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Forest Service

# The San Lorenzo Protected Area:

## *Panama's Caribbean Treasure*

**Peter L. Weaver, Gerald P. Bauer, and Belkys Jiménez**

**International Institute of Tropical Forestry**

General Technical
Report IITF-23



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**Cover photo:** Beginning as a water level battery in 1597, Fort San Lorenzo was later constructed 25 m above sea level on a plateau overlooking the Chagres River. The interior of the Fort contains parade grounds and several enclosed cells designed for prisoners and storage.

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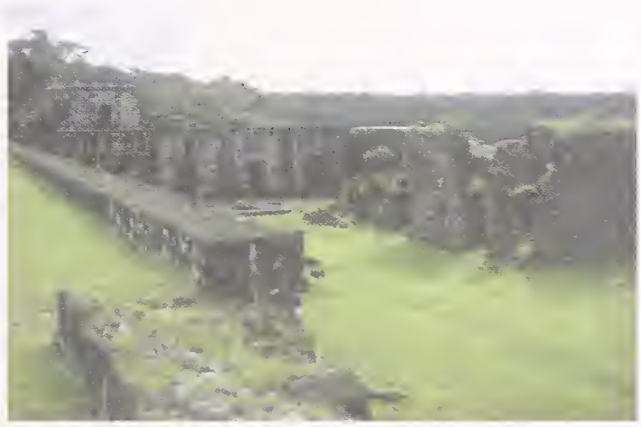


**Abstract**

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 the Yucatan of Mexico to Panama's border with Colombia. The SLPA includes Fort San Lorenzo, where the Spanish initiated a water level battery in 1597, and later built a fort to protect the gold route over the isthmus at the mouth of the Chagres River. Fort Sherman, a U.S. military base, was established in 1910 to protect the northern entrance to the Panama Canal. Both forts fulfilled their military objectives; Fort Sherman has also maintained control over the area's natural resources during the 20th century. This slide program highlights the SLPA as part of a major crossroads between continents and oceans, and briefly describes pre-Columbian activities, the Spanish conquest, the legacy of fortune seekers and the Chagres River, French and U.S. efforts on the canal, the role of immigrants in building Panama's infrastructure, the military history of Forts San Lorenzo and Sherman, and early agricultural activities. The SLPA's flora, fauna, hydrological network, marine resources, current research, and proposed conservation, including both protection and use, are also mentioned. A chronology of major events relevant to the SLPA is included.

**Keywords:** Fauna, flora, Fort San Lorenzo, Fort Sherman, historical chronology, Panama Canal, slide program.

# *Contents*

## Slide 1. Overview of slide program


This program of 80 slides is designed to familiarize visitors with the natural and cultural resources of the 12,000-ha San Lorenzo Protected Area (SLPA), situated at the northwestern entrance to the Panama Canal.

The visual tour highlights the following themes:

- Panama as the crossroads of the Americas
- the legacies of Forts San Lorenzo and Sherman
- points of historic, cultural, and human interest
- fauna and flora in their natural habitat
- the importance of research in understanding the ecology of the SLPA
- the role of collaborating agencies in furthering conservation and environmental education in Panama.

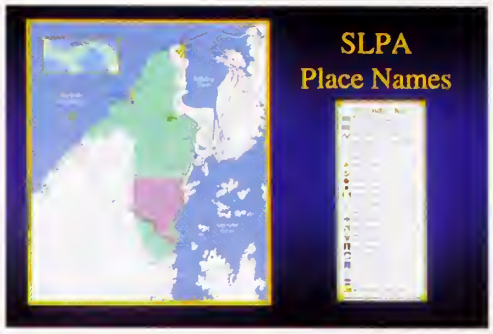
(slide: Gerald P. Bauer)

## Slide 2. The Mesoamerican corridor (Paseo Pantera)


The Mesoamerican corridor (previously, Paseo Pantera), conceived in 1990, is an ambitious project designed to join protected areas throughout Central America by ecological corridors, or land bridges, so that the habitat necessary for migration of the region's wildlife can be protected. In June, 1992, the convention for the conservation of biodiversity and protection of priority wildlife areas in Central America was created; it established a regional council on protected areas. The protected areas range from the Yucatan peninsula in Mexico to the Darién in Panama (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. All Central American countries agreed to protect their national heritage, adopt sustainable development programs, use natural resources optimally, control pollution, and reestablish ecological equilibrium. San Lorenzo is part of the Meso-american corridor. Its location on the Caribbean side of the isthmus, where 70 percent of Panama's remaining forests are situated, represents a significant addition to the regional system. The cougar or mountain lion (*Felis concolor*), is an appropriate namesake for the corridor. The cougar originally occupied virtually all temperate and tropical habitats including the plains, forests, mountains, and swamps, from northern Canada to Patagonia. The cougar is nomadic and wanders as far as 500 km during its life. Unfortunately, it has been severely reduced in numbers due to habitat destruction, hunting, and trapping throughout its range.

(slide: Paseo Pantera Project)

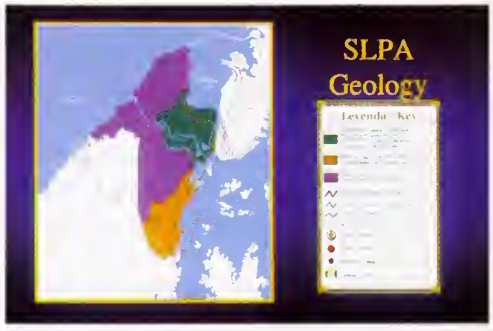
## Slide 3. Place names in the SLPA




The SLPA, occupying about 12,000 ha, 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 (fig. 1). 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. Named beaches include: Shimmey, 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 19$^{th}$ and early to middle 20$^{th}$ centuries include the French Canal, the Fort Sherman complex, numerous World War I batteries, and the Gatún Locks and Dam. The major research site is the canopy crane of the Smithsonian Institute situated in closed forest.

(slide: Gerald P. Bauer)

## Slide 4. Geology and physiography




Underlying the SLPA are sedimentary formations ranging in age from the Middle Miocene to the Recent Epochs (fig. 2). The uplands are composed of consolidated sedimentary rocks, and the lowlands are underlain in most areas by unconsolidated clays and silts. The bedrock formations have been fractured and faulted so that adjacent blocks are upraised and depressed relatively close to one another. This geologic history has produced two major topographic features, dissected upland blocks and flat alluvial lowlands. The three upland blocks are: the Fort Sherman uplands reaching 111 m; the low and rounded Mindi hills, with a highpoint of 88 m; and the rugged Piña-Escobal highlands, reaching 198 m in elevation (fig. 3). The three lowland areas are: the Chagres-Mojinga-Gatún lowlands; the Limón Bay lowlands; and the Caribbean shore lowlands. The principal soil textures are clays and silt loams.

(slide: Gerald P. Bauer)

### Slide 5. SLPA underground: coquina and cave sites

The Toro member, a coarse limestone of lower Pliocene origin containing interbedded coquina (organic remains with an accumulation of large shell fragments), occupies portions of the SLPA. Where exposed, the coquina provide a look into the past of the SLPA. In addition, the SLPA has numerous small caves in the upland areas and at least one stretch of a small, underground stream, located in the hills east of Providencia on the Achiote Road (route S11). The caves and subterranean streams have not been explored and pose some unanswered questions regarding their total number, location, size, and extent. Future research could provide important information on these sites, their fauna, and their tourist potential.

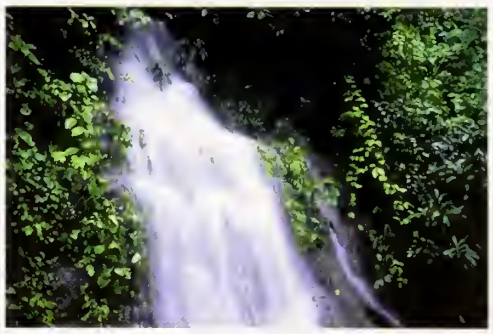
(slide: Gerald P. Bauer)

### Slide 6. Climate: past and present

Panama's climate has changed over time. Within the past 10,000 years, global warming raised the sea-level by nearly 50 m, decreasing Panama's surface area by 100,000 $km^2$, mainly in the Gulfs of Panama and Chiriqui. Later, with gradual cooling, the climate became more humid and forest cover, including mangroves, expanded into areas that were previously dominated by herbs and grasslands. This climatic change, in conjunction with human activity, led to the loss of Panama's megafauna (giant sloth and mastodon). Panama's climate today is characterized by a wet season from May to December and a dry season from January through April. Nearly 100 years of rainfall records from Gatún Locks show an average of 3000 mm per year, with the dry season receiving only 10 percent of the total. Despite greater rainfall, the Caribbean coast of Panama receives an average of nearly one-half hour more sunshine per day than the Pacific coast. Temperature data from the nearby coastal town of Coco Solo show a yearly average of 27 °C with monthly means varying by less than 1 °C during the year. Relative humidity averages 75 percent for the entire year, varying from the low 70s during the dry season to the mid- to high-70s during the wet season. Annual wind velocity averages 16 km per hour with dry season averages between 19 and 24 km per hour, and wet season averages between 10 and 14 km per hour. Panama is south of the Caribbean hurricane belt but often experiences heavy, convectional downpours, occasionally accompanied by high winds.

(slide: Gerald P. Bauer)

## Slide 7. Waterfalls: permanent and ephemeral



The SLPA, with its average rainfall of 3000 mm annually, has numerous permanent and intermittent streams and waterfalls. About one-half of the annual rainfall is either intercepted and evaporated directly back into the atmosphere or absorbed by vegetation and later transpired. The remainder escapes to the ocean by means of streams and rivers that traverse the SLPA. Seasonal variation in rainfall produces greater average flows during the wet season, although heavy downpours at anytime will cause high runoff. The steep slopes of the SLPA produce many temporary waterfalls during rainstorms; the most notable, shown in this slide, is conveniently located along the Gatún Locks-Escobal Road (route S10) just above Gatún Lake. The highest waterfall in the area is located in the Fort Sherman uplands, about a 4-hour hike along the well-marked trail from the Gatún Dam.

(slide: Gerald P. Bauer)

## Slide 8. A variety of scenic views

The SLPA offers a variety of opportunities for photographers. There are views of passing vessels and the city of Colón from the Limón Bay or Fort Sherman shorelines; farther west, between Forts Sherman and San Lorenzo, a series of sandy coves bordered by wooded ridges provide glimpses of the Caribbean shoreline. Along the Gatún Locks-Sherman Road (route S2), the principal thoroughfare in the area, monkeys, sloths, and anteaters are frequently seen—as are several species of birds, lizards, and butterflies, including the iridescent blue morpho. Wetland forests (mangrove, bloodwood (*Pterocarpus* sp.), and cativo (*Prioria copaifera*) swamps and typical flora (flowers, mangrove ferns, large trees, and numerous *Heliconia*) are readily visible from the car. At Fort Sherman, the architecture of the residences, administration buildings, and World War I batteries provides a glimpse into military life during the early to middle 20$^{th}$ century. Hikers venturing along gravel roads and trails into the interior will encounter panoramas from rugged high points as well as occasional views of waterfalls, small caves, and some of the more timid fauna of the area. A short distance away are views of the Panama Canal, Gatún Locks, and innumerable ships from all over the world. Gatún Hill, one of several vantage points in the SLPA, provides this panorama.

(slide: Charlotte Elton)

## Slide 9. Hydrological system: Chagres River

The rivers or creeks that drain the SLPA flow into the Caribbean Sea (e.g., the Chagres, Iglesias, Grande, Naranjitos, and the Arenal Rivers) or into Limón Bay (e.g., the Aguadulce and Petitpie Rivers, and Morito Creek), as shown in figure 4. The Chagres separates the SLPA into a northeastern one-third containing Fort Sherman, and a southwestern two-thirds containing the Piña Range. Paulino Creek and the Indio and Negrita Rivers flow into the Chagres from the south, and the Mojinga (draining the Mojinga swamp), Congo, and Buena Vista Rivers enter from the northeast. The Chagres, the river that has transported more gold than all of the world's rivers combined, is 193 km long, its watershed draining 3,262 $km^2$, or 4.2 percent of Panama. Also called the world's most valuable river, the Chagres feeds the lakes and locks that operate the canal; provides hydropower, drinking water, and game fishing; and boasts a 500-year history of adventure. For years, the Chagres River was the center of the debate on the proposed sea-level canal. Before construction of the Gatún Dam, high rainfall in the Chagres headwaters often flooded the lowlands south of Fort San Lorenzo, and, in the 1850s, swept away a nearly completed railroad bridge.

(slide: Gerald P. Bauer)

### Slide 10. Indian heritage: the first inhabitants

The Isthmus of Panama served as a migratory route for populations that settled South Ameriea, and has been oeeupied by human groups for more than 12,000 years (fig. 5). The first evidenee of human aetivity dates from the end of the lee Age about 10,000 years ago. Finely made projeetile points for hunting large mammals were found within the Chagres watcrshed in an area later flooded by Lake Madden (Lake Alajuela). The Caribbean side of the isthmus has been continuously oceupied by small populations that gradually developed innovations in teehnology and subsistenee living, sueh as eeramies, in the 2nd millennium B.C., followed by root crop, or manioc agriculture, in the first millennium B.C. In the early 16th century, European explorers found permanent villages and relatively dense human populations, among them the aneestors of the Buglé, Ngobe, and Kuna groups that now inhabit Panama. The Cuevas, a group that occupied the Darien, are now extinet. During the 17th and 18th centuries, the eastern isthmus was reoccupied by the Emberá (shown in this slide), and Wounaan, neighboring groups from the Colombian Chocó. Their continued oeeupation of forested areas has preserved artistic expressions such as carving and weaving. The Emberá, native to the upper Chagres, eontinue to dress as they did when Colombus arrived. Their detailed miniature seulptures earved from the "tagua" palm nut (*Phytelephas macrocarpa*) are popular with tourists. They are also known for animal carvings made from the leguminous tree cocobolo (*Dalbergia retusa*), and baskets woven from the chunga palm (*Astrocaryum standleyanum*).

(slide: Gerald P. Bauer)

### Slide 11. Spanish heritage: San Lorenzo, the quest for gold

In 1502, Columbus diseovered the Chagres River, ealling it "Lagartos," in referenee to alligators. He also established Nombre de Dios, about 70 km to the northeast, visited Portobelo, and before returning to Spain, abandoned his caravel Gallega at the mouth of the Belén River about 100 km to the west. In 1523, Charles V of Spain ordered Cortés to seareh for a passage across the isthmus, later directing Panama's governor to explore south of the Chagres River for a eanal route to the Paeifie Oeean. In 1534, Philip II of Spain foresaw the need for a fort at the mouth of the Chagres River to protect Spain's gold route over the isthmus. Construetion of a water level battery began in 1597 and

cannons were fitted in 1626. The current fort was later built 25 m above sea-level on a cliff overlooking the mouth of the Chagres River. The walls of Fort San Lorenzo on the landward side were surrounded by a 10-m wide dry moat and drawbridge. The fort contains an interior parade ground and several enclosed cells designed for prisoners and the storage of equipment and supplies. In 1748, the Spanish abandoned the Chagres route over the isthmus, preferring to travel around the tip of South America at Cape Horn. The fort subsequently became a prison, a use that continued into the late 19th century. In 1980, the United Nations Educational, Scientific and Cultural Organization (UNESCO), declared Fort San Lorenzo and its surrounding 5 ha a World Heritage site. Fort San Lorenzo and associated historic settlements are considered prime sites for uncovering new colonial finds.

(slide: Gerald P. Bauer)

### Slide 12. Trenches on Gatún Hill: a mystery

About 1750, as part of efforts to fortify Panama, the Spanish excavated six trenches totaling 700 m in length on Gatún Hill. 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 then 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 definitely military, with a firing step and broad earth parapet held with stone and the strategic location on Gatún Hill providing a clear view of both the Chagres River and Limón Bay. The trenches were possibly intended for the defense of Fort Gatún, should Fort San Lorenzo fall to invaders. 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. The trenches might also have been built as a last means of defense to which river inhabitants could escape in case of attack. The trenches are closed at this time, and will require access trails, restoration, interpretation, and maintenance before public access is allowed.

(slide: Gerald P. Bauer)

### Slide 13. British heritage: pirates plundering the Caribbean


The Spanish discovery of gold in Peru led to the development of the "Camino Real" in Panama—the route by which all goods had to pass. Pirate attacks along the coast of Panama began around 1560 and continued for nearly two centuries. Among the most famous pirates were Sir Francis Drake and Sir Henry Morgan. In 1571, Drake entered the Chagres River and sacked Cruces, plundering barges en route. In 1573, with the help of escaped slaves known as Cimarrons, Drake robbed a mule train laden with treasure bound for Nombre de Díos. After catching a fever, he died and was buried at sea in 1595. His remains lie in the shallow waters off Portobelo—an appropriate site for a Caribbean buccaneer. Perhaps the most famous and ruthless character in the Caribbean, however, was Welch-born Henry Morgan (shown here as depicted in Esquemelin 1684), who was a buccaneer, admiral, and finally, Lieutenant Governor of Jamaica. Using Port Royal, Jamaica as a base, Morgan first plundered Puerto Príncipe, Cuba, and Portobelo, Panama. In 1670, he 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 gold and silver mart in the world. Morgan later robbed his own men of their loot, escaping to Jamaica. The coastal waters off San Lorenzo contain shipwrecks and eroded remnants of the fort and its cannons. The shipwrecks provide an opportunity for underwater research and have attracted proposals for exploration and salvage.

(slide: Gerald P. Bauer)

## Slide 14. Fortune-seekers heritage: gold rush and train


The 1848 discovery of gold at Sutter's Mill caused a rush from the U.S. eastern seaboard west to California via four major routes: across the North American plains, up the San Juan River and through Western Nicaragua, around Cape Horn in South America, or over the Isthmus of Panama. In the beginning, the trip over the isthmus included a canoe ride that started at the mouth of the Chagres River on the Atlantic coast, and was followed by an overland trek by mule or foot south to Panama City on the Pacific coast. The gold rush and the need for an efficient east-west mail route in the United States were the stimuli behind the construction of the Panama railroad (maps of the railroad route indicate that its closest approach to the SLPA may have been in the vicinity of today's Gatún Locks). The heavy demand for passage across the isthmus— 27,000 people in 1853 alone—hastened the completion of the world's first transcontinental railroad in 1855. The cost in human lives from cholera, dysentery, malaria, yellow fever, smallpox, and other maladies was legendary. An often repeated, though grossly inflated, estimate is that one person died for every railroad tie placed along the 75-km track. The Panama railroad served the east-west migration in the United States before the completion of the U.S. Transcontinental Railroad in May 1869.

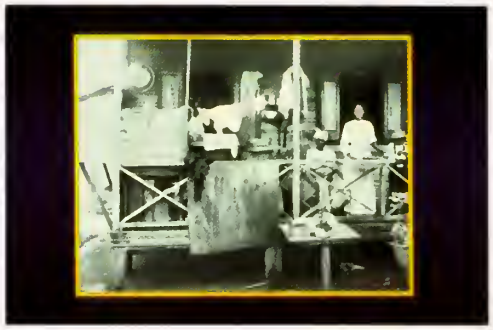
(slide: Gerald P. Bauer)

## Slide 15. French heritage: remnants of the sea-level canal

Quiet backwaters are the surviving remnants of the proposed sea-level canal initiated by the French in January 1880. Promoted by the energetic Ferdinand de Lesseps, a key player in the construction of the Suez Canal, the effort met its demise in May 1889, after countless engineering failures, health problems, and the financial crash of the French canal company's worthless stock. After building docks, living quarters, hospitals and offices were built, and excavating 50 million cubic meters of soil—an amount equivalent to two-thirds of that removed for the Suez Canal—de Lesseps' dream was conquered by the Panamanian jungle. Some blamed the failure on a combination of factors including lack of foresight, extravagance, corruption, bribery, and the incapacity to cope with disease. Another relic from the French era is the lighthouse at Toro Point. Built in 1893, it once had a Fresnel lens capable of casting a beam of light more than 30 km to the horizon.

(slide: Gerald P. Bauer )

### Slide 16. Caribbean heritage: immigrants help build canal



The rapid decline of the indigenous peoples after Spanish colonization was not immediately matched by an increase of Europeans or the Africans forcibly imported in the 16th century as slave labor. Later, between 1850 and 1950, an estimated 200,000 West Indians emigrated to Panama in search of employment and a better life in four major movements: the first, from 1850 to 1855, for the construction of the Panama railroad; the second, between 1880 and 1889, in response to the French attempt to build the sea-level canal; the third, from 1904 to 1914, stimulated by the construction of the Panama Canal; and the fourth and last, from 1940 to 1942, due to the initiation of a third set of locks, work that was never completed. Many West Indians made Panama their home after the work was finished.

(slide: U.S. National Archives)

### Slide 17. Plantation heritage: a forgotten past

Before World War I, migratory farming was a major cause of forest loss in the SLPA. Numerous small farms and some larger ones operated near Toro Point in the watersheds of the Arenal and Aguadulce Rivers, and along the Caribbean coast, including the mouth of the Naranjitos River and the coastal fringe between the Chagres and Piña Rivers. Several small population centers existed along the Chagres River in 1912, the most famous being the 16th century town of Chagres near Fort San Lorenzo. In 1916, Chagres, shown in this slide, had 96 houses and 400 to 500 inhabitants. About 2 km upstream from Chagres, at the bend in the river, was the prosperous San Andreas Hacienda, which was surrounded by agricultural lands, coconut plantations, and pasture. Other farms were located near the Indio River. After World War I, the banana industry expanded in the Canal Zone, particularly in the hills around Gatún Lake. 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 (route S10), and in the Mindi Hills and lowlands to the south and east. By the start of World War II, most of the land leased for banana plantations had been abandoned.

(slide: U.S. National Archives)

### Slide 18. United States heritage: the Panama Canal and Gatún Lake

Few passengers aboard the cargo ships and cruisers that rise and fall 25 m while passing through the Panama Canal know much about its past. The "manifest destiny" of the United States, the dynamic character of Teddy Roosevelt, the French attempt to salvage everything possible from their 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! This history includes the excavation of 200 million cubic meters of soil, the building of three locks measuring 33 by 300 m, the construction of the world's largest earth dam creating Gatún Lake, and the opening of a pathway across the isthmus—a dream first conceived by the Spanish 400 years earlier. The canal, built at a cost of $387 million and 25,000 human lives lost to disease, now provides safe passage to 14,000 ships per year.

(slide: Smithsonian (STRI) Files)

### Slide 19. Gatún tug: first through Gatún Locks

The tugboat "Gatún," shown entering the west chamber of the Gatún Locks on September 26, 1913, was the first vessel to pass through the Gatún Locks in the Panama Canal. The first vessel to traverse the entire Canal was the Panama Canal´s steamship "Ancón" on August 15, 1914. Soon after its discovery by the Europeans, Panama was recognized as an important crossroads linking two oceans and two continents: Simón Bolivar even suggested that Panama could serve as a world capital, should one ever be created. The dream of constructing a canal across the isthmus, initially conceived by the Spanish in colonial times, was resurrected again in the 1880s. Access across the isthmus as an Indian trail was followed by a Spanish cobble road soon after discovery of the Pacific Ocean, a railroad in 1855, and finally the canal in 1914. Even before Panama's independence from Spain, Panamanians had developed what some intellectuals described as a "transit" personality.

(slide: U.S. National Archives)

## *Fort Sherman History: Military Occupation and Natural Resource Protection*

### Slide 20. Fort Sherman: a short history

In 1909, the U.S. Secretary of War requested plans for the defense of the Panama Canal. The plans included building and maintaining Fort Sherman, named in honor of General William Tecumseh Sherman, a renowned Civil War commander. The first troops arrived in October 1911, when construction began at Toro Point. From this time until shortly after World War II, Fort Sherman remained heavily fortified to protect the northwest entrance to the canal, including the city of Colon and the Gatún Locks. The canal's opening on August 15, 1914, was only one week after the outbreak of World War I: the defensive structures, training programs, and protective measures implemented at Sherman reflected immediate military concerns. As weapons and their delivery systems advanced and international relations improved, concerns about belligerent nations were refocused on terrorism, natural disasters, and environmental protection. In 1977, treaties negotiated between Omar Torrijos and Jimmy Carter returned 7,000 military and civilian buildings in the Canal Zone to the Panamanian government, including the barracks and residences at Fort Sherman. Today, Sherman still has World War I batteries, an airstrip, barracks, officers' quarters, docks, warehouses, recreational facilities, as well as a theater, chapel, and gym. Recently, available space in Fort Sherman was set aside as administrative offices for agencies involved in the management of the SLPA.

(slide: Charlotte Elton)

## Slide 21. Forest corridors: streams, roads, and trails

The SLPA has numerous natural and constructed corridors, the latter being associated with the area's military past. The Chagres River, navigable for 13 km through riparian forest between Gatún Dam and Fort San Lorenzo, is the largest natural corridor. The lower stretches of other small rivers are also navigable, but only for short distances in small boats. Four major roads traverse parts of the SLPA: the 13 km Gatún Locks-Sherman Road (route S2); the 18 km Gatún Locks-Escobal Road (route S10); the 15 km Achiote Road (route S11); and, the 6 km Sherman-San Lorenzo Road (route S8). The first three are paved and the last is gravel. In addition, there are numerous secondary roads, jeep trails, specialty roads (to batteries, docks, military facilities, and research sites), and hiking trials that provide access to the forests, scenic vistas, and waterfalls of the area. Most of the SLPA shoreline, from Piña to Sherman along the Caribbean, and from Gatún Dam to Escobal along the shore of Gatún Lake, is accessible by boat. All of the corridors and shorelines provide opportunities to view the fauna, flora, and scenery of the SLPA.

(slide: CEASPA Files)

## Slide 22. First World War batteries

Battery Stanley, originally defended with two 14-inch and two 6-inch rifles and eight 12-inch mortars, was named after Major General David S. Stanley, commander of the 4th corps during the Civil War. Battery Stanley was one of seven batteries—Baird, Howard, Kilpatrick, MacKenzie, Mower, Pratt, and Stanley—constructed between 1912 and 1924 along the Caribbean shoreline to protect the northern entrance of the canal. Each battery was comprised of a defensive wall, rotary cannons, and bunkers for the storage of munitions and communications equipment. The use of aircraft in World War II made these defensive structures obsolete. The batteries originally operated in communication with soldiers stationed at observation points, some located at a considerable distance. Baird and Howard are still in relatively good condition, having been used recently for training. The remaining batteries are also in excellent condition as relics of an earlier military era, but are in need of restoration.

(slide: Gerald P. Bauer )

### Slide 23. Army jungle training

Starting in 1943, Fort Sherman was used as a training site for the Pacific Theater because of its rugged terrain, notably the Piña Range. In 1953, the U.S. Army designated Fort Sherman as the Jungle Warfare Training Center, later called the Jungle Operations Training Center. 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 during the Vietnam War increased from 1,700 trainees in 1961 to 9,145 in 1967. A normal training cycle involved individual soldier, small unit, and company skills. Soldier skills included jungle survival, camouflage, navigation, mines and booby traps, and information about jungle plants. Small unit training involved patrol, attack, and ambush tactics. 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 in Panama. Training programs involved instruction on battalion level techniques of jungle survival and operations for units from the continental United States.

(slide: U.S. Army)

### Slide 24. Firing ranges: unexploded ordnance


Since World War I, the Piña range has been used by U.S. and Panamanian forces for live fire training and munitions testing. Because not all munitions explode on impact, the Piña range contains unexploded ordnance (UXO), which over the past three-quarters of a century, have claimed several lives. The U.S. Defense Department argues that it is impossible to completely clear the range because of the steep hills and dense jungle foliage. Both the presence of UXOs and the legacy of chemical weapons testing (mustard gas, phosgene, sarin nerve gas, and Agent Orange herbicide) are safety concerns for the area. United States laws and policies govern the closure of domestic military bases (the National Environmental Policy Act (NEPA), and the Comprehensive Environmental Response Cleanup and Liability Act (CERCLA)). U.S. Department of Defense policy also calls for detailed investigations of environmental conditions for domestic bases slated for closure. It has been suggested that, legally and morally, these laws should apply to the closure of bases in Panama. Presently, the Piña range remains officially under separate management from the SLPA, although the forests are contiguous. The range is off limits to visitors.

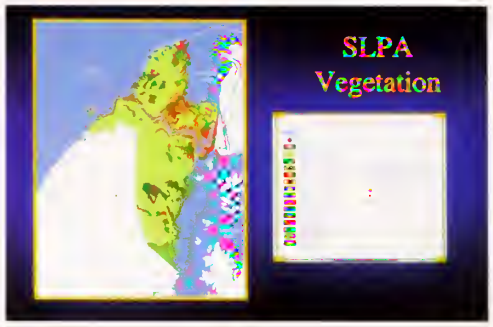
(slide: Gerald P. Bauer)

### Slide 25. Orchids (*Oncidium* sp.): part of a diverse flora

The total flora of the SLPA is unknown, but a 1996 rapid ecological assessment encountered more than 500 vascular plants in the Fort Sherman area and 300 in the Piña firing range. In comparison, the well-studied Barro Colorado Island (BCI)—only 8 percent of the size of the SLPA—contains 1,370 vascular species. Undoubtedly, a more detailed investigation of the flora of the SLPA will detect more species, probably in excess of the total recorded for BCI. During the SLPA survey, only 15 orchid species were noted. Orchids, with at least 25,000 wild species worldwide, are perennial herbs. The group contains about 750 Oncidiums (*Oncidium* sp., subtribe Oncidiiae) that flower mainly in shades of yellow or brown. Oncidiums, growing principally as epiphytes, range from southern Florida and Mexico throughout tropical America to Argentina, with their greatest diversification in Brazil and in the Andes from Colombia to Peru. Thousands of orchid hybrids, many in the genus *Oncidium*, have been registered: in fact, the number of orchid hybrids far exceeds naturally occurring wild species.

(slide: Smithsonian (STRI) files)

## Slide 26. Map of vegetation types




The SLPA has three ecological life zones: tropical moist forest (54 percent) includes the west bank of Limón Bay, Fort Sherman, and the west shore of Gatún Lake; tropical wet forest (3 percent) occurs in an isolated patch along the west central border; and tropical premontane wet forest (43 percent), is found between the Caribbean Sea and the northwest shores of Gatún Lake. Within Panama, these same life zones represent about two-thirds of the country. Several moisture gradients exist within the SLPA. One of these is rainfall, ranging from northeast to south-central, in accordance with the ecological life zones. The other gradients are topographic, ranging from wet lowlands to better drained uplands, and from moist lower slopes to drier ridge tops. These gradients provide a diversity of habitats for 12 recognized vegetation types (fig. 6). Seasonal evergreen forest, divided into tall, mixed, and short types, occupies 61 percent of the SLPA. Semideciduous seasonal forest, partitioned into mixed and short types, covers another 11 percent, with deciduous forest occupying only 2 percent. Flooded vegetation types occupy 21 percent of the total area, including three forests (cativo, palm, and mangrove) and non-tree types (shrub and herb covered lands). Urban areas and cultivated lands cover the remaining 5 percent of the SLPA. Coral reefs and sea grass communities grow along the Caribbean shore and in Limón Bay.

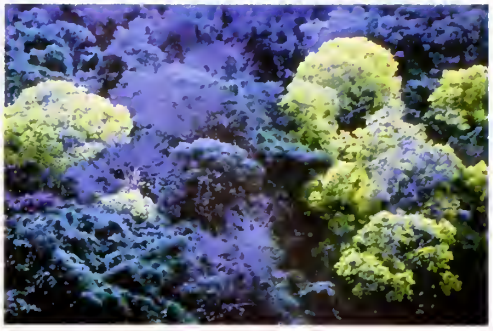
(slide: URBIO S.A.)

## Slide 27. Evergreen seasonal mixed forest

The SLPA has three types of evergreen seasonal forest distinguished on the basis of tree height; e.g., tall, mixed, and short. Of the three types, the mixed forest is the most common in the SLPA. Mixed forest is characterized by a greater diversity in terms of forest structure; e.g., variable crown width and height, and species composition than is found in the evergreen seasonal tall forest. The canopy in mixed seasonal forest typically reaches 25 to 35 m and is dominated by Verbá (*Brosimum* sp., family Moraceae), Amargo amargo (*Vatairea* sp., family Leguminosae), arcabú (*Zanthoxylum procerum*, family Rutaceae), Guácimo colorado (*Luehea seemannii*, family Tiliaceae), Yellow plum (*Spondias mombin*, family Anacardiaceae), West Indian elm (*Guazuma ulmifolia*, family Sterculiaceae), and olivo (*Sapium candatum*, family Euphorbiaceae). Very few trees in evergreen forests lose their leaves during the January to April dry season when both flowering and fruiting are prominent.

(slide: Peter L. Weaver)

### Slide 28. *Tabebuia guayacan*: a burst of yellow in a sea of green



Guayacan (*Tabebuia guayacan*, family Bignoniaceae), a tree growing in tropical wet forests up to 900 m in elevation, ranges from Mexico to Colombia. Common in mature forests, where it reaches from 15 to 40 m tall and rarely up to 2 m in diameter, guayacan occasionally occurs as an emergent. The species typically loses its foliage during the January to May dry season, when it produces a burst of yellow flowers visible at considerable distances. Guayacan—with a heavy, hard and very durable wood—accounts for the remaining snags visible 85 years after the flooding of Gatún Lake. A valued commercial species with many of the properties of lignum vitae (*Guaiacum officinale*, family Zygophyllaceae), guayacan is used for durable outdoor construction where great strength is required. Recently reported within the SLPA, guayacan grows abundantly on nearby Barro Colorado Island.

(slide: Smithsonian (STRI) files)

### Slide 29. Cativo forest

Cativo (*Prioria copaifera*, family Leguminosae) forest, common in the coastal fringe along the Gatún Locks-Sherman Road (route S2), and along the Chagres River, covers 15 percent of the SLPA, and alone or in mixture with other tree species, occupies 1.3 percent of Panama. Cativo develops on poorly drained lowland soils subject to frequent, temporary flooding after rainstorms. Cativo trees, reaching 30 m or more in height, and 0.5 to 1.2 m in diameter, are regularly spaced from 6 to 15 m apart. Cativo regeneration dominates the understory, but other species such as the black palm (*Astrocaryom standleyanum*, family Arecaceae) and wild pigeon plum (*Ouratea lucens*, family Ochnaceae) are also present. The only other common species that attains large size in the Cativo forest, however, is the fig (*Ficus glabrata*, family Moraceae).

(slide: Gerald P. Bauer)

## Slide 30. Mangrove woodland

Mangrove woodland, covering about 1 percent of the SLPA and 5 percent of Panama, is comprised mainly of four tree species: red, black, white and button mangrove. Red mangroves (*Rhizophora mangle*, family Rhizophoraceae), reaching 10 to 12 m or taller in height, are adapted to salt and brackish waters along the shoreline, where their stilt roots form an impenetrable thicket at high tide. Red mangrove seeds germinate inside a conical fruit, forming a long, heavy, narrow first root that will drop into the water when it reaches about 30 cm in length. After floating for a short time, the root becomes firmly attached in the substrate and begins to grow into a new plant. The remaining species, black mangrove (*Avicennia germinans*, family Verbenaceae), white mangrove (*Laguncularia racemosa*, family Combretaceae), and button mangrove (*Conocarpus erectus*, family Combretaceae), grow inland from the red mangroves, the button mangrove at the landward edge of tidal mangrove swamps. Black mangroves have numerous pencillike structures (pneumatophores) rising vertically from their roots that help in respiration. Mangrove woodlands provide breeding grounds for fish and habitat for numerous bird species. Because their woods are dense, mangroves have been commonly harvested for fence posts, fuelwood, and charcoal. Moreover, the bark of all mangroves is a source of tannin used for tanning leather.

(slide: Peter L. Weaver )

## Slide 31. Raphia Palm (*Raphia taedigera*) and its distribution

The Raphia palm (*Raphia taedigera*, family Arecaeae), covering 3 percent of the SLPA, grows in swamps, where it forms clumps of trees of different sizes. The spacing between clumps is close and approximately equidistant, and little herbaceous vegetation, except for occasional ferns, grasses, or vines, grows underneath. Raphia's growth habit allows it to control a site for a long time. Perhaps the most interesting aspect of Raphia, which has been present in the neotropics for at least 2,800 years, is the tree's intriguing history of long-range dispersal. *R. taedigera* is the only one of 20 species in the genus that grows in the neotropics; the remainder are African. The hypothesis that best explains this phenomenon is that the African palm (*R. vinifera*), which is concentrated around the Congo River in central Africa, rafted across the Atlantic Ocean as a fruit or with other vegetation to become *R. taedigera* in the neotropics. Raphia's neotropical distribution occurs in five disjunct

populations ranging from Nicaragua to Brazil: the coastal Caribbean between the Matagalpa River in Nicaragua and Bocas del Toro in Panama; the Chagres River in Panama; Colombia's Caribbean coast around the Atrato River; the mouth of the Amazon River in Brazil; and the Osa Peninsula on Costa Rica's Pacific shore. The first four sites may have been connected in the past; dispersal to the last site could be explained by wide ranging animals such as the peccaries or tapirs that eat the fruits. Unfortunately, Panama's western populations of Raphia are being replaced by subsistence crops.

(slide: Peter L. Weaver)

### Slide 32. Pterocarpus swamp

The range of bloodwood (*Pterocarpus officinalis*, family Leguminosae) extends from the Gulf of Campache in Mexico and from Jamaica and Hispaniola in the Caribbean south to Ecuador and the mouth of the Amazon River in Brazil. Confined mainly to temporarily flooded coastal wetlands and stream banks, the tree reaches 40 m tall and 60 to 90 cm in diameter. Bloodwood is easily identified by the long, sinuous buttresses that extend from the trunk, very light wood, dark red latex that exudes from cuts, and round, winged seedpods. Formerly, the latex of bloodwood was exported under the name "dragon's blood" from Colombia to Spain, where it was used as a hemostatic and astringent. Bloodwood has been used to float fishnets in open water and as a honey plant for bees in coastal Guyana. It has also been planted for shade in southern Florida and Cuba. Bloodwood, like the Raphia palm, has a disjunct distribution, with populations occurring in both Africa and the neotropics. This attractive bloodwood stand is located in the wetlands bordering the road at Sherman.

(slide: Peter L. Weaver)

## Slide 35. **Heliconias**

Heliconias (family Heliconiaceae), large upright herbs with red or yellow inflorescent bracts and yellow petals, were previously classed with the bananas (family Musaceae) and birds-of-paradise (family Strelitziaceae), but are now placed in their own family. Heliconias are native to the American tropics from central Mexico to Brazil and Bolivia, and to some of the South Pacific Islands. Heliconias grow most luxuriantly at elevations below 500 m but attain their greatest diversity and endemism in mid-elevation rain and cloud forest habitats. About 250 species occur naturally, but with hybrids and varieties, total heliconia species may approach 500. Nectar-feeding hummingbirds, attracted by the bright colors, are the only pollinators of heliconias in the American tropics, whereas bats play that role in the South Pacific Islands. The roadside *Heliconia platystachys* shown here grows naturally from Costa Rica to Colombia, and is also widely cultivated. Heliconias, because of their brilliant and diverse colors and large size, are favorites in gardens throughout the tropics.

(slide: Peter L. Weaver)

## Slide 36. **Fungi: much that happens goes unnoticed**

Although the species of fungi linked to the Irish potato famine and the medicine penicillin are well known, most of the remaining 1.5 million fungi species live unnoticed. Fallen trees normally host a myriad of organisms, from bacteria and fungi to insects that break down the wood and recycle its nutrients. Most of the fungi go unobserved because their fruiting is ephemeral or their fruiting bodies emerge within logs. Wood boring insects such as beetles, termites, and some species of ants hasten the invasion of fungi when they tunnel into fallen logs. With greater time on the ground, decomposing logs change in size and shape, and increase their water holding capacity. Bark is lost, twigs and small branches decompose, wood texture becomes soft and powdery, wood color changes, and invading roots from surrounding vegetation enter the sapwood and finally, the heartwood. Decomposition creates special habitats for a variety of microorganisms whose populations continually change as decay progresses. During periods of drought, the tree-soil interface provides a relatively cool, moist habitat for fauna, and a substrate for microbial activity. Ultimately, the decaying trees release large accumulations of nutrients to the soil and provide habitat for the growth and development of other species.

(slide: Smithsonian (STRI) files)

### Slide 37. **Medicinal plants: forest drugstore**

Knowledge of the medicinal and hallucinatory qualities of forest vegetation and how to prepare and administer plant extracts—a tradition passed down for centuries—has contributed to the aura of mysticism surrounding the shaman, or medicine man, in many Indian tribes. Recent surveys highlight the continuing importance of medicinal plants in traditional folk medicine. A review carried out in 21 Latin American countries showed that 270 plant species in 82 families were highly regarded for their medicinal properties. More than 400 of the 10,000 plant species in Panama are used in folkloric medicine. Moreover, in the provinces of Panama and Colón alone, more than 80 species are employed, among them achiote (*Bixa orellana*, family Bixaceae), 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 stomachaches, hemorrhaging, and cardiac illnesses. Achiote is also used as an aphrodisiac, laxative, and insecticide. Lastly, it has apparently loaned its name to a community bordering the SLPA.

(slide: Gerald P. Bauer)

## *Among the Most Conspicuous Animals*

### Slide 38. **Ocelot (*Felis pardalis*)**

The SLPA has at least 81 species of mammals, or 35 percent of all the mammals found in Panama. The ocelot (*Felis pardalis*) ranges from southern Texas, throughout Central and South America, to northern Argentina. Of Central America's spotted cats (the others are the jaguar, margay, and oncilla), the ocelot is the most commonly sighted in the wild. A solitary hunter by day or night, the ocelot is entirely carnivorous, feeding mainly on rodents, but also on birds, lizards, snakes, and other small mammals and vertebrates. Ocelots hunt on the ground, rarely climbing trees except to cross a stream or to rest on a branch. Formerly hunted for its pelt, the ocelot is listed on Appendix II of the Convention on International Trade in Endangered Species (CITES).

(slide: Gerald P. Bauer)

### Slide 39. Howler monkeys (*Alouatta palliata*)

Howler monkeys, noted for their noisy exchanges along territorial boundaries, can be heard for great distances in the forest. Mantled howler monkeys (*Alouatta palliata*) are arboreal and diurnal, usually roaming in groups of 10 to 18 individuals. They range from forest lowlands to 1,500 m in elevation, including Central America from eastern Mexico to Panama, and western South America from Colombia to Peru. Their home ranges are small and they can successfully survive in fragmented forest. Most frequently seen in parks and around archaeological ruins, they survive in mature and old secondary evergreen forests, often along streams. The mantled howler is threatened by deforestation and hunting, and is listed on Appendix I of CITES.

(slide: Gerald P. Bauer)

### Slide 40. Northern Tamandua Anteater (*Tamandua mexicana*)

The northern Tamandua anteater (*Tamandua mexicana*) ranges from southeastern Mexico throughout Central America to South America west of the Andes, from northern Venezuela to northern Peru. These anteaters forage alone on the ground or in trees, and are active during the day or night. They eat ants, termites or bees, ripping apart insect nests. This species is most common along streams and in trees covered with vines and epiphytes—habitats where their prey are concentrated. When inactive, they rest in burrows, hollow trees, or other natural shelters. The northern Tamandua anteater is threatened by habitat destruction throughout much of its range. This particular animal nearly wandered onto the shoes of the photographer.

(slide: Gerald P. Bauer)

### Slide 41. Baird's Tapir (*Tapirus bairdii*)

Baird's tapir (*Tapirus bairdii*), ranging from southeastern Mexico to western Ecuador, is the largest native terrestrial mammal in Central America. Tapirs, weighing from 150 to 300 kg, have long and flexible upper lips they use to pluck leaves beyond the reach of their tongue and teeth. They are usually solitary, timid and docile, and are active during both day and night, spending up to 90 percent of their waking hours browsing. Much of the diet of the tapir is vegetarian, consisting of aquatic plants, roots, stems, leaves, fruits, seeds, and flowers; occasionally, small aquatic animals, are eaten. Juveniles accompany their mothers for about 1 year after birth. Before it was hunted with guns, the tapir was common in a wide variety of habitats, including mangrove swamps, rain and deciduous forests, and montane forests up to 3,500 m in elevation. Tapirs often spend part of the day in mud wallows or in shaded thickets, and avoid people even in areas where hunting is controlled. Habitat destruction and hunting have reduced tapir populations throughout their range, including Barro Colorado Island and probably the SLPA, where they have not been sighted recently. Despite their scarcity, canoeing the Chagres at night might result in an encounter with a tapir. Listed on Appendix I of CITES, the species is considered endangered and today is largely confined to protected areas.

(slide: Gerald P. Bauer)

### Slide 42. Great Fruit-eating Bat (*Artibeus literatus*)

Bats, with about 1,000 species worldwide, or nearly one-quarter of all known mammals, evolved about 50 million years ago. Latin America alone has nine families and 270 species of bats. Bats forage at night using sonar (echolocation) to find food. During the day they roost in caves, hollow trees, or in tangles of vines, on tree trunks, on exposed roots along watercourses, or on the undersurface of large leaves such as bananas. Many have specialized feeding habits. About 70 percent of bats are insectivores, capturing insects in the air or on leaf surfaces, branches, tree trunks, and the soil. Most of the remainder are frugivores or nectivores, feeding on fruits, nectar, and pollen. A few are carnivores, eating frogs, lizards, small rodents, birds, and other bats. The fishing bat (*Noctilio leporinus*) that inhabits the SLPA uses its long hind claws to catch small fish in forest streams. Bats help control insects, pollinate plants, and disperse seeds, playing an important role in the

regeneration of forests after disturbance. The forests, streamsides, numerous small caves, and buildings of the SLPA support 41 known bat species, or one-half of the area's known mammals. The great fruit-eating bat (*Artibeus literatus*) shown in the slide is among the most common species in neo-tropical rain forests, ranging from Mexico to Bolivia and northern Argentina, and to the Lesser Antilles. This species feeds on the fruits—especially figs—flowers, and the pollen of several canopy trees.

(slide: Keith Christenson)

### Slide 43. Green Iguana (*Iguana iguana*)

Panama has 228 species of reptiles (10 percent endemic) including 127 snakes, 81 lizards and iguanas, 15 marine and freshwater turtles, three worm lizards, a crocodile, and a caiman. Of these, the SLPA contains 35 species, or 15 percent of Panama's total. The green iguana (*Iguana iguana*), predominantly a vegetarian, may grow to 1.8 m long. It lives in tropical and subtropical America at elevations less than 1000 m, favoring wooded areas near water. Early in the dry season, the green iguana lays about 30 eggs that take nearly 3 months to hatch; the young emerge at the beginning of the wet season. Humans are the iguana's major enemies, mainly through habitat destruction, hunting, and egg stealing. Other predators include large felines, birds of prey, snakes, alligators, and crocodiles. The iguana, long favored in the diets of the native peoples and rural populations of Panama, is also a popular item in the pet trade. The dramatic decline of Panama's iguana populations has been counteracted by legislation, educational programs, reforestation, and by breeding the reptiles in captivity for later release.

(slide: Gerald P. Bauer)

## Slide 44. Caiman (*Caiman crocodilus*)

On his fourth expedition, Columbus discovered the Chagres River and named it "Lagartos" (alligators) for the animals he saw on its banks. Of the 23 known species of crocodilians, the Caribbean coast of Panama has two, a caiman (*Caiman crocodilus*) and a crocodile (*Crocodylus acutus*). The common caiman (with up to five recognized races) shown here has the largest range, extending from southern Mexico to northern Argentina. Rarely attaining 3 m in length, caimans usually occupy the quiet waters of marshes, lakes, or slow-flowing rivers, but are highly adaptable. They can also survive in brackish waters, and during droughts will typically congregate in shrinking pools, occasionally burrowing into the mud at the bottom to await wet season rains (aestivation). Mating occurs at the end of the dry season and eggs are laid in nests of grass, leaves, twigs, and soil as water levels begin to rise. Caiman nests are typically located in communes, where predation may account for the loss of 80 percent of the nests. Common predators on young and juveniles include herons, egrets, anhingas, and raccoons; adult caiman are the prey of humans. Young caiman feed mainly on aquatic insects; adults, on fish and amphibians.

(slide: Gerald P. Bauer)

## Slide 45. Large neotropical constrictor (*Boa constrictor*)

The boa constrictor (*Boa constrictor*, family Boidiae), a large and non-venomous snake, ranges from central Mexico to Argentina, and is also found in the Lesser Antilles. The boa inhabits wet and dry forests, thorn scrub, and cultivated fields, from sea-level to 1,000 m in elevation. Growing to 5 m in length, the boa constrictor ranks fifth in size among the world's 2,500 species of snakes, ceding first place in the Americas to the anaconda (*Eunectes murinus*, family Boidiae). Boas, being heavy bodied, have been assumed to have a "sit and wait" approach to hunting. Recent observations, however, show that they actively search for good places to sit and wait, including near the burrows of ground dwelling prey and in flowering trees for birds. Boas hunt day and night on the ground and in trees, grabbing and impaling prey with their sharp, recurved teeth. The boa feeds on a variety of lizards, birds, and mammals, including wild iguanas, tanagers, ant birds, bats, spiny rats, opossums, rabbits, juvenile porcupines, young deer, coatis, ocelots, mongoose, as well as domestic poultry and dogs. Boas give birth to live young in litters from 20 to 60. They are long-lived, one reported to have survived for 38 years in captivity.

As with other primitive snakes, they have a pelvis and vestigial hind limbs, the latter apparently playing a role during courtship.

(slide: Gerald P. Bauer)

### Slide 46. Poison dart frog (*Dendrobates auratus*)

Of Panama's 170 species of amphibians (16 percent endemic), including 141 toads and frogs, 21 salamanders, and 8 cecilias, the SLPA has at least 36 species, or 21 percent of the country's total. The poison dart frog (*Dendrobates auratus*, family Dendrobatidae), is among the most conspicuous and interesting. The frog ranges from southern Nicaragua to Colombia at elevations between sea-level and 800 m. Diurnal in habit, it hunts on the forest floor and in trees, and is very active on mornings after rainfalls. The frog's bright coloration, black with glossy green spots, warns potential predators of its poisonous skin secretions. The frog is probably best known as a source of skin poison used by Amerindians when hunting. Other frog species die after contact with poison dart frogs in collection bags. The poison dart frog lays its eggs away from water; after the tadpoles are hatched, the parent frog carries them on its back to streams or pools.

(slide: Smithsonian (STRI) files)

### Slide 47. Chestnut-mandibled toucan (*Ramphastos swainsonii*)

Panama has about 930 species of birds, of which 75 percent are residents, 14 percent regular migrants, 6 percent occasional visitors, and 1 percent pelagic, with the remainder being considered as unconfirmed sightings. Nearly one-half of this total has been recorded within the SLPA. The toucans (Ramphastidae), with 42 species in continental tropical America, are among the most easily recognized birds because of their enlarged, multicolored bills. They nest in tree hollows and are gregarious, often converging to feed in fruiting trees. Their diet also includes large insects, small reptiles and amphibians, nestling birds, and the eggs of other bird species. Among the most colorful species, the chestnut-mandibled toucan (*Ramphastos swainsonii*) ranges from Honduras to western Ecuador, and is common in Panama's Caribbean lowlands below 900 m in elevation. Habitat destruction and hunting have contributed to its decline in recent years.

(slide: Gerald P. Bauer)

### Slide 48. Slaty-tailed trogon (*Trogon massena*)

Trogons (Trogonidae), with their greatest diversity and abundance in Central and South America, are among the most colorful of tropical birds. Ranging from southern Mexico to western Ecuador, the slaty-tailed trogon (*Trogon massena*) is fairly common in Panama's lowland forests and secondary woodlands, including mangroves. The species is usually found singly or in pairs, and occasionally in small groups. Trogons often perch motionless for considerable periods and are difficult to sight in the canopy. They eat both fruits (*Conssarea*, *Hamelia*, *Gnatteria*, and small palms) and insects (katydids, caterpillars), often procuring the latter in a spectacular fashion. They occasionally follow monkey groups, catching insects flushed by them. Trogons nest in tree cavities or in holes dug out of arboreal wasp or termite nests, laying three white to bluish-white eggs.

(slide: Gerald P. Bauer)

### Slide 49. Harpy eagle (*Harpia harpjya*)

Hawks, eagles, and kites (Accipitridae), diurnal birds of prey well represented in Panama, are characterized by a hooked bill and gripping feet. The harpy eagle (*Harpia harpjya*), with legs 5 cm thick and a wingspan of more than 2 m, is considered the most powerful bird of prey in the world. Measuring almost 1 m from head crest to tail when mature, the harpy remains inconspicuous in flight; it rarely soars, and then only low and briefly. Harpies usually stay in or below the canopy, where they hunt from a perch in rapid, agile flight. Among the favored prey are macaws and large iguanas and small to medium-sized mammals, particularly sloths and monkeys. Harpies, never very common in undisturbed forested areas in the Caribbean lowlands and lower slopes, are rarely sighted in the vicinity of the canal due to habitat destruction and hunting. A single bird requires about 30 square kilometers to search for prey in the wild. Harpies, not particularly shy in the presence of humans, are opportunistically shot despite their legal protection. The species has been recently sighted in the SLPA, but nesting within the area has not been confirmed. The continued succession of secondary forests in the SLPA—and their maintenance as part of a large, unfragmented unit—should one day assure the habitat required for Panama's national bird.

(slide: Gerald P. Bauer)

## Slide 50. Freshwater fish: Peacock bass (*Cichla ocellaris*)

A survey of freshwater fish showed that at least 42 species live in some part of the Chagres River watershed, including Barro Colorado Island and Gatún Lake, and in the Fort Sherman streams that drain directly into the Caribbean Sea, mainly near Toro Point. Most fishes of eastern and central Panama are of South American origin, such as the characins (family Characidae) and the suckermouthed armored catfish (family Loricaridae), both large families. The migration of these families of fish to the Chagres 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. Freshwater fish were introduced into the Chagres watershed (including Gatún Lake) on four occasions, as follows: guppies (*Lebistes reticulatus*) from Barbados for mosquito control about 1910; large mouth bass (*Micropterus salmoides*), catfish (species not certain), and sunfish (*Lepomis* sp.) in 1917; large mouth bass, bluegills (*Lepomis macrorochirus*), and crappies (*Pomoxis* sp.) for sport fishing in 1925; and peacock bass (*Cichla ocellaris*) from the Amazon in 1967 for sport fishing. Only the peacock bass survived. The peacock bass, a major fish predator, reduced or eliminated eight native species and had secondary impacts on zooplankton and bird species. Recently, tilapia (*Tilapia* sp.) have been introduced to local communities through artificial fish ponds and floating cages suspended in Gatún Lake; inevitably, some have escaped and reproduced successfully.

(slide: Gerald P. Bauer)

## Slide 51. Morpho butterfly (*Morpho peleides*)

The morpho butterfly (*Morpho peleides,* family Morphoidae), ranging from Mexico to Colombia, is common in Panama's Caribbean lowland forests. Adults, found descending along forest streams, trails, and roads, are spectacular in flight as their iridescent blue wings glitter in the forest. Morphos deposit their eggs on the underside of host plant leaves (*Lonchocarpus* sp., *Machaerium* sp., and *Pterocarpus* sp., family Leguminosae); about 4 months are required for them to develop through the last larval stage. Adult morphos eat the fallen fruits of several forest species that are also grown for food or timber on subsistence farms. These plants include *Brosimum* sp. (Moraceae), *Manilkara* spp. (Sapotaceae), *Guazuma ulmifolia* (Sterculiaceae), *Mangifera indica* and *Spondias* spp. (Anacardiaceae), *Musa* sp. (Musaceae), and *Theobroma cacao* (Sterculiaceae). Morphos also feed on mud and carrion. Despite their

Slide 51. Morpho butterfly (*Morpho peleides*) cont.

adeptness at avoiding butterfly nets, predators such as jacamars (Galbulidae) and large flycatchers (Tyrannidae) feed on the butterfly. Morphos are among the favorite butterflies for sale in mounted displays.

(slide: Gerald P. Bauer)

## Slide 52. Spiders (*Nephila* sp.) and their webs

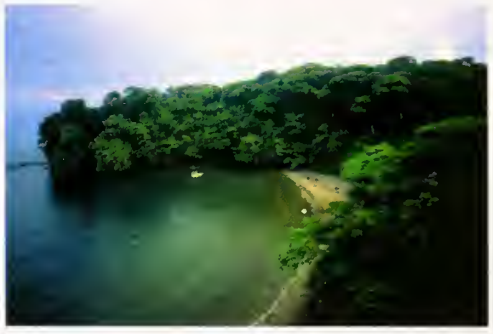
Spiders, with some 34,000 species grouped into about 100 families, are voracious predators. The nephila (*Nephila* sp., family Aranidae) is an orb-web spider found in forest clearings and secondary growth in lowland and mid-elevation habitats. The spider builds a broad web with a hub near the top and a tangle of threads called barrier webs that function as a trap for airborne insects such as flies, beetles, and moths. The spider, active both day and night, occupies the hub and monitors the web for vibrations produced when insects fly into it. The spider immobilizes prey by biting and injecting venom along with digestive enzymes. Nephila then cuts the prey out of the web and carries it back to the hub to feed. Bulkier prey, after being bitten, are wrapped in silk and transported back to the hub. There is an enormous disparity in size between the nephila sexes, the males weighing from 100 to 1,000 times less than the females, depending on species and habitat. The males are so small that they are below the size of the female's normal prey and therefore are not eaten. Nephila silk, strong and durable, was formerly used for gun sights. The silk of a related species of *Nephila* is currently used by New Guinea natives for fishing lures.

(slide: Smithsonian (STRI) files)

## Slide 53. Leaf cutter ants (*Atta* sp.): miniature gardeners

Of the 10,000 species of ants in the world, one group known as the leaf cutters (the attines, 12 genera and about 190 species) cultivates fungus gardens. Some leaf-cutter (*Atta* sp., family Formicidae) colonies contain as many as one million workers tending a thousand fungus gardens. Activities on the soil surface include constructing trails, harvesting leaves, and searching for new resources. Medium-sized ants, protected by larger soldier ants, march in columns to surrounding trees and shrubs to cut off parts of leaves and carry them back to the underground nests. Distances between the nests and vegetative resources vary, often ranging from 50 to 150 m. Ants generally travel at the rate

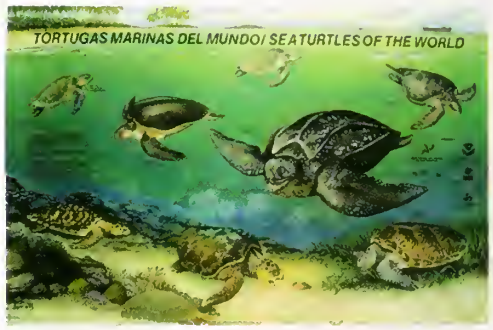
### Slide 55. Cove beaches and headlands



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. 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. Today, these secluded areas offer the visitor precious moments of respite from a busy world. One such area, Hidden Beach (Tortuguilla Beach), is situated about 500 m directly north of Fort San Lorenzo, hidden from the fishermen shown in the slide by a forested ridge.

(slide: Gerald P. Bauer)

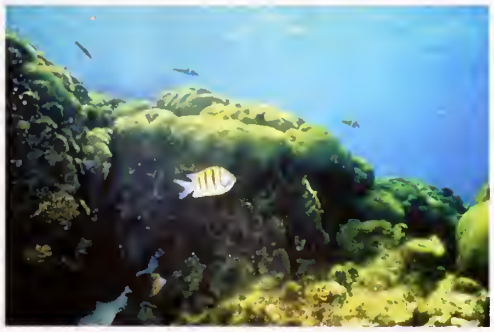
### Slide 56. Sea turtles and nesting beaches




Sea turtles, with a fossil record of at least 200 million years, are represented today by only eight species in two genera. Fishermen in the coastal town of Piña, at the western end of the SLPA, remember the "old days" when four turtle species—loggerhead (*Caretta caretta*), green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), and leatherback (*Dermochelys coriacea*)—were occasionally seen in the vicinity. Leatherbacks are still common farther west in Bocas del Toro. Sea turtles, adapted to life in the ocean, are tied to the land only for reproduction. Their high commercial value as a source for meat, eggs, oil, leather, ornaments and jewelry, cultural and ceremonial uses, and other products, has made them the target 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. Today, all four of the above species are listed as threatened or endangered. Recent hazards 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 valuable of those once sighted near Piña.

(slide: Smithsonian (STRI) files)

## Slide 57. Corals and marine fish species



Reef flats border most of the Caribbean shore. The longest segment stretches for nearly 2.5 km along the coastline of the SLPA, from Devil's Beach to Naranjitos Point, rising nearly 20 m and forming Brujas Island. The barrier reefs, paralleling the Caribbean 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. The absence of some species of corals may be due to 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. Sergeant majors (*Abudefduf saxatilis,* family Pomacentridae), shown here with prominent black stripes, are an aggressive, fast-swimming member of the reef community. Pantropical in distribution, immature sergeant majors are frequently found in tide pools seeking refuge among rocks.

(slide: Smithsonian (STRI) files)

## Slide 58. Seagrass communities: *Thalassia testudum* and other species

Seagrass communities along the SLPA coast—two in Limón Bay and one at Punta Brujas—contain food sources for many of the organisms that inhabit nearby mangroves and coral reefs. Moreover, they help collect sediment and form a protective habitat for innumerable marine invertebrates. Seagrass beds, comprised of *Thalassia testudinum* (family Hydrocharitaceae), *Halodule wrightii* (family Posidoniaceae), and *Syringodium filiforme* (Posidoniaceae) in shallow waters, and *Halophila decipiens* (Hydrocharitaceae) in deeper waters with less light, have been shown to be sensitive to urban development, deforestation, and coastal dredging—all of which increase coastal sedimentation. In addition to providing habitat for at least 35 identified species of young and adult fish, seagrass is grazed by the West Indian manatee (*Trichechus manatus*), previously hunted for its meat, oil, and hide, and now considered threatened. Manatees, recorded in the Chagres River before the construction of the Panama Canal, were reintroduced into the river in 1964 and subsequently escaped into Gatún Lake and the canal. Viable wild populations still survive west of the SLPA in Bocas del Toro.

(slide: Smithsonian (STRI) files)

### Slide 59. Stuck in the mud

The difficulties of studying tropical flora and fauna are probably best demonstrated by this four-wheel drive vehicle stuck in the mud. Researchers throughout the tropics could commiserate for hours about the time spent reaching isolated sites, particularly during heavy wet season downpours. The muddy stretches along this road to the Smithsonian's crane site have been aggravated by unauthorized dump trucks mining beach sand. Unfortunately, the decision to develop a road network to remote areas is not easily resolved. It is often a matter of opting for costly road improvements that facilitate work, but also increase the threat of squatting, poaching, and illegal use, despite surveillance. Alternatively, unimproved roads cost more in research time, effort, and vehicle repairs, but discourage illicit use. In their attempt to address issues of resource use and maintenance, SLPA managers have stopped sand mining; moreover, they have also installed an entrance gate and improved the road to the crane site for authorized users.

(slide: Peter L. Weaver)

### Slide 60. STRI crane: a look at the forest canopy

For decades, lack of access to treetops has limited research in tropical forests. Recent attempts at canopy access have included using climbing gear and hot air balloons that drop a fabric mesh anchored by air-filled pontoons. The Smithsonian crane was installed in September 1997. It ascends 55 m vertically and extends 54 m laterally through the canopy, allowing scientists to reach nearly 0.92 ha of forest at virtually any height. One goal of the crane research program is to determine the biological details of the forest system; another is to use findings at the level of leaf, tree, stand, and landscape to develop models of regional gas exchange. Among the topics being investigated are: insect biodiversity; the vertical gradient of herbivores; changes in herbivory from excluding birds that normally prey on leaf-eating insects; the community structure of epiphytes; plant-pollinator interactions; flowering, fruiting and shoot growth of canopy species; and plant photosynthetic responses to microclimate and carbon dioxide concentrations. The crane gondola provides a view of the surrounding forest and the Chagres River as it enters the Caribbean Sea. This elevated perch has been described by some visitors as "the perfect set-up," and "the best seat in the house." Another

Smithsonian crane located in the Parque Natural Metropolitano (Metropolitan Natural Park) near Panama City allows for comparisons between wet and dry forests.
(slide: Gerald P. Bauer)

### Slide 61. Looking down to ground from crane

Soaring through the treetops, where an estimated 90 percent of all tropical organisms live, sounds like a long forgotten childhood dream. Monitoring the same canopy area throughout the year without damaging the vegetation is the forest ecologist's dream. The crane, "a forest canopy access system," reaches 55 m above the ground, however, and the seemingly tenuous protection afforded by a guardrail mounted on a thin, steel and wire mesh gondola does little to assure those queasy of heights that Newton´s laws are temporarily held in abeyance! Some look up, some pray, and others, undoubtedly, fleetingly recall the gruesome fate of many of Edgar Allen Poe's principal characters. Safety, however, is always the main consideration. The crane, one of 12 worldwide, is carefully inspected monthly, and scientists do not venture into the canopy during inclement weather.
(slide: Gerald P. Bauer)

### Slide 62. Epiphytes: canopy gardens

Epiphytes grow like elevated gardens on tree trunks and branches. Lichens, fungi, bryophytes (liverworts and mosses), ferns, orchids, bromeliads, vines, and the seedlings of many common forest species germinate and grow as epiphytes for a period of time. Strangler figs (*Ficus* spp.), and other tree species with a similar growth habit, often regenerate in the forest canopy. As epiphytes die and decompose, a soil-like substrate forms, clinging to tree trunks and branches. As the substrate accumulates, the numbers of epiphytes that can be supported in the elevated gardens increase. Epiphytes provide habitat and food sources for soil microorganisms, innumerable insects, small reptiles and amphibians, birds, and mammals. They also play an important role in the movement of water and the chemistry of water within the forest. Epiphytes intercept rainfall and filter cloud moisture, redistributing it within and below the tree canopy. Bromeliad tanks serve as aquatic reservoirs for considerable periods, providing breeding sites for many species, and refugia during dry periods for others. As elsewhere in the rain forest, some canopy epiphytes provide direct benefits as medicines or as ornamentals, and sources of food and flavoring. An example of the last is vanillin (*Vanilla planifolia*, family Orchidaceae).
(slide: Gerald P. Bauer)

## Slide 63. Beetles: their numbers and activity

The crane allows entomologists to make long-term observations of canopy insects and to evaluate earlier estimates of global insect diversity. Truly astonishing numbers of species have been found in the canopy, including 95 previously undescribed species of beetles in the flowers of a single tree! Most insects appear to be host specific, feeding on a single plant species. These observations suggest that 30 million, the highest estimate for the number of insect species inhabiting tropical forests, may be correct. Another area of interest is the amount of vegetation consumed (herbivory) by insects, vertebrates, and pathogens. Studies have shown that two species of moth larva (Lepidoptera) and one species of beetle destroy more than 99 percent of the flower buds of the wild cashew (*Anacardium excelsum*, family Anacardiaceae). Herbivory, however, is lower in the canopy than in the understory. Future research will try to determine the reasons for this, which may be related to plant compounds used for defense, predation on canopy herbivores, canopy climate (humidity or temperature), or some combination of all three.

(slide: Smithsonian (STRI) files)

## Slide 64. Long-term monitoring plot

All trees at least 1 cm in diameter on 4.96 ha of forest surrounding the crane were permanently tagged in January 1996. Tree diameters and heights were measured to determine the current structure of the forest. Future remeasurement of all trees will provide insights into forest dynamics, including tree growth and development, ingrowth and mortality rates, tree age and size relationships, and changes in species composition due to normal tree mortality or major climatic events such as wind storms or severe drought. Regular forest monitoring also provides the basis for specialized ecological studies in physiology, phenology, autecology, phytosociology, succession, and forest modeling. Similar data collected in other tropical forests allow comparisons of structure and dynamics throughout the world.

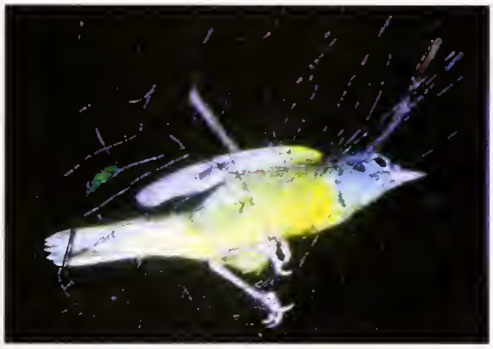
(slide: Gerald P. Bauer)

### Slide 65. Large trees—some not as old as they appear

Certain species in the Bombacaeae family, for example, the cuipo (*Cavanillesia platanifolia*), cedro espino (*Bombacapsis quinatum*), and ceiba (*Ceiba pentandra*), stand out as exceptionally large trees in the SLPA. These trees germinate and start growing in forest openings, sending up unbranched trunks that spread when they reach the canopy. The wood of the large trees is not dense; consequently, the trees grow very rapidly in height and diameter. Since most tropical tree species do not produce annual rings, a ring count does not help determine their age. One simple technique to estimate tree age is to tag several trees in different diameter classes and monitor their growth for a period of time. Once the average diameter growth within a size class is determined, the time required for the average tree to grow through that size class is known. Subsequently, a crude estimate of the tree's age can be made by summing the number of years required for the average tree to grow through all of the size classes being measured.

(slide: Gerald P. Bauer)

### Slide 66. Mist nets sample bird populations



Knowledge of migrant and resident bird species may be gained through a variety of sampling techniques including counts from stationary positions, transects, tape recordings and playbacks of songs, Christmas bird counts, and mist netting. The last is particularly useful for density estimates and is often done by capture and release after color banding for field identification. Mist netting provides data on species diversity and habitat partitioning. It also allows biologists to monitor population changes (bird dispersal and survival over extended periods), and provides detailed information (sex, age, weight, fat condition, and reproductive condition) related to the health and condition of individuals and populations. The mourning warbler (*Oporonis philadelphia*) shown in the slide breeds in North America and winters in the tropics from Nicaragua through Ecuador and Venezuela—including the SLPA—preferring woodlands and clearings with dense scrub, particularly near water. Panama receives well over 100 migrant bird species annually from North and South America, mostly from the former. The recent decline of migratory birds in northern breeding areas has been linked to deforestation in the tropics. With continued deforestation, protected areas such as the SLPA assume even greater importance as wintering habitat for migratory birds.

(slide: Smithsonian (STRI) files)

### Slide 67. Green urania moth (*Urania fulgens*)

The diurnal urania moth (*Urania fulgens*, family Uraniidae), with its iridescent green bars and white tails, resembles a swallowtail butterfly. Four urania species are recognized; however, differences among them are slight, and all may actually be races of a single species. The moth has an intriguing life history. It undergoes population explosions and massive migrations, more or less in synchrony, throughout the neotropical latitudes from Mexico to Bolivia. Urania moths breed in May; population movements (some migrate, others do not) begin in July and August, and are generally south and/or east in Central America, continuing unabated for up to 5 months. The moths are strong fliers, averaging 20 km per hour, and barely influenced by winds, can cross up to 250 km of open water. Records from 1850 to the mid-1950s show average migrations at 8-year intervals, and at 4 years since then. Migrations are followed by return flights, mainly local and for less than 2 weeks, starting in March of the next year. The moths lay eggs in clutches; when touched, the initial larval stages flip off leaves on a silken thread, a presumed defense against ants. The central question is "Why do urania migrate?" Current research suggests that after three generations of attack by urania larvae, the moth's primary food source, a canopy liana (*Omphalea* sp., family Euphorbiaceae), may increase the defensive compounds in the leaves to a level that would be toxic to developing larva of the next generation. Urania females can detect plants of lesser toxicity, and migrate to find them.

(slide: Neal Smith)

### Slide 68. Barro Colorado Island and the Smithsonian

Barro Colorado Island (BCI) in Gatún Lake is less than 6 km from the SLPA. BCI, gradually formed after the dam on the Chagres River was built in 1910, has been a biological reserve since 1923. The island, with an irregular shoreline of 48 km, covers 1565 ha and reaches an elevation of 145 m above the surrounding lake, and 170 m above sea-level. The island's first laboratory was established in 1924 by visiting scientists. In 1940, BCI was dedicated as a Natural Monument; in 1946, it was placed under the administration of the Smithsonian Institution. Scientists at the Smithsonian Tropical Research Institute (STRI) currently maintain a permanent monitoring plot at the crane site in the SLPA.

Moreover, their legacy of studies on the flora and fauna of BCI is relevant to SLPA's management. More than 500 vertebrates species have been identified on the island: 60 bats, 384 birds, 30 frogs, 22 lizards, and 40 snakes. As part of the Canal Treaty of 1977, the relationship of STRI with Panama was relegated to a status similar to those of international missions. In 1986, a public nature trail was designed on BCI to promote education and appreciation for tropical ecosystems. 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 possibly the most studied tropical forest in the world.

(slide: Gerald P. Bauer)

## *Forest Conservation: Protection and Use*

### Slide 69. **Conservation issues: poachers**

Numerous environmental issues are of concern for the management of the SLPA. These include past military activities, the impacts of canal operations on surrounding waters, the threat of inappropriate development, poaching, the unauthorized use or exploitation of natural resources (wildlife, forest, sand, and corals) and lax law enforcement. Land use on the SLPA is continually monitored. The main interests in 2001 centered around:

- the development of a management plan
- community programs with the residents of Achiote, Escobal, and Piña
- educational programs, including interpretative trails of varying length highlighting the historical and cultural past of the SLPA
- basic and applied research
- an interpretation center, resource library, and map file.

(slide: Smithsonian (STRI) files)

### Slide 70. Congo culture: celebration of freedom

During the Congo festivities, which last from late January until Ash Wednesday, descendents of the African slaves brought to Panama during the colonial period commemorate their freedom by playing the roles of escaped slaves. Scattered among small towns such as Achiote, Escobal, and Piña along the Caribbean coast around Colon, group members meet in their own private retreats (el palenque) to sing, dance, prepare special meals, and enact a folk drama. Their dance celebrates the flight and settlement of escaped slaves (Cimarrones) led by Juan de Dioso. During the late 1500s, the Cimarrones successfully waged guerilla war against the Spaniards, forcing them to negotiate a peace treaty. During carnival season, mini-kingdoms of Congos exist alongside the civil community. The Congo queen María de Merced and her surrogate husband Juan temporarily reign over the kingdom during the fiesta, sharing the responsibilities for the visits between Congo groups and maintaining discipline during the festivities. In the past, Congo celebrants who moved from villages to crowded urban dwellings found that their celebrations were not tolerated. Indeed, one of the typical carnival pranks, which involves a group of men in outlandish costumes capturing strangers for ransom after entering Congo territory, could be easily interpreted as criminal activity.

(Slide: Gerald P. Bauer)

### Slide 71. Local communities and schools: more education

The 1990 population of Colon province, including the four "corregimientos" (Spanish territorial units, under the jurisdiction of a mayor appointed by the king) that encompass the SLPA, averaged from 10 to 30 persons per square kilometer. The nearest communities in 2000 had 2,378 persons—Achiote with 365, Escobal with 1,653, and Piña with 360. The past and current negative impacts of these communities on the SLPA are the results of clandestine timber cutting, scattered fuelwood harvest, illegal hunting, unauthorized extraction of plant materials, removal of beach sand for construction, and subsistence farming, mainly coffee production under shade. Several programs have been initiated with the local communities to reduce these impacts. Fundacion Natura is working through CEASPA to reforest with native species. CEASPA also provides educational programs for community leaders and school children emphasizing environmental awareness and community organization.

(slide: Gerald P. Bauer)

### Slide 72. Training of guards

To alleviate pressures on the environmental resources of the SLPA, it is necessary to generate an appreciation for their value and an interest in their conservation. One attractive means to achieve this is to employ people from nearby communities, some of whom have knowledge of trails, cave sites, bird species, folklore, and the traditional use of medicinal plants. Local residents employed as guards already help protect the SLPA and provide information to visitors. Guard training includes the use of a compass, plant and animal identification, and familiarization with the special problem of firing ranges, where unknown quantities of live ammunition (unexploded ordnance, or UXOs) remain scattered on the ground. Guards receive additional training in first aid, map reading, patrolling techniques, and interaction with visitors.

(slide: CEASPA files)

### Slide 73. Coffee shade: the agroforestry tradeoff

Growing coffee under a forest canopy, a type of agroforestry, is widespread in the tropics. Coffee shade agroforestry modifies the microclimate favorably, protects the soil, recycles nutrients, and provides habitat for arthropods, amphibians, bats, birds, and mammals. Shade coffee matures over a longer period than coffee grown in the sun, and generally results in a greater proportion of export quality beans than open grown coffee. Subsistence crops such as bananas and tubers, often grown in association, allow local farmers a measure of profit. Coffee shade plantations support bird species that favor areas with an overstory, especially migrants, whose habitat requirements are likely to be less stringent than resident species. Fundacion Natura, working through CEASPA, recently initiated a program with the local communities in the buffer zone of the SLPA to improve the productivity of their coffee crops.

(slide: Gerald P. Bauer)

### Slide 74. Water sports: boating and fishing

Panama is well known for its fresh and saltwater fishing. Sites in and around the SLPA include Gatún Lake, the Chagres River below the dam, Limon Bay, and the Caribbean Sea. Boat ramps are available on Gatún Lake, at Fort Sherman, and at the mouth of the Chagres. Gatún Lake, where peacock bass (*Cichla ocellaris),* snook (*Centropomus undecimalis*), tarpon (*Megalops atlanticus*), and crevalle jack (*Caranx hippos*) are available throughout the year, is the favorite freshwater fishing destination near the SLPA. The lake occupies 423 $km^2$ and measures 37 km between the Gatún Locks and the Culebra Cut. Peacock bass is the most common species; snook, tarpon, and crevalle jack 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, they are known to swarm Caribbean rivers to consume figs falling from riverbank trees. 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*), and are available the entire year but in limited quantities. The Caribbean 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.

(slide: Gerald P. Bauer)

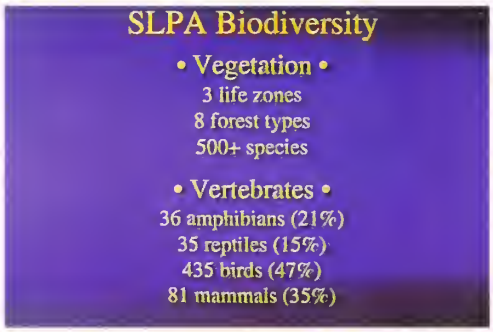
### Slide 75. Birdwatching, hiking, and sightseeing

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. Five convenient birdwatching areas are recommended. Along the Gatún Locks-Sherman Road (route S2) paralleling the western shore of Limón Bay, 27 birds species were listed, among them pigeons and doves, parrots, trogons, toucans, flycatchers, honeycreepers, caciques, tanagers, and possibly mangrove warblers. Along the Fort Sherman-San Lorenzo Road (route S8) paralleling the Caribbean shoreline, 41 species were noted, including hawks, pigeons and doves, parrots, hummingbirds, toucans, woodpeckers, antbirds,

jays, wrens, honeycreepers, tanagers, and others. At Fort San Lorenzo, a promontory above the Chagres River, 13 species were recorded, among them terns, parakeets, flycatchers, elaenia, martins, swallows, and robins. On the Achiote Road (route S11) inside the Atlantic lowland forest, at least 65 species were observed, including tinamous, vultures, hawks, pigeons and doves, parrots, hummingbirds, trogons, toucans, woodpeckers, flycatchers, wrens, euphonias, tanagers, and saltators. Ten of these forest bird species are found nowhere else in the canal area. At the mouth of the Chagres River, 24 species were seen, among them pelicans, frigate birds, herons, terns, doves, martins, swallows, tanagers, seedeaters, and grassquits. All of these areas, readily accessible by car, are located within a few minutes of each other. Opportunities also exist for hiking and sightseeing in each area.

(slide: Gerald P. Bauer)

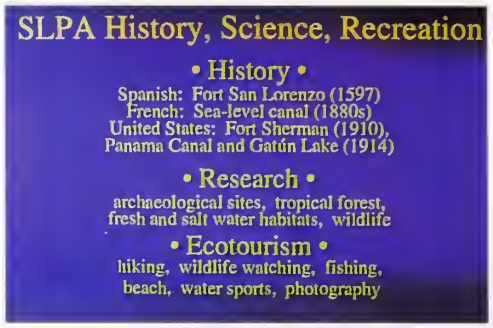
### Slide 76. **Biodiversity**




The 12,000-ha SLPA, occupying only 0.4 percent of Panama, contains three life zones, 12 vegetation types, and at least 500 species of higher plants, about 5 percent of the total recorded for the country. Nearly 600 species of vertebrates have been identified, or nearly 40 percent of the country's total, as follows: 36 amphibians (21 percent), 35 reptiles (15 percent), 435 birds (47 percent), and 81 mammals (35 percent). The number of bird species, the most studied group, approaches one-half of Panama's total. The high diversity in the SLPA can partly be attributed to its variable topography, different vegetation types, and the proximity of large undisturbed tracts of forest to the west. Another critical factor is the relatively large size of the SLPA and limited human disturbance. Major development or widespread clearing for agriculture on the periphery of the SLPA would effectively make it a small island like Barro Colorado (BCI). Such fragmentation could cause incidences of local species extinction, notably for groups that require extensive habitat or that have small populations. The SLPA is a critical part of the interoceanic corridor across the isthmus, and of the Caribbean coastal corridor. Future studies will undoubtedly add new species to the SLPA list and also help determine the impact of humans on its fauna.

(slide: Gerald P. Bauer)

### Slide 77. Ecotourist's paradise




In addition to the high faunal and floral biodiversity, numerous other attractions are available for visitors to San Lorenzo. Tourists will find both terrestrial and aquatic activities that include hiking, kayaking, birdwatching, crocodile photographing safaris, game fishing, scuba diving, and snorkeling. The grounds on Fort Sherman will hopefully soon house an interpretative center highlighting Sherman's historical and cultural past; moreover, plans to develop butterfly and botanical gardens have been discussed. Researchers will have their hands full with the archaeological sites and challenges of the tropical forest. This experience is enriched by the legacy of the past—the proximity of the early French Canal, the Gatún Locks of the Panama Canal, and the rich history of the site dating back to the 16th century.

(slide: Gerald P. Bauer)

### Slide 78. Major partners of the SLPA

The SLPA has many friends and supporters eager to ensure the protection and sustainable use of its numerous historic, cultural, and natural resources. The National Environmental Authority (ANAM) is responsible for Panama's national system of protected areas, including the SLPA, through an interinstitutional agreement with the Interoceanic Regional Authority (ARI), the Panamanian Institute of Culture (INAC), and the Panamanian Tourist Institute (IPAT). The Panamanian Center for Research and Social Action (CEASPA), a non-governmental organization created in 1977, works with these government agencies and local communities in the SLPA's buffer zone to achieve three goals: sustainable development, participatory democracy, and empowering leadership among women in their role as citizens. In the SLPA and its buffer zone, CEASPA concentrates on helping local communities promote conservation through the sustainable use and management of natural resources.

(slide: Gerald P. Bauer)

### Slide 79. Panama's future: The canal and adjacent properties

The conservation of Panama's natural resources and protection of the canal are linked. Today, nearly one-half of the canal watershed is forested; of the forested area, 69 percent is in parks and protected areas. Most of the remainder is in agriculture and settlements, with about 10 percent covered by water. Water from the canal watersheds generates electricity and passes through the locks; it takes 52 million gallons of water to raise and lower each ship a distance of 25 m. Alajuela Lake behind Madden Dam, which was built in 1934 to control flooding and to regulate flow into Gatún Lake, provides the water for canal operations. The 1000 $km^2$ basin behind the dam—steep and susceptible to erosion—receives heavy rainfall. Maintaining the entire canal watershed and surrounding areas as part of an integrated system can help assure prosperity into the future. This is Panama's environmental challenge. As one Panamanian author, Pereira-Jiménez, has stated "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."

(slide: Gerald P. Bauer)

### Slide 80. Conservation of the San Lorenzo Protected Area (SLPA)

The SLPA is a treasured resource of the Panamanian people. Protecting it is everyone's responsibility.

(slide: Gerald P. Bauer)

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**Appendix Table 1—Chronology of main events in the history of the San Lorenzo Protected Area[1]**

| Date | Event |
|---|---|
| BC: | |
| 9000 | Spear points of paleoindians found in the vicinity around Madden Dam, 50 km east of the San Lorenzo Protected Area, 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 the century, indigenous village located at "Fort Chagres town." |
| 1501 | Rodrigo de Bastides is the first European to land in Panama. |
| 1502 | Columbus explores Panama's Caribbean coast 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 the west coasts of Central or South America; the mouth of Chagres River becomes a principal terminus for travel across the isthmus. |
| 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 Panama's local governor to look for a canal route. |
| 1535 | Philip II of Spain first calls 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 on route. |

*continued*

**Appendix Table 1—Chronology of main events in the history of the San Lorenzo Protected Area[1] (continued)**

| Date | Event |
|---|---|
| 1579 | As many as 30 flat-bottom barges operate on the Chagres River. |
| 1587 | Trenches are dug at the mouth of the Chagres (San Lorenzo) to guard the river mouth. |
| 1596 | Drake burns Nombre de Dios and Portobelo becomes the Atlantic port of 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, destroying San Lorenzo on departure. |
| 1680s | A major effort undertaken to rebuild the fort resulted in a three-level fortress; the town of Chagres was established under the protection of the fort. |
| 1681 | The merchant ship Chaperon sinks at the mouth of the Chagres River. An unidentified treasure galleon also sinks off Punta de Brujas and the ship Boticaria near the Isla de Naranjos. |
| 1730s | Panama declines as a transhipment area; between 1520 and 1730, it was the main route for colonists to Central America and the west coast of South America. |
| 1739 | In attacks made between 1739 and 1742, Admiral Vernon captures San Lorenzo and burns the town of Chagres; the route across the isthmus through the Chagres River is abandoned for another farther east in the Choco region. 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. |

*continued*

**Appendix Table 1—Chronology of main events in the history of the San Lorenzo Protected Area[1] (continued)**

| Date | Event |
|---|---|
| 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 travel across the isthmus; 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 the Western United States via Panama declines with the completion of the Union Pacific Railroad. |
| 1879 | The 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 directed by 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 as "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 of Fort Sherman begins to protect the entrance of the Panama Canal; about 850 troops arrive 1 year later. |
| 1911 | Fort Sherman named in honor of renowned Civil War General William Tecumseh Sherman. |
| 1912 | Construction of coastal batteries (Mower, Stanley, Howard, Baird, Pratt, MacKenzie, and Kilpatrick) named in honor of Civil War military personnel is initiated; work is finished by 1924. |

*continued*

**Appendix Table 1—Chronology of main events in the history of the San Lorenzo Protected Area[1] (continued)**

| Date | Event |
|---|---|
| 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 Panama 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 Majagual Rivers is added to Fort Sherman; the eastern breakwater is completed in July. |
| 1920 | Military "jungle training" starts at Fort Sherman. |
| 1923 | U.S. Congress establishes Barro Colorado Island under the administration of the Smithsonian Institution. |
| 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 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 San Lorenzo Protected Area. |

[1]Sources: References. Not all of the references concurred on dates.

**Appendix Table 2—Various groups associated with the San Lorenzo Protected Area**

**Panamanian Groups:**

Autoridad del Canal de Panamá (ACP) . . . The Panama Canal Authority

Autoridad Marítima de Panamá (AMP) . . . National Maritime Authority

Autoridad Nacional del Ambiente (ANAM) . . . National Environmental Authority

Autoridad de la Región Interoceánica (ARI) . . . Interoceanic Regional Authority

Centro de Estudios y Acción Social Panameño (CEASPA) . . . Panamanian Centre for Research and Social Action

Fundación Natura . . . Natura Foundation

Instituto Nacional de Cultura (INAC) . . . National Institute of Culture

Instituto Panameño de Turismo (IPAT) . . . Panamanian Tourism Institute

Sociedad Audubon de Panamá . . . Panama Audubon Society

**U.S. Groups:**

The United States Agency for International Development (USAID)

USDA Forest Service (International Institute of Tropical Forestry)

National Fish and Wildlife Foundation

U.S. Peace Corps

Smithsonian Tropical Research Institute (STRI)

**International Groups:**

Global Environment Facility

Organizacion de las Naciones Unidas para la Educacion, la Ciencia y la Cultura (UNESCO) . . . United Nations Educational, Scientific and Cultural Organization

Programa de las Naciones Unidas para el Medio Ambiente (UNEP) . . . United Nations Environment Programme

World Bank

World Monument Fund

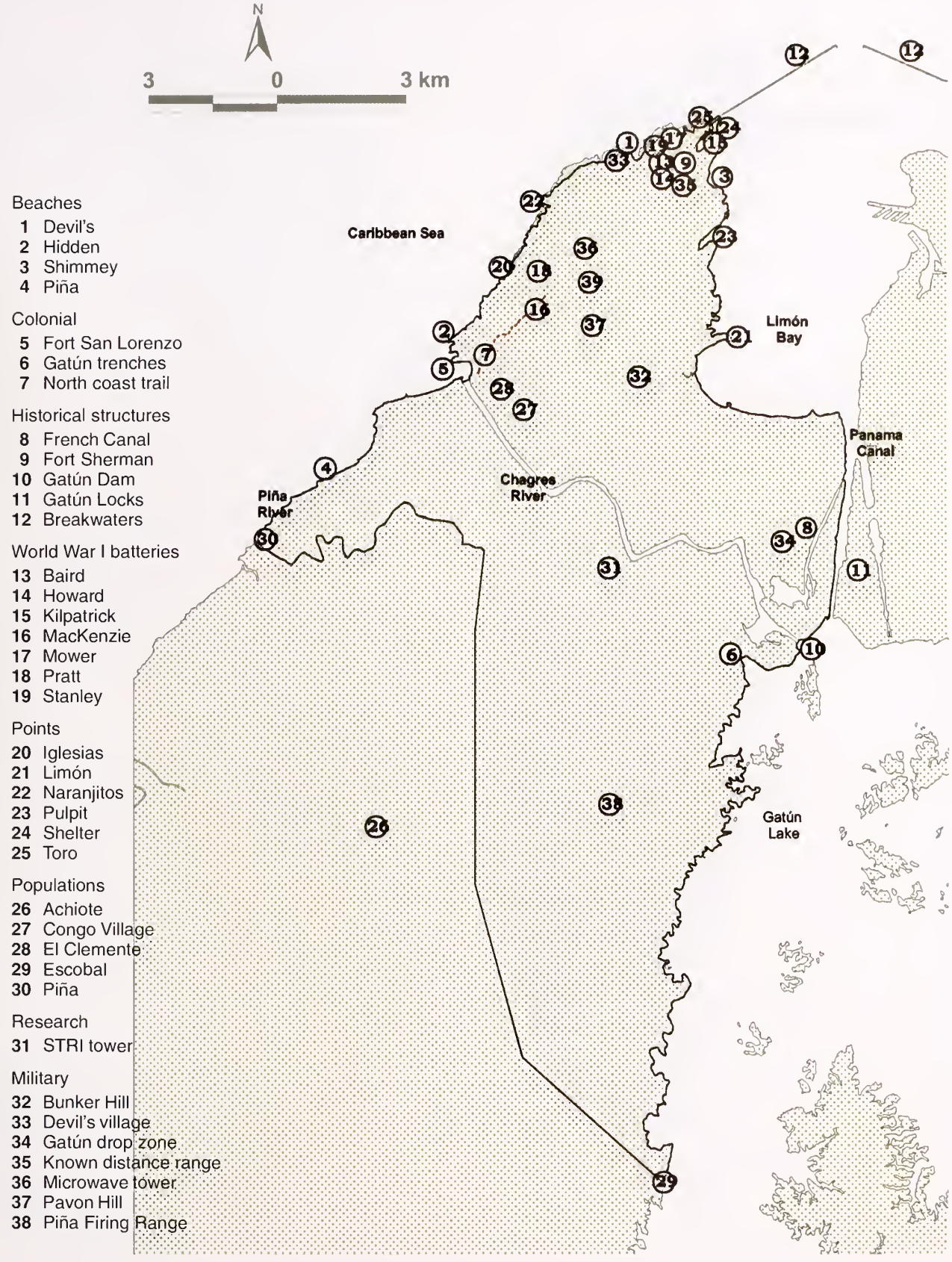



Figure 1—Place names in the San Lorenzo Protected Area.

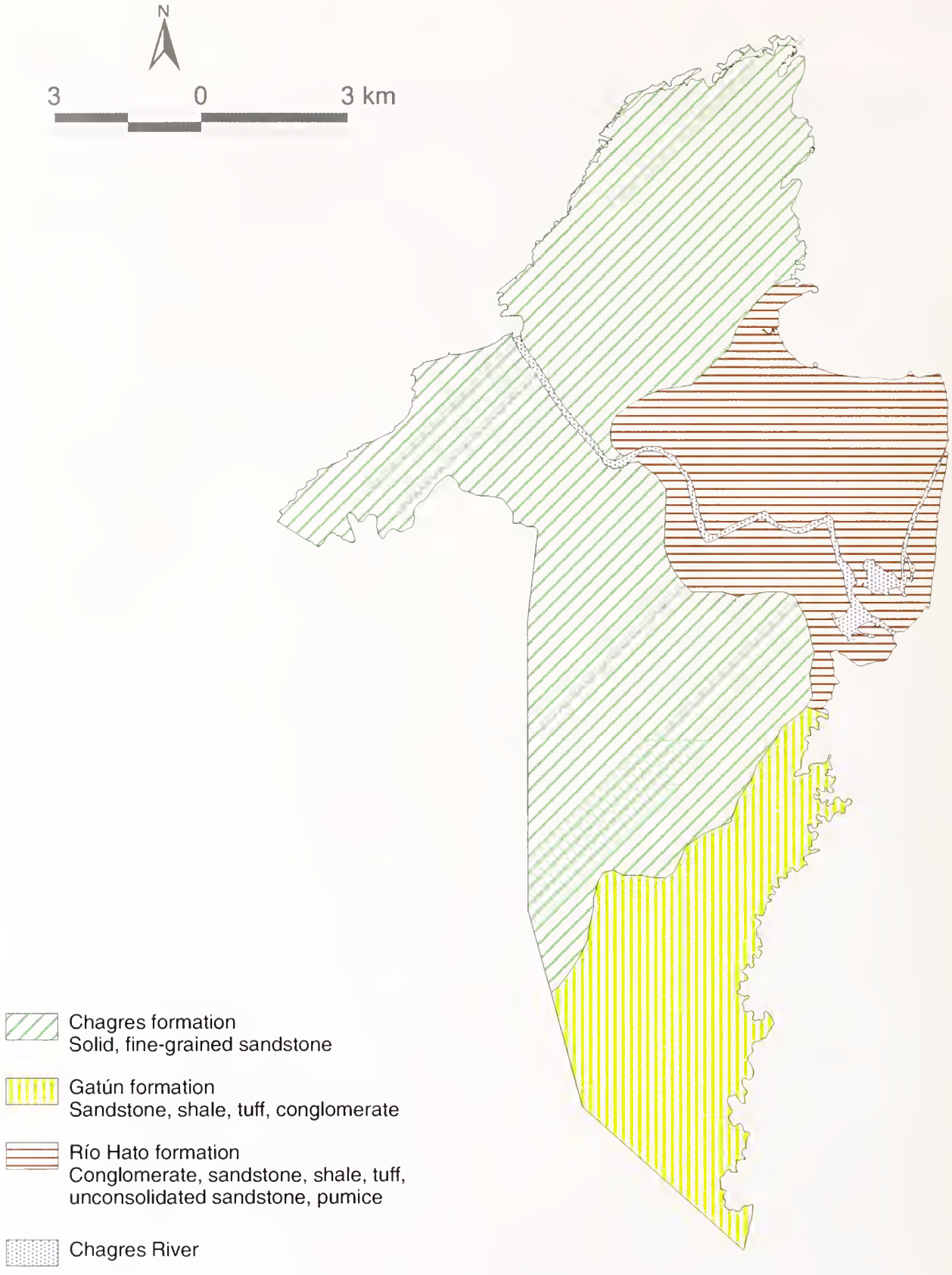



Figure 2—Geology of the San Lorenzo Protected Area.

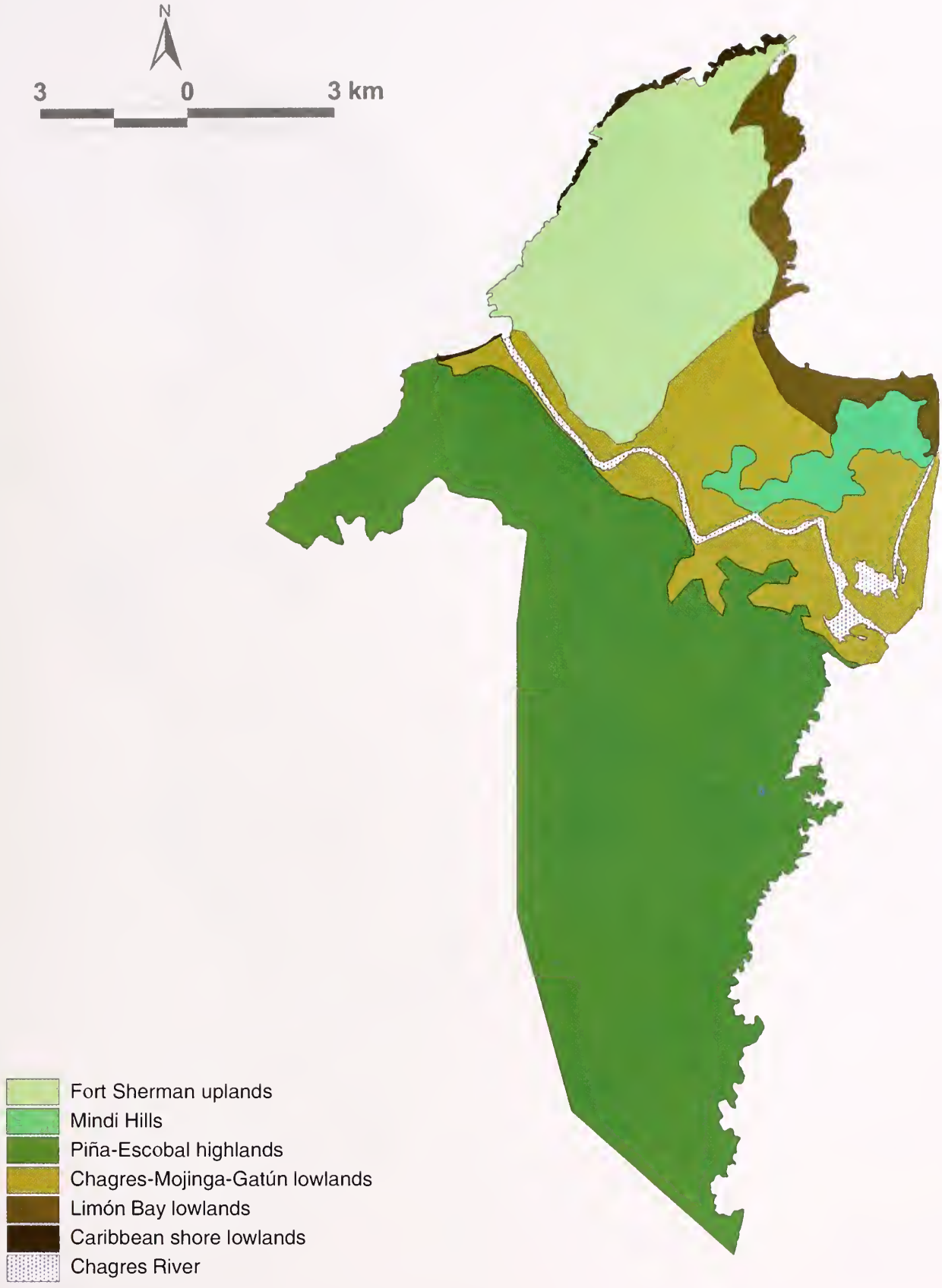
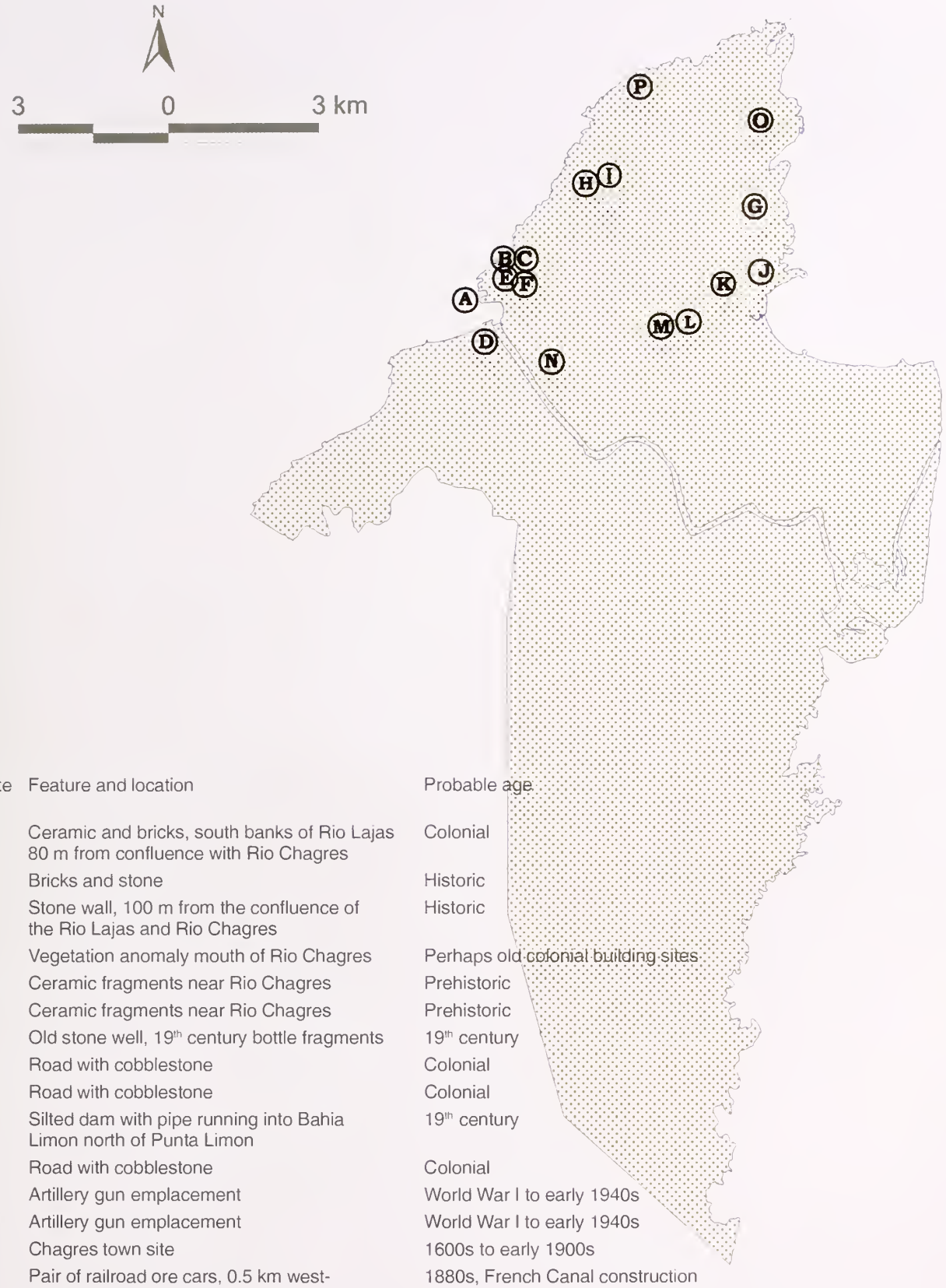



Figure 3—Physiography of the San Lorenzo Protected Area.


Figure 4—Roads and rivers in the San Lorenzo Protected Area.




| 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 5—Archaeological sites in the San Lorenzo Protected Area.

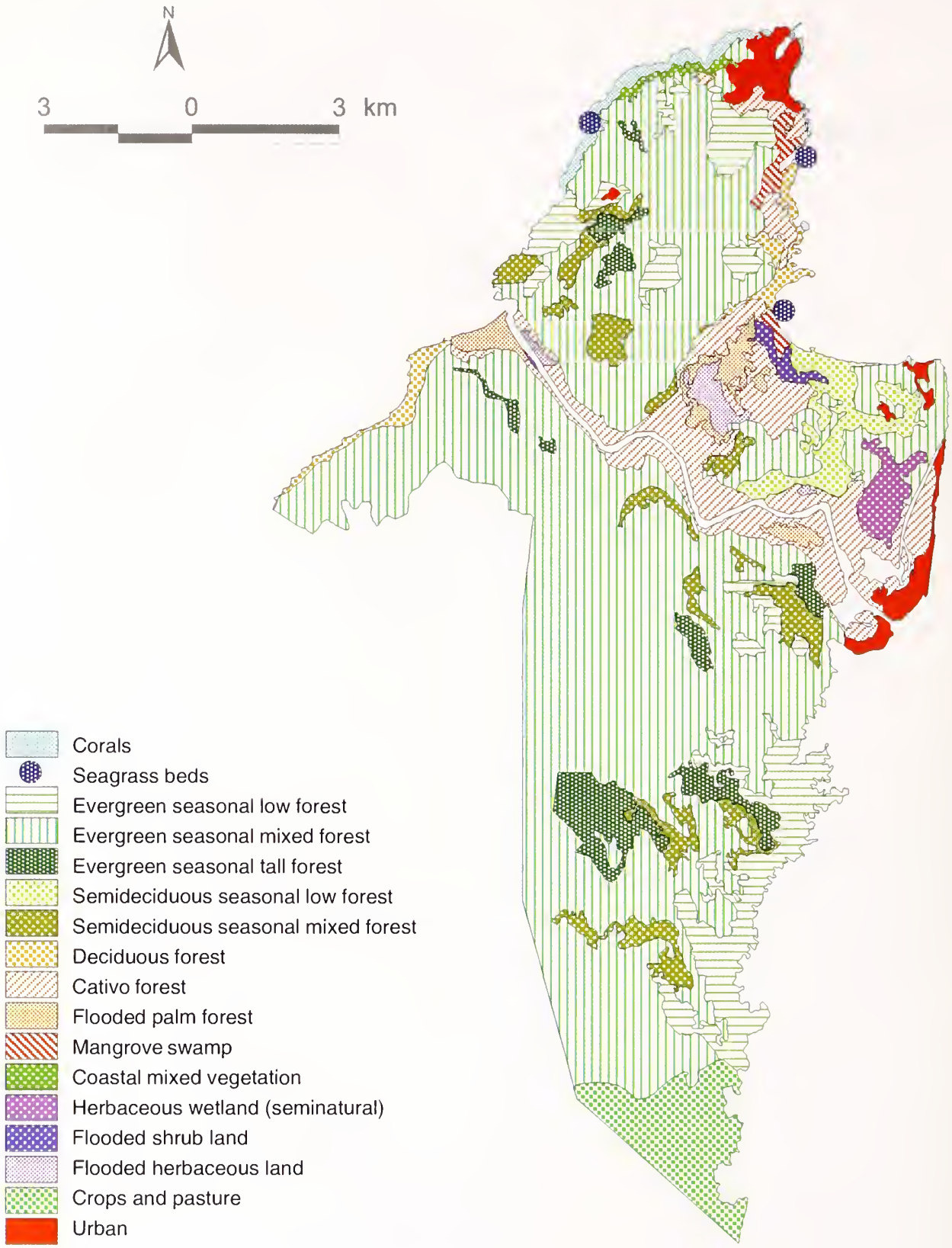



Figure 6—Vegetation types in the San Lorenzo Protected Area.

**Weaver, Peter L.; Bauer, Gerald P.; Jiménez, Belkys.** 2003. The San Lorenzo Protected Area: Panama's Caribbean treasure. Gen. Tech. Rep. IITF-23. San Juan, PR: U.S. Department of Agriculture, Forest Service, International Institute of Tropical Forestry. 60 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 the Yucatan of Mexico to Panama's border with Colombia. The SLPA includes Fort San Lorenzo, where the Spanish initiated a water level battery in 1597, and later built a fort to protect the gold route over the isthmus at the mouth of the Chagres River. Fort Sherman, a U.S. military base, was established in 1910 to protect the northern entrance to the Panama Canal. Both forts fulfilled their military objectives; Fort Sherman has also maintained control over the area's natural resources during the 20th century. This slide program highlights the SLPA as part of a major crossroads between continents and oceans, and briefly describes pre-Columbian activities, the Spanish conquest, the legacy of fortune seekers and the Chagres River, French and U.S. efforts on the canal, the role of immigrants in building Panama's infrastructure, the military history of Forts San Lorenzo and Sherman, and early agricultural activities. The SLPA's flora, fauna, hydrological network, marine resources, current research, and proposed conservation, including both protection and use, are also mentioned. A chronology of major events relevant to the SLPA is included.

**Keywords:** Fauna, flora, Fort San Lorenzo, Fort Sherman, historical chronology, Panama Canal, slide program.

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