres." The canal watershed and the surrounding areas that include the SLPA are intimately linked. Maintenance of both as part of an integrated system can assure prosperity in the future. This is a major environmental challenge for Panama—and for SLPA managers.

Photo courtesy of Gerald P. Bauer.

The conservation of Panama's natural resources and protection of the canal are linked. Today, nearly one-half of the Canal Area is forested, one-third of that in parks and protected areas. Most of the remainder is in agriculture and settlements, with about 10 percent covered by water. The entire canal watershed (including the San Lorenzo Protected Area) should be conserved as an integrated system.

The conservation of resources in the canal watershed involves several issues: (1) damage and hazards from past military activities, (2) the impact of canal operations on surrounding waters and shorelines, (3) the protection of archaeological and historic sites, (4) the threat of inappropriate development, and (5) the unauthorized use of natural resources including lax law enforcement. First, the U.S. military presence in Panama for nearly a century has left a legacy of environmental damage and hazards to human life and safety in and around its bases (Autoridad de la Region Interoceánica 1998, Corcoran 1999, Manfredo 1999, Wagner and Popovic 1998). The weapons practice and other military activities carried out at Fort Sherman and the Piña Range resulted in structural damage to the vegetation, soil and water contamination, and unknown quantities of unexploded ordnance (UXO). The Piña Range, about 2550 ha in size, was set aside in 1948 for testing artillery, bombs, guided missiles, rockets, mortar, and recoilless rifle projectiles; the oldest ordnance dates to the late 1940s (Keefe and others 1997). The effects of chemical weapons such as mustard gas, phosgene, sarin nerve gas, and Agent Orange were also tested in the area (Jungle Expert 2000).

Over the past three-quarters of a century, UXOs have resulted in about 25 deaths; however, the U.S. Government continues to claim that the remoteness and steepness of the affected areas, along with estimated costs, make an extensive cleanup "not practicable." Alternatively, the United States proposes that most of the contaminated lands could be set aside as protected areas, using the American and European models for such properties (Corcoran 1999). Numerous laws and policies govern the closure of U.S. domestic military bases, including the National Environmental Policy Act (NEPA) and the Comprehensive Environmental Response Cleanup and Liability Act (CERCLA). The policy of the U.S. Department of Defense also calls for detailed

investigations of environmental conditions for domestic bases slated for closure. Legally and morally, these laws should apply to the closure of bases in Panama (Wagner and Popovic 1998). For now, the Piña Range remains officially under separate management from the SLPA and off limits to visitors, although the forests are contiguous.

Second, accidents related to the operation of the canal, such as oil spills (Guzmán and others 1991, Keller and Jackson 1991), remain a concern for SLPA managers. The effects of oil spills vary considerably with the quantity of oil lost and proximity to the source, and do gradually decline with time. Oil directly affects vertebrate wildlife dependent on the shoreline and littoral biota (corals, mangrove forests, mangrove root organisms, and sea-grass communities). The effects of oil may be detected in shoreline sediments and littoral organisms many years after a spill.

Third, recommendations made during a recent assessment of the SLPA's cultural resources (Lange 1999) merit consideration. These include proposed archaeological excavations in and around Fort San Lorenzo and exploration of the Caribbean Sea and Chagres River near the fort. Documentation of the extent of the Gatún trenches, past railroad routes, possible remnants of colonial homes and historic cemeteries, as well as more detailed information on the construction of the Gatún Locks and structures at Fort Sherman, are important topics for the interpretation of the SLPA's past.

Fourth, there is widespread agreement that ecotourism should be the main use of the SLPA (Intercarib S.A. per NATHAN Associates, Inc. and others 1997). The coastal strip between the SLPA interior and the Limón Bay shoreline (that is, from the Gatún Locks to within 0.5 km of the Fort Sherman complex) contains critical wetlands that serve as a biological corridor between the SLPA interior and the

Situated on a promontory above the Chagres River, Fort San Lorenzo is among the most attractive of the many hiking, sightseeing, and bird watching areas in the San Lorenzo Protected Area. In addition to the historic ruins, several bird species may be seen on any day—among them terns, parakeets, flycatchers, elaenia, martins, swallows, and robins.

Photo courtesy of Gerald P. Bauer.

sea. The proposed plan for the canal area, however, includes urban, industrial, and commercial uses for this area that would fragment the SLPA. Currently, the Gatún Locks-Sherman Road (S2) is a tourist attraction because it offers views of wildlife that cannot be seen from highways elsewhere in Central America. If ecotourism is to be emphasized on the SLPA, greater sensitivity to conserving the forests and wildlife of the SLPA must be incorporated into current and future planning.

Fifth, unauthorized activities; e.g. deforestation, illicit hunting or fishing, and sand removal, within the SLPA could result in a gradual loss of flora and fauna, and other resources, depreciating the ecotourism potential of the area. Illegal hunting could cause serious problems, as it did earlier on Barro Colorado Island (Anon. 1987). Egg poaching will permanently eliminate the beaches of the SLPA as future sea turtle habitat. Uncontrolled fishing, either overexploitation or the use of destructive gear, will lead to coral reef degradation (Cortés 1997).

Management Issues

Management of the SLPA will involve outlining program objectives, identifying potential environmental conflicts, determining economic benefits and costs, formulating construction and maintenance protocols, fostering educational opportunities, and developing linkages with similar environmental groups elsewhere (McNeely and others 1994). Cooperation among governmental institutions and private interests is imperative. The civil society, nongovernmental organizations, and the surrounding communities should be involved through cooperative administrative and management activities (Girot and others 1998, Núñez Saravia 2000).

The management plan should include social and economic benefits for the local communities by generating income and diversifying the rural economy. One approach might involve employing local people in profitable domestic enterprises such as restaurants, souvenir and handicraft stores, or travel agencies. Others could work as interpreters or guides for fishing or snorkeling sites, trails, local folklore, animal species, or the traditional use of medicinal plants. To alleviate pressures on the natural resources of the SLPA, managers need to stimulate an appreciation for their value and an interest in their conservation by expanding community education programs for the residents of Achiote, Escobal, and Piña as well as soliciting the input of residents for management direction. Colon residents have already been hired and trained as rangers to help monitor the SLPA, orient the public, and report illegal activities. SLPA managers also need to promote the truly unique military tradition and myriad environmental values of the SLPA to a wide variety of audiences in Panama and elsewhere, emphasizing the importance of conserving the SLPA intact as a major historic and cultural site (Weaver and others 2003).

An effort should also be made to use basic and applied research for improved management by developing relationships with research institutions in Panama and elsewhere. A list of potential studies centered at the SLPA should be developed and circulated among prospective collaborators. Databases developed on selected topics; e.g., flora, fauna, and archaeological information, could be used for planning, education, site interpretation, and management, while a resource library and maps would facilitate both research and management. A brief, inexpensive annual report highlighting ongoing research and management activities could serve to attract additional cooperators. Modest charges for use of the SLPA facilities and resources should be considered if the SLPA is to be self-supporting.

An interpretation center, highlighting the biological resources of the SLPA and the area's colorful historic and cultural past, should receive attention. Field restoration of existing facilities such as Fort San Lorenzo, Fort Sherman and its military batteries, and the Gatún trenches, should be done immediately to protect both the resources and visitors. Access trails, interpretive signs, and brochures should accompany this effort.

Other attractions that could be developed include a botanic garden and a butterfly garden, both of which could generate income for SLPA management. The 1,600 botanic gardens worldwide receive an estimated 150 million visitors annually (Botanic Gardens Conservation International 1994). Some predict that within the next half century, up to 25 percent of the

known higher plants will be threatened with genetic erosion or extinction. Many botanic garden programs include conservation, in particular of endangered species, education opportunities for youngsters and policymakers, and research. Audiences and facilities are variable, but most gardens include interpretative signs, brochures, and accommodations for persons with special needs.

Several other management alternatives exist for providing environmental services and controlling negative impacts in the SLPA (Lieberknecht and others 1999), among them

- Determining carrying capacities of the SLPA to avoid overcrowding, overdevelopment, pollution, noise, vandalism, or inappropriate use of vehicles
- Using and maintaining the existing infrastructure, including military buildings, roads, trails, and other improvements
- Collecting basic data to facilitate planning, such as the number of vehicles and persons entering the SLPA, travel and resource use patterns, periods of use, origin of visitors (local vs. foreign), typical lengths of stay by season, and levels of satisfaction and/or suggestions for improvements
- Cooperating on site plans for roads, powerlines, and other public services to avoid negative impacts on existing resources
- Using concessions for lodging, restaurants, the sale of souvenirs and books, and refuse collection
- Reinvesting a percentage of profits (perhaps collected as user fees, or as royalties on postcards, slides, or photographs) in maintaining the natural and cultural services provided by the SLPA.

Acknowledgments

The authors are grateful to administrative personnel and library staffs in Panama where information was collected: Ada Ávila, ANCON; Charlotte Elton and Belkys Jiménez, CEASPA; Rosa Valdivieso, Instituto Geográfico Nacional Tommy Guardia; Angel Aguirre, Ricardo Beteta, Apolinar Guerrero, and Elizabeth Sánchez, STRI; and Rolando Cochez, Francia Herrera, and Gisela Lamments van Bueran, Technical Resources Center for the Canal Authority (ACP). Georgina de Alba, Reineldo Urriola, Marcos Guerra, and Nelly Flores of STRI were very helpful with the selection of several slides from the Smithsonian collection. Slides 2, 16, 17, and 19 were finalized by Francisco Cedeño. The appendix figures were completed by Maya Quiñones and Wilmari Díaz of the Landscape Ecology Program at the IITF in Río Piedras, Puerto Rico.

STRI scientists and collaborators provided valuable assistance: George R. Angehr and W. Douglas Robinson, birds; Richard Condit and Samuel J. Wright, orientation at STRI; Roberto Ibañez D., amphibians and reptiles; Steve Paton, climate; Rafael Samudio Jr., mammals; and Neal Smith, background information. Vibeke Horlyck, United Nations Environment Programme (UNEP), provided an orientation and access to the STRI crane.

Valuable comments on the text were received from the following reviewers: Bill L. Bailey, on fishing; Carlos Fitzgerald, of INAC and the University of Panama, on anthropology and history; and Charlotte Elton of CEASPA and Cecilia Guerra of ANAM, on several topics; José Ignacio Mata of Panamá GreenCom cordially allowed the use of computer facilities on weekends and holidays to finish this work in a timely fashion.

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Appendix A

Acronyms used in text or in literature cited

Acronym	Spanish (English translation)
ACP	Autoridad del Canal de Panamá (Panama Canal Authority, previously the PCC—The Panama Canal Commission)
AECI	Agencia Española de Cooperación Internacional (Spanish Agency for International Cooperation)
ANAM	Autoridad Nacional del Ambiente (National Environmental Authority)
ANCON	Asociación Nacional para la Conservación de la Naturaleza (National Association for the Conservation of Nature)
ARI	Autoridad de la Region Interoceánica (Interoceanic Regional Authority)
CAPAS	Sistema Centroamericano para Áreas Protegidas (Central American Protected Area System)
CEASPA	Centro de Estudios y Acción Social Panameño (Panamanian Centre for Research and Social Action)
CITES	Convenio Internacional de Especies Amenazadas de Fauna y Flora Silvestre (Convention on International Trade in Endangered Species)
FAO	Organización de la Naciones Unidas para la Agricultura y Alimentación (Food and Agricultural Organization of the United Nations)
ICOMOS	International Council on Monuments and Sites—World Heritage
ICONA	Instituto para la Conservación de la Naturaleza (Institute for the Conservation of Nature)
INAC	Instituto Nacional de Cultura (National Institute of Panamanian Culture)
INRENARE	Instituto Nacional de Recursos Naturales Renovables (National Institute of Renewable Natural Resources)
IPAT	Instituto Panameño de Turismo (Panamanian Tourism Institute)
MIDA	Ministerio de Desarrollo Agropecuario (Ministry of Agricultural Development)
MIPPE	Ministerio de Planificación y Política Económica (Ministry of Planning and Economic Policy)
NORAD	Agencia Noruega para Desarrollo Internacional (Norwegian Agency for International Development)
PAMBC	Corredor Biológico Mesoamericano (Panama Atlantic Mesoamerican Biologial Corridor)

continued

Appendix A (continued)

PNUD	Programa de las Naciones Unidas para el Desarrollo (UNDP—United Nations Development Program)
PROARCA	Programa Ambiental Regional para Centroamérica (Central American Regional Environmental Program)
SLPA	Area Protegida de San Lorenzo (San Lorenzo Protected Area)
STRI	Instituto Smithsonian de Investigaciones Tropicales (Smithsonian Tropical Research Institute)
TNC	The Nature Conservancy
UICN	Unión Internacional para la Naturaleza (IUCN—The World Conservation Union)
UNEP	Programa Ambiental de las Naciones Unidas (United Nations Environmental Programme)
UNESCO	Organización de las Naciones Unidas para la Educación, la Ciéncia y la Cultura (United Nations Organization for Education, Science and Culture)
USAID	Agencia de los Estados Unidos para el Desarrollo Internacional (United States Agency for International Development)
WTO	World Tourism Organization—Madrid, Spain
WWF	Fondo Mundial para la Naturaleza (World Wildlife Fund)

Appendix B

Major partners with activities in the San Lorenzo Protected Area (SLPA)

Panamanian Groups

Autoridad de la Región Interoceánica (ARI)—The Authority of the Interoceanic Region, created by Law 5 of 1993 and later modified by Law 7 of 1995, is the autonomous entity responsible for the administration of reverted canal properties during the period of transition. ARI's objectives include planning, coordination, and decisionmaking for projects designed to use, conserve, and develop reverted properties. ARI is also responsible for expediting regulations for the sale, rent, or lease of these properties.

Autoridad del Canal de Panamá (ACP)—The Panama Canal Authority, created in 1997, is an autonomous government entity charged with the administration, operation, maintenance, and modernization of the Panama Canal. The Panama Canal Commission (PCC) was responsible for the maintenance and operation of the canal waterway through December 31, 1999, when the Panama Canal Authority assumed the activities.

Autoridad Nacional del Ambiente (ANAM)—The National Environmental Authority, created by Law 41 of 1998, replaced the National Institute for Renewable Natural Resources (INRENARE) as Panama's natural resource agency. Law 21 of 1986 created the INRENARE, an institute with responsibilities in the planning, organization, coordination, regulation, and development of policies for the benefit, conservation, and use of renewable natural resources. ANAM, a national authority, has greater powers and responsibilities than the former institute.

Centro de Estudios y Acción Social Panameño (CEASPA)—The Panamanian Centre for Research and Social Action, a nongovernment organization created in 1977, works in three major program areas: sustainable development, empowering women as citizens, and participatory democracy. Among the several themes receiving attention are the environmental movement and policy, the Panama Canal, sustainable agriculture, and decentralization in local and regional development. With regard to the SLPA, CEASPA's main job is to promote a consensus on the best use of the reverted lands. CEASPA cooperates with several local and international entities in the development of their programs. CEASPA will negotiate collaborative agreements for implementing the project's objectives with other civil society groups, both nationally and internationally.

Fundación Natura—The Natura Foundation was established in 1995 to manage a permanent fund designed to finance and foster the conservation and sustained development in Panama. The foundation promotes civil participation in conservation and sustained development of Panama's natural resources by cooperating with the public and private sectors.

Instituto Nacional de Cultura (INAC)—The National Institute of Panamanian Culture was created by Law 63 in 1974 to design, orient, and implement cultural policy in Panama. The policy is based on the rights of all individuals to create, enjoy, and attain cultural properties and values and the obligation of the State to conserve, restore, defend, and develop them. Furthermore INAC promotes and communicates Panamanian folklore by cultural activities throughout the country.

Instituto Panameño de Turismo (IPAT)—The Panamanian Tourism Institute was founded to convert Panama into a primary business and tourist center by developing a first-class tourism sector that encourages foreign investment, generates local employment, increases exports, and, in general, facilitates local economies of scale.

Sociedad Audubon de Panamá—The Panama Audubon Society is a nonprofit conservation society whose objective is to promote an understanding and interest in wildlife and the ecosystems on which they depend, with a particular interest in the study and observation of birds. The local society, active for more than 25 years, is affiliated with the National Audubon Society, which has more than 700,000 members. The local society participates in environmental studies and educational activities, seminars, and excursions throughout the country.

continued

Appendix B (continued)

Foreign Groups

Smithsonian Tropical Research Institute (STRI)—STRI is a bureau of the Smithsonian Institution, which is centered in Washington, DC, and funded largely by the U.S. Government. The long history of STRI's biological research in Panama dates back to the creation of Barro Colorado Island in Lake Gatún. The STRI research and conference center in Panama City provides logistic support for field activities. The center's library, with more than 61,000 volumes and 1,000 journal subscriptions, has online access to the Smithsonian Library in Washington as well as other information sources.

U.S. Agency for International Development (USAID)—USAID provides technical assistance and financial support for development projects throughout the World. In Panama since 1961, USAID has a mandate to protect natural resources. Current programs in the agency involve forest protection, monitoring, and restoration.

U.S. Department of Agriculture Forest Service (USFS)—The USFS is responsible for management, research, and technical assistance in the forests of the United States. Current activities in the international arena are carried out through the Office of International Programs in Washington and the International Institute of Tropical Forestry in San Juan, Puerto Rico. Technical assistance, training, and research cooperation are offered in the management of watersheds, fires, wildlife, and protected areas, and in forest planning, monitoring, policy, ecotourism, and disaster assistance.

U.S. National Fish and Wildlife Foundation—The foundation, established by Congress in 1984, is a private, nonprofit, tax-exempt organization, dedicated to the conservation and management of fish, wildlife, and plant resources, and their habitats. The foundation's goals include species conservation, natural resources management, habitat and ecosystem restoration, and leadership training for professionals. The goals are met through grants that create public-private partnerships leading to increased investments in conservation activities.

U.S. Peace Corps—The corps was established in 1961, with goals that include helping peoples in interested countries meet their need for trained individuals in various fields. The cooperative activities promote a better understanding among peoples—on the part of those serving, and on the part of those being served. Among the specialty areas are environmental programs and forestry.

International Groups

Global Environment Facility (GEF)—The GEF was established in 1991 to forge international cooperation and to finance actions aimed at alleviating four critical threats to the global environment: biodiversity loss, climate change, degradation of international waters, and ozone depletion. Issues relating to land degradation are also eligible for funding. The GEF serves environmental interests worldwide by grouping 166 member governments, leading development institutions, the scientific community, and a wide spectrum of private sector and nongovernmental organizations on behalf of a common global agenda.

World Bank—The World Bank promotes economic and social progress in developing nations by helping to raise productivity. The bank invests mainly in projects that have environmental objectives after screening them for potential environmental impacts. Moreover, the bank is an implementing agency of the Global Environment Facility.

World Monument Fund (WMF)—The WMF was founded in 1965 to safeguard human heritage by encouraging the conservation and preservation of culturally and historically significant works of art and architecture worldwide. The WMF works in conjunction with public- and private-sector partners to provide financial and technical support for project planning and management.

Appendix C

Chronology of main events in the history of the San Lorenzo Protected Area (SLPA)[1]

Date	Event
BC:	
9000	Spear points of Paleo-Indians found in the vicinity of Madden Dam, 50 km east of the SLPA, indicate megafauna hunters were present
5000-250	Indians use Panama as gateway between Central and South America; agriculture begins
AD:	
1500	Panama is occupied by 60 Indian groups related to the Chibchas of Colombia, the most important being the Cuna, Choco, and Guaymi Indians
1500s	Early in century, an indigenous village begins at "Fort Chagres town"
1501	Rodrigo de Bastides is the first European to land in Panama
1502	Columbus explores the Caribbean Coast of Panama near the mouth of the Chagres River on his fourth voyage and establishes a settlement at Nombre de Dios
1513	Vasco Nuñez de Balboa sights the Pacific Ocean from a mountain peak in the Darién
1519	Panama City, the oldest surviving European settlement on the American mainland, is founded on the Pacific Coast by Pedro Arias Dávila, Balboa's successor; Panama becomes a transshipment route for Spanish colonists moving to west coasts of Central or South America; mouth of Chagres River becomes a principal terminus for transisthmus travel
1523	Charles V of Spain directs Cortes to find a strait across the isthmus
1527	Hernando de la Serna finds the Chagres River navigable and advises the construction of a warehouse at Las Cruces and a road between Cruces and Panama City
1530s	Pizarro conquers Peru and Panama becomes the portage between the oceans; Las Cruces trail (Panama City to Chagres River to San Lorenzo) first established; use continues through the days of the California gold rush
1534	Charles V directs the local Governor of Panama to look for a canal route
1535	Philip II of Spain is the first to call for defenses at the mouth of the Chagres River
1540	"Camino Real" built from Panama City to Portobelo and Nombre de Dios
1571	Drake enters the Chagres River and sacks Las Cruces, plundering barges en route
1579	As many as 30 flat-bottom barges operate on the Chagres River
1587	Trenches are dug at San Lorenzo to guard entrance to the Chagres River
1596	Drake burns Nombre de Dios, and Portobelo supercedes it as the Atlantic port-o-call
1597	Antonelli, an Italian engineer, constructs a water-level battery at San Lorenzo; the work is completed in 1599
1619	Several flat-bottomed boats transporting treasure are sunk in Chagres River
1626	San Lorenzo is reconstructed and fitted with six cannons
1637	Tomás Lanza suggests that San Lorenzo be fortified at 25 m above sea level on the plateau overlooking the Chagres River (its current location)
1670	British pirates under Bradley capture Fort San Lorenzo; Henry Morgan loses five ships on a reef at the mouth of the Chagres River; Morgan then uses San Lorenzo as a base to plunder Panama City in 1671; Morgan destroys San Lorenzo on departure
1680s	A major effort undertaken to rebuild the fort results in a three-level fortress; the town of Chagres is established under the protection of the fort
1681	The merchant ship Chaperon sinks at the mouth of the Chagres River; in addition, an unidentified treasure galleon sinks off Punta de Brujas and the ship Boticaria near the Isla de Naranjos

continued

Appendix C (continued)

1730s	Panama declines as a transhipment area; between 1520 and 1730, it had been the main route for colonists to Central America and the west coast of South America
1739	Admiral Vernon captures San Lorenzo and burns the town of Chagres in attacks between 1739 and 1742; the transisthmus route through the Chagres River is abandoned; later, San Lorenzo is used as a prison
1740	Two Spanish vessels sink at the mouth of the Chagres River
1748	Spanish law establishes Cape Horn as the main route for shipment of cargo between the Pacific coast of South America and Spain, and isthmus travel dwindles
1750	Approximate date of current San Lorenzo ruins; presumed date for the construction of the Gatún Hill trenches and Fort Gatún (now flooded) at the confluence of the Chagres and Gatún Rivers
1751	Peruvian traders favor route around Cape Horn and Panama becomes a quiet, geographically isolated appendage of New Granada
1819	Old Chagres town sacked and burned by British corsairs
1821	Panama declares its independence from Spain
1849	Sutter's gold mine in California stimulates transisthmus travel; the town of Chagres becomes "Yankee Town"
1855	The railroad across the isthmus, started in 1850, is completed
1869	Colombia declares San Lorenzo a State prison; travel to Western United States via Panama declines with the completion of the Union Pacific Railroad
1879	French buy the rights to construct the Panama Canal from Colombia
1880	The French begin the construction of a proposed sea-level canal across the isthmus; by 1889, the French dream under de Lesseps fails
1898	Spanish-American War highlights U.S. inability to move ships from the Pacific to the Atlantic Ocean rapidly
1899	United Fruit Company (old Boston Fruit Company) sets up operations in Panama
1903	Panama declares its independence from Colombia and signs the Hay-Bunau-Varilla Treaty with the United States for construction of the Panama Canal
1904	The United States delineates the Canal Zone and declares Fort San Lorenzo "the oldest fort under the American flag"
1906	The United States adopts a high-level lake and lock plan for construction of the canal; Theodore Roosevelt visits Panama Canal construction work
1908	The Panamanian Government declares Fort San Lorenzo an historic monument
1910	Construction begins at the entrance of the Panama Canal; about 850 troops arrive 1 year later when Fort Sherman is named in honor of renowned Civil War General William Tecumseh Sherman
1912	Construction starts on coastal batteries (Baird, Howard, Kilpatrick, MacKenzie, Mower, Pratt, and Stanley), named in honor of Civil War military personnel; work is finished by 1924
1913	Tug Gatún is the first boat lifted in the Gatún Locks
1914	The Panama Canal Zone is designated by Act of Congress on April 28 as a strip of land 5 miles (8 km) wide on either side of the canal; the 119th Company, U.S. Coast Artillery, is assigned to Fort Sherman; the western breakwater is completed in May; the canal opens and the steamship Ancon makes the first commercial passage from Cristóbal to Panama City on August 15
1916	A coastal strip of land between the Chagres and Piña Rivers is added to Fort Sherman; the eastern breakwater is completed in July
1920	Military "jungle training" is initiated at Fort Sherman
1923	U.S. Congress establishes Barro Colorado Island (BCI) under the administration of the Smithsonian Institution

continued

Appendix C (continued)

1942	Japanese use of aircraft carriers for combat makes Fort Sherman shoreline batteries obsolete
1943	Piña Range first used for "jungle training"
1951	The U.S. Army is given the responsibility of "keeping the art of jungle warfare alive in the Army"
1953	Fort Sherman functions as a jungle operations training center
1964	Flag riots, related to sovereignty of the Panama Canal, begin in the Canal Zone
1977	Torrijos-Carter Treaty outlines reversion of the Canal Zone to Panama, including 7,000 military and civilian buildings
1979	Panama gains sovereignty over the canal and nominates Fort San Lorenzo as a World Heritage site
1980	Fort San Lorenzo is declared as a World Heritage site by UNESCO
1980s	Panama adopts several environmental measures to protect the canal watershed, a policy that continued into the 1990s
1999	Military training at Fort Sherman ceases; Fort Sherman and San Lorenzo revert to Panama on June 30; the surrounding forest becomes the SLPA

[1] Source: literature cited.

Weaver, Peter L.; Bauer, Gerald P. 2004. The San Lorenzo Protected Area: A summary of cultural and natural resources. Gen. Tech. Rep. IITF-25. San Juan, PR: U.S. Department of Agriculture, Forest Service, International Institute of Tropical Forestry. 89 p.

The 12 000-ha San Lorenzo Protected Area (SLPA), located at the northwestern entrance to the Panama Canal, is currently part of the Mesoamerican corridor of protected areas extending from Guatemala to the Colombian border. The SLPA contains two forts built for similar protective functions: Fort San Lorenzo at the mouth of the Chagres River, first initiated by the Spanish in 1597 to protect the "Camino de las Cruces," the gold route over the isthmus; and Fort Sherman, started in 1911 to protect the northern entrance to the Panama Canal, the 20th century's "royal corridor" through Panama. Both forts successfully fulfilled their military objectives, and Fort Sherman simultaneously protected the area's natural resources during the 20th century. This report highlights the SLPA's setting as a major crossroads, and briefly describes pre-Columbian activities, the Spanish conquest, the legacy of fortune seekers and the Chagres River including pirates and shipwrecks, the building of the Panama railroad, the efforts of France and the United States on the Panama Canal, and early agricultural activities. It also mentions the military history of Forts San Lorenzo and Sherman, and current knowledge on the geology, soils, flora, fauna, marine resources, ecological research, and proposed conservation of the SLPA, including ecotourism. Relevant environmental legislation is outlined along with the major functions of all entities that are cooperating with programs on the SLPA. Also included is a chronology of major historical events related to the SLPA.

Keywords: Cultural resources, fauna, flora, Panama, protected area.

The Forest Service, United States Department of Agriculture (USDA), is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives—as directed by Congress—to provide increasingly greater service to a growing Nation.