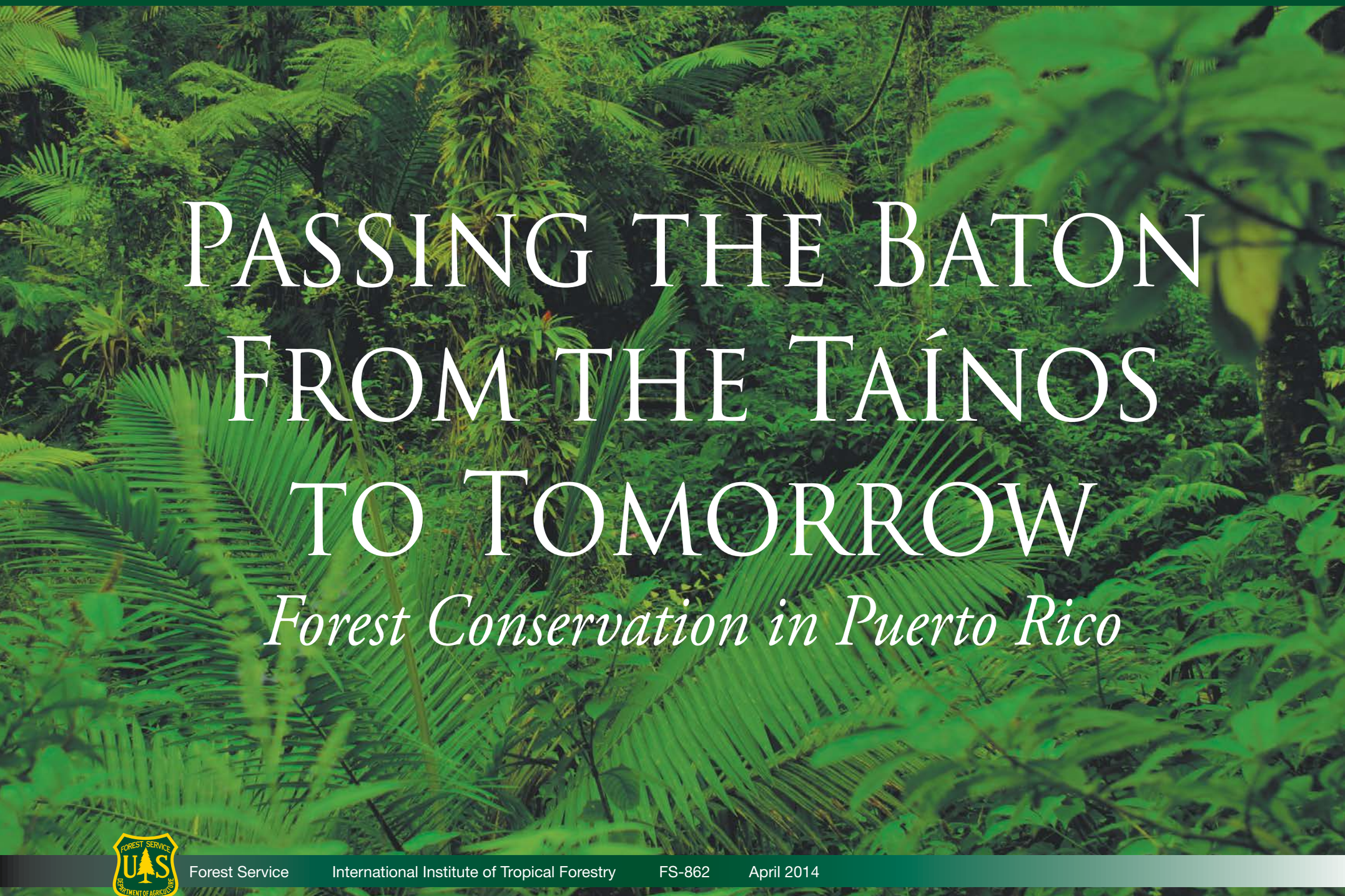
USDA
United States Department of Agriculture



Passing the Baton From the Taínos to Tomorrow

Forest Conservation in Puerto Rico

Forest Service International Institute of Tropical Forestry FS-862 April 2014

Passing the Baton
From the Taínos to Tomorrow

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Edited by
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USDA Forest Service • International Institute of Tropical Forestry

Official Names and dates when they were used for what today is known as the El Yunque National Forest; the U.S. Department of Agriculture (USDA), Forest Service; and the International Institute of Tropical Forestry. These names and dates were compiled from many sources, including personal communications with Carlos Domínguez Cristóbal, Peter Weaver, and Frank Wadsworth.

El Yunque National Forest
The region was known as Yukiyu in Pre-Columbian time before 1500.
1876 to 1898—The forests of *Sierra de Luquillo* were managed as a Forest Reserve by the *Inspección de Montes de Puerto Rico* under the jurisdiction of the Government of Spain. The Forest Reserve had multiple locations and names within the Luquillo Mountains.
1903 to 1907—Luquillo Forest Reserve
1907 to 1935—Luquillo National Forest
1935 to 2007—Caribbean National Forest
1956 to present: The national forest was designated the Luquillo Experimental Forest in its entirety.
2007 to present—El Yunque National Forest*

USDA Forest Service
1881 to June 1901—Division of Forestry
July 1901 to January 1905—Bureau of Forestry
1905 to present—USDA Forest Service

International Institute of Tropical Forestry
1939—Tropical Forest Experimental Station
1955—Tropical Forest Research Center
1961—Institute of Tropical Forestry
1992—International Institute of Tropical Forestry

*Well before its formal designation as El Yunque National Forest, Puerto Ricans nicknamed the forest "El Yunque" after the peak of the same name.

CONTENTS

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This publication was developed in collaboration with the University of Puerto Rico.

Preface

At the start of the new millennium, in anticipation of the U.S. Deparment of Agriculture (USDA), Forest Service's century anniversary in Puerto Rico in 2005, the staffs of the International Institute of Tropical Forestry and the Caribbean National Forest (see table on page 4) researched a timeline about forests, forestry, and the USDA Forest Service in Puerto Rico. The chart began with the Pre-Columbian Era, before 1508, when aboriginal groups settled the island; continued with the Spanish Era, from 1508 to 1898; and concentrated in greater depth on the U.S. Era, from 1898 to the present, and the work of the USDA Forest Service on the island. When completed, it wrapped around a room at El Portal Rainforest Center in El Yunque National Forest (see table on page 4), fascinating thousands of forest visitors. After it was taken down, many thought the timeline should be made permanent in a publication, and the idea behind this book took shape.

Passing the Baton From the Taínos to Tomorrow: Forest Conservation in Puerto Rico fleshes out the work done for the original timeline, which is presented along the outer margins of the book's pages. The book was written to appeal to a general audience interested in conservation in general and the outstanding conservation efforts carried out in Puerto Rico, particularly in the past century. To many islanders, the USDA Forest Service is "the agency up north" in charge of maintaining El Yunque National Forest. It is that, but it is also much more, and its existence on the island has been instrumental in making Puerto Rico one of the few places on our planet that has more forested land now than it had a century ago.

How that came about is part of the story behind this book. It is not intended to be a technical "how-to" for foresters or scientists and is not meant as the definitive book on forestry in Puerto Rico. It does offer an overview of the rich history found in Puerto Rico's forests and the untiring efforts of foresters and scientists in shaping island conservation up to the present and into the future. Interspersed within the text, highlighted in green, are sidebars of interest about related flora and fauna, biographies, anecdotes, and events. The first edition of Passing the Baton is being published in English so that others in the USDA Forest Service and outside Puerto Rico can learn about what is happening here in the tropics; later, it will be translated into Spanish. To learn more about Puerto Rico's forests and forest conservation, please refer to the recommended reading list at the end of the book.

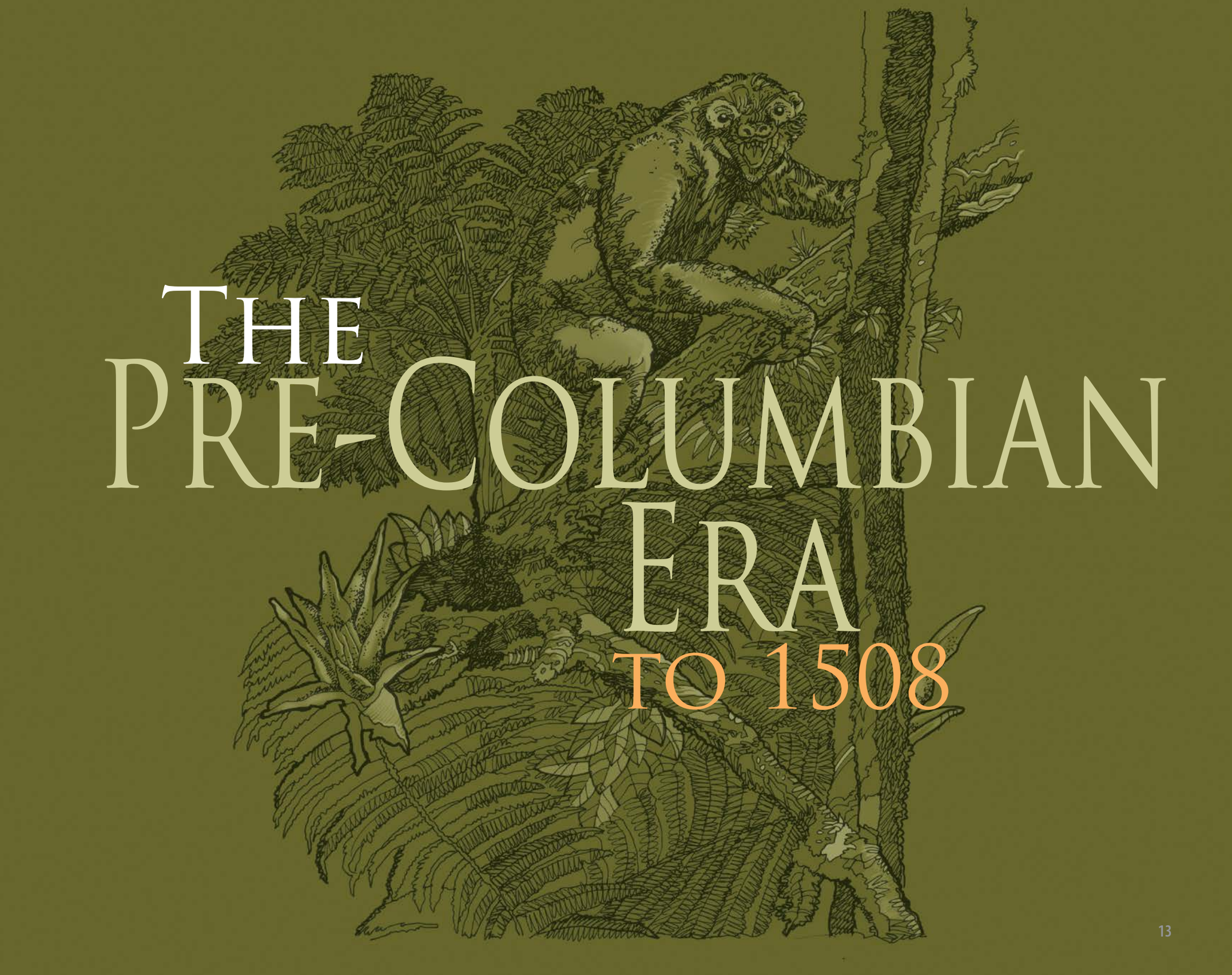
As the book was being prepared for publication, the official name of the Caribbean National Forest was changed to El Yunque National Forest in 2007. The former name, used for most of the 20th century, has been kept when referring to that time period. See the table on page 4 for a list of the official names that have been used for the USDA Forest Service, El Yunque National Forest, and the International Institute of Tropical Forestry. The table also lists the dates the names were changed.

Introduction

Ariel E. Lugo, Director, International Institute of Tropical Forestry

This book contains a brief history of the U.S. Department of Agriculture (USDA), Forest Service in Puerto Rico. We wrote the book to celebrate the centennial of the agency and to draw attention to the role of the USDA Forest Service in the conservation of natural resources in the tropics. To tell the story in its proper historical context, we begin in prehistory, because El Yunque, now under the custodianship of the USDA Forest Service, has awed and influenced even the earliest of the island's inhabitants. The story also takes us to an overview of some 400 years of Spanish rule that ended in the 19th century, when numerous conservation actions were implemented by the Spanish authorities. USDA Forest Service activities on the island actually date back more than 100 years. Foresters from the Bureau of Forestry were active in Puerto Rico since just before the turn of the 20th century, and the national forest was proclaimed in 1903, before the USDA Forest Service was created in 1905.

The activities of the USDA Forest Service in Puerto Rico mirror those of the agency in the mainland United States, but with two important differences: Puerto Rico is tropical and Hispanic. New conservation methods had to be developed and implemented in a culture and physical environment different from those the agency was accustomed to on the mainland. It took people of great wisdom, character, and vision to adapt USDA Forest Service stewardship principles to the tropics. Today, those of us responsible for carrying on the mission of the USDA Forest Service in a new century are inspired by what our predecessors were able to do under the most difficult of circumstances. For this reason, we dedicate this book to all USDA Forest Service employees who dedicated their productive lives to "caring for the land and serving people" in Puerto Rico.



The Pre-Columbian Era

to 1508

Chapter I

The Prehistoric Island

to 1508

Chapter I
The Prehistoric Island
to 1508

Jeff Walker, Archaeologist, El Yunque National Forest

Recent archaeological discoveries suggest that as early as 5,000 years ago humans began to settle the island of Puerto Rico. The earliest groups may have come from Florida or Central America. They lived a nomadic, communal life, hunting and gathering the resources around them. By the start of the first millennium, Indian groups from South America were traveling around the Caribbean islands in long, dug-out canoes. These Indians were farmers, stoneworkers, and potters. In Puerto Rico, three distinct phases of pre-Columbian culture evolved. The most advanced, that of the Taínos, appeared around 1100 A.D. The Taínos built thatched huts, slept in hammocks, spoke a common language, and participated in a common social and political system. These were the Indians Columbus glimpsed when he first landed in Puerto Rico, then called Borinkén, in 1493.

5000 B.C.–300 B.C.

Archaic Culture

The first people to reach Puerto Rico were the Chiboney or Archaic groups; they may have arrived as early as 5000 B.C. from Central America. Materials left by these indigenous groups, consisting of stone artifacts, such as chips and scrapers, and food remains, such as shells and bird and fish bones, indicate their livelihood was based on fishing, gathering, and hunting. Evidence suggests they also used a wide variety of cultigens, including maize.

Skyline of the Luquillo Mountains in eastern Puerto Rico and a zoomorph *cemi* from the Taíno culture, showing the similarities between the land formation and the Taíno artifact (2006).

Untouched

When we look within today's political boundary of the Caribbean National Forest for signs of pre-Columbian cultures, we discover a curious pattern. Five recorded pre-Columbian petroglyph sites are within the forest, and probably dozens more are yet to be discovered. Sporadic evidence exists of prehistoric use of the lower rain forest, but not one single site has been recorded where Indians actually lived within the entire forest boundary. In the lower, drier valleys and foothills of the Luquillo Mountains are dozens of prehistoric habitation sites and many more petroglyph sites.

Why were these mountains never settled?

The begonia flower, commonly found in humid areas, is native to the Luquillo Mountains (2005).

Petroglyph Patterns

The petroglyphs found in the Luquillo Mountains are primarily anthropomorphic, although most of the motifs are not realistic portrayals of humans. The most common motif, with perhaps hundreds of them at sites in the region, is a simple circular face with round pits representing the mouth and eyes. Less common motifs are complex faces with detailed eyes, mouth, and face treatment and with elaborate crowns, ear pools, and "beards." Also widespread throughout the region are perhaps a dozen glyphs of the "wrapped ancestor" motif, consisting of a face atop an elongated cross-hatched body. Geometric patterns, such as spirals, are represented at only a very few sites, and zoomorphic representations, such as frogs and a sea turtle, are the least commonly represented.

Taíno petroglyph, Río Espíritu Santo (2006).

1430 B.C.–250 B.C.
La Hueca Culture
The Hueca culture, which probably originated in the Andean regions of Bolivia and Peru, was the first phase of the island's settlement by groups of farmers-potters. Their subsistence revolved around fishing, hunting small animals, and agriculture. The cultivation of root crops, such as *yuca* (manioc), allowed them to establish villages, which remained inhabited for hundreds of years.

430 B.C.–800 A.D.
Saladoid Culture
Another early group of farmers-potters to arrive in Puerto Rico was the Saladoid culture (also known as Igneri culture). This indigenous culture, originally linked to the Arawaks, migrated from the Orinoco-Amazon area of South America. They mostly settled along the coastal plains, near mangrove forests and estuaries. They established an extensive network of villages characterized by *bohíos* (large collective huts).

460 A.D.–1000 A.D.
Ostiones Culture
During the time of the Ostiones culture, a significant growth in towns and villages occurred. Settlements spread along the coastline and also into the mountains and interior valleys of Puerto Rico. The Ostiones made extensive use of shells and other marine remains to manufacture hatchets, chisels, plates, spoons, and personal ornaments. This transitional culture showed the first elements that later characterized the Taíno culture, elements such as stone *cemís* (mythico-religious effigies), *bateyes* (ball courts), larger settlements, and intensified agriculture.

Modern-day interpretation of Taíno culture during the Indigenous Festival of Jayuya, an annual event held in a small mountain village in central Puerto Rico (2006).

Settlements

Archaeologists classify the Taínos and the Indians who came before them as agriculturalists, but their survival also depended on fishing, hunting, and shellfish gathering. The primary staple of the Taíno diet was *yuca* (manioc)(Manihot esculenta), a root crop brought to the Antilles from South America. It was usually consumed as cassava, unleavened bread that involves a complicated preparation process to extract toxins. According to the Spanish chroniclers, the Taínos also grew corn, beans, squash, sweet potatoes, peppers, peanuts, pineapple, calabash, cotton, tobacco, and tubers. It is unclear to what extent they cultivated native fruit trees.

For the most part, the Taínos relied on hunting, fishing, and collecting fresh sources of animal protein. They did not produce much protein by rearing domestic animals nor by growing many protein-rich plants. It was essential that they actively hunt birds, turtles, lizards, and snakes from the forests and exploit crab, sea turtle, shellfish, and fish from the island's streams and rivers, mangroves and estuaries, and seashores and reefs.

In addition to serving as vital sources of protein, the forests provided the Taínos with logs for canoes, all of their house-building materials, and most of the material for their tools and furnishings. The forests also provided incidental and seasonal sources of fruits, nuts, and edible and medicinal plants.

Many of the Taíno settlements were strategically located on the coastal plain, a short distance from the essential maritime resources and the equally essential forest resources. The larger settlements

were located along major rivers or on the coast at the mouths of rivers, which provided an essential supply of fresh water and other river resources.

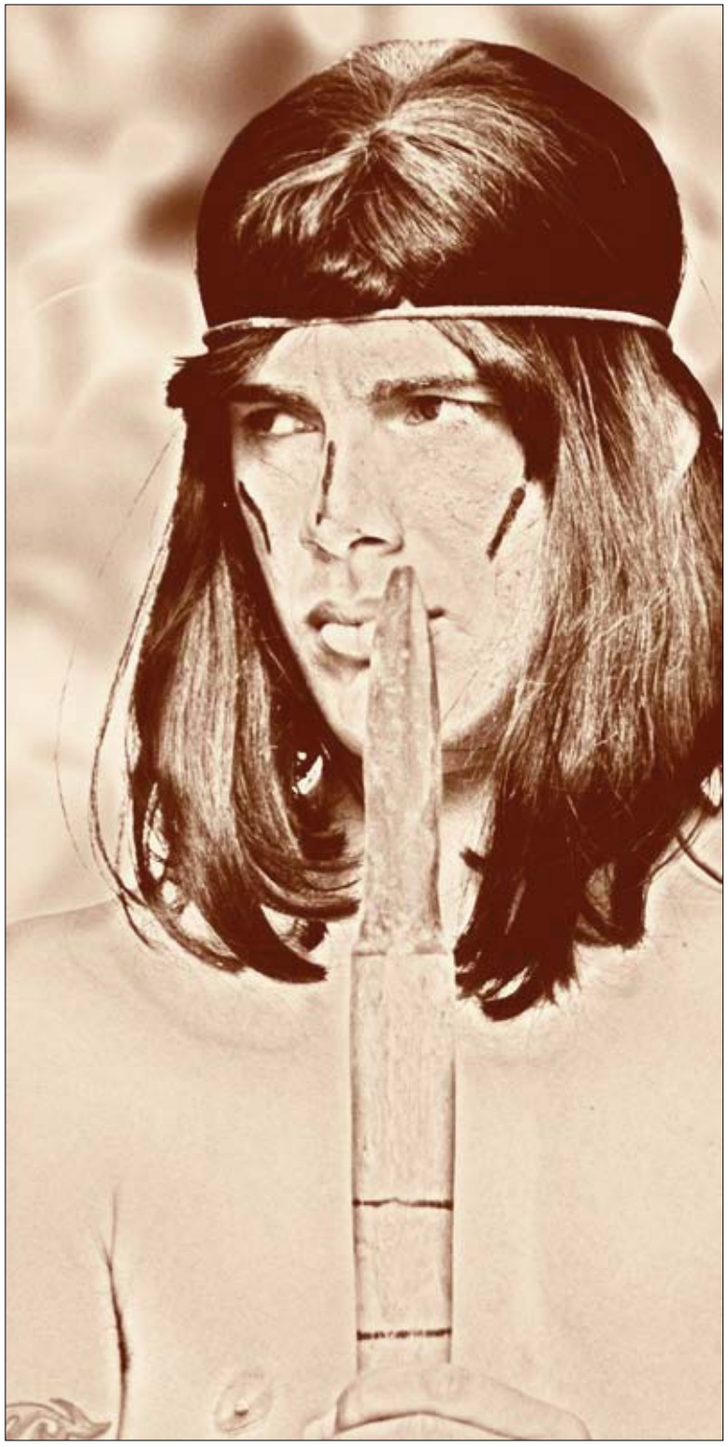
Because the Taínos relied heavily on the forest, we must assume their knowledge of and relationship to the rain forest was comprehensive and profound.

Secondary Forest

The question then becomes—"If the pre-Columbian inhabitants of the island interior were so dependent on a broad range of forest resources for their survival, why didn't they live deep within the primary forests?"

The response is—" At one time they did." When the island was first colonized by small groups of nomadic, preceramic people, the coastal plains were most probably dense forests similar in many ways to the midslope forests of today. The archaeological record shows that these nonagricultural, coastal-oriented people minimally affected the forest vegetation. Their hunting practices, however, drastically affected the forests' fauna, with ground-dwelling and ground-nesting bird populations being hardest hit.

The subsequent waves of pre-Columbian people who migrated to the island were agriculturalists. The earliest immigrants began settling coastal sites and, after several centuries of growing populations, they expanded inland to interior valleys and foothills. Most agricultural crops cannot thrive under dense forest canopy, so around each settlement these farmers cleared the forest. In regions with poor soils, crop productivity dropped off after several years, so it became necessary to clear more forest to create new agricultural plots. Eventually, they abandoned the original plantings. This practice ultimately must have felled much of the original forests. As forests slowly grew back, a pattern of staggered stages of forest succession surrounded each settlement. For more than 15 centuries, the Indian population grew and settlements expanded throughout the island. The practice of clearing forests to create agricultural plots in all probability resulted in most of the original forests on the island's coastal plain being cut, leaving large tracts of secondary forest in various stages of growth.



Modern-day participant in Puerto Rico's Indigenous Festival of Jayuya (2006).

1100 A.D.–1500 A.D.

Taíno Culture

Taíno culture was the first indigenous group in the West Indies to come in contact with the Europeans. The Taínos (meaning "good") were the most dominant cultural group inhabiting Puerto Rico, Hispaniola, and Cuba at the time of the Spanish conquest. The Taínos, hunter-gatherers, lived in small villages led by a *cacique,* or chief. Even though they had a limited knowledge of agriculture, they grew pineapples, manioc, and sweet potatoes and supplemented their diet with seafood. They called the island Borinkén, which means "The Land of the Mighty Lord."

■ ***circa* 1000 A.D.**
This 1,000-year-old large stone celt (prehistoric axe) found in the lower forest was possibly used by a Taíno Indian to fell a tree, fashion a canoe, or use as a house post. In addition to exploiting the lower tabonuco forest type for its wood, the Taíno Indians and their predecessors visited the rain forest to cut vines and palm fronds, which they used to make baskets and roofing thatch, collect fruits and roots, and gather medicinal plants. (Found close by on private forest by Ronald Garrison Robertson.)

Lack of Settlements

An archaeological site known as Barrazas, located along the western edge of the Luquillo Mountains, is, at 100 meters, one of the highest elevation pre-Columbian habitation sites on record in the region. This contrasts markedly with the location of prehistoric sites in the mountainous interior of central Puerto Rico. In places like Jayuya, Utuado, and Cayey, settlements are common at well over 100 meters, with extreme examples as high as 800 meters above sea level.

Why did the Taínos establish settlements at higher elevations in the island's Central Mountains while avoiding those same elevations in Luquillo?

Several reasons are possible. First, the midslopes and upper reaches of the Luquillo Mountains may have been too wet for habitation. Even on the lower slopes, rainfall is as great as or greater than elsewhere on the island. At higher elevations, precipitation exceeds the island's other mountain regions by as much as 100 inches annually, almost double in some cases. In addition, the soils on the slopes of Luquillo are classified as some of the poorest agricultural soils possible. They are dense, with poor drainage, and full of rocks. The Taínos' staple root crop of *yuca* is better adapted to drier, well-drained areas, which would have been a crucial factor in deciding where to live. Nevertheless, midslope areas deep within the Luquillo Mountains were inhabited and cultivated by subsistence farmers centuries later, and it is clear that at least some crops can be grown. At the highest, wettest, steepest elevations, no agricultural plots ever existed.

The Taínos may have preferred the lower forests and coastal forests because they were more diverse. The lower elevation forests of the Luquillo Mountains, particularly the forest where tabonuco trees were predominant, would have provided a much wider variety of plant and animal resources than the higher elevation forests. At the same time, the climate would have been more favorable and the forest itself would have been more open and, therefore, more "walkable" beneath the canopy. The advantages of the lower forests are particularly apparent when contrasted with the dense and impenetrable elfin woodland on the highest peaks.

A final possibility for the absence of prehistoric settlements high within the Luquillo Mountains is somewhat more conjectural but, nonetheless, a very strong possibility: The mountain range and its high peaks may have been sacred to the pre-Columbian people, and it may have been considered dangerous or forbidden to visit them.

Batey (ball court) at the Caguana Indian Ceremonial Park near Utuado (2007).

Forest Resources Used by the Taínos

Resource	Use
Jobillo, maricao, icacos, ausubo, jagua	Wild fruits, in season, for eating
Coroso palm, icacos	Wild nuts, for eating
Ñame, yautía, lerenes	Roots/tubers, for eating
Resins and gums	Tabonuco for incense, resin torches; cupey seed pod for adhesives, sealants for canoes
Vines (bejucos), emajagua bark fibers	Cordage, hammocks, string, rope, building ligatures for houses
Vines, canes, palm fronds, bark	Basketry materials
Palm fronds, grasses, vines	Roofing thatch and ties
Timber/wood	House posts, beams, and roof members; canoe logs and paddles; furniture (dujos); wooden utensils (platters); wooden tools (macana, coa); ceremonial objects (idols, containers); musical instruments (rattles, drums); firewood
Gourds (higüeras)	Storage containers, bowls, utensils, water jugs, serving vessels; rattles (maracas)
Birds and bird eggs, hutía, fish, eels, crawfish, land crab (buruquena), nerite snails, land snails, and snakes	Variety of food, for eating
Ortiga, verbena, guaco, tabonuco resin	Medicinal plants, for healing
Stones	Cutting tools, hammers, pounders and choppers, firedogs, stone beads and adornos, ceremonial three-pointers, and stone collars

Geographical Bearings

The Luquillo Mountain Range (Sierra de Luquillo) is the easternmost range in Puerto Rico, rising from the island's eastern coastal plain. Covered with rain forest, it is drained by the Gurabo and Blanco Rivers on the south; the Río Fajardo on the east; and the Sabana, Mameyes, and Espíritu Santo Rivers on the north. The rain-drenched massif extends westward to the Caguas Valley, where it is drained by the eastern tributaries of the Río Grande de Loíza. The Caribbean National Forest encompasses a few foothills, most of the upper slopes, and all the peaks of the Sierra de Luquillo—El Yunque, East Peak, West Peak, Mt. Britton, La Mina, El Toro, El Cacique, and El Negro.

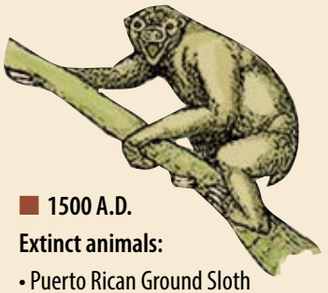
1493 A.D.
Christopher Columbus and his crew, during their second voyage of discovery, became the first Europeans to set foot in Puerto Rico. At the time, the island was populated by as many as 50,000 Taíno Indians.

The population of the Puerto Rican parrot was estimated at one million.

A chromolithograph made by the Prang Education Company, depicting Columbus claiming possession of the New World somewhere in the Caribbean (1893).

Second Voyage of Columbus 1493 to 1496

Views that Columbus could have seen during his second voyage in November 1493, when he discovered what is known today as Puerto Rico: small mangrove island (left), sunrise over Guánica Bay (center), tropical dry forest (right) (2006).



1500 A.D.
Extinct animals:
- Puerto Rican Ground Sloth
- Puerto Rican Paca
- Lesser Puerto Rican Agouti
- Greater Puerto Rican Agouti

This Spanish olive jar was made between 1490 and 1570, the time of initial European exploration and colonization of the Americas. In this jar, a Spaniard exploring the mountains may have carried food, or possibly mercury to process and validate the gold he hoped to find. (Found by Dr. John Thomlinson of the Institute for Tropical Ecosystem Studies, University of Puerto Rico, while conducting research in the elfin woodland forest type.)

Petroglyphs and Shamans

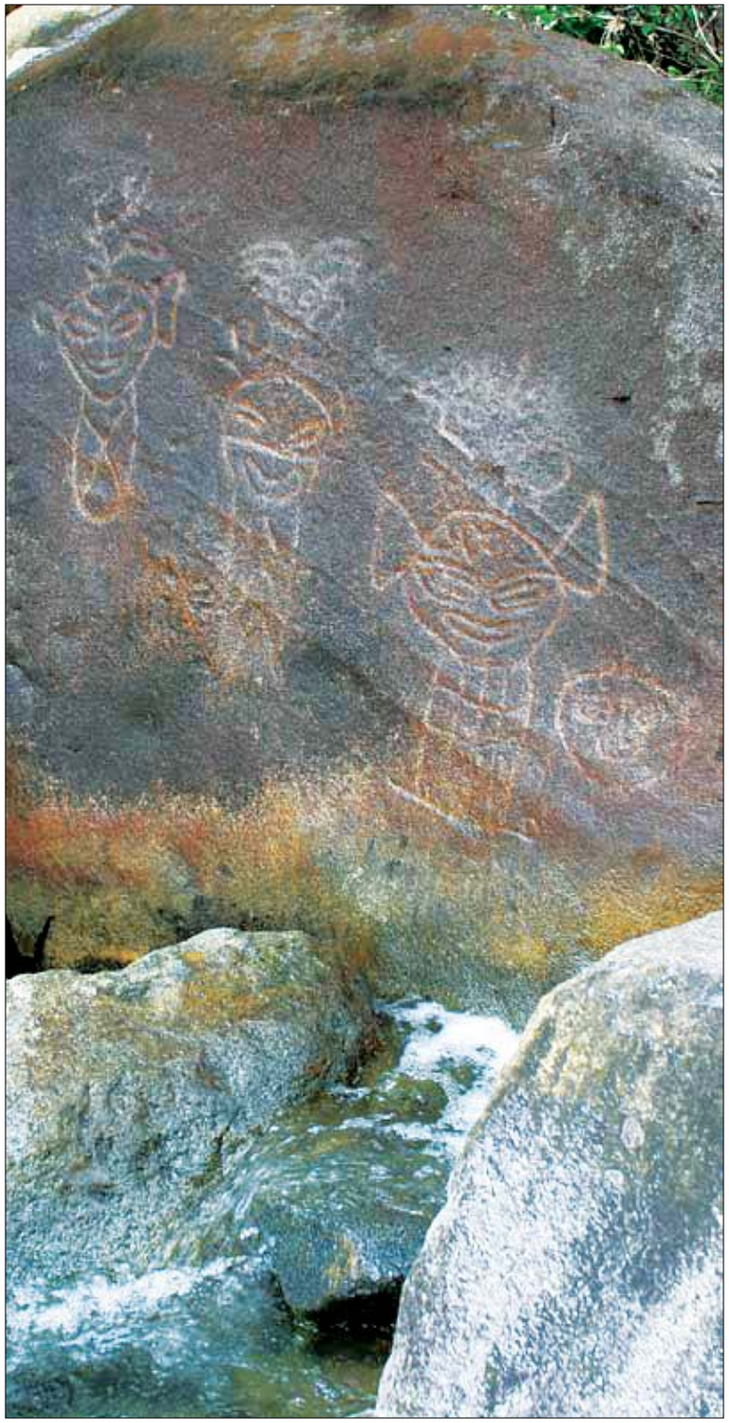
The only Taíno sites found within the boundaries of the Caribbean National Forest are petroglyph sites, and all petroglyphs occur in sacred contexts. In the area of the lower Río Blanco on the southern side of the mountains are nearly a dozen distinct petroglyph groupings, with carvings that range from simple faces to spirals and complex frog figures. The striking variety in styles is noteworthy. It almost certainly resulted from different types of use, possibly by distinct cultural groups, and/or during different periods of time. We must conclude that, for much of the island's prehistory, the populations considered this entire river system to be a sacred and spiritual landscape.

The Río Blanco complex covered a large area and was out in the open. Most of the petroglyph sites in the forest, however, are small, confined to several square meters on a single boulder, or covering the walls of small rock shelters. Virtually all are found close to running water. For what were they used?

Much like today, the "deep forest" on the middle and upper slopes of El Yunque, along El Cacique, El Toro, and East peaks, must have been a remote, menacing, and perilous realm. The dangerous, dense forest contrasted sharply with the commonplace and safe domestic world of the settlement, with its very open ball field and sunny surrounding fields. Incursions into the deep forest were few and, by all indications, were made only by those equipped with the proper spiritual fortitude to venture into that dark, ominous, and foreboding territory. It was the *behique,* the Taíno shaman, who grappled with the complex and dangerous spirit world. By entering that world, interacting with the spirits, and conducting sacred ceremonies and rituals, he would, after time, have pacified the more malevolent spirits lurking there. The *behiques* almost certainly created and used the petroglyph sites found in the Luquillo Mountains. Two basic types of sites are those that were enclosed and private and those that were open and public in nature.

The open-air public sites could have accommodated literally hundreds of people. We presume they were used by larger audiences for communal performances of public rituals. A variety of those sites are scattered around the island, some with as many as several hundred petroglyphs on different boulders and rock formations,

Taíno petroglyph in the Luquillo Mountains in eastern Puerto Rico (2003).



Taíno petroglyph on the Río Blanco near Naguabo in the Luquillo Mountains in eastern Puerto Rico (2005).

such as the sites along the lower Río Blanco. These petroglyphs were probably part of a ritual theater, presumably coordinated by the shaman for the benefit of the crowd.

Some of the private sites were small, possibly used for burial or storage, while others could accommodate up to 20 people. The presence of a limited number of individuals suggests the larger private sites might have been for restricted societies practicing ceremonies closed to nonmembers. These ceremonies could have included divination rites or hallucinogenic journeys to the spirit world induced by the cohoba plant.

Inward and Upward

As prehistoric populations grew, and nearby forest plant and animal resources became depleted, it would have become necessary to travel deeper and deeper into the forest to find game, house timber, canoe logs, basketry materials, medicinal plants, and other essential forest products. As the exploitation progressed deeper and deeper into the woods, and it became necessary to walk farther and farther inland to gather the resources, eventually it would have become more practical to move closer to these resources and establish a new settlement nearer the hinterland. Such a venture would necessarily have required the intervention by the behique on behalf of the group to pacify the dangerous spirits. Only then could the area safely be occupied by the rest of the more spiritually vulnerable community members.

At the close of the 15th century, were the Taínos making their way to the higher reaches of the Luquillo Mountains? Were the behiques preparing the way with their numerous petroglyph sites? Or were the mountain peaks considered sacred, the abode of the gods, and thus taboo to human settlement?

With the arrival of Spaniards, the Taíno period ended. Those questions may never have answers.

For a glimpse of the island forests as they were before the populations of pre-Columbian and Spaniard settlers altered them, visit the upper slopes of El Yunque National Forest.

1501 A.D.
The Spanish Crown permitted the export of slaves to America.

1508 A.D.
Juan Ponce de León, who accompanied Columbus and worked to colonize nearby Hispaniola, was granted permission by Queen Isabella to explore the island. On a well-protected bay on the north coast, he founded Caparra, where the island's first mining and farming began.

The Spanish Era

1508 to 1898

Chapter II

The Early Centuries

1508 to 1823

Chapter II
The Early Centuries
1508 to 1823

Carlos Domínguez Cristóbal, Historian,
International Institute of Tropical
Forestry

In 1508, explorer Juan Ponce de León and a small band of settlers sailed from Hispaniola (today's Dominican Republic and Haiti) to establish a colony in Puerto Rico. The settlers traveled counter-clockwise around the island until they reached the large bay on the north coast that we know today as San Juan Bay. Along the way, they were impressed by the richness of the island–thick mangroves along the coast, forested plains and grassy savannas, and blue-green mountains forming the steep Cordillera Central. As the men established their first settlement, they cut down trees to make a fort and cleared land for agriculture. These cuttings represented the first island deforestation by Europeans. For centuries, the view of most of the island to new arrivals was little changed. Puerto Rico was a sparsely populated outpost, where military matters were first and foremost, commercial development languished, and most of the forests endured.

1508 A.D.
Spanish colonization began in Puerto Rico.

Juan Ponce de León founded Caparra village.

First school was established in Caparra.

1509 A.D.
Spanish authorities refused to grant Diego Columbus (Christopher's son) privileges to all discovered land.

1510 A.D.
Taíno chieftain Urayoán ordered his warriors to drown Diego Salcedo to determine whether the Spaniards were inmortal.

1511 A.D.
Realizing the Spaniards did not have divine powers, the Taínos staged an unsuccessful revolt.

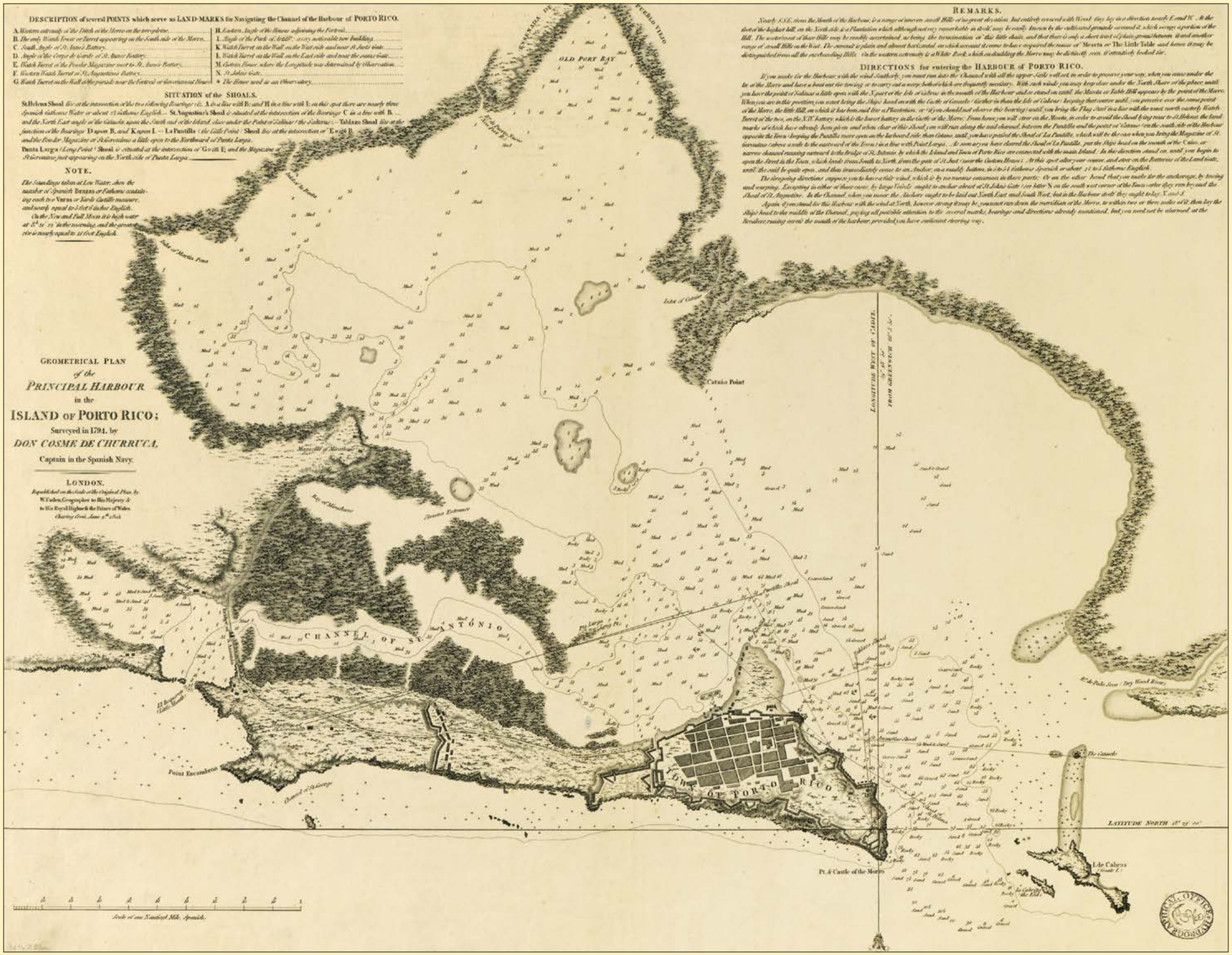
1511 A.D.
King Ferdinand approved the Puerto Rico Coat of Arms.

Modest Economy of Gold and Sugarcane

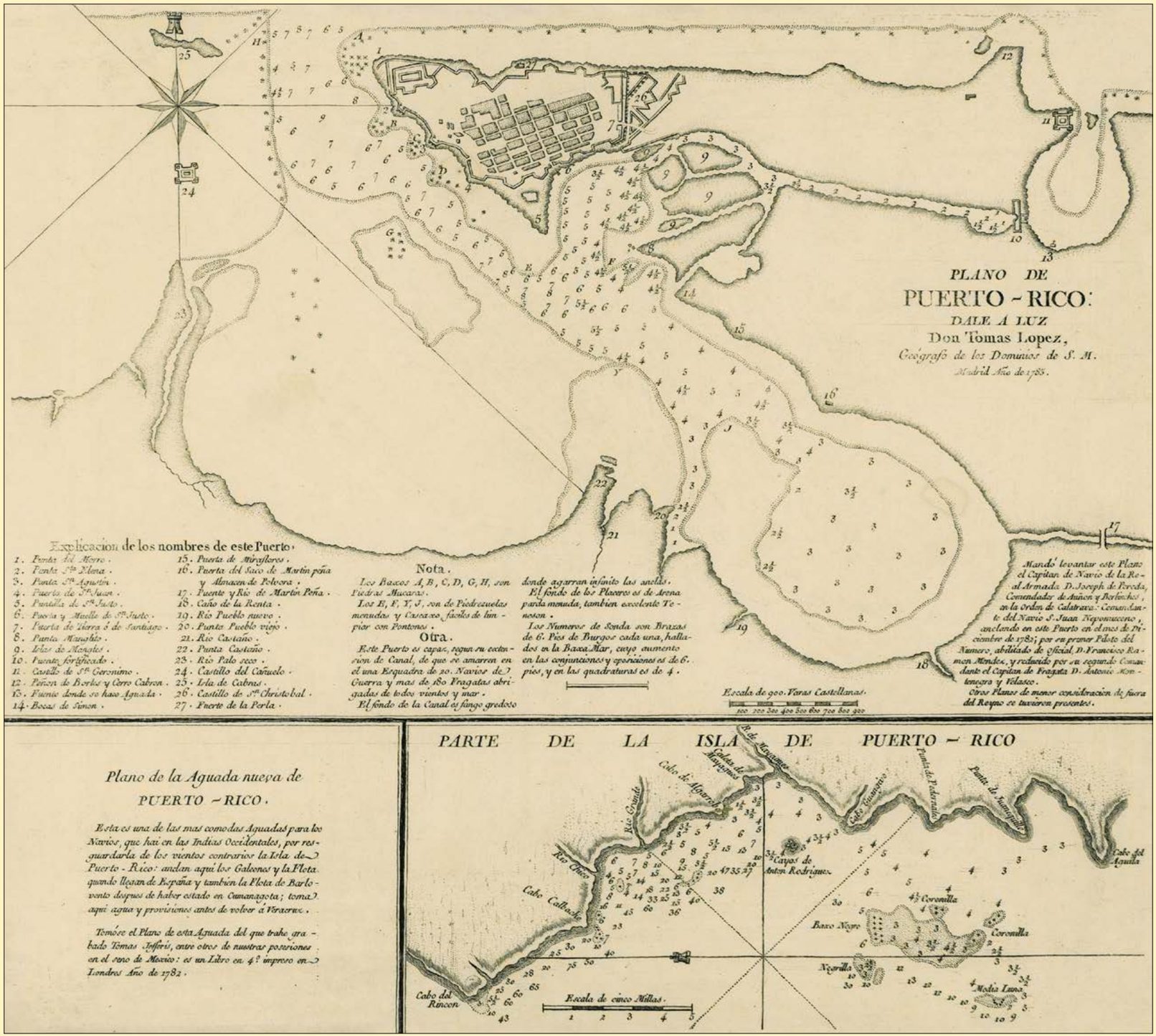
Visions of vast gold deposits danced in the heads of all New World settlers, and Puerto Rican settlers were no exception. The first Spanish explorers to enter Puerto Rico's forests did not care about the rich woods or oversized leaves; instead, they were looking for gold nuggets in the streams and rivers. In the first decades of the 1500s, gold ran the island's fledgling economy, and miners fanned out around the island. Remote Mount Guilarte in the western Cordillera Central got its name from two miners in the region: one died, and their plight became a popular legend.

Unfortunately for the miners, gold deposits were small in Puerto Rico. Colonists soon realized they had to leave the island—and pay dearly if they were caught—or turn to more mundane livelihoods to survive. Some grew tubers and other subsistence crops. Others returned to the forests to hunt down feral livestock that had been let loose decades earlier. Raising livestock, harvesting ginger, and cultivating imported sugarcane became the occupations that turned the economy. Sugarcane production proved the most promising, but it initially benefited only a few.

The colony endured, but it did not prosper, and it was often bypassed by Spanish ships sailing to more lucrative ports. For centuries, European goods were in scarce supply, and colonists had to make do with local resources. The first official chronicler of the Americas, Gonzalo Fernández de Oviedo, praised the woods of two island trees, the guayacán *(Guaiacum officinale)* and the tabonuco *(Dacryodes excelsa)*. Other early commentators noted local fruit trees, the availability of land for agriculture, and the abundance of timber trees in the Luquillo region. The seagrape *(Coccoloba uvifera)* became known as the survival shrub for shipwrecked sailors, who made use of its fruit, leaves, and wood. The leaves of the cupey *(Clusea rosea)* were used as a substitute for paper, which was rarely available.



A historic map of the "Principal Harbour in the Island of Porto Rico," surveyed in 1794. The island of Porto Rico in this map is known today as Old San Juan. (Notice that the map is drawn upside down, with Old San Juan to the south and the bay to the north.)

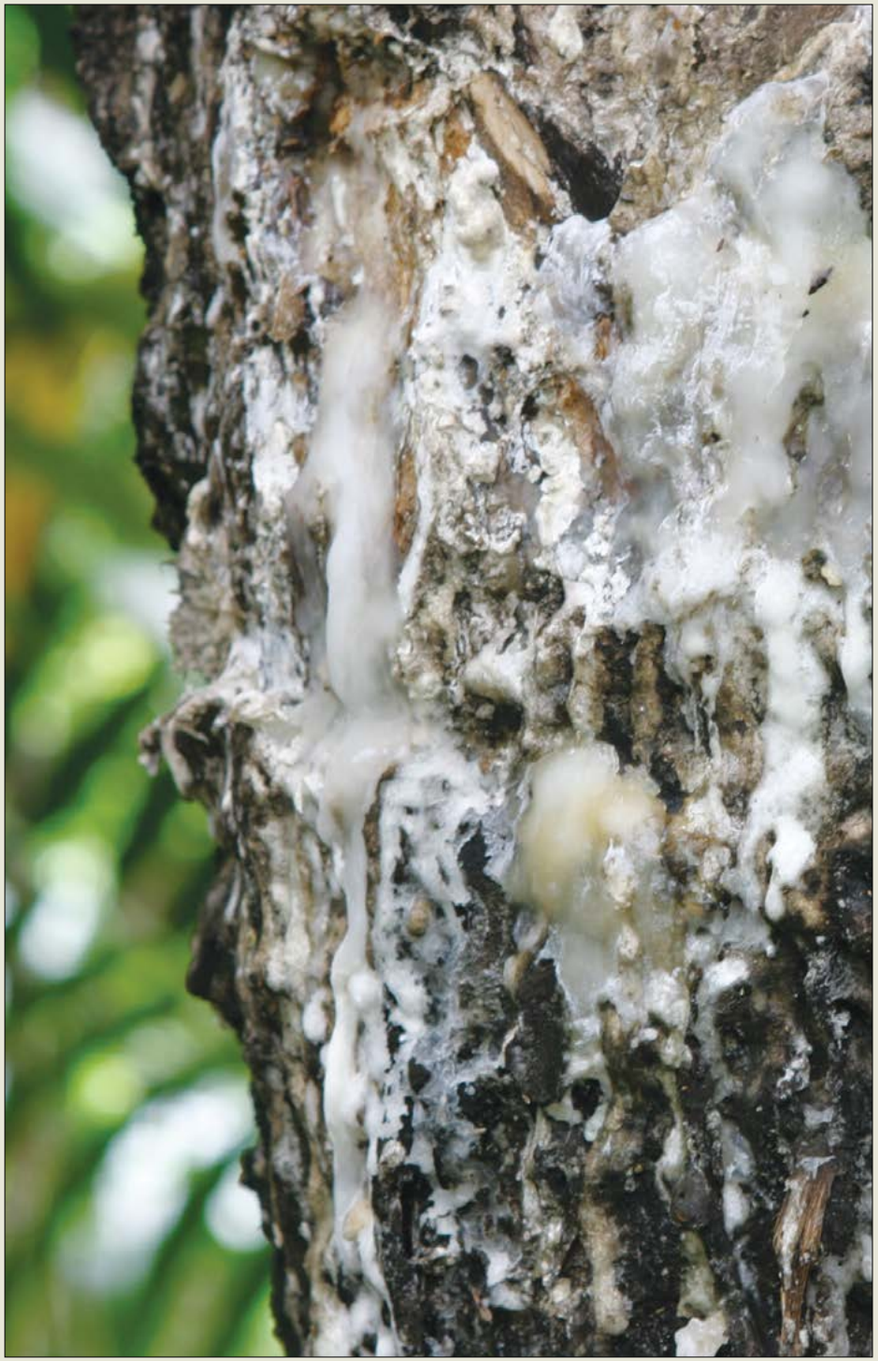


A historic map of Puerto Rico on the island of San Juan Bautista de Puerto Rico, drawn in 1785. Today, this island is known as Old San Juan.

Tabonuco

Known in the Lesser Antilles as gommier and candlewood, tabonuco *(Dacryodes excelsa)* is one of the dominant trees in the lowland forests of northern Puerto Rico. This magnificent tree grows tall and straight with a smooth white bole, usually spotted with the growth of lichens. Tabonuco is one of the best timber trees on the Caribbean islands. Its wood is used for all types of furniture, cabinetwork, interior trim, general construction, and carpentry. Tabonuco also has many other uses, such as providing a clear, fragrant, and inflammable resin that hardens and turns white on exposure. This resin has many uses, including making candles and torches, caulking boats, and formulating incense and medicine.

Tabonuco trees are "unionized;" that is, groves of trees are interconnected by roots that graft them into a tightly knit community that shares nutrients and organic matter. The union enables tabonuco trees to survive on ridges where conditions for tree growth are optimal, but where winds can be devastating during hurricanes. Because the trees are interconnected, when a tree loses its canopy, it receives nourishment from others that survive. At one time, the tabonuco grew throughout Puerto Rico at low elevations, and the parrot used its fruits as a food source. Today, both the parrot and the tabonuco have a reduced distribution throughout the island.



A contemporary view of tabonuco tree resin (2005).

1513 A.D.
Escaped Taíno slaves who were opposed to outsiders invading the forest destroyed Santiago de Daguao, a settlement near present day Naguabo founded by Christopher Columbus's son Diego to exploit gold in the nearby rivers.

1514 A.D.
The Spanish Crown granted permission for Spaniards to marry native Taíno Indians.

1519 A.D.
The government moved from Caparra to today's Old San Juan.

1522 A.D.
San José Church was founded. Today, it remains the oldest church still in use in the Americas.

1530 A.D.
Sugar became the island's most important agricultural product.

Farmer Cristóbal de Guzmán was killed by Taíno Indians, who also destroyed his farm on the banks of the Mameyes River in opposition to settlement of that forested area.

1542 A.D.
The coconut tree was introduced to the island.

1576 A.D.
Hurricane San Mateo struck Puerto Rico on September 21, on the feast day of St. Matthew.

1582 A.D.
Taíno Indians still surviving in the Luquillo Mountains delayed deforestation of the valleys of the Espíritu Santo, Fajardo, Sabana, and Río Grande Rivers.

1587 A.D.
Engineers Juan de Tejada and Juan Bautista Antonelli planned the main design for the fortress at El Morro.

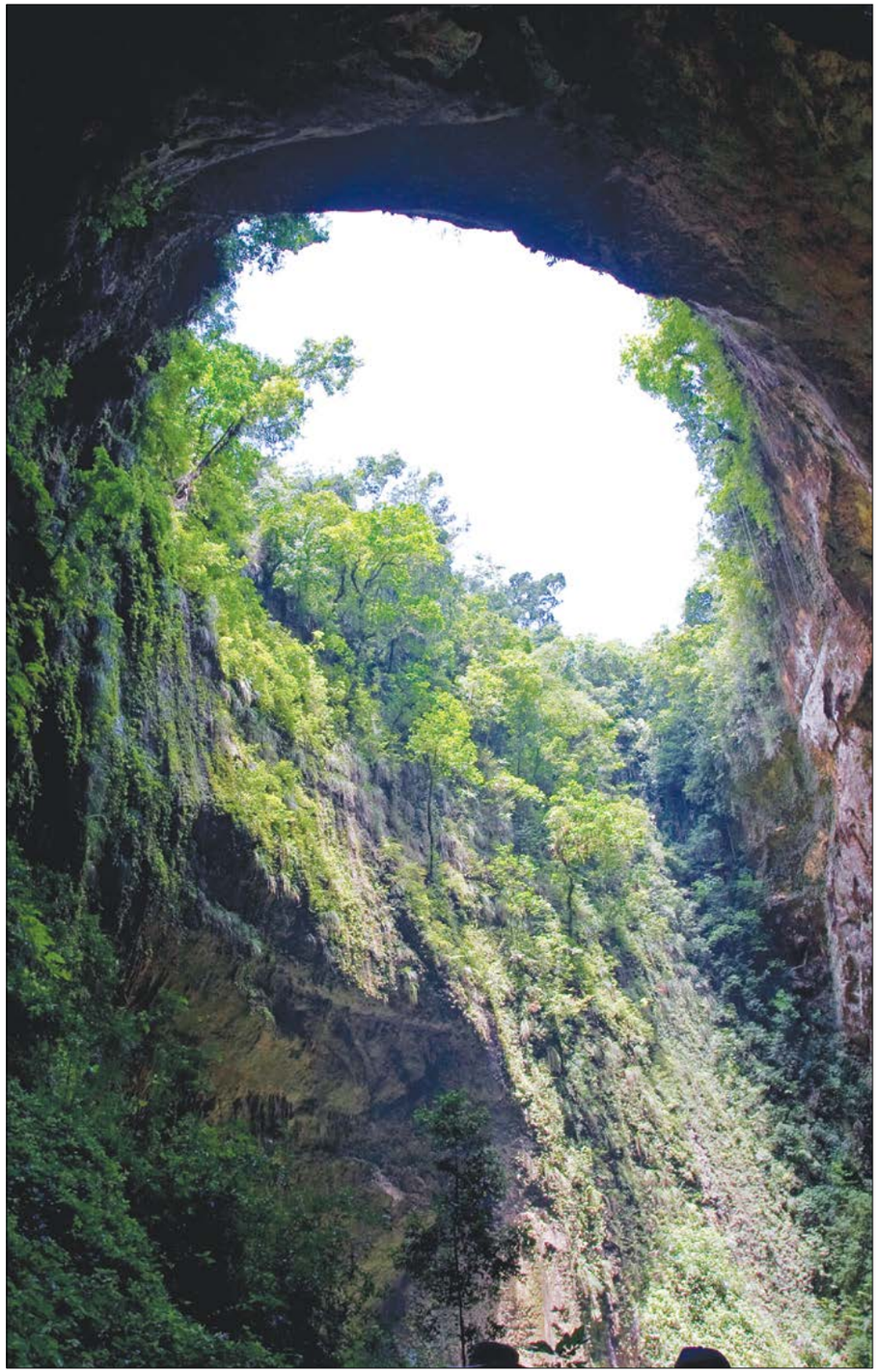
The Forests as Refuge

Being relatively cool, forests became a place where new arrivals from Spain—be they humans, animals, or plants—acclimatized to the tropics. An agricultural experiment station was established at Toa, "to the west" of San Juan.

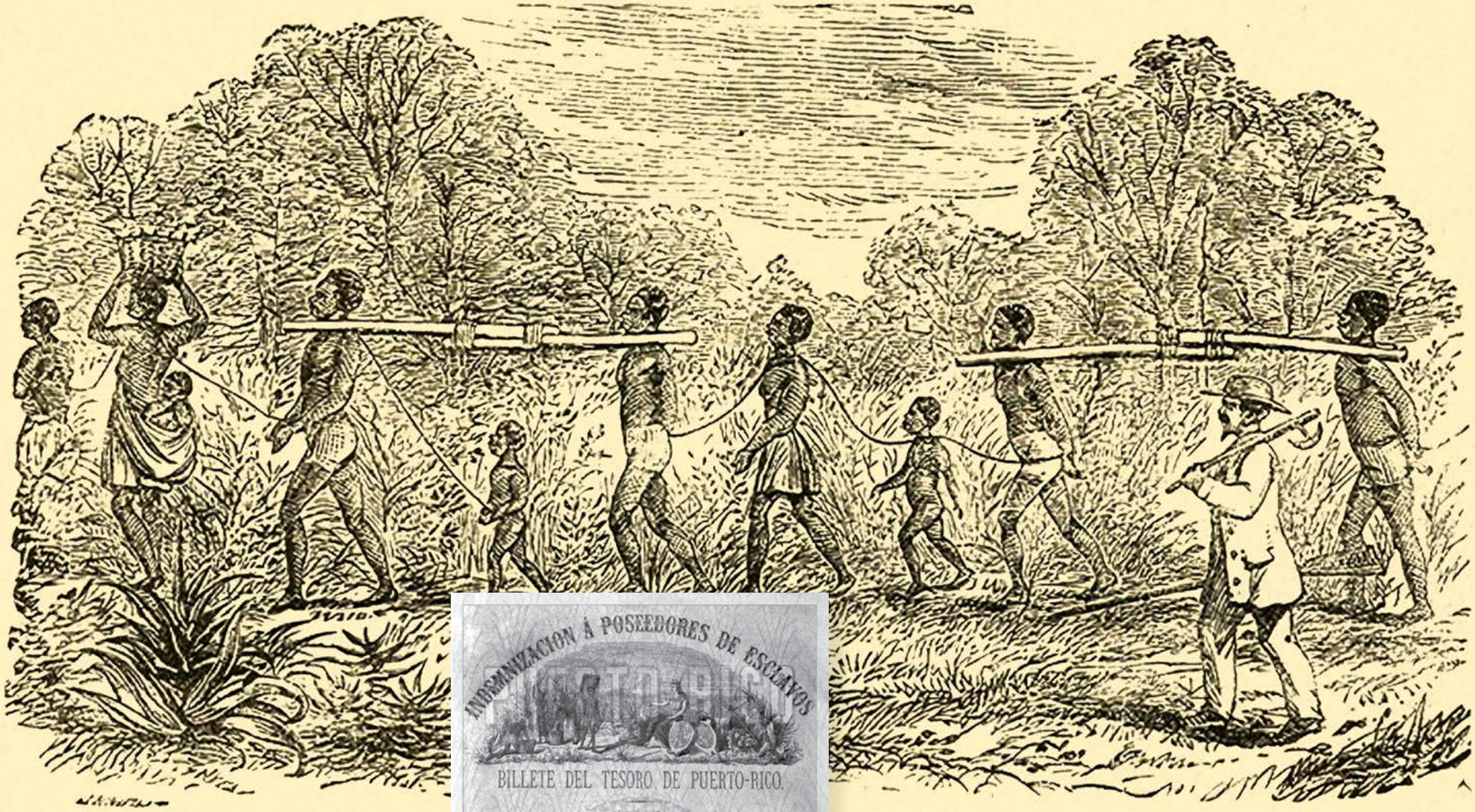
Forests also became a place of refuge. Initially, the indigenous Taínos welcomed the Spaniards, but they soon began to suffer from the conquistadors' harsh demands. Many escaped into the forests, from where they attacked the fledgling settlements. Yet their cause was hopeless. Within decades, most Taínos had died of disease or unaccustomed labor. Survivors lived primarily in the forests.

Slaves were soon imported from Africa to take the place of the Taínos in the fields. Many looked longingly at the scarcely penetrable forests surrounding them, and a few were fortunate enough to escape. Bands of these slaves, called *cimarrones,* shared the forests with the Taínos. Before long, they also harbored disillusioned Spanish soldiers and settlers who wanted to distance themselves from the long arm of Spanish law.

Large trees, common in the forests of Puerto Rico in the 1500s, may have resembled the tree in this 20th-century photo (c. 1930).



Caves such as this one are common in the karst country in western Puerto Rico. Pirates and escaped slaves often used these caves for shelter and as hideouts (2003).



- Slave transport in Africa, engraving from Redenbacher, 1890 (top).
- Indemnity bond paid as compensation to former owners of freed slaves in Puerto Rico (date unknown).

1595 A.D.
On November 22, Sir Francis Drake, hero of the battle of the Spanish Armada, with 26 vessels and in company of Sir John Hawkins, tried fruitlessly to conquer the island and set the city of San Juan on fire.

1598 A.D.
On June 15, the British Navy, led by George Clifford, 3rd Earl of Cumberland, landed in Santurce, conquered the island, and held it for several months. Clifford was forced to abandon his conquest, owing to an outbreak of plague among his troops.

Ginger replaced sugar as Puerto Rico's main cash crop.

1625 A.D.
On September 25, Holland attacked San Juan, under the leadership of Boudewijn Hendrick, besieging El Morro and La Fortaleza and burning the city, but the Spanish repelled the Dutch troops.

1639 A.D.
San Juan Gate was built as the entry to San Juan.

Military Importance

By the end of the 1500s, European powers came to recognize the importance of Puerto Rico as the coveted gateway to the Indies, point of entry and exit to the New World. Enemy vessels roamed the Caribbean, and British and Dutch forces attacked San Juan three times in as many decades. The Spanish colonial government, recognizing the urgent need to fortify its settlement against future attack, put virtually all its efforts into building up the town's military and strategic capabilities. Forts were strengthened and walls were erected around the city. Large amounts of wood were needed for many of these projects, and the forest boundary shrunk ever farther from the city. Among other local trees, ausubo *(Manilkara bidentata)* became renowned for its excellent properties in construction, and its timbers are still seen in the ceilings of many Old San Juan homes. It was also an excellent wood for masts, and Spain prohibited its export to prevent it from getting into enemy hands. Hunters damaged remaining patches of neighboring forests in their search for feral livestock, which supplied meat and leather for a variety of military uses.

The Fixed Regiment of Puerto Rico is a living history group composed of volunteers. This organization is dedicated to educating the public about the life and times of soldiers, militia, and their families in 18th century Puerto Rico. Activities include research, demonstrations, and lifestyle reenactments at living history events (2006).

Fort San Felipe de El Morro (2007).

Recreated typical *caney* (chieftain's home) of the Taíno Indians, at the Caguana Indian Ceremonial Park, in Utuado (2007).

Commercial Lethargy

The all-powerful Andalusian merchants desired gold, silver, pearls, and other lucrative resources, found in places like Mexico and Peru. Their southerly trade route to the Americas bypassed Puerto Rico entirely. While San Juan prospered as a military outpost, other towns on the island languished. Although the colonial government prohibited trade in contraband, most islanders, to have any chance to prosper, had little choice but to carry on such trade. One major exported contraband product was lumber.

Life in 17th century Puerto Rico was difficult for the average settler. Clearing the dense forests for agriculture was back-breaking work. Wood had to be prepared for charcoal, and timber was cut and transported down the mountains for use in furniture. Periodically, settlers had to deal with crippling hurricanes and devastating epidemics, which often left family members dead, homes destroyed, and plantations in ruin. Yet there was beauty in the lush vegetation, and occasional festivities lifted the soul.

1648 A.D.
In San Germán, Porta Coeli Chapel was completed.

1736 A.D.
Coffee was introduced to the island from Santo Domingo.

1582–1788 A.D.
During this time period, four separate explorers described the island of Puerto Rico as entirely covered by forest, especially in the uplands, including the Luquillo region.

1776 A.D.
The Spanish Crown granted Luis Balboa Bertone, a French privateer, four *leguas* of land in the Luquillo Mountains (about 76 square km or 48 square miles). Balboa helped Spain capture the Balearic Islands, for which the King awarded him the title Duque de Mahon-Crillon. Bilbao retained the land until 1829, but part of Naguabo kept the name "El Duque" to modern times.

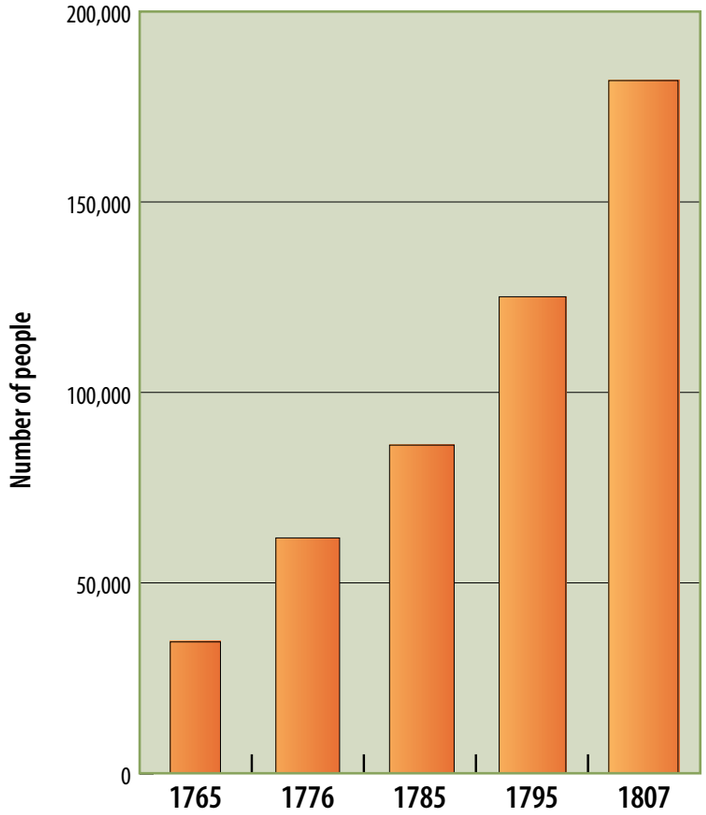
1786 A.D.
The first history of Puerto Rico was published by Spanish priest and historian Iñigo Abbad y La Sierra.

1800 A.D.
The population of Puerto Rico was 136,000.

Fledgling Development

During the 1700s, Puerto Rico began to break out of its lethargy. In the growing enlightenment of the time, Spain enacted a series of reforms within its own government and took a more analytical look at nature and society. The modern-minded engineer Alexander O'Reilly, who came to San Juan to work on its fortifications, also examined other aspects of the island. He made a report on tree species and noted that certain species were already becoming hard to find. He also noted a connection between the destruction of forests and a lack of rainfall. In the 1770s, an energetic friar, Íñigo Abbad y Lasierra, traveled the island and produced its first comprehensive history. In his reports, he described island forests and specific species, discussing their potential for economic and commercial use. Both men looked for solutions to the island's economic difficulties and spoke of the need to free up commerce, distribute land, import slaves, and encourage agriculture.

Higüera, a native fruit, was used by the Taíno Indians for cooking and eating utensils (2007).



Population growth in Puerto Rico from 1765 to 1807.

The island's population rose dramatically during this time. A mere 6,000 inhabitants were recorded in 1700; by 1765, the population had jumped to 44,000; and, by the end of the century, it topped 130,000. Settlements were being established not only along the coast but also in the interior of the island. Towns like Moca and Corozal were named for common trees in the region, yet many of these trees were felled to make way for the towns and the necessary homes. Today, it is hard to find a moca tree in the town that bears its name. Nevertheless, the overwhelming majority of the island remained rural.

In an effort to analyze the island's natural resources, a series of botanical expeditions arrived at the end of the century. Naturalists like André Pierre Ledrú, part of a French expedition, collected woods, seeds, dried plants, and other essentials for classifying species. Ledrú observed forests as old as time on the island, but he also noted the harvesting of contraband wood.

Fray Íñigo Abbad y Lasierra

Fray Íñigo Abbad y Lasierra was a Benedictine monk who came to Puerto Rico in 1771 as secretary to the island's new bishop, Manuel Jiménez Pérez. As he traveled around the island with the bishop, he recorded his observations. He also spoke his opinions, and they were not favorable to the governor of the time. In 1778 Abbad was sent back to Spain, where he began to write about what he had seen. His *Historia Geográfica, Civil y Natural de la Isla de San Juan Bautista de Puerto Rico* (Geographic, Civil and Natural History of the Island of St. John the Baptist of Puerto Rico), released in 1788, is the first published history of the island. It offers useful information about the island's past and a vivid description of Puerto Rico during the 1770s. The history is not only an important document as such but also a beautiful and inspiring literary work. Abbad y Lasierra loved nature and folklore and wrote wonderful descriptions of the landscape and the towns.

A few of Abbad y Lasierra's observations:

- Most ports dealt in contraband goods, and a few towns survived almost entirely on this illegal trade.
- Country homes tended to be of Taíno style, with wood posts to raise them off the ground, walls and roofs of palm fronds tied together with vines, and rustic ladders leading up to the homes.
- To get to the mountain town of Utuado, one had to cross the Río Arecibo 33 times. Its church was in ruins, roads were impassable most of the year, and the people seemed a sorry lot due to their extreme isolation.
- Toa Alta had one of the healthiest climates, and supported a convalescent hospital.
- Toa Baja had the best sugar and rum.
- The church at Manatí was the best-constructed and most spacious.
- The healthiest and most robust people came from the Isabela region.
- Hormigueros lay at the center of the most beautiful and fertile plain.
- Guánica had the best bay, but no town.
- Other Caribbean islands preferred coffee processed in Ponce to that of any other place in the Americas.
- San Juan (as the island was then known: the capital was called Puerto Rico) was covered with great tracts of forest and had an impressive number of lumber trees, fruit trees and potential crops that could be grown. Yet so many of these natural resources were going unused.

[Excerpted from Puerto Rico: A Political and Cultural History by Arturo Morales Carrión and Abbad's Historia Geográfica]

1804 A.D.
A major hurricane hit Puerto Rico on the feast day of St. Matthew on September 21. The hurricane became known as San Mateo II.

1815 A.D.
The Cédula de Gracias ceded Crown lands to the public for agricultural purposes. Each grant of 200 *cuerdas* (roughly 80 hectares/198 acres) mandated that trees be planted on the boundaries. Some of these plots were in the Luquillo Mountains.

1816 A.D.
Simón Bolívar, from Venezuela, known as the Great Liberator of the Americas, landed on Vieques Island.

Puerto Rico's Governor Brigadier Salvador Meléndez Bruna limited cutting of wood for use in Spanish ship and building construction.

The Cédula de Gracias

In the early decades of the 19th century, Spain saw its New World empire crumble as one colony after another fought for independence. To maintain a strong presence in Puerto Rico, Spain enacted a series of concessions known as the Real Cédula de Gracias in 1815. These concessions, among other factors, were made to attract pro-Spanish Catholic settlers and military personnel to Puerto Rico.

Agriculture was deemed the best way to develop the island's economy. New settlers would receive, free of charge, uncultivated Crown lands to farm in accordance with government rules and regulations. The land had to be surveyed, and this came to produce a more detailed picture of island forests. In addition, a certain amount of the land had to be cleared in a limited amount of time or it would return to the Crown. The quickest and easiest way to do this was by felling the trees and burning them when they dried. Pastureland was also burned periodically, and many an out-of-control fire caused further destruction of forest.

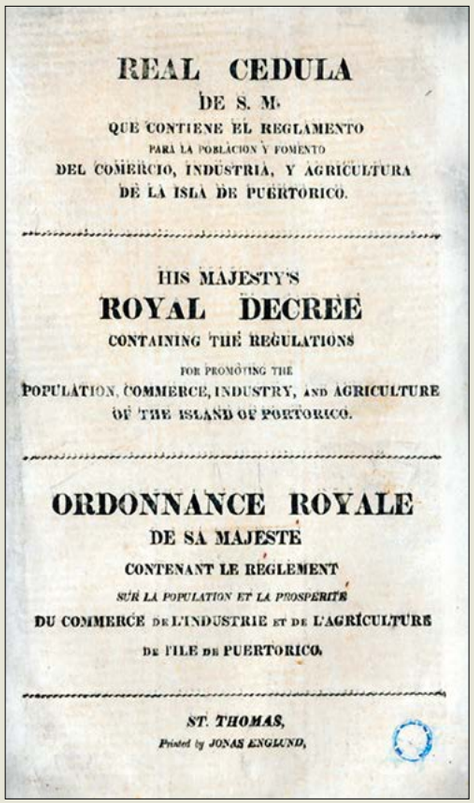
As a result of the Cédula de Gracias, settlers, many of them farmers, arrived from as far away as Venezuela and Spain. Ports were built, commercial restrictions were loosened, export duties were exacted, and contraband trade was fined. Puerto Rico was poised to prosper, both for the islanders and for the Spanish Crown.

Excerpts From the Cédula de Gracias of 1815

Article 10: Each white person of either sex will be given four and 2/7 fanegas [each fanega is 1.59 acres] of land, and half that amount for each Negro slave or mulatto brought by the settlers. Within the land grant, all will share equally in the profits and losses of production. Information will be entered in the public register for each settler at the day of the registration. All members of the family of the settler, along with their origins and their standing in the community, will be included in the registered copies of their records, which will serve as title deeds.

Article 11: Free Negro slaves and mulattos who come as settlers or family heads to establish themselves in Puerto Rico will be entitled to half of the land grant which the whites have been given. If they bring their own slaves, their percentage will be increased accordingly and noted in the document justifying the action. [Note: Although this distribution does not seem fair to us today, it was actually quite a liberal concept for its time.]

Article 28: Old and new inhabitants will be supplied with farming implements and tools from the foundries in Biscay and other parts of Spain. The cost and shipping of these tools will be provided for over a period of 15 years. After this period, the settler will have to pay for obtaining tools. If for some reason settlers don't have tools and the tools are urgently needed, they will be allowed to get them on the foreign islands that have friendly-nation status with the Spanish Crown. Payment for these will be made, not in legal tender, but in agricultural products. They will also have to pay the Crown a tax of three percent on the products.


REAL CEDULA
DE S. M.
QUE CONTIENE EL REGLAMENTO
PARA LA POBLACION Y FOMENTO
DEL COMERCIO, INDUSTRIA, Y AGRICULTURA
DE LA ISLA DE PUERTORICO.

HIS MAJESTY'S
ROYAL DECREE
CONTAINING THE REGULATIONS
FOR PROMOTING THE
POPULATION, COMMERCE, INDUSTRY, AND AGRICULTURE
OF THE ISLAND OF PORTORICO.

ORDONNANCE ROYALE
DE SA MAJESTE
CONTENANT LE REGLEMENT
SUR LA POPULATION ET LA PROSPERITE
DU COMMERCE DE L'INDUSTRIE ET DE L'AGRICULTURE
DE L'ILE DE PUERTORICO.

ST. THOMAS,
Printed by JONAS ENGLUND.

Artifact dating from the late 19th century on display at the Casa Canales museum, which is the re-creation of the home of Jayuya's first mayor, Rosario Canales (2006).

Chapter III

Conservation Concerns

1824 to 1898

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Conservation Concerns
1824 to 1898

Carlos Domínguez Cristóbal, Historian,
International Institute of Tropical Forestry

On August 6, 1824, Puerto Rico's Governor Miguel De La Torre introduced Circular No. 493. A highly advanced forestry document for its day, the circular became Puerto Rico's first conservation law. Decrying the amount of forested land being cleared on the island and the negative effect this deforestation was having on the water supply, the circular suggested measures to deal with the problem, such as prohibiting the cutting of trees around the island's watersheds and reforesting denuded watersheds using fast-growing tree species.

De La Torre, a veteran of the revolt in Venezuela, which Spain lost, governed Puerto Rico from 1822 to 1837. Determined the island would remain in Spanish control, he fought off revolutionary rumblings with an iron hand. Yet he worked equally hard to improve the quality of life on the island by erecting public buildings and stimulating agriculture. He also enacted a series of measures that illustrated his concern for the island's forest situation. This push and pull between development and conservation would continue throughout the rest of the 19th century.

1824 A.D.
Alarmed by the extent of deforestation caused by government-sponsored farms, Governor Lieutenant General Miguel de la Torre issued the island's first conservation law, Circular No. 493. The law required the planting of trees to stem harm to watersheds.

Using the Island's Resources

The island's resources were being used in a number of ways. The wave of immigrants to Puerto Rico continued. More immigrants meant the expansion of urban areas, the construction of wooden homes, and the need for charcoal for cooking. Forests were felled without official controls.

Trees were not cut just to make way for the burgeoning population. In spite of laws to the contrary, oxen-pulled cartloads of lumber were still being pulled out of the mountain forests and shipped as contraband to farflung Caribbean ports. Even more was being used in the local furniture industry. In addition, entrepreneurs armed with the latest in mining paraphernalia were revisiting the forest in the centuries-old search for its metals. In the Luquillo Mountains alone, gold and silver were being mined on the northern slopes, and copper mining was established on the southern slopes.

The biggest leveler of trees was the agriculture industry. Many new immigrants turned to farming, and those who wanted permanent title to the government's Crown land had to prove that they were using it, in part by clearing it of trees. Most farmers worked small plots of land, where they grew subsistence crops. Over the decades, sugarcane and coffee became the major crops. Sugarcane grew best in lower elevations along the coast, and trees were felled to accommodate the crop. In the cooler mountain regions, coffee thrived. Here the land was only partially cleared, for the coffee bushes needed overhead shade trees. Coffee production was especially lucrative. Puerto Rican coffee became sought after by the drink's connoisseurs throughout Europe. As demand increased, so too did the proliferation of coffee farms, and the forests decreased.

At the start of the 19th century, some 175,000 people lived in Puerto Rico. By the century's end, nearly a million people lived there, agriculture flourished, and only 161,821 acres or 8.27 percent of the island was covered by forest.

Coffee Production

From 1736, the year coffee was introduced into Puerto Rico, this crop proved a promising newcomer in the agricultural economy of the island. By the end of the 19th century, coffee had become the island's main agricultural export product, displacing sugarcane. The economic crisis sugar was undergoing, the quality and excellence of Puerto Rican coffee, the availability of much fertile land, and the existence of abundant and cheap manual labor all worked together to make coffee the staple of island agriculture. As coffee production increased, thousands of acres in the mountainous interior of the island were deforested, leaving only a few tree species that were used to provide shade for the coffee. Along with the deforested land came the problem of erosion as well as a decrease in the quality and quantity of river water. The cultivation of coffee produced a number of direct and indirect effects on the island, among them the rising indebtedness among the small coffee producers, the enrichment of commercial firms that exported the coffee, and the significant increase in the population of the mountainous interior.

Coffee production in the central mountain region of Puerto Rico contributed to deforestation, as seen in the background (c. 1930).

1824 A.D.
In addition to harboring Spain's enemies of the Crown, the island became a host to an assortment of pirates and smugglers. One of the more famous was Puerto Rican Roberto Cofresí, who is said to have shared his spoils with the poor. Pirate Cofresí and his crew attacked eight ships, one of them an American ship. As a result, the U.S. Naval Forces sent the schooner *Grampus* to pursue him. After a ferocious battle, Cofresí and his crew were captured by Captain John Sloat and executed by a Spanish military firing squad in Old San Juan a year later.

1828 A.D.
Timber was reported abundant in the Luquillo Mountains.

Gold-washing Device

1832 A.D.
Manuel Martínez Zercenán developed a silver and gold mine claim on Río La Mina.

Pioneering Conservation Efforts

During de la Torre's term as governor, several botanical expeditions scoured the island. One of the most important arrived from the Natural History Museum of Paris and was led by the French naturalist, Augusto Plee. In addition, the governor's secretary, Pedro Tomás de Córdova, wrote two volumes over the course of a decade, chronicling the island's forests and trees and updating the descriptions made by Íñigo Abbad a half century earlier. Like Abbad, Córdova spoke of the promise of many island species, but he also noted the problems of uncontrolled deforestation.

By the end of the 1830s, government officials on both sides of the Atlantic, aware that trees were not an unlimited resource and wanting an ample supply for their own naval, military, and construction needs, began to take serious measures to control deforestation. In 1839, the Spanish Crown announced the first of a series of forest regulations. The Board for the Protection of Forest, Fish, and Wildlife was established, and one of its major goals was to control the indiscriminate cutting of trees. Over the years, the board enacted a number of measures: trees could be cut on vacant Crown lands only with government permission, the burning of vegetation on Crown lands was prohibited, no trees adjacent to rivers could be cut, and vacant Crown lands best used as forest would remain with the government. Duties were exacted for exported woods, and violations were punishable by fines.

Land crabs, commonly found in the mangrove forests, have been a food source since Taíno times (2007).

Coquí tree frog, commonly found throughout Puerto Rico (2007).

In addition, the board created auxiliary boards in towns around the island. To establish a national forest policy, mayors were asked to take stock of their region's forest situation. They were also asked to implement conservation measures and to plant trees along the roadway. A great contrast emerged between the remote, underpopulated, forest-rich regions in the interior of the island and the more populated, denuded regions along the coast.

In 1853, by Royal Decree, a commission dealing exclusively with forestry was created for Puerto Rico. The commission was mandated to write reports about the forestry situation, and these reports had to follow very strict guidelines. Each report was divided into three sections. The natural report focused on data about the forests, including the types of plants and trees found on the island; the legal report studied the history and uses of the forests; the forestry report included a general summary outlining personnel, production, and consumption. The reports were required to include wood samples and visuals of machinery and other tools in use.

Enlightened ideas, strict laws, detailed reports—now all the government had to do was enforce the new regulations, and that would prove to be the most difficult task of all.

Humans used forest resources for lumber, which also contributed to island deforestation (no date).

1839 A.D.
A Spanish Crown forest regulation was promulgated within Puerto Rico that required permission from the government to cut down trees in vacant Crown land, prohibited clear cutting, and called for preservation of riparian (river valley) forests and the construction of a forest headquarters.

1843 A.D.
The first lighthouse in Puerto Rico was constructed atop El Morro.

1844 A.D.
A regulation by the Board for the Protection of Forests, Fish, and Wildlife required the appointment of forest guards, prohibited the burning of lands conceded by the Crown, and required the planting of trees on the borders of Crown lands, with reversion of such lands to the Crown if they were found in violation.

1845 A.D.
The population of Puerto Rico was 443,140.

1853 A.D.
By Royal Decree, two Spanish foresters were to survey, mark, and manage Crown forests, including forests in the Luquillo Mountains.

1858 A.D.
The telegraph was introduced into the island with the assistance of Samuel F.B. Morse at Hacienda La Enriqueta in Arroyo. His daughter and son-in-law Edward Lind had a plantation outside Arroyo.

1860 A.D.
An appropriation of Puerto Rican governmental funds for forest management was first approved. This appropriation appeared in the public record in varying amounts until 1870, when, due to a lack of funds, the position of Forest Engineer was eliminated.

The First Foresters

In 1853, two recently graduated forest engineers from Spain arrived in Puerto Rico and were authorized to survey and manage the remaining Crown lands, including those in the Luquillo Mountains. These engineers were the island's first official foresters. The young men got off to a slow start as they waited for their instruments, materials, and books to arrive. They were commissioned to send detailed reports back to Spain, but the commission's final report was completed very late. Among the difficulties encountered were a cholera outbreak, a great quantity of unknown flora to document, and several changes in island governors. The foresters did not adjust well to the tropical climate, and, by 1860, both of them had returned to Spain.

A third forester, Miguel Fernández Balmaseda, arrived to take the place of the two who had left. It was estimated that some 13 percent of the island was covered with forest. Although Fernández Balmaseda admitted the actual area might be larger, it was still much less than what the island should have. In his report, he explained many of the hardships the earlier foresters had encountered. It seems he too encountered them, because, within 3 years, Fernández Balmaseda returned to Spain for reasons of health. It took 2 years for the government to find a new forester.

1876 emblem of the Inspectors de Montes (forest inspectors) (official brand of the Government of Spain).

1876 emblem of the Cuerpo de Ingenieros de Montes (engineer corps) (official brand of the Government of Spain).

Based on the information provided by the foresters and by the mayors of island towns, important forest documents were written in the latter half of the 1860s, describing the general state of the forests and providing an inventory of available resources in the public forests. It was estimated that the island had 263,954.65 acres of forest, of which some 18 percent belonged to the Crown. Only 55 of 68 island municipalities claimed to have any kind of forest. The forest in the Luquillo Mountains was the largest in Puerto Rico. The island had 34 public forests in 10 towns. Mangroves at this time were not counted as forests and were under marine command. This report would be used to determine the best way to make use of the resources.

In 1870, an economic crisis gripped the island. Measures that would have protected island forests could not be implemented, and the post of forester was eliminated. Realizing the connections among forests, water supplies, and agriculture, a number of private societies came to the rescue, experimenting in the planting of several imported tree species, among them mahogany, Canary Island pine, and eucalyptus.

Mangroves: On Land or Sea?

Although not the most majestic of trees, mangroves are extremely versatile and of great importance in Puerto Rico's ecology. They are found in large flat areas of silty or muddy shoreline in salt and brackish water around the island. Their leaves are small, shiny, and green; their roots resemble an elaborate tangle of stilts; and their pencil-shaped seedling pods often float for a distance in the water before becoming anchored to soil.

With their many stilt roots, mangrove forests maintain coastlines, and, over time, they can even extend the land toward the ocean. The waters around mangrove forests, darkened by the tannin found in the tree's bark, provide protective habitats for small fish and a number of other sea organisms. Among the most famous micro-organisms are bioluminescent dinoflagellates found only in certain mangrove-bordered bays. The rich food base in the water in turn attracts many coastal bird species.

During most of the 19th century, mangroves rooted in coastal waters were not classified as forests; instead, they were placed in the jurisdiction of the island's Marine Command. Until 1876, the Marine Command was responsible for all affairs involving the marine ecosystem, which included mangrove forests. But with the passage of the Forestry Ordinance in 1876, forests were defined as lands used in the production of timber, charcoal, and uncultivated pastureland. These lands included mangroves, which were commonly used for fuel, and, in 1877, the Marine Command released its authority over the mangroves, transferring them to the jurisdiction of the Inspection of Forests.

[Excerpted from text by Carlos Domínguez Cristóbal and Common Trees of Puerto Rico and the Virgin Islands *by Elbert L. Little, Jr., and Frank H. Wadsworth.]*

Mangroves in Boquerón Bay look much as they did in the 19th Century (2006).

1864 A.D.
American naturalist E.C. Taylor described the Puerto Rican parrot as "abundant in the eastern lowlands of the island."

1866 A.D.
Copper mining along the south border of the Luquillo Mountains began, but was abandoned in 1899 due to hurricane damage.

1867 A.D.
The first islandwide forest inventory performed by Ingenieros de Montes for the Cuerpo de Montes was staffed by graduates of the Spanish Crown forestry school.

Local farmers protect their land by patrolling on horseback, such as they did in the mid-19th century (1929).

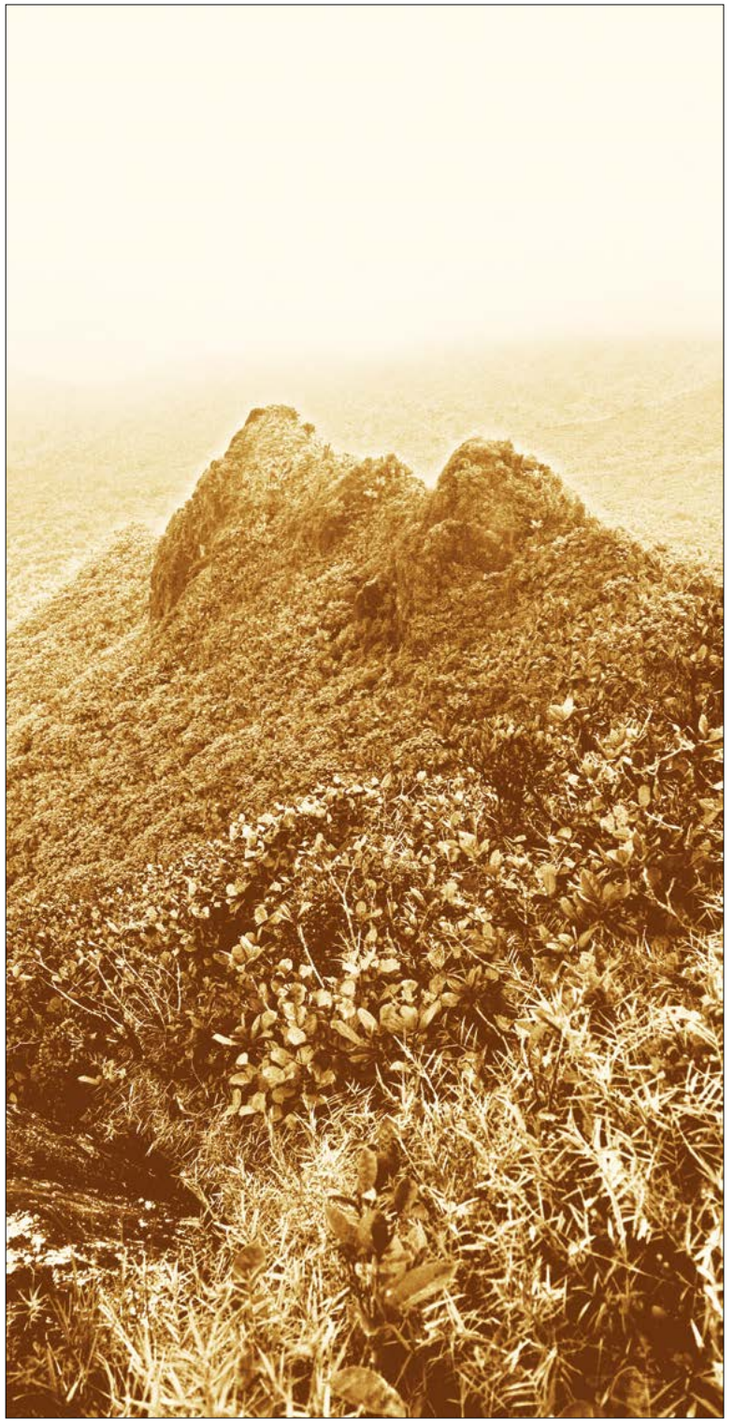
Topographic map of Puerto Rico (1886).

1870 A.D.
Forest Engineer Juan Fernández Ledón published a forest inventory that covered 18,682 hectares (46,164 acres). Exotic eucalyptus trees *(Eucalyptus globulus)* were introduced from Australia into Puerto Rico by the Sociedad Económica de Amigos del País (Economics Society of Friends of the Country).

1873 A.D.
The Spanish Crown abolished slavery in Puerto Rico.

1874 A.D.
Rafael de León, Mayor of Ponce, issued a circular describing the urgent need to conserve Puerto Rico's forests to avoid ruining the island's agriculture.

A total of 9,700 hectares (23,969 acres) of heavily timbered forest remained in the Luquillo Mountains.



Los Picachos Peak in the Luquillo Mountains is part of the Crown lands that were declared a forest reserve in 1876 by the King of Spain (1995).

The Enlightened Times of King Alfonso XII

The forests' fortunes changed in 1875, when the newly crowned King Alfonso XII established the Puerto Rico Inspection of Forests. A forester would be responsible for conservation and improvements to public forests, which were the remaining Crown lands. All forest documents were transferred to Inspection of Forests. Concessions could be reviewed, and the Inspection could decide which public land should be used for agriculture and which should remain as forest. Agricultural lands had to be taxed and surveyed, at the owner's expense, and forest-designated lands were to be reforested if they were currently bare. The inspection established forest policies to conserve water, control flooding, and avoid landslides. Fines could be given out to people who broke rules, and 10 percent of money obtained by selling public lands would go toward growing more forests.

A year later, King Alfonso XII established a Forestry Ordinance for the development of forests in Puerto Rico and Cuba. This ordinance would be the primary policy for forest activity on the island. Its eight chapters dealt with everything from administration to marking public forest boundaries. All plans for forest use had to follow strict procedures: they had to be drawn up by a forester, approved by the governor, and put up to public bid. Throughout the decade, much effort was spent in repopulating forests. Each forest was evaluated to decide the most economical and convenient method to reforest. These methods could include establishing plantations, planting seed directly, or letting the forest return naturally.

Some 40.9 percent of the island's forested land, by far the largest tract, was located in the Luquillo Mountains. In 1876, through the ordinance, its 24,710 acres became a forest reserve, making it one of the first reserves established in the Americas. In the 1880s, timber sales were authorized within the Crown lands, under contracts that were quite progressive for their time, requiring prior marking, determination of volumes, and controls of damage.

Although the forest policies were defined in detail—or perhaps because they were defined in such detail—they were often not properly followed. One of the most difficult aspects of the new forest policy was establishing and maintaining forest boundaries, particularly in the areas where coffee flourished and farmers who bordered public forests "borrowed" additional acres to increase their yields.

King Alfonso XII

King Alfonso XII reigned as king of Spain from 1874, when he was just 17 years old, until he died of tuberculosis in 1885. The eldest surviving son of Queen Isabella II, he followed her into exile after a revolution in 1868. While in exile, he received an education in Austria and England. In 1870, the Queen abdicated her rights in her son's favor, but he did not take the crown until 4 years later. The King married twice: his first wife died, and with his second he had two daughters and a son.

During King Alfonso's reign, Spain enjoyed unaccustomed tranquility. Although he was politically inexperienced, he demonstrated great natural tact and sound judgment, qualities that influenced the course of events as far away as Puerto Rico. He enjoyed considerable popularity, and his untimely death at 28 years of age was a great disappointment to those who looked to him as the hope for a constitutional monarchy in Spain.

1875 A.D.
Governor José Laureano Sanz published a decree that served to regulate the use of the forests of Puerto Rico, declaring lands nonconceded and conceded without compliance by the Crown as public forest, as well as prohibiting the burning off of trees on private lands without a permit. The Ponce Agricultural Society imported forest tree seeds of various species to be used to plant forests, thus improving the climate of the island.

1876 A.D.
Spanish King Alphonso XII proclaimed forest in the Luquillo Mountains as a reserve of 10,000 hectares (24,710 acres) with soil and water conservation and timber removal regulated and enforced by the Inspección de Montes (Spanish Forest Service), making it today one of the oldest forest reserves in the Western Hemisphere.

1876 A.D.
The newly formed Inspección de Montes submitted a plan to regulate forest use on the island.

The coastal mangrove forests were placed under the supervision of the Inspección de Montes.

1880 A.D.
Illicit timber extraction was eliminated in the Mameyes and Jiménez river valleys of the Luquillo Mountains.

1880–1881 A.D.
The land set aside as a forest reserve in the Luquillo Mountains was referred to as the Sierra de Luquillo.

1885 A.D.
The 12,000 hectare (29,652 acre) Luquillo Forest Reserve was patrolled by one part-time guard, who, in 1 year, presented a dozen trespass cases before the mayor of Luquillo.

The Temporary Demise of Forestry

Puerto Rico was divided into four forest regions—Luquillo, Cayey, Utuado, and Yauco—and each region was guarded by a lone forester. Those who aspired to be foresters had to possess certain requirements: they had to be Spanish members of the Civil Guard; be between 25 and 40 years of age; know the basics in reading, writing, and arithmetic; and have a good conduct record. In addition, they had to own a horse and saddle in good condition. For its part, the government would provide a gun, machete, uniform, and an official-looking metal badge. Once hired, the foresters would earn 500 pesos a year plus commissions. As always, part of their work involved writing reports, an aspect of forestry that has not changed to this day.

Unfortunately, in 1889, the four jurisdictions were abolished due to budget cuts.

Mining Ventures

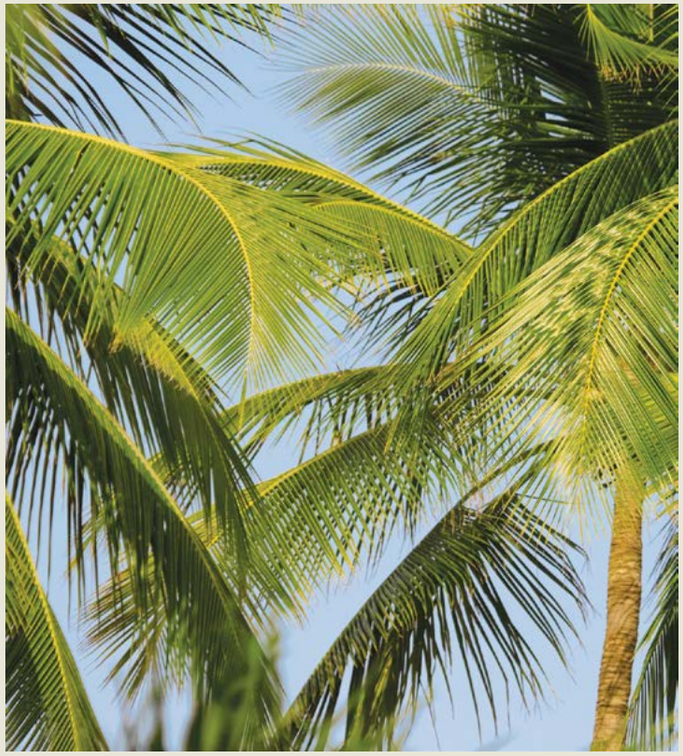
In 1832, Manuel Martínez Zercenán developed a silver and gold mine claim on La Mina River.

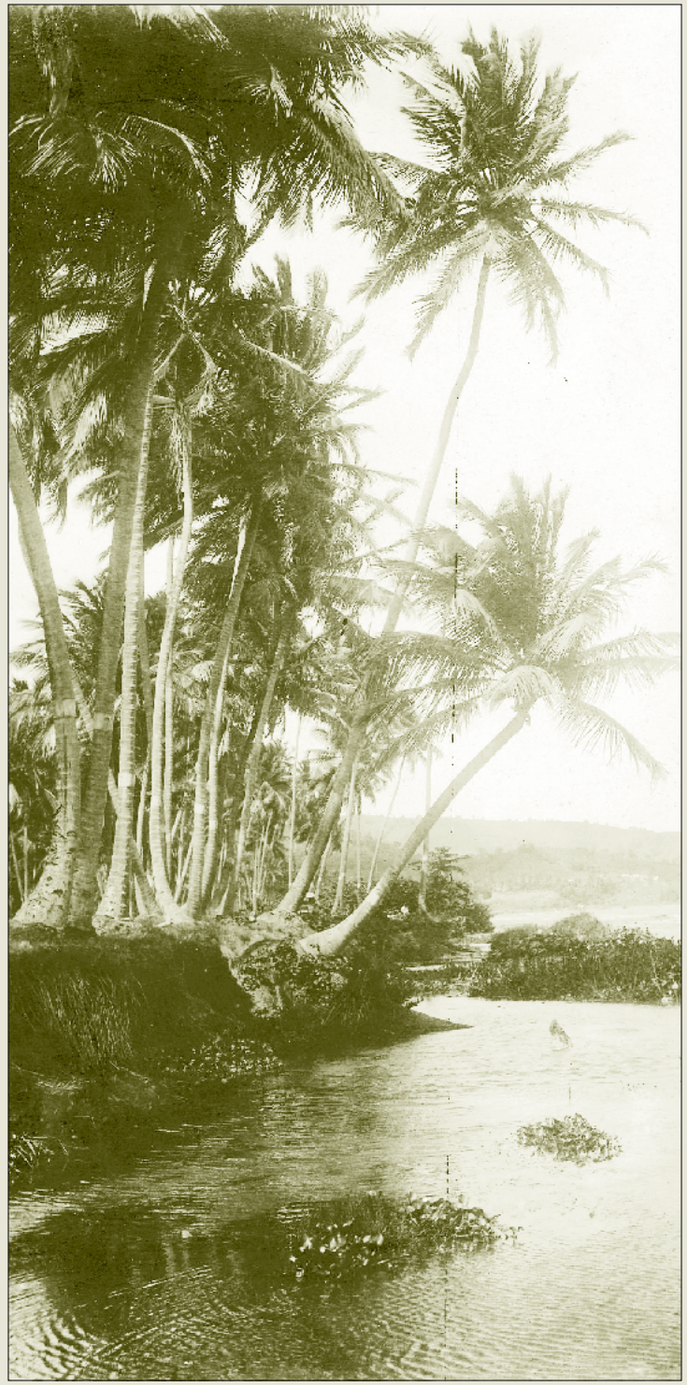
In 1866, copper mining along the southern border of the Luquillo Mountains began, but it was abandoned in 1899 due to hurricane damage.

c 1930s

Do Coconut Palms Keep Hurricanes Away?

In 1825, Puerto Rico was lashed by Hurricane Santa Ana, one of the worst recorded storms to pass over the island. A theory at the time of Hurricane Santa Ana suggested that the strength of a hurricane was determined by the number of coconut palms destroyed. To keep storms at bay, the thinking continued, it was necessary to plant coconut palms everywhere along coastlines that were in the paths of hurricanes.





1886 A.D.
A water law was enacted that prohibited the cutting of trees at the sources and along the banks of rivers on the island.

1886–1898 A.D.
Crown forest timber prices were established by public auction, and trees were sold "on the stump," marked previously by a government forester.

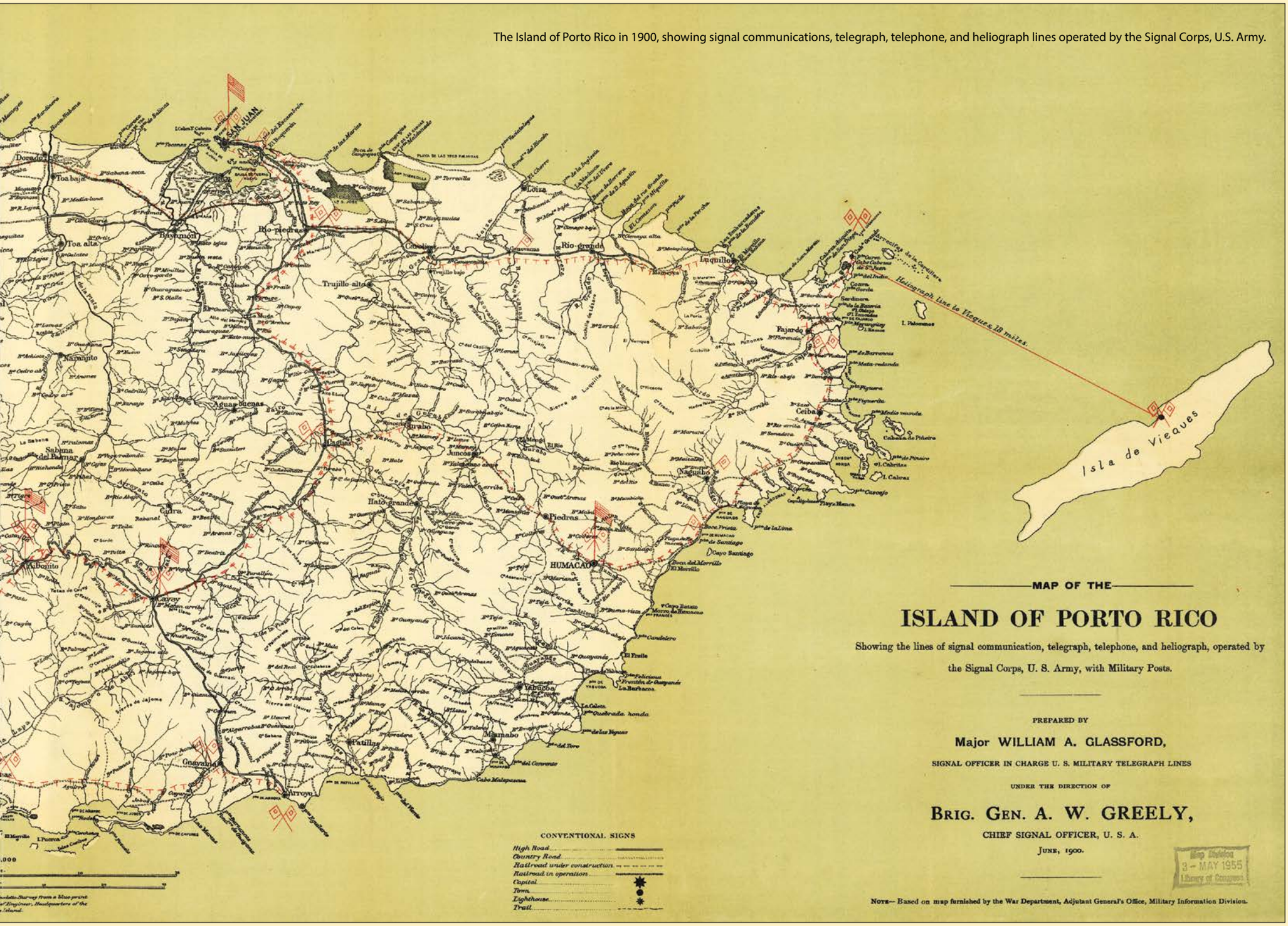
1891 A.D.
The railroad was inaugurated in Puerto Rico.

1895 A.D.
A permit from the Cuerpo de Montes de la Inspección de Montes was required to extract timber from Crown lands in the Luquillo Mountains.

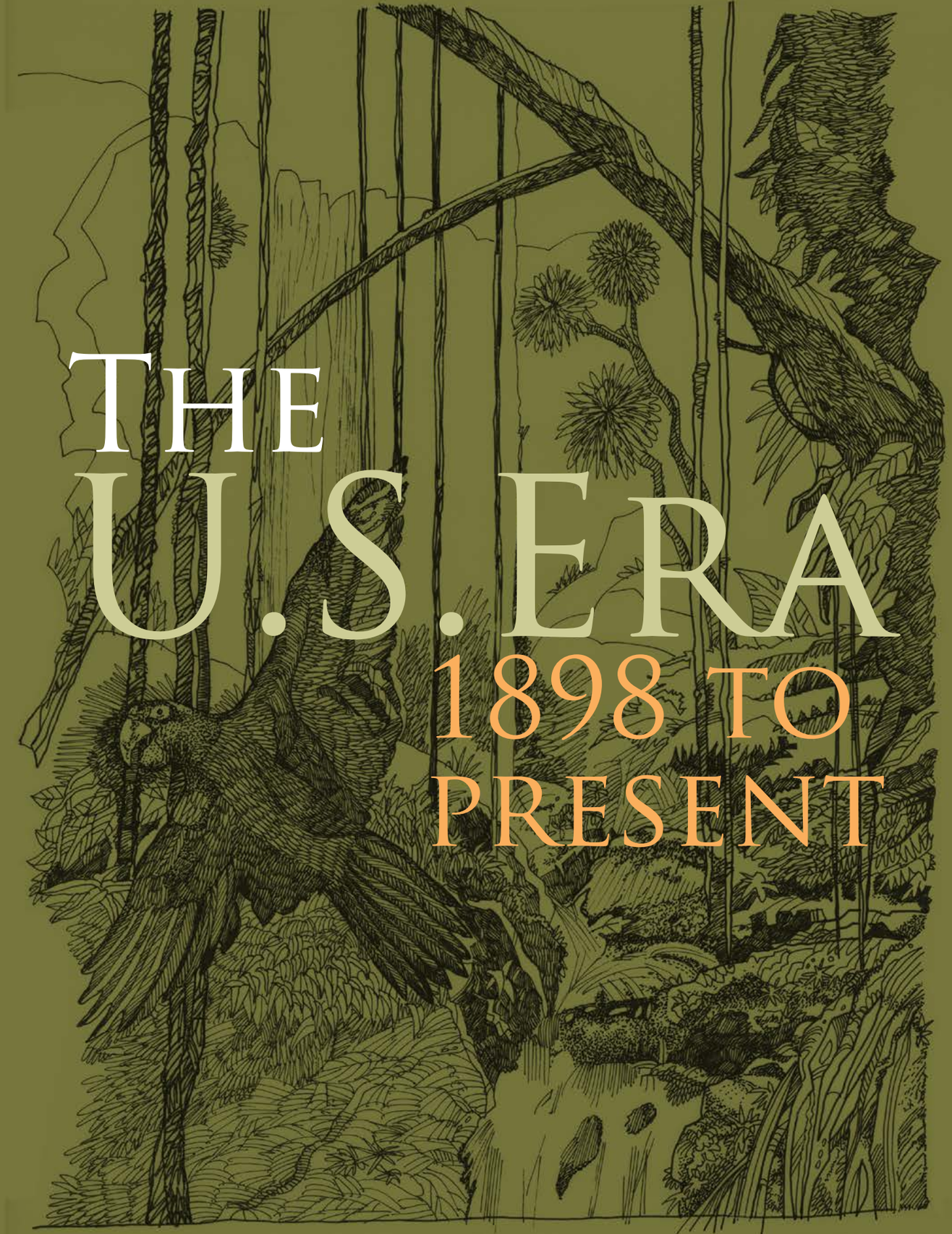
1897 A.D.
Arbor Day was celebrated for the first time in San Juan, Puerto Rico.


AGUADILLA
Aguada
Rincon
MAYAGUEZ
Hormigueros
Cabo Rojo
Lajas
Sabana Grande
San Sebastian
Isabela
Quebradillas
Camuy
Hatillo
ARECIBO
Barceloneta
Manati
Vega Alta
Vega Baja
Morovis
Ciales
Las Marias
Utuado
Adjuntas
Barros
Barranquitas
Coamo
Juana Diaz
PONCE
Penuelas
Guayanilla
Guanica
Santa Isabel
MILITARY POST AND TELEGRAPH OR TELEPHONE STATION.
UNITED STATES TELEGRAPH OFFICES OPERATED BY THE SIGNAL CORPS, U. S. ARMY.
TELEPHONE STATIONS.
SINGLE LINE
DOUBLE LINE
UNITED STATES MILITARY TELEGRAPH LINES, RECONSTRUCTED SINCE AUGUST, 1899, NOW IN OPERATION; LINE BETWEEN SAN JUAN AND PONCE IS A DOUBLE WIRE.
UNITED STATES MILITARY TELEGRAPH LINES, RECONSTRUCTED SINCE AUGUST, 1899, AND OPERATED BY TELEPHONE.
HELIOGRAPH LINE, OPERATED BY SIGNALISTS OF SIGNAL CORPS, U. S. ARMY.
I. Caja de Muertos
SCALE 1:150
Statute Mile
Kilometers
466

The Island of Porto Rico in 1900, showing signal communications, telegraph, telephone, and heliograph lines operated by the Signal Corps, U.S. Army.




USV



THE U.S. ERA

1898 TO PRESENT

Chapter IV
Organizing the Forests
1898 to 1917

Chapter IV
Organizing the Forests
1898 to 1917

Carlos Domínguez Cristóbal, Historian,
International Institute of Tropical Forestry

As a result of the Spanish-American War of 1898, Puerto Rico, along with all Crown lands, passed from Spain into U.S. hands. For the first time, the United States took on the duty of administering a colony, an agricultural colony whose rich coffee plantations in the high reaches of the mountains fueled the local economy at the end of the 19th century. Crown lands now belonged to the Federal Government, and it was up to the United States to continue their protection and management. A challenge came immediately in 1899 when San Ciriaco, one of the most devastating hurricanes to cross Puerto Rico, unleashed its fury on both coffee plantations and newly aquired forests.

◀ Foresters evaluating a timber plantation after a thinning (no date).

1898 A.D.
As part of the settlement of the Spanish-American War, the Treaty of Paris ceded control of Puerto Rico to the United States. The settlement included approximately 127,000 hectares (313, 822 acres) of forested land.

Forested land remaining in the Luquillo Mountains was estimated at 2,070 hectares (5,116 acres).

1898 A.D.
The population of Puerto Rico was 953,200.

1899 A.D.
Hurricane San Ciriaco caused great damage to Puerto Rico. The hurricane caused minimal tree loss in the Luquillo Mountains.

Getting To Know the Island

One of the first acts of the United States in Puerto Rico was to compile a detailed look of the island and its people. The U.S. War Department prepared a census report for the entire island. The Forest Division of the U.S. Department of Agriculture (USDA) sent a representative to file a report on forest conditions. A host of intrepid U.S. travelers came down to explore the new U.S. island in the Caribbean sun. Most of the reports concurred that the amount of forested land in Puerto Rico was small and getting smaller. Some 18 percent of the land was forested, according to one report, but of that, more than one-half was merely scrub trees or weed thicket. Deforestation on the island had resulted primarily from the need to use the land for agricultural purposes and to export wood for construction. The largest remaining chunk of forest was located around El Yunque Peak in the Luquillo Mountains. This region also sheltered one of the few zones of untouched virgin forest on the island and harbored many tree species unknown to the American market, but even the forest here was rapidly being destroyed.

In 1929, the forest near El Yunque Peak in the Luquillo Mountains was much the same as it was when it was set aside as a forest reserve by the King of Spain in 1876 (c. 1929).

Spanish-American War

The seeds of the Spanish-American War originated with Cuba's struggle for independence from Spain, a struggle that began in 1895. Americans were horrified by newspaper reports of the brutally repressive measures used to halt the rebellion, and the growing popular demand for U.S. intervention increased after the unexplained sinking of the battleship USS *Maine* (sent to protect U.S. citizens) in Havana harbor. By April 1898, Spain and the United States had declared war on each other. The ensuing war was pathetically one-sided because Spain had not prepared for such distant combat. First Spanish forces in the Philippines were defeated, then in Cuba, and, by July 17, the war had basically ended. Through the Treaty of Paris, signed on December 10, 1898, Spain renounced all claim to Cuba, ceded Guam and Puerto Rico to the United States, and transferred sovereignty over the Philippines to the United States for $20 million. The war was a turning point for both countries. Spain's defeat ended Spanish colonial rule in the Americas and forced the country to focus inward on its own domestic needs. The United States, on the other hand, emerged from the war a world power with far-flung overseas possessions and a new stake in international politics.

Historical map of the Spanish-American War in 1898.

1903 A.D.
President Theodore Roosevelt proclaimed the Luquillo Forest Reserve under the authority of a 1902 Act of Congress, which allowed him to reserve public Crown lands, ceded to the United States by Spain in 1898, to form this public forest reservation.

The Sabana river valley in the new Luquillo Forest Reserve was seen to be heavily timbered, a testimony to the former forest authority's conservation efforts.

1905 A.D.
Landowners adjacent to the forest, who were obtaining timber illegally themselves, reported the trespassing of others to obtain timber.

An infrequently used trail crossed the forest via El Yunque Peak from north to south.

Luquillo National Forest office located in Río Piedras (1928).

Establishing Luquillo National Forest

In 1902, the U.S. Congress enacted a law giving President Theodore Roosevelt the power to determine, within a period of 1 year, Federal uses for the various public lands and public buildings in Puerto Rico, now under U.S. jurisdiction; whatever would not be needed for Federal uses would be handed over to the island government (which was run by U.S. governors until the 1940s). In response, the USDA Bureau of Forestry sent John C. Gifford to the island to determine which public lands could be appointed for use as forests. Gifford's report inspired Roosevelt to declare the creation of the Luquillo Forest Reserve in 1903. Gifford also recommended surveying the forest and constructing a road to facilitate public access and transport forest products, suggestions that Roosevelt took seriously. The nearby offshore islands of Culebra and Vieques also figured as part of the forest reserve in this early report. In 1905, Gifford published a book, *The Luquillo Forest Reserve,* an important work on the natural history of the forest and its vegetation. From its inception, Luquillo was considered part of the Federal forest system, and its purpose was clearly defined to provide wood for local use and to protect water supplies. After the creation of the USDA Forest Service in 1905, officials changed the name of the forest reserve in 1907 to the Luquillo National Forest.


Mountain stream originating in the Luquillo Mountains (c. 1930).

By the President of the
United States of America

A Proclamation

Now, therefore, I, Theodore Roosevelt, President of the United States, by virtue of the power in me vested by ... Act of Congress, do hereby make known and proclaim that there is hereby reserved and set apart as a Public Forest Reservation ... in the island of Porto Rico. … The reservation hereby established shall be known as The Luquillo Forest Reserve.

In Witness Whereof, I have hereunto set my hand and caused the seal of the United States to be affixed.

Done at the city of Washington this 17th day of January, in the year of our Lord one thousand, nine hundred and three, and of the Independence of the United States the one hundred and twenty-seventh.

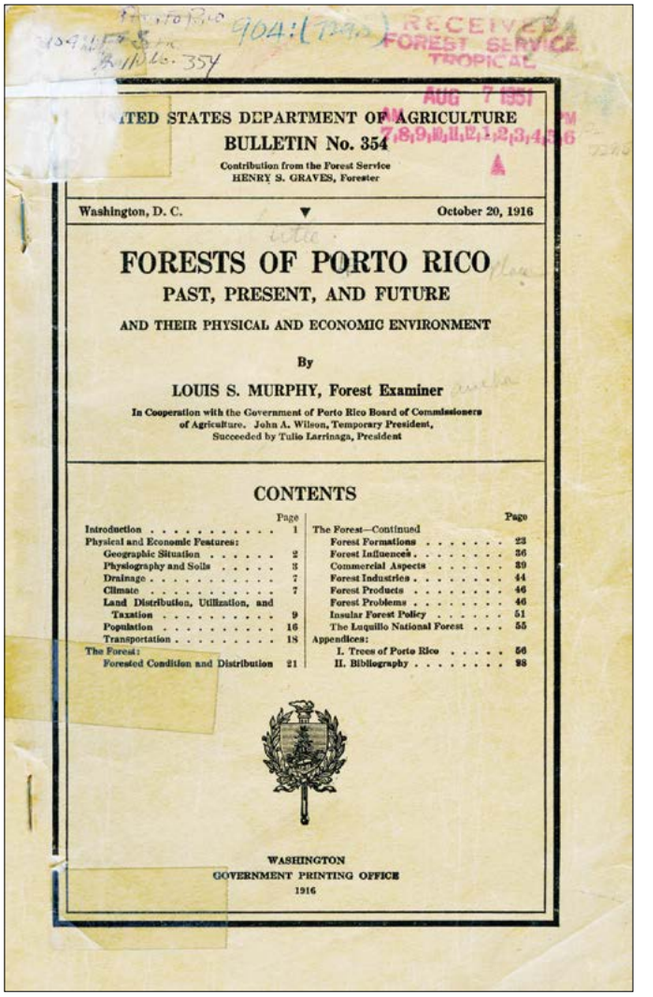
Theodore Roosevelt

1905 A.D.
USDA Bureau of Forestry published the report "Luquillo Forest Reserve, Porto Rico," (known officially as Porto Rico by the U.S. Government until 1932) the first detailed report about the forest and its resources.

1905 A.D.
The population of Puerto Rico was 1,070,000.

1907 A.D.
The Luquillo Forest Reserve was renamed the Luquillo National Forest.

Because of its unique location in the Caribbean, the Luquillo National Forest became the single tropical rainforest in the USDA National Forest System.



...TED STATES DEPARTMENT OF AGRICULTURE
BULLETIN No. 354
Contribution from the Forest Service
HENRY S. GRAVES, Forester

Washington, D. C. ▼ October 20, 1916

FORESTS OF PORTO RICO
PAST, PRESENT, AND FUTURE
AND THEIR PHYSICAL AND ECONOMIC ENVIRONMENT

By

LOUIS S. MURPHY, Forest Examiner

In Cooperation with the Government of Porto Rico Board of Commissioners of Agriculture. John A. Wilson, Temporary President, Succeeded by Tulio Larrinaga, President

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WASHINGTON
GOVERNMENT PRINTING OFFICE
1916

One of the first technical reports about the forests of Puerto Rico (1916). An original copy of this report is in the Frank H. Wadsworth Library.

Early Challenges to the New National Forest

The mere designation of Luquillo as a forest reserve did not guarantee the future safety of the region. A lack of forestry personnel, particularly guards, made the forest available to anyone who cared to enter, and many did. Thousands of trees were being felled to make charcoal. Time-consuming though this process was, it was a way for the very poor mountain residents to earn a little extra money for their families. After several petitions, the USDA Forest Service sent a forestry advisor to Luquillo in 1909, but he did not stay long.

A more serious challenge to naming Luquillo a national forest occurred a year later. Upon evaluating the area a bit more closely, it was found that much of the land was lacking a key component of a forest—trees. Recommendations were made to take Luquillo out of the National Forest System and transfer it to the island government. For some reason, the island governor of the time, George Colton, opposed the idea, suggesting instead the Federal Government buy adjacent lands. USDA Forest Service officials in Washington sent down several experts to study the situation. The experts agreed with the earlier evaluations, and they reiterated that Luquillo should be handed over to the local government. To this end, the island should establish a local forest service. Nevertheless, they agreed the land should be surveyed. One of the experts, Louis S. Murphy, remained on the island and wrote a seminal book about the forests of Puerto Rico and the woods found in them.

It took 4 years, from 1912 to 1916, to survey the forest boundaries on the land reserved in 1903. Local surveyors paid with Federal funding needed to establish the boundaries, measure them, and place permanent markers to maintain them. The task was fraught with difficulties: the exact location of boundary lines had never been determined, people were occupying public land and alleging it was private property, very little documentation backed up legitimate claims, and the local property registry was in chaos. Surveyors noted some of the daily activities going on in the forest—oxen pulling timber down the mountainside, palm leaves being crafted into hats or ties for packs of tobacco, resin from the tabonuco tree being used to start kitchen fires in small wood and thatch homes, sand being extracted from the rivers, and honey being taken from the forest's numerous beehives.

When the surveying was done, the Puerto Rican Interior Commission reported 12,503.98 acres, which was about 30,000 fewer acres than the 42,369.5 reported in Spanish documents. Undaunted, the island governor asked for a superintendent for the forest. Although he did not get his wish immediately, the island did get its first forestry graduate from a U.S. school. Gabriel Mitchell was given a scholarship to attend the Ohio School of Forestry and graduated in 1914.

Making Charcoal

In the centuries before gas and electricity came to Puerto Rico, meals were cooked over charcoal or wood. In the cities, charcoal was preferred, because it yields more heat over a longer period of time than the same amount of wood. To produce charcoal, wood is heated with limited access to air, and the result is a residue of almost pure carbon.

Charcoal-making in Puerto Rico was a major forest industry, one involving a large amount of time. First, laborers gathered up suitable pieces of wood, such as guamá, guaba (common coffee shade trees), or moca. They chopped the pieces into 1- to 3-foot lengths, stacked them to form a low tepee with a stick in the center, and covered the wood with grass or bits of branches. Taking the stick out of the center, they filled the tepee with pieces of lit charcoal, added fire to the entire structure, and placed soil around the bottom and halfway up the sides. Then they waited. For 2 or 3 days the laborers waited as the tepee smoldered, occasionally piling more soil on the wood. The laborers built temporary tentlike shelters with palm fronds to provide protection in case of rain. When the smoldering was finally complete, the laborers doused the tepee with water and moved away the soil. They pulled out the pieces of wood, which had been transformed into charcoal. Stuffing the charcoal into sacks, they lugged the sacks, two in front and two in back, on a stick hoisted onto their shoulders, down the mountainside to market. Their compensation in the national forest was 5 cents for a 40-pound sack in the first years of the 20th century. Today, there is a limited market for old-style charcoal, and laborers earn more than $10 a sack.

[Excerpted from Where Dwarfs Reign: A Tropical Rain Forest in Puerto Rico *by Kathryn Robinson]*

Local farmer making charcoal in the Luquillo Mountains (date unknown).

1908 A.D.
Illegal trails used for unlawful timber extraction appeared in the El Verde and Jimenez Valleys of the forest.

The Luquillo National Forest proclamation boundaries were located and marked with concrete markers by the U.S. Coast and Geodetic Survey.

Timber extraction trails existed from the town of Mameyes to the forest edge and on into the forest watershed areas.

1908–1912 A.D.
Local officials made repeated requests to the USDA Forest Service to appoint guards to control trespassers in the Luquillo National Forest.

1910–1911 A.D.

A representative from the USDA Forest Service traveled to Puerto Rico to study local forests and found "property ownership in the Luquillo Mountains in chaos." He recommended releasing the forest to the local government. Governor George B. Colton responded that Puerto Rico needed USDA Forest Service assistance and that withdrawal would be "exceedingly regretted." The Puerto Rico government prevailed in their effort to persuade the USDA Forest Service to study the Luquillo National Forest area and agreed to survey the land for the USDA Forest Service.

1911 A.D.

The College of Agriculture and Mechanical Arts, today's University of Puerto Rico, Mayagüez Campus, was founded.

The New York Academy of Sciences in Puerto Rico

Among the many visitors to Puerto Rico in the early years of the 20th century were biologists and botanists fascinated by the tropical flora and fauna. In 1913, the prestigious New York Academy of Sciences, along with Columbia University, the New York Botanical Garden, the U.S. Museum of Natural History, and the local government, began an indepth study of Puerto Rico and the U.S. Virgin Islands. The study was expected to be completed in several years but actually continued into the 1940s, resulting in the most complete scientific investigation every carried out on the natural history of Puerto Rico. Filling 19 thick volumes and covering everything from butterflies to fungi, the studies are still respected and used to this day.

Biologist on an exploratory trip to observe forest conditions in the Luquillo Mountains (c. 1930).

The legend, the voice, and the persona of American hero Theodore Roosevelt lives on through the interpretation of actor Keith McGough who performs "Theodore Roosevelt… Today" at events throughout the United States. McGough performed at the centennial celebration of the Caribbean National Forest in January 2003.

Puerto Rico's Forest Service

The year 1917 was important in the annals of forestry on the island. A long-awaited law was enacted to establish a forestry policy. After years of back-and-forth debate, Luquillo remained a national forest. The governor could now set aside land not only for Federal use, as in Luquillo, but also for State (local) use. All public lands that were not being used for other purposes could become local forests. In addition, the Puerto Rico Forest Service was established under the direction of the Supervisor of the Luquillo National Forest. Plans included an experimental station for woods, a botanical garden, and tree nurseries. The responsibilities of the Puerto Rico Forest Service would include producing lumber, safeguarding water sources, controlling erosion, protecting wildlife, regulating forest use, developing educational programs, and providing forest security. The forest ranger in charge of Luquillo National Forest would also be in charge of the local forests.

The basic forest plan was now in place, but it would be amended soon, and often, to adapt to the needs of the island.

Arbor Day and the Palma Real

One of the island's first forestry festivals was Arbor Day, inaugurated in San Juan in 1897, when Puerto Rico was still part of the Spanish Empire. Marking the centennial of the British attack on San Juan, the activity included planting hundreds of trees. After the arrival of the Americans, Arbor Day was celebrated within the school system. The celebrations became so successful that, in 1904, the governor declared the last Friday in December an official Arbor Day holiday. At the end of 1903, elections were held among students in the public schools to select a symbolic tree for Puerto Rico. The students chose the palma real *(Roystonea borinquena),* although neither this tree nor any other has ever been named the official tree of the island. The students gave many reasons for choosing the palma real: it was one of the loveliest, most useful, and most resistant of the native trees; it made sturdy construction material; it provided excellent food for hogs; it added beauty to the landscape; and it was a favorite perch for melodious birds.

The palma real, or Puerto Rican royal palm, is a majestic palm tree that grows up to 60 feet high. The tree's smooth gray trunk bulges at some distance above the base, then narrows as it reaches a cluster of feathery leaves up to 12 feet long. It is common in forests, pastures, and river banks throughout the island but is restricted to Puerto Rico, the offshore island of Vieques, and St. Croix in the U.S. Virgin Islands. A related species is found in Cuba. Its scientific name honors General Roy Stone (1835–1905), U.S. Army engineer, "who rendered outstanding service to the island during the Spanish-American War." Although boards hewn from the palma real were once commonly used in siding and flooring, they are very susceptible to attack by dry-wood termites. The dried leaf blades have served as thatch for roofs, and the broad sheaths, known as yaguas, are spread out to make sides of buildings. Its small whitish flowers attract numerous bees.

[Excerpted from text by Carlos Domínguez Cristóbal and from Common Trees of Puerto Rico and the Virgin Islands *by Elbert L. Little, Jr., and Frank H. Wadsworth]*

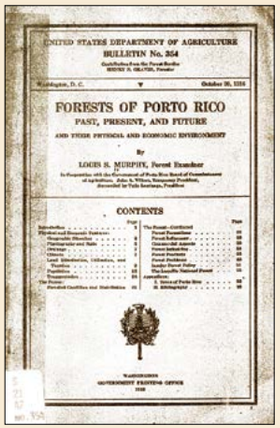
1912 A.D.

Alexander Wetmore found small parrot populations in the Mameyes River Valley and Luquillo Mountains.

Under the auspices of the New York Academy of Sciences, the New York Botanical Garden, the University of Puerto Rico Experimental Station, and the Puerto Rican Legislature, botanist Nathaniel Lord Britton and his wife, bryologist (a botanist specializing in mosses and lichens) Elizabeth Knight Britton, began compiling a "Scientific Survey of Porto Rico," a survey of the physical and natural history of the island, focusing on its geology, zoology, botany, culture, and broader natural science fields. The 19-volume product of this survey stands as one of the most complete descriptions of the natural history of any tropical area in the world.

1914 A.D.
Gabriel Mitchell, the first native Puerto Rican forester, was appointed.

1915 A.D.
Deforestation was reported to an elevation of 548 meters (1,797 feet) on the southern slopes of the Luquillo Mountains.


UNITED STATES DEPARTMENT OF AGRICULTURE
BULLETIN No. 354
FORESTS OF PORTO RICO
PAST, PRESENT, AND FUTURE
By
LOUIS S. MURPHY, Forest Examiner
CONTENTS

1916 A.D.
USDA Bulletin No. 354, "Forests of Porto Rico, Past, Present and Future and their Physical and Economic Environment," by Forest Examiner Louis S. Murphy, was published.

The Puerto Rican Government donated 575 hectares (1,420 acres) of land, adjacent to the forest, to the Luquillo National Forest.

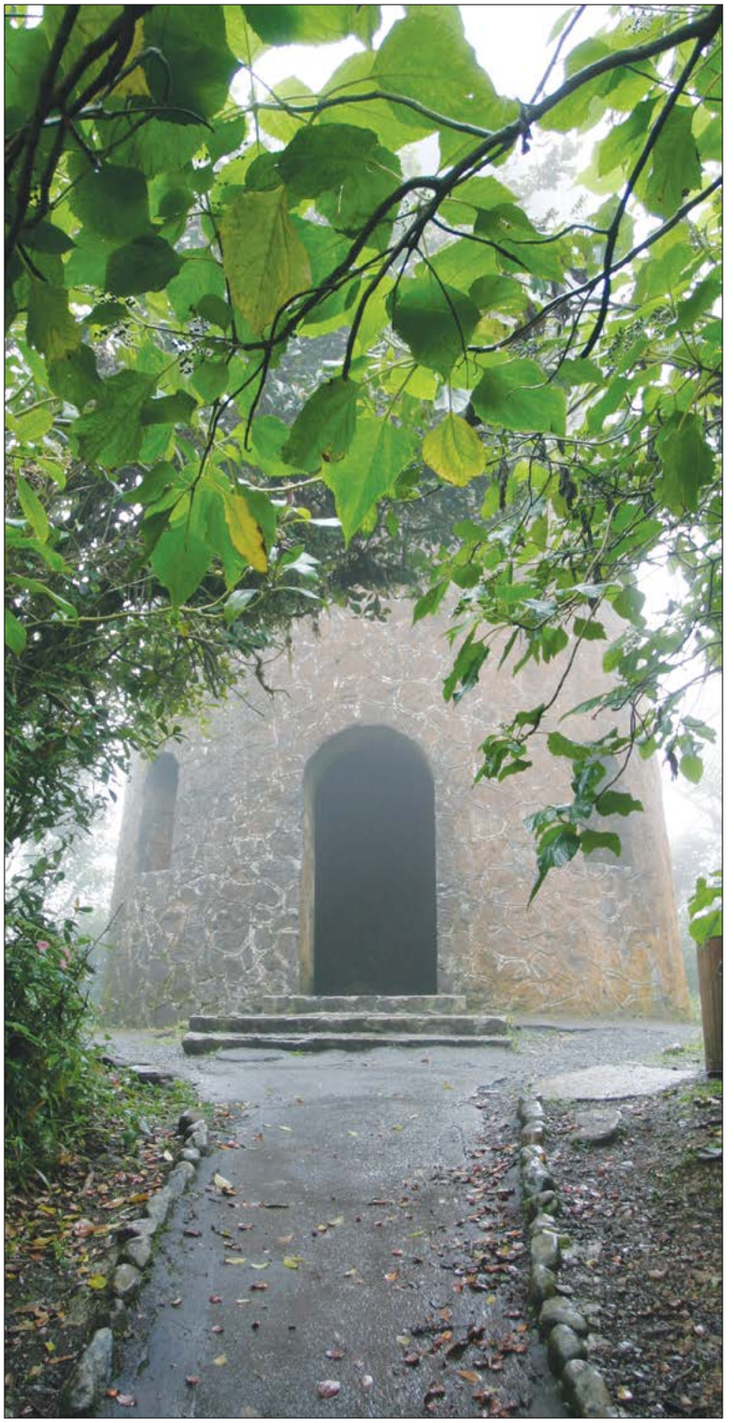
Dr. Nathaniel Britton, Mrs. Britton, Puerto Rico Commissioner Carlos Chardón, Mr. Kramer, Mr. Dale, and Mr. Dexter (1924).

Nathaniel Britton

Botanist Nathaniel Britton and fellow scientists from the New York Botanical Garden extensively surveyed the Luquillo flora from 1914 to 1930 as part of the study sponsored by the New York Academy of Sciences. Along with Percy Wilson (who in 1902 hiked from the Luquillo foothills to El Yunque Peak to collect some 3,000 specimens), Britton compiled the forest's largest collection of spermatophytes (seed-bearing plants). The tower-topped peak known as Mount Britton is named for Britton and his wife.

"I read a report in which Nathaniel Britton said he saw trees cut in the Luquillo forest whose severed branches were still green when he returned three months later. I think he was speaking somewhat hyperbolically."

[Frank H. Wadsworth, when walking through a particularly humid patch of forest]



Mount Britton Tower, constructed in the 1930s by the Civilian Conservation Corps for recreational use, honors the work of Nathaniel and Elizabeth Britton (2005).

Mount Britton Tower, surrounded by sierra palm and elfin woodland on a prominent point close to El Yunque Peak (2007).

1916 A.D.

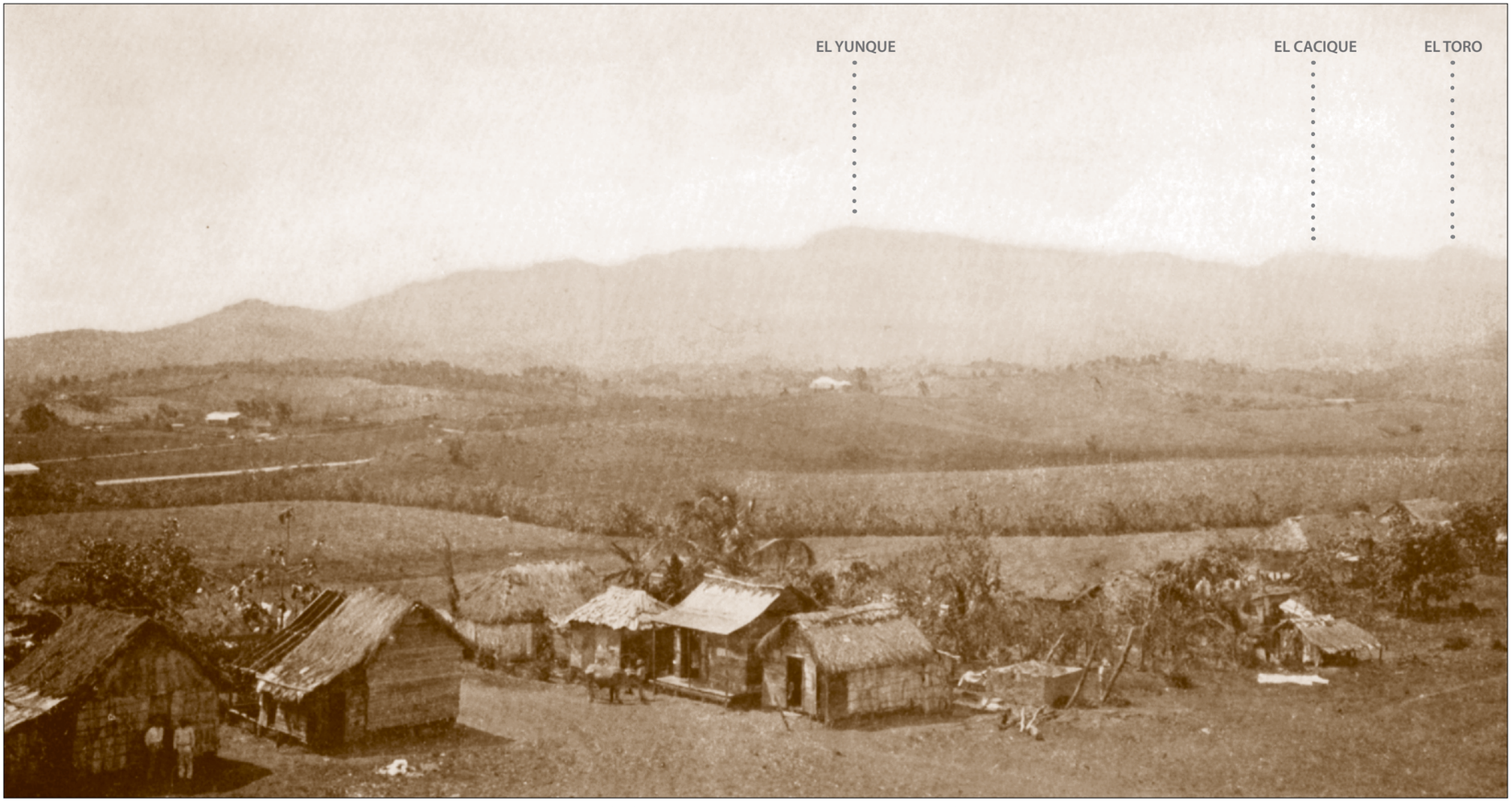
The first forest boundary survey by Puerto Rican Government engineers indicated that the former Crown lands, now the Luquillo National Forest, comprised 5,035 hectares (12,441 acres).

1917 A.D.

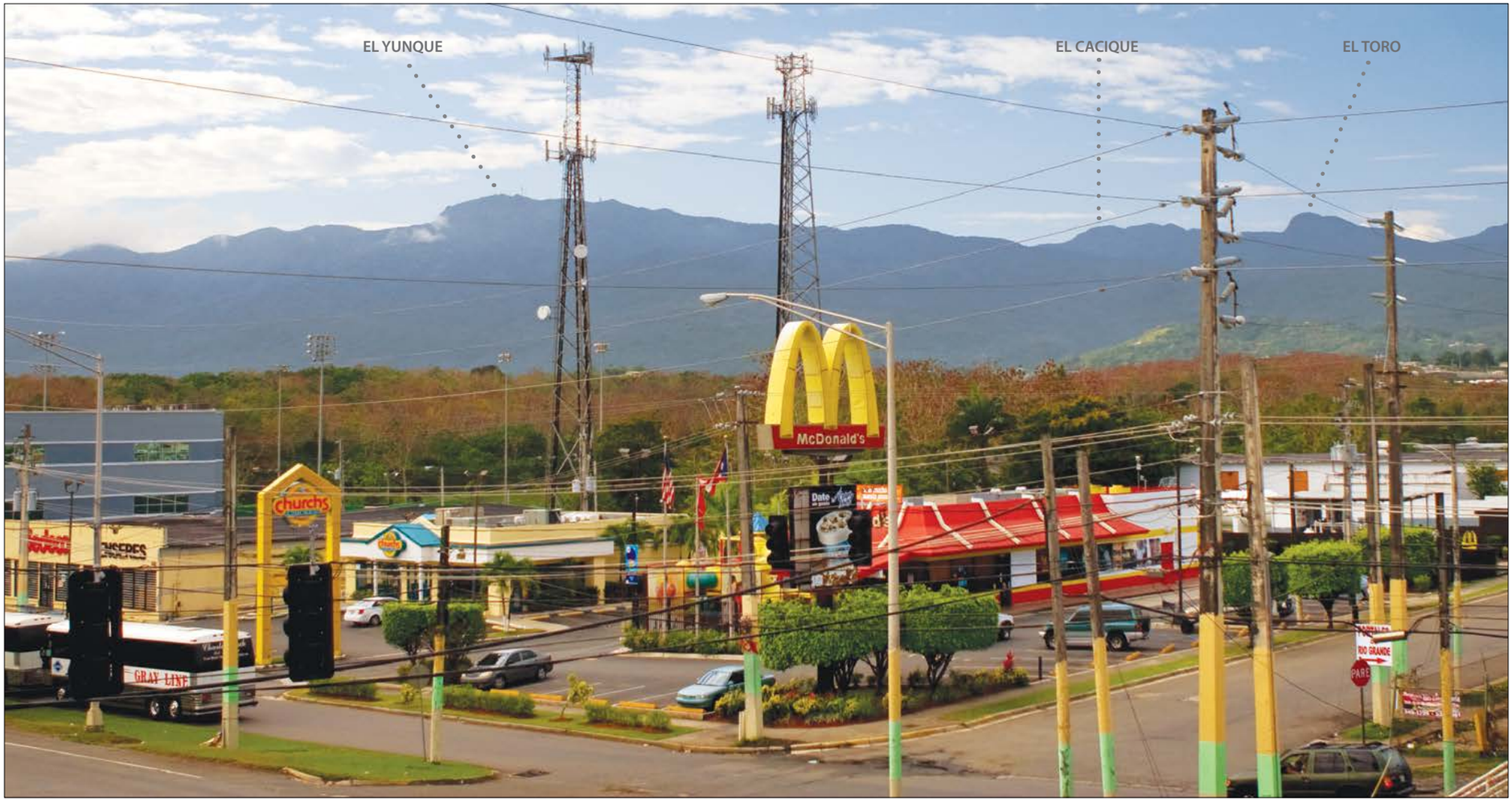
Emory M. Bruner, the first forest supervisor of the Luquillo National Forest and chief forester of Puerto Rico, drafted the first forest law to be implemented since the Spanish administration.

The Puerto Rican Legislature established the Puerto Rico Forest Service and provided for the reservation of local forests from Crown lands.

Governor Arthur Yager issued a proclamation setting aside 6,000 hectares (14,826 acres) of coastal mangrove forests as forest reserves.



The mountains of the Luquillo Forest Reserve (El Yunque National Forest) from the town of Río Grande. The three dominant peaks El Yunque, El Cacique, and El Toro can all be identified. The photograph above was taken about 1905 and the photograph on the right was taken in 2008, from approximately the same location.


EL YUNQUE
EL CACIQUE
EL TORO
McDonald's
churchs
GRAY LINE
RIO GRANDE
PARE

Chapter V

Managing the Forests

1918 to 1952

Chapter V
Managing the Forests
1918 to 1952

Frank H. Wadsworth, Retired,
USDA Forest Service Employee

As mentioned in the previous chapter, the year 1917 marked a turning point in U.S. relations with Puerto Rico, setting the stage for events that would affect the island for decades. That year, the U.S. Congress passed the Jones Act, which gave Puerto Ricans U.S. citizenship. Young Puerto Rican men were drafted to fight with other U.S. troops in World War I, and, in a vote symbolized by a coconut versus a bottle, many illiterate islanders chose the coconut and voted themselves into Prohibition.

Luquillo, which was renamed a national forest in 1907, was officially made part of the National Forest System. State (local) forests were authorized, and Emory Bruner arrived on the island as the USDA Forest Service's first supervisor, in charge of both the Federal and local forests. Now it was up to both Forest Services to implement their objectives of managing forests wisely. To do so would require the development of many facets of forestry on the island—land acquisition and control of access, access roads, recreational facilities, administration buildings, a library, a laboratory, an herbarium, a tree nursery and wood samples, research plots, data collection facilities, manuals, and more. For the next several decades, foresters would define and reserve forest areas, develop techniques for reforestation and forest management, and communicate these experiences to others.

Expansion: From Mangroves to Mountain Peaks

A fundamental step in forest conservation is setting aside forested land for that purpose. In 1918, the Luquillo National Forest had slightly more than 12,500 acres. The U.S. Geological Survey surveyed the land and placed concrete-filled lard cans along the boundaries. A skeleton crew of forest guards, armed with pistols, patrolled the boundary on horseback. Trespassing was rife, and patrolling was not always peaceful. Tales emerged of trespassing cattle spending time in jail and guards vanishing from their posts. Patrolling against trespassers went on for years.

Additional land was added to the Luquillo National Forest in the 1930s, and Toro Negro, encompassing the island's highest peaks, became a western unit of the forest. As a result, the official name of the combined forests had to change to include both units, and, in 1935, they became the Caribbean National Forest. Even after Toro Negro was turned over to the Puerto Rico Forest Service system decades later, the Luquillo unit officially remained the Caribbean National Forest until 2007, when it became El Yunque National Forest. Since the 1800s, island residents have commonly referred to the forest as "El Yunque," for the peak of the same name.

In the 1920s, the government of Puerto Rico began to reserve land for the islandwide local forests. These forests encompassed the former Spanish Crown coastal mangroves in the Monte del Estado of Maricao, in the coastal hills near Guánica, and on Mona Island. The Great Depression era of the 1930s and the destruction caused by two major hurricanes forced many farmers to abandon their land and try to make a better livelihood in urban areas. The USDA Forest Service bought much of this abandoned land, embarking on a period of extensive acquisition that resulted in five more state forests and ended with the arrival of World War II.

1918 A.D.
First forest guards, Bartolo Peraza and Bienvenido Gerena, were appointed to the Luquillo National Forest. Enforcing violations of forest grazing laws, they walked trespassing cattle to local jails, where they were kept until they were reclaimed by their owners and the fines were paid.

Agricultural activity was reported up to 548 meters (1,798 feet) on the southern slope of the forest.

1919 A.D.
To effectively patrol the boundaries of the forest on horseback, beginning in 1919, the forest guards built 61 kilometers (38 miles) of trails.

The governor of Puerto Rico issued a proclamation setting aside the former Crown lands of Guánica, Maricao, and Mona Island to be in the Puerto Rico Forest Service system.

Forest Supervisor Emory M. Bruner published the first description of the four forest types—tabonuco, sierra palm, palo colorado, and elfin woodland.

A sign at the entrance to the El Toro Commonwealth Forest, which was part of the Caribbean National Forest in the mid-20th century (2007).

Red mangrove forests were common in the 1920s and 1930s along coastal areas in Puerto Rico (c. 1930).

1920 A.D.

A large-scale program involving trial planting of exotic and native plants began in Puerto Rico.

The first tree nursery was established, funded by the Puerto Rican Legislature and operated by the University of Puerto Rico.

A site was made available to house the headquarters of the Federal and local forest services on the University of Puerto Rico, Río Piedras Campus.

The first sawmill serving the Luquillo National Forest was established in the Sabana Valley.

1922 A.D.

William P. Kramer succeeded Emory M. Bruner as forest supervisor of Luquillo National Forest and chief forester of Puerto Rico.

About 4,000 hectares (9,880 acres) of the 8,000 hectares (19,768 acres) of forested land in the Luquillo Mountains were privately owned.

1922 A.D.
A horse trail to El Yunque Peak was constructed.

1925 A.D.
The USDA Forest Service began support of local tree production under the Clarke-McNary Act.

" Ley 9 del 1925 de Puerto Rico" provided tax relief for forests existing on private lands.

1926 A.D.
Construction of initial portions of Road 191, which would ultimately provide convenient access to the forest, began. The USDA Forest Service State and Private Forestry Program began in Puerto Rico.

1927 A.D.
Forest tree nurseries were established in San Germán and Utuado by municipal governments for farm tree planting.

Use: Pressure for Forest Uses

As part of its management goals, the USDA Forest Service authorizes permits for uses that are compatible with conserving resources. Over the decades, many assorted requests have been made. Some have been permitted, others rejected, and a few permitted but later regretted. Requests have included the construction of roads, the use of water for consumption, and the removal of selected trees for timber or fuelwood (all permitted), summer homes (permitted but later rescinded), a major hotel in the Luquillo Mountains, a tramway from Luquillo Beach to El Yunque Peak (rejected), a trout hatchery in Luquillo (permitted but unsuccessful), a Girl Scout Camp (permitted and still in use), and communication towers atop peaks (permitted with limitations). One of the most unique use permits in the annals of the USDA Forest Service history was that of the *parcelero* plot system.

Typical jíbaro (rural peasant) dwelling in the mountains in the 1920s and 1930s (c. 1934).

Parcelero dwelling (rural farmer) near Toro Negro Forest (c. 1930).

The Parcelero System

Landowners who sold lands to the government during the acquisition boom of the 1930s were loath to evict their laborer families, so the government received them along with the land. They were subsistence farmers, working Puerto Rico's poorest soils, and many were also part-time forest workers and charcoal-makers. The Puerto Rico Forest Service concluded that the public forests had a responsibility toward such people. In what became known as the parcelero system, the workers were allowed to continue conservative farming under permit, with the proviso that they plant and care for trees interspersed with their crops, an adaptation of the practice called "taungya" developed in Burma. Few of these families had sturdy dwellings with floors, so each parcelero family was provided a dwelling—the USDA Forest Service installed a sawmill in the Luquillo Forest to produce tabonuco timber for the homes—and a concrete cistern for rainwater from the roof. Later, it was learned that the exchange of government resources for planting services was a policy violation, so parcelero farmers were charged a small rental fee for the land and the dwelling and were, in turn, paid for the reforesting. During World War II, charcoal-makers were in great demand, with as many as 130 working in the Caribbean National Forest. (After the war, kerosene stoves were imported and the local charcoal market collapsed.) The parcelero system in the Federal and State forests served a purpose—to sustain more than 1,000 families (250 in the national forest alone) living on acquired forest lands. From the outset, it was recognized that their land was too poor for sustainable agriculture. As the trees they interplanted among their crops grew and as jobs outside the public forests appeared, the parceleros were given better opportunities, until, by the 1950s, they were almost all gone.

Recreation: The CCC Legacy

During the Great Depression of the 1930s, island poverty, which was already chronic, deepened. In part, to counter the dire situation, two Federal programs—the Civilian Conservation Corps (CCC) and the Puerto Rican Reconstruction Administration (PRRA)—were established. For 8 years, until the end of 1942, these programs engaged as many as 2,600 employees in the public forests of Puerto Rico, most of them sharing work time with work on their farms.

To this day, recreational visitors to the island's forests can appreciate their accomplishments. In the Federal and State (local) forests during the 1930s, more than 256 kilometers of internal roads were built, primarily by CCC workers. Former trails were improved to road standard for forest protection, administration, and management, and almost 400 kilometers of foot trails were constructed, many of them from former paths made by farmers. In Luquillo and the local forests, recreational foot trails were completed, linking recreation areas with the forests' highest peaks. Luquillo's recreation area also showcased observation towers, picnic areas, swimming ponds, bath houses, and a restaurant, all constructed by CCC workers. For the most part, the work of the CCC has withstood the ravages of hurricanes and time.

Flag station at a Civilian Conservation Corps Camp in Puerto Rico (c. 1933).

1928 A.D.
Hurricane San Felipe caused massive destruction on the island.

Timber from the forest was provided to the public to reconstruct under the Free Use Provision Act.

The McSweeney-McNary Forest Research Act authorized the establishment of a forest research station in Puerto Rico.

1930 A.D.
The population of Puerto Rico was 1,543,000.

1931 A.D.
William R. Barbour succeeded William P. Kramer as forest supervisor and chief forester.

The first mahogany plantations were established within the Luquillo National Forest.

The USDA Forest Service first authorized the sale of timber from the Luquillo National Forest, although actual sales did not begin until a year later.

The total Puerto Rican parrot population was estimated at approximately 2,000 birds.

1931 A.D.
Beginning in 1931 through 1939, L.R. Holdridge of the Luquillo National Forest planting staff, built an herbarium that represents two-thirds of the trees of Puerto Rico and that eventually became part of the collection of the University of Puerto Rico Botanical Gardens.

1932 A.D.
On May 17, the Congress of United States approved a law to return the name of Porto Rico back to its original name, Puerto Rico.

The first National Forest Policy Statement for the Luquillo National Forest was published.

Acquisition of 20,234 hectares (50,000 acres) of forest for the purpose of research, silviculture, and reforestation was proposed.

Two overnight cabins were constructed on the north and south sides of the forest to facilitate guard patrols.

Reforestation: Learning From One's Mistakes

With the earlier successes of agriculture in Puerto Rico, particularly of coffee in the 19th century and sugarcane in the 19th and early 20th centuries, many of the slopes of Puerto Rico's newly acquired "forests" were partially or totally denuded of trees. Thus, reforestation was not merely important; it was essential. In 1921, Puerto Rico's fledgling nursery began to produce trees, the first being casuarinas for use on farms. Luquillo's first plantings began in 1931, on a site still known as the Harvey plantation. The seed, which came from St. Croix, surprised everyone when it proved to be a hybrid of two types of mahogany.

Reforestation means more than throwing down seeds and hoping for the best, or letting nature "take its course" on crop-abused land. Yet, in the early years, the reforestation efforts in Puerto Rico, though large in scale, were accomplished largely by trial and error. Foresters had virtually no experience on which to build. Successful reforestation had been done primarily in temperate forests, and what had worked there did not necessarily work in the tropics. In the course of acquiring experience, many mistakes were, inadvertently, made: native trees that had flourished in the island's mature forests failed when planted on exposed, degraded slopes; tree species that prospered in international forests with similar conditions did not work here; and promising young saplings often succumbed to disease, flooding, or other local calamities. More than one-half of the public forest plantings had to be partially replanted. In addition, millions of trees had been distributed to private farmers by 1938, but, in part because the trees had been delivered at no expense to the farmers, few good plantations were produced.

At this time, it was decided to back the program with investigations, and, in 1939, the USDA Forest Service created the Tropical Forest Experimental Station. Its job was to assess some 78 recent plantations with 35 tree species in public forests and 50 million trees distributed to private landowners during the previous 20 years to see what was going wrong. The headquarters were located on land provided by the University of Puerto Rico in Río Piedras, and research field stations were established at El Verde in Luquillo and in the Río Abajo Insular Forest. The station soon encompassed a tropical forestry library, one of the first of its kind in the hemisphere; an herbarium; and an invaluable collection of wood samples.

Before the Tropical Forest Experimental Station existed, the Caribbean National Forest, under Leslie Holdridge and George Gerhart,

Laborers tending cedar seedlings at the Río Piedras Nursery (1931).

had begun research. Gerhart placed regeneration plots in the Luquillo National Forest in 1937, and Holdridge had accumulated a good herbarium of most of Puerto Rico's trees, which he passed on to the station. With the studies of plantations throughout the Federal and local forests, the station began a series of permanent growth plots with trees numbered individually, beginning in 1943. By 1950, about 40 plots, many an acre in size, were distributed through the entire Federal and local forest systems. (Their remeasurement brought to light findings about forest density and the relation between spacing and light and tree growth that led to a universal practice for improvement of wood production in tropical moist forests.) These research plots remain among the oldest in the Western Hemisphere.

Renowned tropical scientists of the first half of the 20th century—Nathaniel Britton, H.A. Gleason, Leslie Holdridge, José Marrero, L.F. Martorell, Frank H. Wadsworth, Alexander Wetmore, George N. Wolcott, and nursery wizard José Gilormini—did some of their major research in Puerto Rico, exploring the conditions of the natural environment to determine subsequent management plans. They described and mapped ecological life zones of Puerto Rico, recognized four forest types in the Luquillo Mountains, described the tree flora of Puerto Rico, wrote a bilingual glossary of terms and planting manuals, and studied birds, insects, and other fauna.

Holdridge, who came to Puerto Rico in 1932 and later developed the internationally known Life Zone System, launched *The Caribbean Forester,* a regional technical forestry quarterly journal. The magazine endured for 24 years, carrying articles from throughout the tropics and publishing the station's technical findings and annual reports. For a time it was published in three languages (English, Spanish, and French) and distributed through a mailing list that rose to more than 2,000.

Between 1934 and 1946, more than 29 million trees of 53 species (24 of them native) were planted in the public forests. By 1949, virtually all public forest land had been reforested: within the national forest, 8,790 acres had reforested naturally and 3,600 acres had been reforested by planting. José Marrero, a forest regeneration scientist who worked for more than 30 years with the USDA Forest Service, admitted that the early mistakes were invaluable to the later successes, and the successes produced information about tropical reforestation that was unequalled in tropical America at the time.

Rural farmer showing success of reforestation (c. 1930).

1932 A.D.

Beginning in 1932 and continuing for 17 years, 292,966 cubic meters (961,174 cubed feet) of wood was sold from the Luquillo National Forest, 83 percent of which was fuelwood.

On September 30, Hurricane San Ciprián struck the island. Two hundred people were killed, a thousand were injured, and property damage reached $40 million.

1933 A.D.

Congress enacted the Federal Emergency Conservation Program.

Civilian Conservation Corps (CCC) programs began in the Luquillo National Forest, under Forest Supervisor William R. Barbour's control.

Projects included "building a road through the cliffs and jungles of the Luquillo Mountains," reforestation, and recreational and administrative improvements. Most of the present-day El Yunque recreation area was constructed at that time.

Beginning in 1933 and continuing through 1949, 505 hectares (1,247 acres) of land were acquired and added to the Luquillo National Forest.

Deforested land in the mountains from Comerio Road. Tobacco is being grown under the white cloth (1930).

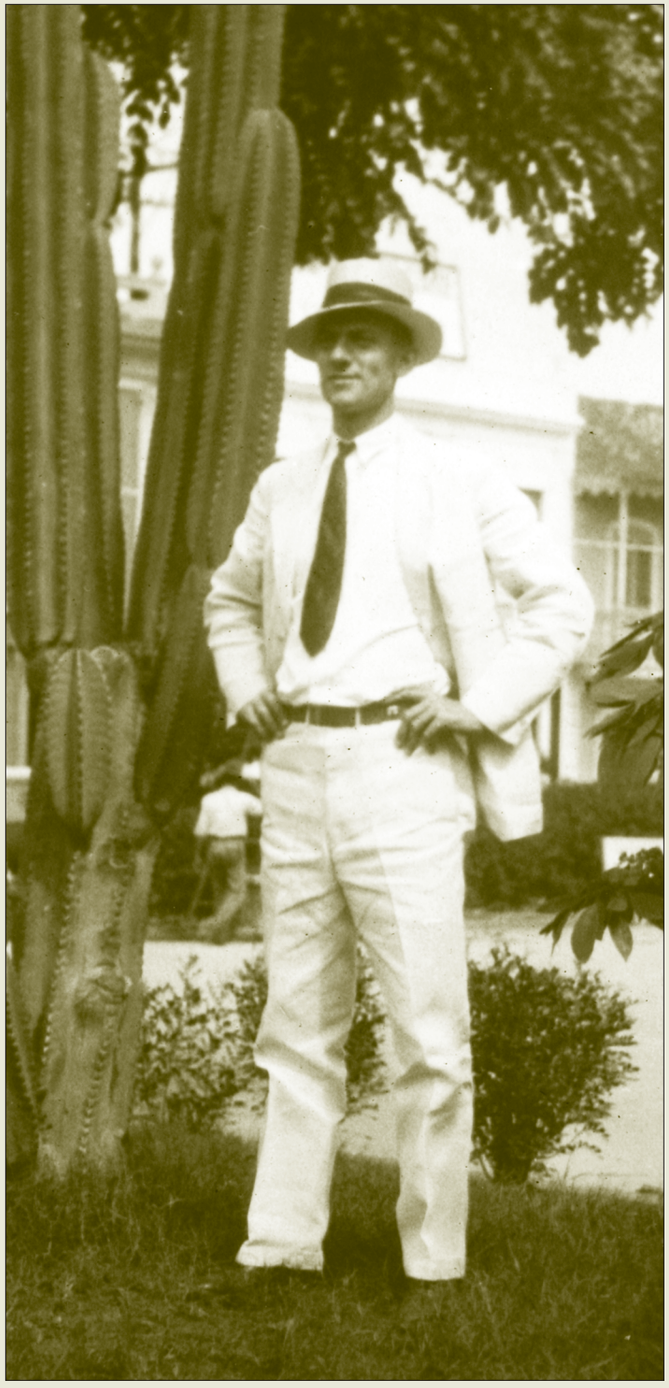
George Albert Gerhart

George A. Gerhart was born on November 30, 1905, in Wernersville, PA, the first son of William Peter and Mamie (Yoder) Gerhart. He graduated from Wernersville High School in June 1924.

In September 1924, Gerhart entered the Pennsylvania State Forest School at Mont Alto, PA. For a portion of the academic program, he studied in Germany. He was elected to Xi Sigma Pi, the national forestry honorary fraternity. Gerhart graduated on June 13, 1928, with a baccalaureate degree in forestry.

After graduating, he was hired as forest nurseryman by the Puerto Rican Forest Service. On October 4, 1928, he boarded the steamship *San Lorenzo* in New York City and arrived in San Juan 4 days later. He worked in Puerto Rico for 9 years. His initial focus was operation of the forest tree nursery at "El Yunque." He expanded production of Caribbean pine seedlings in tar-paper cylinders to avoid transplant shock. In the late 1920s and early 1930s, he made a number of voyages to other islands in the Caribbean, collecting seed—primarily mahogany—and establishing provenance trials in Puerto Rico. In addition to carrying out major duties associated with running the forest tree nursery at El Yunque, he performed a number of other duties, including timber inventories and evaluating private lands for purchase by the Bureau of Insular Affairs and later by the USDA Forest Service. He did much of the land acquisition work for the Bisley Watersheds (now a premier research facility). He kept a meticulous daily diary of his work activities, cross-referenced to several volumes of photographs taken on the job, with many reproduced here.

In 1937, Gerhart left Puerto Rico to return to the mainland to work as a reforestation specialist on national forests in the South. Gerhart died on June 9, 2002, and was buried at Wernersville, PA, next to his wife, Annie Lou (Jackson) Gerhart and a daughter, Olivia. He is survived by a second daughter, Shirley Riggins, of Duluth, GA.



1932 A.D.
Hurricane San Ciprián caused extensive damage to Puerto Rican coffee plantations.

The mineral resources of the Luquillo Mountains were described in a book by Puerto Rican geologist Rafael Picó.

1934 A.D.
A major reforestation program began within public forests. Over the next 12 years, more than 7,000 hectares (17,297 acres) were planted, with 53 species of trees, 26 of which were native.

To increase the original Luquillo National Forest proclamation area, 3,000 hectares (7,400 acres) to the east of the forest were acquired.

1935 A.D.
President Franklin D. Roosevelt created the Puerto Rican Reconstruction Administration (PRRA), which provided for agricultural development, public works, and the electrification of the island.

Additional land surrounding the Luquillo National Forest was purchased under the administration of Forest Supervisor and Chief Forester E. Worth Hadley, who succeeded William R. Barbour.

1935 A.D.

The Luquillo National Forest, combined with the Toro Negro Forest in the Central Mountains, was renamed the Caribbean National Forest.

The La Mina Recreation Area was opened.

Beginning in 1935 through 1945, 1,589 hectares (3,926 acres) in the Caribbean National Forest were reforested.

The Civilian Conservation Corps (CCC) employed 2,600 local laborers to engage in forest work throughout the island. In the Caribbean National Forest during the ensuing decade, CCC workers constructed 105 kilometers (65 miles) of roads and 80 kilometers (50 miles) of trails; built towers on Mt. Britton and El Yunque; and built two picnic areas, cabins, a fish hatchery, two swimming pools, and a restaurant.

The construction of major recreational trails in the Caribbean National Forest began.

Silvicultural stand improvement began in the El Verde section of the Caribbean National Forest.

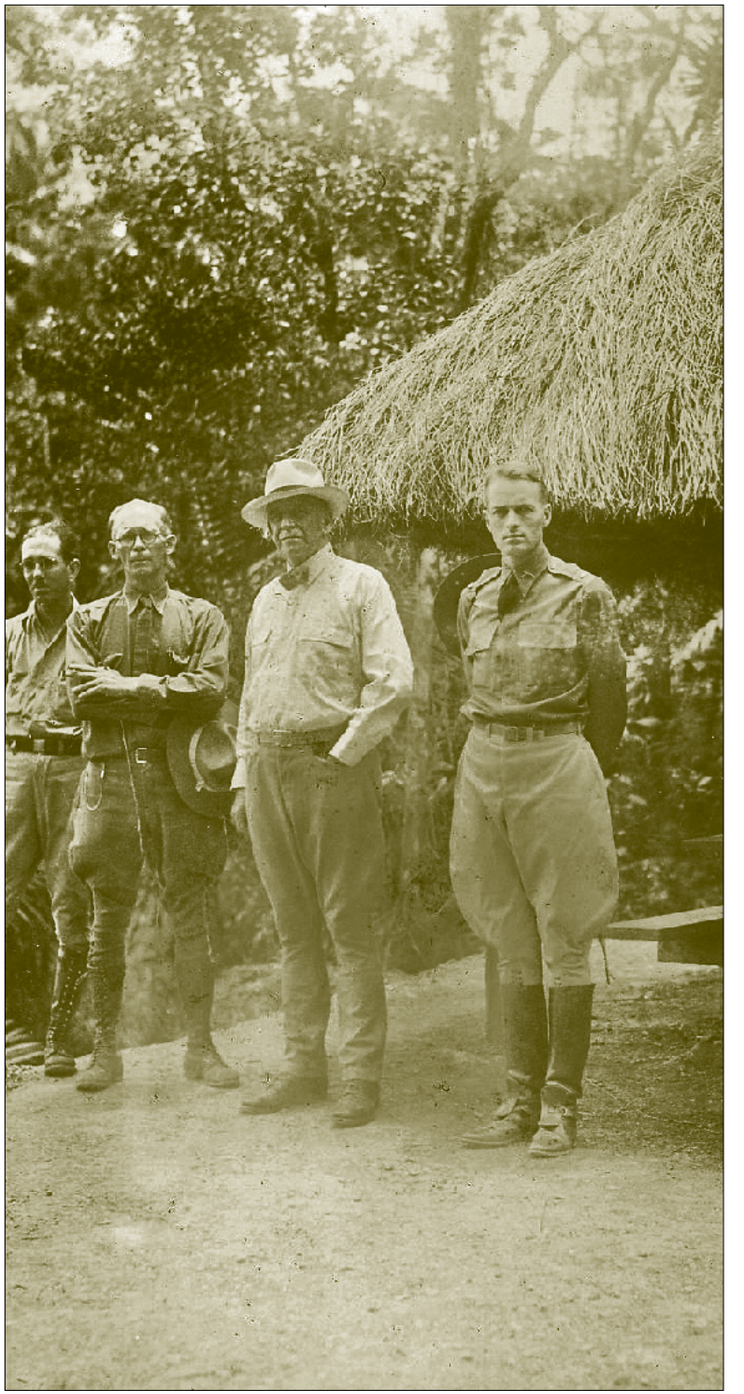
Worthless Research

The forester in the Agricultural Extension Service asked us to clarify the validity of the rural belief that fence posts cut during the waning moon were the only ones that were durable. We were exploring several of the farmers' beliefs. The most common one was that of the waning moon. There were also beliefs that in low tide, or when trees do not have new foliage, durability was longer.

We designed a study to compare all of these options. Four species of posts were selected, with 25 posts for each treatment on the north coast and in the Toro Negro Mountains. Periods for cutting included the middle of the rising and waning moon phases nearest each of the four seasons, days with the greatest differences between low and high tides, and four periods when the crowns had and did not have new foliage. Some 1,800 fence posts were cut at specified times and set in the ground at random on 8-foot centers.

The service life of all treatments ended by the fourth year, except for Vitex at Toro Negro, where the posts took root and sprouted. We reported the results as indicative that there was nothing to the rural beliefs. The farmers responded that our experiment was worthless because it did not show what everybody knew.

[Reminiscence of Frank H. Wadsworth]



Official visitors to the La Mina Recreation Area in the Caribbean National Forest; left to right, Mr. Henzleman, William R. Barbour, and Gov. Blanton Winship (c 1934). (The fourth man is unknown.)

Experimental Forests

The staff at the new Tropical Forest Experimental Station saw a need for plots that were typical of different local sites to test reforestation and other forestry practices. On lands of the University of Puerto Rico, a nearby 9-acre tract of old secondary forest in walking distance from the headquarters became the Río Piedras Woodlot, a site for early studies of tree growth and underplanting. Soon thereafter, a 27-acre tract of Federal land in Carolina was transferred and became the St. Just Experimental Forest. It represented shale soils of poor agricultural potential at low elevation. A third, 600-acre experimental forest was made available by the Puerto Rico Land Authority in 1947. Named the Cambalache Experimental Forest, it was located in the northern limestone hills near Arecibo. It was the site for testing the adaptability of more than 50 tree species and the durability of preservative-treated fence posts set in the ground.

Luquillo Experimental Forest sign at the El Verde field station (no date).

Cambalache

Cambalache, now a Commonwealth forest, had a significant beginning when a 500-acre law released Colonia Wolcott from Central Cambalache (a sugar refinery mill) to the government. Within the forest was an area of concentrated limestone hills that were densely forested. The trees had been used only to fire up the Central (sugar mill) boilers before fuel became available at the beginning of the harvest. With the concession of the area for an experimental forest came a budget for a guard and a small crew. With the construction of a ranger dwelling, a remarkable candidate, José Rodríguez Viruet, took control. He found that some 250 families in the vicinity were dependent on cooking fuelwood from the forest. Because what they were taking was dead material, permission was continued. Then, with the hills mapped, a systematic, 5-year silvicultural program was begun. The forests were selectively thinned to provide more growing space for the more promising trees. This practice produced fuelwood and posts, each being sold to the neighbors. A price for straight posts, set at three times the price for fuelwood, sold only at the fuelwood price until we learned to cut them only during the waning moon. Once this was done and the community was informed, we got the post price. Dependence of the community on free deadwood and freshly cut fuelwood and posts produced loyalty. Neighbors monitored and reported the theft of wood to the guards.

[Reminiscence of Frank H. Wadsworth]

1935–1943 A.D.
The local Puerto Rico Reconstruction Administration voluntarily established a forestry division that acquired 6,800 hectares (16,800 acres) for five State (local) forests. This governmental unit, comprising professionals and rural laborers, established plantations and constructed roads, trails, recreation areas, and administration facilities in those local forests.

1936–1959 A.D.
The University of Puerto Rico's Agricultural Extension Service was instrumental in distributing 60 million trees to island farmers.

1937 A.D.
The first systematic inventory of 6,879 hectares (16,998 acres) of the Caribbean National Forest's timber resources was completed. A USDA Forest Service sawmill was established at Sabana in the forest. Over a 6-year period, the sawmill cut native tabonuco timber used in constructing houses for permitees living in the Sabana and Mameyes Valleys in the forest.

1937 A.D.
USDA Forest Service employees estimated the Puerto Rican parrot population to be about 2,000.

1938 A.D.
In the first application of silviculture in the Caribbean National Forest, poor trees and vines were eliminated and desirable saplings were liberated in a 55-hectare plot.

Timber trees were planted along with their food crops by 700 Puerto Rican *parcelero* families living in the public forests.

The first five study plots were established in the Caribbean National Forest and were later remeasured by forest technicians.

1939 A.D.
A USDA Forest Service Tropical Forest Experimental Station was established on 2 hectares (5 acres) of land on the University of Puerto Rico campus in Río Piedras. The university provided the land rent-free for 50 years. The annual budget was $30,000.

The Tropical Forest Experimental Station Library was established.

Arthur Bevan was named the Tropical Forest Experimental Station's first director.

Multiple Use: Parts of a Whole

Frank H. Wadsworth was a young, recently married forester when he came to Puerto Rico in 1942 to work at the Tropical Forest Experimental Station. He researched his Ph.D. thesis for the Universtiy of Michigan at Ann Arbor on the development of forest land resources in the Luquillo Mountains; it was published 7 years later. For decades, it has stood as a classic land management model for tropical forests. Instituted in the Caribbean National Forest in 1949, the plan reserved 10 percent of the total forest for complete preservation to protect soil and water resources, 8 percent for passive research, 12 percent as parrot habitat, and 6 percent for recreation. The same year, the USDA Forest Service further protected some 1,895 acres of virgin forest in the headwaters of the Río Mameyes in Luquillo by creating the Baño de Oro Research Natural Area, reserved purely for nonmanipulative research.

In addition, 29 percent of the forest was set aside for saw-timber production, 12 percent for the production of poles and small timbers, and 23 percent for the production of charcoal and fuelwood. Production areas were divided into six working circles, with a harvesting cycle of 15 years. During the cycle, workers would be permanently employed as they moved from circle to circle. The goal of the USDA Forest Service was to maintain sustainable growth in the forest by removing a controlled quantity of selected trees while doing a minimum of damage to surrounding trees. To determine what could be considered sustainable, foresters looked at inventories from the 1940s and at plot growth records. The evidence of sustainability began to become apparent from around the time the forest was treated following the application of the 1949 plan until around 1970.

By the early 1950s, Wadsworth was promoted to project leader of the Tropical Forest Research Center (formerly the Tropical Forest Experimental Station). Thanks in large part to his management efforts, by the 1950s, the public forests in Puerto Rico, particularly the Caribbean National Forest, became outstanding examples of how to use forests wisely by implementing multiple-use management, models not only for the island but for all of the Caribbean and tropical America.

Charcoal-making was an important economic activity for rural people in the mid-20th century (c. 1934).

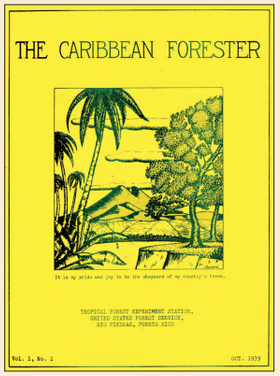
Gov. Blanton Winship at a cabin in La Mina Recreation Area, Caribbean National Forest (1934).

The Rise and Fall of *The Caribbean Forester*

With the opening of the experimental station, Leslie Holdridge recognized the need for a regional technical journal and began *The Caribbean Forester* in 1939. For several years, Caribbean islands shared the cost of the publication. It appeared quarterly and ultimately appeared in three languages. It presented much of the research of the station and of other workers in the Caribbean. Editing was a big job, because many of the sources were not trained in scientific writing. Many articles were almost emasculated but without complaints, due to the authors' appreciation of appearing in print. The journal was terminated in 1964.

[Reminiscence of Frank H. Wadsworth]

Benchmark placed by the U.S. Geological Survey at El Yunque Peak in 1940 (2006).



1939 A.D.
The first of 24 volumes of *The Caribbean Forester* were published.

Scientific testing of the Site Adaptability Program began, testing more than 100 native and 350 introduced species over the ensuing years.

1940 A.D.
The population of Puerto Rico was 1,869,000.

1940 A.D.
The Puerto Rico Reconstruction Administration completed the El Verde Field Station, a research base within the Caribbean National Forest.

1942 A.D.
The Mameyes-Río Blanco Forest Highway (Road 191) that once bisected the Caribbean National Forest and served the forest's recreation area was completed after 16 years of construction.

1942 A.D.

The U.S. Postal Service issued a stamp to commemorate the 450th anniversary of Columbus's landing on Puerto Rico.

1943 A.D.

The Caribbean National Forest and the Tropical Forest Experimental Station were consolidated as the Tropical Forest Unit, with Arthur Upson as Director.

Research on silviculture of natural forests began in the Caribbean National Forest, conducted by the Tropical Forest Experimental Station. This research represented the first information on the structure and composition of the forest. Three permanent natural forest growth plots were established at El Verde for long-term research. This effort continued and reached a total of 554 plots by 1956.

Tropical Forest Experimental Station in Río Piedras (1945).

Epilogue to Road 191

The first highway through the Luquillo Mountains connected the area of Mameyes near the north coast with the Río Blanco on the southern side of the mountains. Known today as Road 191, it was started in 1926 and completed in 1942, and the entire route was built by hand. In the 1970s, tropical storms and hurricanes produced abnormally heavy rains that caused the largest landslide ever recorded on the island. It severed Road 191. From that time until today, the road has been closed in the area of the landslide, a longer period of time than it was opened.

After the landslide, the Caribbean National Forest and the Federal Highway Department pushed to reopen the road. They gave out a contract, but the company went bankrupt during construction and could not finish the job. The Institute of Tropical Forestry, on the other hand, opposed reopening the road for a number of reasons. Among them—the geologic formation of the Río Blanco stock, common in the region, was highly susceptible to slope failures; the overwhelming majority of landslides in the forest are road related; road-related slides are larger in size and retard vegetation cover for a longer period of time than nonroad-related slides; clearing for a new road would create enormous environmental impacts, including the destruction of portions of the only remaining original forest stands in Puerto Rico (i.e., those that were here when Columbus landed); and landslides would still occur, because the whole side of the mountain is in the Río Blanco Formation.

Pressure to reopen the road remained very heavy, particularly from the Federal Highway Department and the national forest. Eventually, a nongovernmental organization, the San Francisco Office of the Environmental Defense Fund, intervened, sued in court, and won. The Federal court stopped construction to reopen the road. Today, national forest personnel understand that it was best not to reopen the road. The new Land Use Plan for the forest contains a new concept—"the quiet side of El Yunque"—to provide recreational use on the southern slopes of the mountain.

[Ariel E. Lugo]

Construction of Road 191 in the Caribbean National Forest (1935).

1943 A.D.

Wartime greatly accelerated the timber sales program required for charcoal fuel production at all public forests.

Estimates showed that less than 1 percent of Puerto Rico was virgin forest.

The USDA Forest Service authorized construction of a paved road to El Yunque Peak to be built by the U.S. Army to provide access to a wartime observation post.

The Land Authority of Puerto Rico conceded 267 hectares (659 acres) of limestone forest, which became the Cambalache Experimental Forest.

This effort was supported by a single forest guard who served the fuelwood needs of 240 nearby families during the first years of his employment.

1944 A.D.

The Caribbean National Forest sold 992,428 board meters (3,255,997 board feet) of timber, much of which was made into charcoal by local *carboneros.* Trees removed for sale were premarked by local forest officers, leaving more promising immature trees to survive for the future.

José Marrero: A Forester Speaks Out

José Marrero was born in 1910 in the mountains of central Puerto Rico, near the town of Utuado. When he was of school age, he left the mountains and studied in schools in the coastal city of Arecibo.

"I lived in a rural area and I loved the countryside and my mother and my family. At that time there weren't rural schools and my mother decided to send me to an aunt's house in Arecibo. This for me was a tragedy. To leave the farm and leave my mother to go to Arecibo, it was a tragedy. I got up before dawn and that day for me was the end of the world. All that darkness. I saddled up the horse because there were only horses back then. I mounted the horse and began to cry.

"Of course the family in Arecibo was very nice and in a little while I got settled. I came to love cowboy movies. Elmond Lincoln was my favorite and he was Tarzan and he also worked in a movie about a forest ranger. The forest ranger fought the thieves who robbed the lumber, stepping from log to log as the logs floated down a chute of water, and he landed punch after punch on the thieves. Those movies were so primitive.

"That was my first contact with forests."

When he graduated from high school, Marrero studied in the Agronomy College of the University of Puerto Rico, Mayagüez campus.

"I liked horticulture, and I studied the cultivation of vegetables, citrus fruits, coffee, everything that was horticulture. A big reason I studied that was because I admired Professor Cowells. I thought he was an outstanding professor, and he was Dean of the Agronomy College."

In the mid-1930s, Marrero began to work with the USDA Forest Service as part of the Civilian Conservation Corps. During that time he married Grisel Carrasquillo; their daughter studied biology. His first job was as a supervisor for men working in the Toro Negro Forest. When the Tropical Forest Experimental Station opened in 1939, he went to work with Leslie Holdridge. In the 1940s, the USDA Forest Service began a series of studies in foreign countries. Holdridge was in charge of the mission in Ecuador, and he asked Marrero to go with him.

"It was a forestry mission to study the forest system and to make recommendations of what to do to conserve the forests. I had experience and I spoke Spanish, I knew the idiosyncrasies of the Spanish Americans. When the mission ended in 6 months, Dr. Holdridge went on to jobs in the United States, but I stayed for 3 more months.

"During that time, I got an attack of appendicitis while I was in the middle of the jungle. There was an American forester with a lot of tropical experience. He laid me down in a truck. There were no roads, the beach was the road, and he told the driver to go quickly, before the tide rose. We reached a town, where a doctor had a brother who was a good surgeon. There was also a U.S. base in the little town of Manca, with an American surgeon. So I had the good luck that two excellent surgeons could have operated on me."

In the mid-1940s, Marrero studied forestry sciences at the University of Michigan. The university was interested in bringing Spanish Americans to study there, and Marrero received a scholarship. He then returned to work with the USDA Forest Service in Puerto Rico.

"My specialty was in reforestation, in forest plantations. I worked in the nurseries, and gave follow-up from the nursery to the plantation. I mainly worked in forest maintenance. I remember writing articles, mostly for *The Caribbean Forester* and the *Puerto Rico Agricultural Review.*"

In 1965, after 30 years of service, Marrero retired from the USDA Forest Service.

"At that time I was interested in the cultivation of roses. Roses interested me a lot. I had a very good collection of roses and became somewhat of an expert in them."

Marrero lived a long and healthy life. He held this interview with historian Carlos M. Domínguez Cristóbal in 2003, at the impressive age of 93. He spoke of the future of forests in Puerto Rico.

"If I were a government leader, I would focus on conserving the federal and local government forests. This would be for me the most important task. I don't have a lot of faith in the private lands because the owners change so often and in general the private entities don't have much interest in conservation. For me the emphasis has to be on the government. In schools, I would stress the importance of trees and the conservation of trees and forests. My message would revolve around conservation."

[Excerpted from an interview with Carlos M. Domínguez Cristóbal]

In Memory of José Marrero (1910-2007)

On April 13, 2007, José Marrero died. The following excerpt from his obituary sums up the amazing career of this dedicated forester:

"The enormity of José's work remains in the trees. His affection was not limited to his favorite tree, the guamá *(Inga laurina),* but to the millions of more than 50 species that got their start under his guidance. When José finished his 30 years of federal service in 1965, there was not one acre in Puerto Rico's public forests that hadn't been reforested: more than 20,000 acres had been planted during his time. These trees, in the forests of El Yunque, Carite, Toro Negro, Aguirre, Cambalache, Río Abajo, Guajataca, Guilarte, Maricao, Susúa, Guánica and Boquerón, remember José as the person who was responsible for their care when they were in diapers."

1945 A.D.
The Caribbean National Forest recorded 1,750 timber sales. That number represented more than 10 percent of the total for the entire National Forest System for the year. Four forest officers provided tree-marking and supervision: José Reyes Mateo, Luis Carrión, Raúl Ybarra Coronado, and Ramiro Agosto Ruíz.

The book *Forest Insects of Puerto Rico*, written by entomologist Luis F. Martorell, was published.

The Puerto Rico Forest Service initiated a Watershed Protection Project, planting stands of exotic bamboo on the periphery of major reservoirs.

1945 A.D.
The population of Puerto Rico was 2,210,700.

1946 A.D.

The Caribbean National Forest, better known to island residents as "El Yunque," was designated a Puerto Rico wildlife refuge.

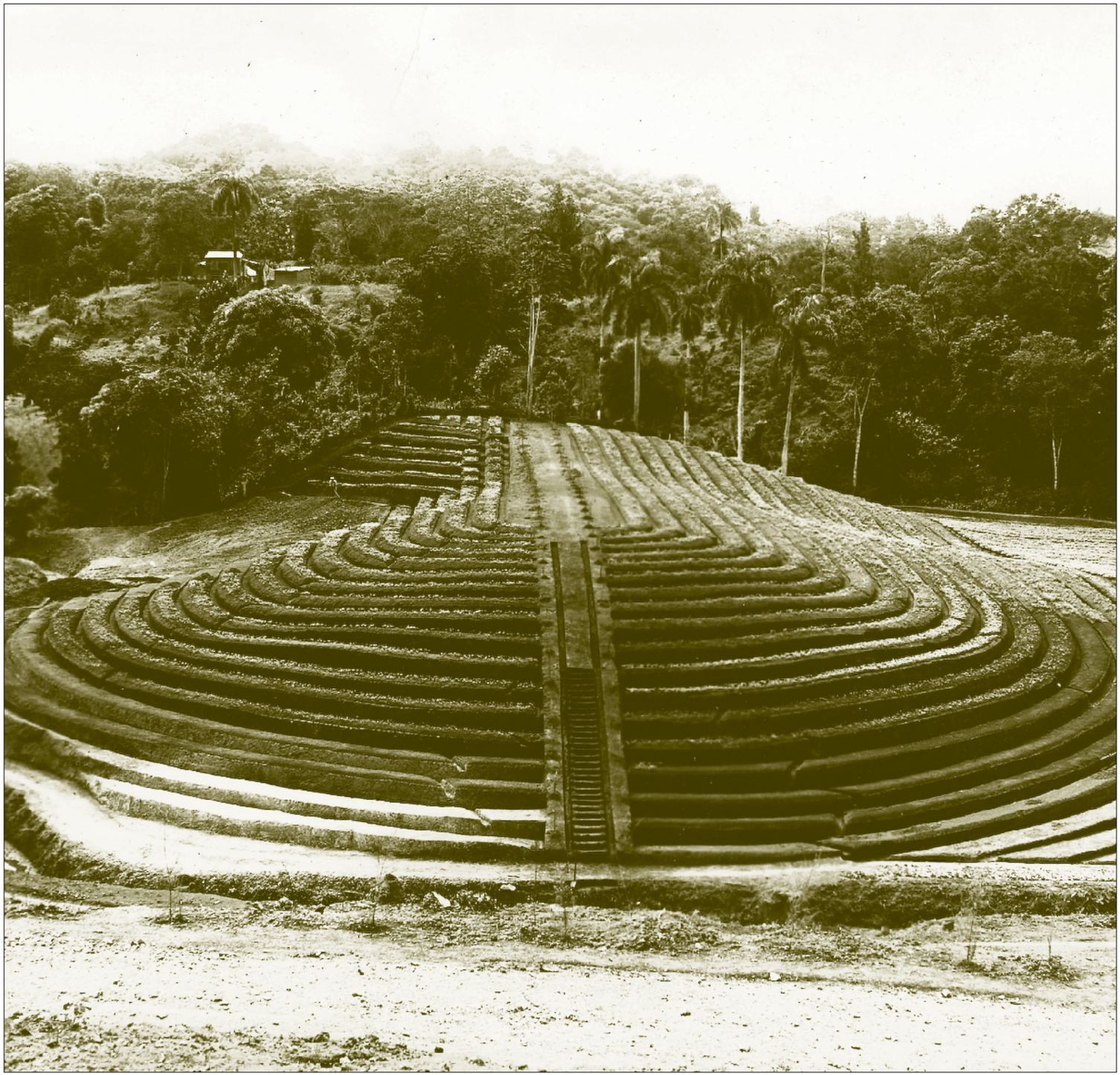
Beginning in 1946 and continuing through 1947, the public forests of the island were inventoried by the Puerto Rico Forest Service.

Large-scale placer mining of gold on the Río Mameyes in the Caribbean National Forest was abandoned.

A systematic inventory of the forest began and was accomplished through strip sampling by local crews.

1947 A.D.

The Puerto Rico Forest Service published the *Forest Nursery Manual* by agronomist José A. Gilormini.



Tree nursery established at Las Mesas by the Puerto Rico Experimental Station (1934).

Valley of the Giants

From the 1948 timber inventory, the largest tree recorded had a dbh (diameter at breast height) of 104 inches. The person who recorded it died shortly thereafter. A group of us was curious and set out to see it. It was about a mile east of Highway 191 at kilometer 17 and thence northeastward toward West Peak. By noon, we had completed the mile and stopped for lunch. There, immediately to the south, on a small level area, we found what has come to be called the Valley of the Giants, a sparse stand of huge palo colorado trees, mostly hollow, and some large enough to shelter a person. Three later searches failed to find it again.

[Frank H. Wadsworth]

Tabonuco tree greater than 6 feet wide (1930).

Palo colorado tree in the Luquillo Experimental Forest (1985).

1948 A.D.

The USDA Forest Service published its technical assessment of the planting of 4 million trees and 22 tons of seeds from 34 tree species in the Caribbean National Forest over an 11-year period starting in 1934. It was written by forester José Marrero.

The 4.5-hectare (11-acre) Elizabeth Colberg Girl Scout Camp was established in the El Verde sector of the Luquillo Mountains.

The Tropical Forest Experimental Station tree herbarium accrued a total of 3,000 specimens, obtained locally.

1949 A.D.

The U.S. Secretary of Agriculture designated 852 hectares (2,105 acres) of the Mameyes Valley in the Caribbean National Forest as the Baño de Oro Research Natural Area.

The first maps showing forest types were produced from aerial reconnaissance photography.

Studies showed 2,266 hectares (5,600 acres) in the National Forest were still unaffected by human activities.

1949 A.D.

A Multiple Use and Timber Management Plan for the Caribbean National Forest, calling for uplands preservation, parrot habitat, and watershed conservation, was completed by Frank Wadsworth of the Tropical Forest Unit (Caribbean National Forest).

The Caribbean National Forest's second timber cruise of 4,548 hectares (11,238 acres) was accomplished.

A total of 3,460 hectares (8,550 acres) reforested naturally due to protection.

Development of the El Yunque Peak Electronic Communication Center for the island was initiated.

1950 A.D.

The USDA Forest Service in Washington, DC, awarded Forest Ranger Emilio Solis for "harmoniously" relocating 125 *parcelero* families onto better land outside the Caribbean National Forest.

The Puerto Rico Forest Nursery was established in the Caribbean National Forest, producing millions of trees for reforesting public and private lands on the island.

The Puerto Rican Government agreed to expand the Caribbean National Forest proclamation area to permit more forest land acquisition.

Rexford G. Tugwell and Luis Muñoz Marín: Governors React

Rexford G. Tugwell was known as a liberal economist, a member of President Franklin D. Roosevelt's Brain Trust, professor, planner, and author. In 1941, he became the last U.S.-appointed, non-Puerto Rican governor of Puerto Rico. Following are some of his reactions to the island.

On visiting "El Yunque":

"There was a kind of token reserve on El Yunque, the Luquillo Forest. We [Tugwell and Chief of the USDA Forest Service, Ferdinand A. Silcox] could see that vastly more acreage would have to be acquired both in this area and in the more desirable one to the west, the Toro Negro, if much was to be done in producing timber. In the decade which followed some of this land was to be acquired and the whole reserve in Puerto Rico would be renamed the Caribbean National Forest. But even more important, Silcox's conception of small lease holding farmers at the forest edge (or even within its boundaries) who got their main living from development work, was, at least on a small scale, to be carried out."

"Luquillo was, in the exact sense of the word, a revelation to both of us. Silcox was a South Carolinian, a product of the Yale School of Forestry and a graduate from the USDA Forest Service into the wider field of industrial conciliation. I had persuaded him to leave this and come back to be Chief of the Service, and had talked the President into consent against the advice of most of the professional pundits who thought him a little unorthodox—as, of course, he was. We saw a good many things in the same way; and it was so here. We thought this forest was an opportunity, and not only for Puerto Rico. For it was unique in being a tropical rain forest, and in developing it we might learn a good deal about the resources of other American subtropics."

"A rain forest is not a comfortable place to be. Not only is there the constant uneasy interest in vegetation which seems to have got completely out of hand, but there is also the atmosphere of mystery created by the drifting rain and mist. For El Yunque is a mountain with its head in a turban of cloud."

"I wondered whether someday a grandchild of mine might not come to a forest of his day hereabouts which had vast stands of mahoganies and other hardwoods, perhaps also Cinchonas and other trees, useful for many purposes, grown to maturity! And the whole serving as the source and reservoir of vast flows of hydroelectric power which would make possible a hundred industries, lifting a whole people to a new level of life."

On February 2, 1942, in his message to the legislature, Tugwell reported that he had suggested to the Federal Government in Washington, DC, to transfer El Yunque from the USDA Forest Service to the National Park Service, along with other natural areas in Puerto Rico, such as beaches. He promoted the acquisition of lands for public recreation and use and a local park service.

[Excerpted from the book The Stricken Land: The Story of Puerto Rico *by Rexford G. Tugwell]*

Luis Muñoz Marín, Puerto Rican author, editor, senator, and the first governor elected by the people of Puerto Rico, in 1948, was also an inflential figure in forestry. After a disastrous 1932 hurricane, he obtained federal funds for the Puerto Rico Reconstruction Administration. PRRA formed a third forest service, also under USDA Forest Service administration. During its 10 years, it financed the purchase of the Susúa, Guilarte, Guajataca, Río Abajo, and Carite forests, their facilities, nurseries, and plantations.

On visiting "El Yunque":

On a rainy afternoon on one of the trails up in the Caribbean National Forest, a raincoat-covered figure approached a forest officer also on foot. As they came together, it was apparent to the forest officer that the figure was Muñoz Marín. Salutations led him to recognize the forest officer by name. He suggested that they go to his cabin for a talk. It was in one of the summer homes he was using as an escape from pressure. That afternoon, he spent 3 hours showing a boyish curiosity about the forest and its management. The depth of his interest in the natural was later exposed when he recommended a panoramic foot and horse trail through the mountains the length of Puerto Rico (the original idea behind today's Panoramic Route).

[Anecdote by Frank H. Wadsworth]

President John F. Kennedy with Puerto Rico Governor Luis Muñoz Marín (1961).

1951 A.D.
Arthur Upson was succeeded by Henry B. Bosworth as Director of what had become the Tropical Region.

1952 A.D.
The United States ratified the Constitution of Puerto Rico and the island became officially known (in English) as the Commonwealth of Puerto Rico.

Chapter VI
Analyzing the Forests/ Training the Foresters
1953 to 1969

Chapter VI
Analyzing the Forests/Training the Foresters
1953 to 1969

Frank H. Wadsworth, Retired USDA Forest Service Employee

In 1956, the Luquillo Forest, nicknamed "El Yunque" by island residents and officially known as the Caribbean National Forest, received another official name—the Luquillo Experimental Forest. With that designation, it became unlike any other U.S. national forest. Most national forests had certain areas within their boundaries that were designated for research purposes, yet Luquillo was the only forest in which the research area encompassed the entire 28,000 acres of the national forest itself.

Luquillo was also unique as the only tropical forest in the National Forest System. Management practices that were successful here could be applied in tropical forests around the world, more specifically in the neighboring forests of Central and South America. By the middle of the 20th century, forestry in Luquillo boasted many success stories. Luquillo's Tropical Forest Research Center sponsored the first of 16 international tropical forestry short courses. Primarily 3 months in length, the courses were designed to train foreign students in tropical forestry. In addition, professional staff members went on assignments to other tropical areas to provide training and technical assistance. Unlike any other national forest, Luquillo was becoming recognized as a leader in tropical forestry on an international level.

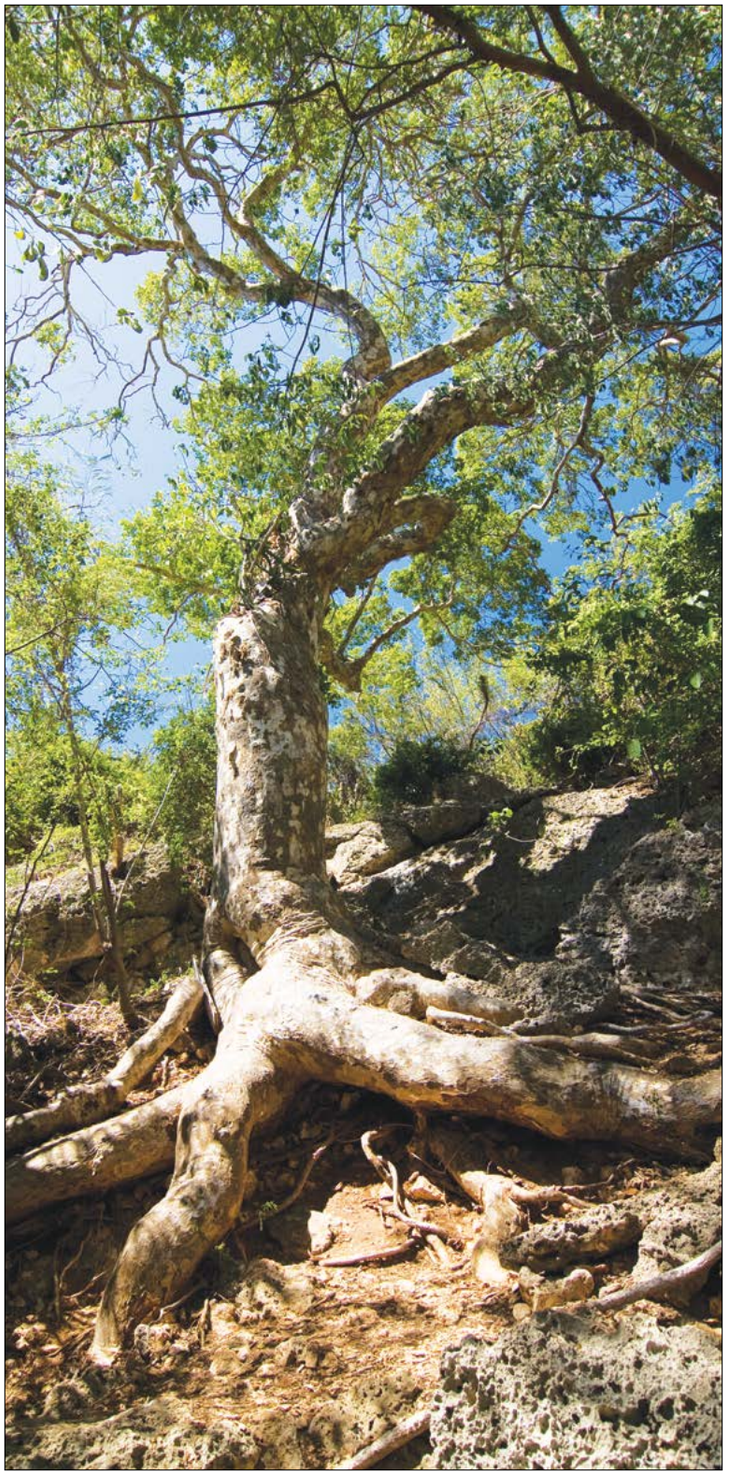
1953 A.D.

The Puerto Rico Forest Service separated from the USDA Forest Service and became the Forests, Fisheries and Wildlife section of the Department of Agriculture and Commerce. Agronomist Miguel Hernández Agosto was appointed as its first director.

The first of 16 international tropical forestry short courses was held at the Tropical Forestry Unit.

Irvin Pat Murray succeeded Henry B. Bosworth as supervisor of the Caribbean National Forest.

Frank H. Wadsworth served as project leader of research.



Cactus and elfin vegetation (above) and an ancient guayacán tree (right) form part of the tropical dry forest in the Guánica Biosphere Reserve (2006).

Shifts

Before the 1956 designation of the Luquillo Experimental Forest, Luquillo hosted two separate entities. The national forest, in charge of management, was led by a forest supervisor. The Tropical Forest Experimental Station, which was renamed the Tropical Forest Research Center in 1955 and the Institute of Tropical Forestry in 1961, was in charge of research and led by a project leader. Occasionally, differences of opinion arose between the two entities and their bosses over how the forest should be run. In 1955, Frank H. Wadsworth became both supervisor and project leader. With one person wearing both hats, forest administration ran more smoothly.

The USDA Forest Service in Puerto Rico underwent other changes. In 1953, the Puerto Rico Forest Service, with a professional forester, had come of age. After 35 years with the USDA Forest Service, it became an independent bureau under the Puerto Rico Department of Agriculture of the newly established Commonwealth of Puerto Rico. Later (1972), it became part of the Department of Natural Resources. By the mid-1960s, the organization managed more than a dozen forests surviving on almost 75,000 acres of land. Mangrove forests grew along the coast, dry forests survived on the south coast, karst forests covered the northern hills, and mountain forests flourished along the Cordillera Central, including the former western unit of the Caribbean National Forest, Toro Negro.

Mangrove forest, about 20 years old, at Las Mareas, Aguirre before a thinning (1950).

1954 A.D.
Agronomist Antonio Rodríguez-Vidal estimated the Puerto Rican parrot population in the Caribbean National Forest at 200.

1955 A.D.
The population of Puerto Rico was 2,250,000.

1955 A.D.
The Tropical Forest Experimental Station was renamed the Tropical Forest Research Center.

1956 A.D.
The entire Caribbean National Forest was additionally designated the Luquillo Experimental Forest to recognize the growing importance of research.

A Land Use Plan for the Caribbean National Forest was completed.

Wood Production

As part of its management plan, the USDA Forest Service sold local timber from the Caribbean National Forest; the timber was primarily used in making furniture. Some of the trees were products of the initial forest plantings several decades earlier. Economic disaster struck in 1953, when the local furniture industry opted to use imported, kiln-dried mahogany. Local timber sales dried up, with the exception of a few eucalyptus plantations in the center of the island. Even the use of wood from thinnings within the plantations declined. In addition, by 1956, tree growth studies showed slow growth in palo colorado forests at high elevations and led to the exclusion of this extensive forest type from future plans for wood harvest.

Undaunted, the USDA Forest Service planned for future timber production along the lower slopes of the Luquillo Mountains, and timber research continued unabated in forests around the island. Some 25,000 trees were under management in 40 plots islandwide. Additional plots were created in the Luquillo Experimental Forest. With the exception of thinning trees in specially designated thinning plots, these plots were still in the observation stage and were not being cut.

In 1960, an arboretum with plots of one-tenth acre per species was established in the western region of the Luquillo Experimental Forest; 3 years later, the arboretum boasted 90 tree species. Also during this time, the entire tree flora of Puerto Rico was described and illustrated in the book *Common Trees of Puerto Rico and the Virgin Islands* by Elbert L. Little, Jr., and Frank H. Wadsworth.

Long-term forest production studies continued throughout the 1950s and 1960s in a variety of forest sites provided by Puerto Rico. Some of the most basic had to do with the differential growth of trees relative to their microenvironments. It was found that regardless of species, in the wet forest light was the stimulus for growth. Dominant trees outgrew suppressed trees fourfold. These studies showed foresters how much to thin the forest to make the trees grow. It was also found that such thinning need not expose the site and thus could be compatible with soil protection.

In mid-century, many people had the misconception that tropical forests, once exploited, were worthless, so the land could and should be used in some other way. To disprove this misconception, foresters selected some 5,450 acres of low-elevation tabonuco forest that had been cut-over for saw timber and fuelwood as the site for a pilot demonstration of productive management in the tropics. In this previously untreated forest, with many unproductive trees, the first treatment was refinement, reducing by timber sales for posts or fuel the number of such trees where better neighbors existed. Once done, it was possible to retreat more positively, selecting those trees best suited for future production and releasing them from excessive competition to accelerate their growth. The practice did not destroy the appearance of the forest but did leave a larger component of productive trees with room to grow. Work on this project continued through the 1970s, when financing was not renewed. Because the national forest has discontinued using wood, the productive benefits of this applied research have not been utilized.

Many other timber-related studies took place during this time. Foresters planted seeds from Central American mahogany throughout the island in preparation for studying genetic variation. They tested the machining properties of local plantation mahogany and found it superior to mahogany imported from Mexico, Honduras, and Peru.

Between 1945 and 1972, they investigated the drying properties and preservation of woods islandwide. Within the Luquillo Mountains, they determined the location and average structure and composition of each of the four forest types. For a number of years, they recorded tree stem growth—by species and canopy position—for thousands of trees. The results—growth was found to be slower at high elevation. After hundreds of attempts, starting in 1923, they successfully introduced a pine *(Pinus caribaea hondurensis)* into Puerto Rico, using imported mycorrhizal fungi, and it became naturalized on degraded land.

In addition, local forestry training and technical assistance programs improved the skills of island foresters. The programs included demonstrations of fence post preservation, pine planting on farms, sawmill layout, guidance on modern nursery operations, and the National Forest Visitor Information Service. Research on detailed wood properties and machining produced a bulletin on 60 local woods for artisans.

Teak plantation at the Sabana Field Station (1950).

1961 A.D.

An arboretum of more than 100 tropical tree species was established in the Luquillo Experimental Forest.

University of Puerto Rico scientists from the Puerto Rico Nuclear Research Center tested the effects of gamma radiation on tropical forests in the El Verde sector of the Luquillo Experimental Forest. Those tests provided scientific evaluation of whether nuclear energy should be used to carve out a proposed interocean waterway through Central America to replace the Panama Canal.

The Tropical Forest Research Center was renamed the Institute of Tropical Forestry.


PUERTO RICAN WOODS

Their Machining, Seasoning and Related Characteristics

by

FRANKLIN R. LONGWOOD

Northeastern Forest Experiment Station, Forest Service; formerly at the Tropical Forest Research Center of the Forest Service in Puerto Rico

U.S. DEPARTMENT OF AGRICULTURE

FOREST SERVICE

Birds in decline

In centuries past, two species of crow, large and small, were abundant in Puerto Rico. The small crow disappeared from the island in the 19th century. The larger one, all black but for a touch of white around the neck and known as the White-necked Crow *(Corvus leucognaphalus),* decreased in number, and, by the early 20th century, was found only in the Luquillo Mountains. In 1963, six crows were spotted. After that, nothing. The bird's disappearance was without explanation.

Puerto Rico has one native parrot. About a foot long, it has predominantly green feathers, white eye-rings, red forehead, and two-toned blue primaries. Once, the large number of parrots darkened the skies, but, with the rise in agriculture in the 18th century, the number of parrots markedly declined. By the 1930s, the Puerto Rican parrot *(Amazona vittata vittata)* was found only in the Luquillo Mountains. By 1968, its population was estimated at 70, and it was added to the Federal list of species in danger of extinction.

Foresters were concerned. In a decade, one bird species disappeared from the forest (it still exists in the Dominican Republic), and a second seemed poised for the same fate. Even worse, the reasons for the crises were unclear. Why, in the protected shelter of a national forest, did the birds continue their precipitous decline?

A revised timber management plan for the Caribbean National Forest was approved in 1968. By this time, parrot research had shown that the habitat area reserved for the parrot in the 1949 plan was inadequate, and, with the bird's endangered status, its habitat needed to be protected at all costs. In part, because of the cases of these two birds, there was a growing belief that wildlife concerns should be fundamental to management throughout the Caribbean National Forest.

Local residents often caught parrots as pets, increasing the species population decline (c. 1930).

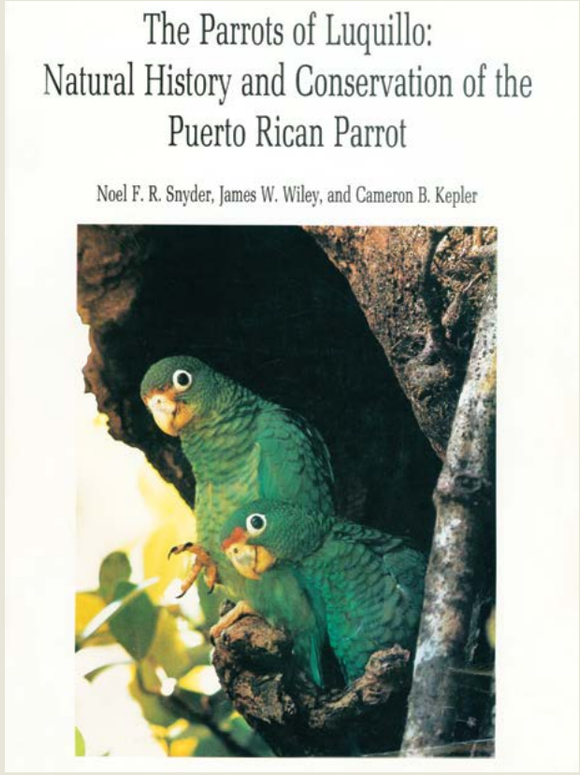
A Life With the Birds

A short time after arriving in Puerto Rico in October 1979 to work on the Caribbean National Forest, I made a trip to the "Puerto Rican parrot aviary." I had heard everyone talk about this place, so I was excited to learn more. As I drove up Road 191 and approached the aviary, I heard for the first time the raucous calls of the parrots. As I got closer, the calls got louder; as I entered the grounds, the calls got louder still. A stranger was entering the parrot territory and they knew it.

I had not been there long when two biologists, James Wiley, U.S. Fish and Wildlife project leader, and Wayne Arendt, USDA Forest Service parrot biologist, came out of the weather-beaten aviary building and greeted me. I was here to learn about the Puerto Rican parrot and the management of this species and its habitat in the Caribbean National Forest. Our meeting was planned to be short, about an hour or so. But after about 5 hours of talking, observing, and asking questions, I was still interested in learning more, and there was much more to tell. So I stayed late in the night and soaked up as much information as I could.

Little did I know at that time in 1979, that 31 years later I would still be working for the USDA Forest Service in Puerto Rico and that I would be as interested in the Puerto Rican parrot in 2010 as I was in 1979. What have I learned in these 31 years? A lot—too much to write here.

But I think the most important thing that I have learned in these 31 years is that we owe the survival of this species to the lifelong dedication of a larger number of biologists, from both Puerto Rico and the United States. These biologists—too many to name here—have lived day and night, year after year, with these birds—feeding, caring, and tending to them like they were their children. They have been up all night long to help an egg hatch, get the chick in an incubator before it was too late, and feed the squawking birds a special



diet. They have done this at the same time every day of the year. In addition to providing care at the aviary, these biologists also have either led or assisted with field research. The parrot success story has been accomplished because of these biologists' dedication, because of volunteer help (many times from spouses), and because of cooperation between Commonwealth and Federal agencies, all working together for the benefit of the species.

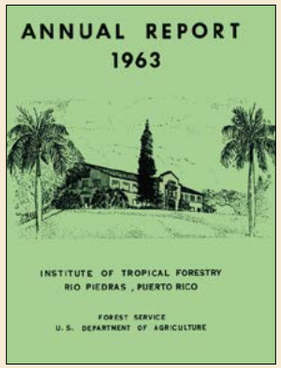
Today, in 2013, the job is not yet done. New aviaries have been established—one in Río Abajo State Forest and one in El Yunque—at a better location than the original. A new breed of biologists are now the leaders and are hard at work, because the old guys are retiring or have moved on. The parrot is better off today than it was in 1979, but it is not yet a "saved" species.

[Jerry Bauer]

1962 A.D.
Forester Juan Muñoz published a timber management plan for the Caribbean National Forest/ Luquillo Experimental Forest, which determined the available timber volume and projected sustainable silvicultural harvest.

1963 A.D.
Larry Hill was appointed project leader to administer the Luquillo Experimental Forest.

Line plantings of 1,274 hectares (3,148 acres) of mahogany in the forest began.



1963 A.D.
Construction of the Yokahú Observation Tower was completed, and the tower was opened to the public.

Juan A. Rivero discovered *Elutherodactylus hedricki,* a new species of coquí tree frog, in the "El Yunque Forest."

The White-necked Crow *(Corvus leucognaphalus)* was last seen in the Caribbean National Forest.

Botonist Roy Woodbury sighted a minimum of about 130 Puerto Rican parrots in the wild in the Luquillo Mountains.

Communities Under Study

Irradiation and Ecology at El Verde

The El Verde study came about when a new, wider waterway was being considered to supplement the Panama Canal. Engineers thought atomic power would be required for excavation, but they were concerned about the possible effects an anticipated byproduct, gamma radiation, would have on the tropical forests. Luquillo, the only federally owned tropical rain forest comparable to that of Central America, was requested as a site for the test. Since 1961, the University of Puerto Rico, as a collaborator with the USDA Forest Service, had been using the Luquillo Forest for ecological research, and the U.S. Atomic Energy Commission selected it for the investigation. El Verde Field Station became the base of operations.

On January 19, 1965, gamma radiation was released from a cylindrical block of metal placed on the ground in the western region of Luquillo Experimental Forest. For 93 days, the radiation penetrated the surrounding forest. Before, during, and after the release, between 1963 and 1967, some 80 scientists studied the forest community. When the El Verde study was completed, it became the most monumental research project undertaken within the Luquillo Experimental Forest, and Luquillo became the world's most studied tropical forest ecosystem. The effects of the radiation were minimal and visible only very close to the source. Meanwhile, scientists, led by Howard T. Odum, were able to study everything from sierra palm germination to evapotranspiration. The resulting book had 111 chapters and was long considered the bible of tropical forest ecology.

Arboricides in Luquillo

Again, as the only federally owned tropical rain forest, Luquillo became a secondary site for another study. This one, less publicized than the El Verde irradiation and ecology project, sprang from a national need to screen airborne arboricides (defoliants). U.S. soldiers were fighting in Vietnam, and the military wanted to eliminate the leaves on trees that were concealing snipers along the Vietnamese rivers. The USDA Agricultural Research Service Station at Mayagüez was assigned the research. Screening started with small-scale tests in Maricao and other Commonwealth forests. Permission was also given to test a small area in the heart of the Luquillo Forest. One arboricide being tested became known as Agent Orange. Following the national controversy surrounding Agent Orange, concerned experts searched the site for residual chemicals, using extremely sensitive indicators, and found none.

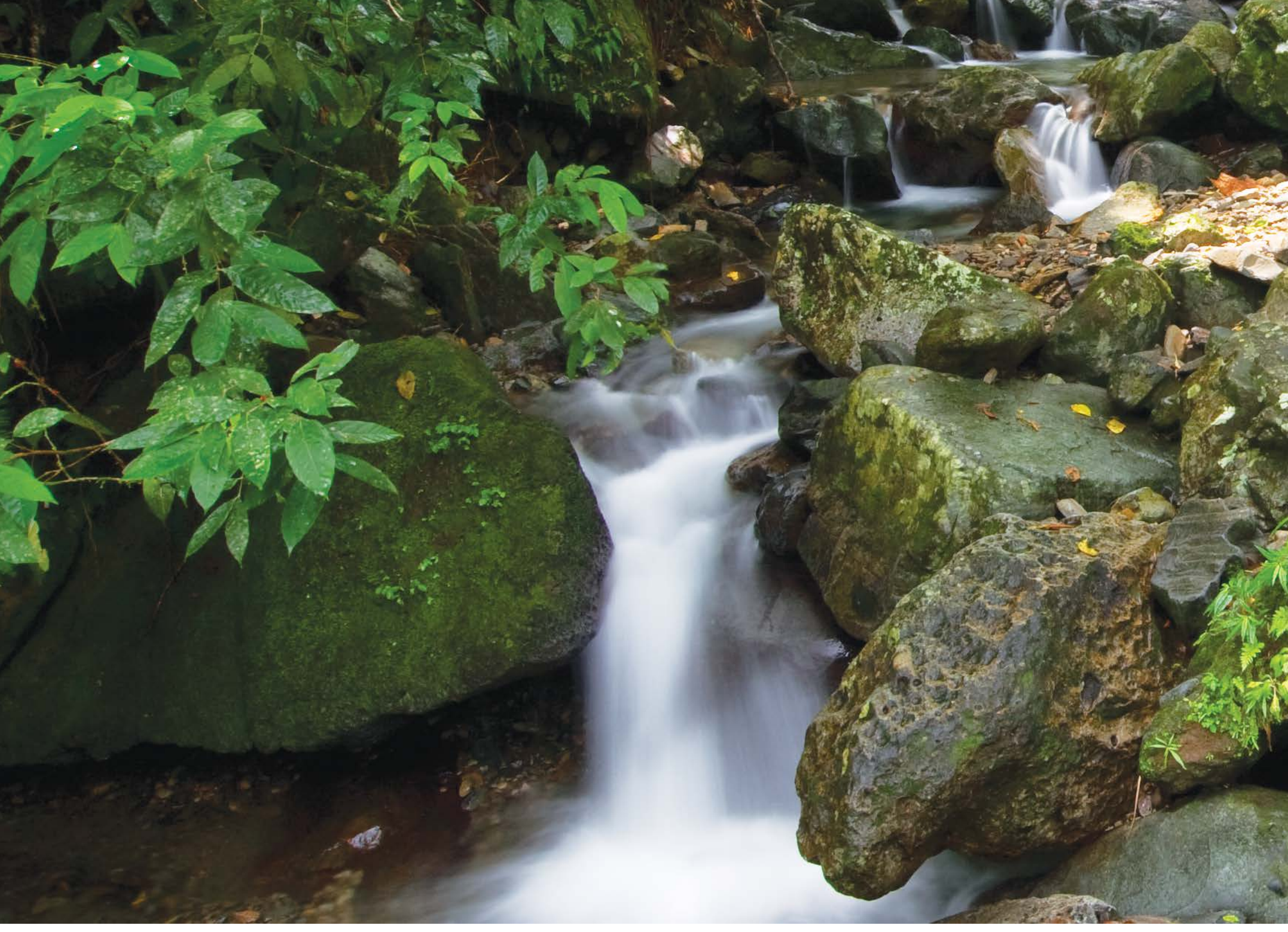
Plants in the elfin woodland forest engulf a tree trunk (2008).

Ecology of Dwarfed Vegetation

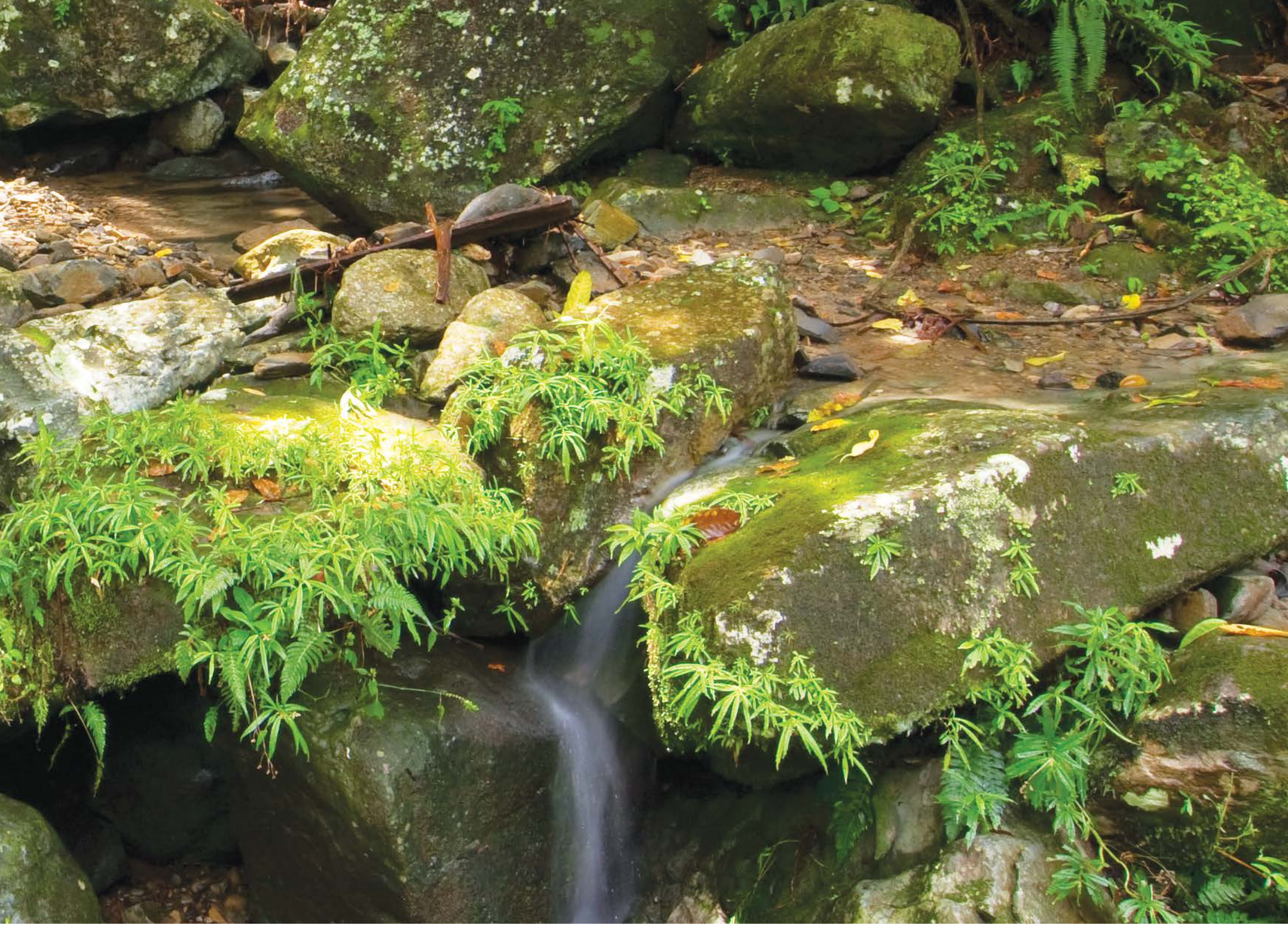
In the upper reaches of the forest, elfin woodland tops the highest peaks. The trees are short and gnarled, mosses and liverworts are abundant, winds are constant, and the weather is often foggy and excessively humid. Elfin woodland is very vulnerable; it survives under specific conditions, and, if damaged or destroyed, it is extremely slow to recover. During World War II, the U.S. Army was permitted to build a road through elfin woodland to El Yunque Peak, and, in 1963, a 5-kilometer road to East Peak, requested by the U.S. Navy, was completed. (Today, communications towers top these and several other peaks across the island.) A small amount of elfin woodland was lost in the construction of the two roads. The East Peak Road destroyed less than on El Yunque Peak, and the Navy was required to finance the revegetation of the entire roadway.

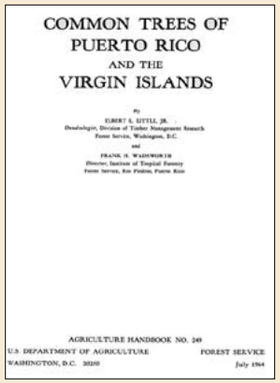
As a result of the construction of the East Peak Road, untouched elfin woodland atop nearby West Peak became easily accessible to scientists. In the 1960s, Richard Howard of Arnold Arboretum in Massachusetts began a decade-long study of the ecology of dwarfed vegetation. Scientists collected rainfall, examined algae, analyzed the chemical components of numerous plants, and performed a host of other studies. The results were presented in 17 articles spanning various issues of the Journal of the Arnold Arboretum, information that would not have been known without the road.

The elfin woodland forest is in the upper reaches of the Luquillo Mountains, surrounding Los Picachos Peak (2008).



Quebrada Juan Diego is one of the most beautiful streams originating in the Luquillo Mountains. The crystal-clear water coming from these mountains provides drinking water to thousands of Puerto Ricans today (2008).




COMMON TREES OF
PUERTO RICO
AND THE
VIRGIN ISLANDS

AGRICULTURE HANDBOOK NO. 249
U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE
WASHINGTON, D.C. 20250 July 1964

1964 A.D.

Elbert L. Little, Jr., and Frank H. Wadsworth's book, *Common Trees of Puerto Rico and the Virgin Islands,* was published. It contains more than 200 drawings of tree species by island artists.

1965 A.D.

The population of Puerto Rico was 2,594,000.

1966 A.D.

Víctor Márquez counted 70 Puerto Rican parrots in a single flock.

Sustainable Timber Production 101

The cutting and selling of timber in the Caribbean National Forest between 1934 and 1953 was viewed by the USDA Forest Service as an introduction of productivity that could be sustainable. The practice of sustainable timber production merits a full explanation because it has been widely misunderstood.

The goal of every conscientious forester is to make a forest sustainable; that is, to be able to maintain itself indefinitely while producing marketable timber. The difficulty in sustainability is the human pressure, the need for more timber now at the expense of the future. Foresters continually look for ways to satisfy both the forest's and the people's needs.

In unmodified forests, the volume of wood remains relatively stable, tree growth being offset by tree mortality so that, over time, there is no net increase. It was found that forest densities that are reached naturally actually slow tree growth. Thus, by reducing forest density, foresters can initiate volume increases. The trees removed for this purpose were only the following: (1) overmature trees considered susceptible to hurricanes, (2) about half of the other mature trees, (3) trees too close for good growth, and (4) trees of such poor form or wood quality that their removal was conducive to the regeneration of better trees.

Trees were sold on the stump, each paint-marked by a forest officer. Felling, bucking, and skidding of sawtimber were subject to cautionary provisions. The less accessible sawlogs were pit-sawn at the stump, and the boards were headed on footpaths to the roadside. At other sites, oxen skidded logs, leaving skid trails knee deep in mud and visible years later. Crawler tractors were tested and rejected because of soil damage on slopes.

The broadening concept of sustainability toward the end of the period terminated the need for more comprehensive timber inventories. Instead, new concerns over various features of the forest environment were expected to signal a need for experimentation to determine new options for management. It was also expected that external social constraints, governed by the clarity of public goals and understanding, could alter plans for sustainable timber production.

[Frank H. Wadsworth]

Yellow-ringed trees in a sustainable, managed timber plot along the Quebrada Sonadora in El Verde, Luquillo Experimental Forest (1987).

Four Forest Types

For local use, the Luquillo Experimental Forest is classified into four forest types (internationally, scientists tend to use Holdridge's Life Zone System classifications). At the lowest elevations is the tabonuco forest type, named for the most prominent native tree. The tallest, most marketable, and most accessible timber is found here; this is the area where most reforestation has taken place. Higher up is the palo colorado type, also named for a local species. Here the trees are smaller, more suited for making charcoal than for cutting timber. The third type, sierra palm, is found on patches of steep slopes throughout the forest, where palm trees are virtually exclusive, sharing the slopes with ferns and other plants. The fourth type, elfin woodland, consists of a few species of sturdy, stunted trees that survive in wind, rain, and fog on the highest peaks. Timber production was undertaken only in the tabonuco and palo colorado types, never in the sierra palm and elfin woodland forests. In 1956, as a result of the virtual disappearance of the charcoal market, the USDA Forest Service removed the palo colorado type from timber production.

Tabonuco forest (2008).

Palo colorado forest (2008).

Sierra palm forest (2008).

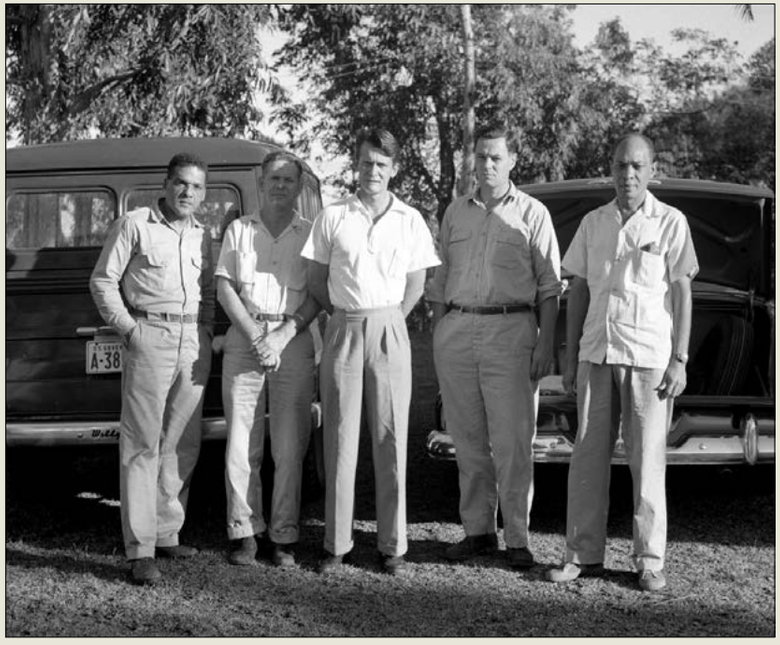
Elfin woodland forest (2008).

1968 A.D.

The USDA Forest Service began formal research efforts to save the Puerto Rican parrot in collaboration with the U.S. Fish and Wildlife Service, the Commonwealth of Puerto Rico, and the World Wildlife Fund. *Amazona vittata* was listed as an endangered species in the *Federal Register*. By the end of the year, 24 birds were counted.

A revised Timber Management Plan for the Caribbean National Forest/Luquillo Experimental Forest was approved after being rewritten to conform to the 1956 Land Use Plan.

A 1-hectare (2.5-acre) forest stand in the Jiménez sector of "El Yunque Forest" was used to test tropical forest canopy defoliants as part of an islandwide study to develop defoliants for use by the military in the Vietnam war.



International students at an institute-sponsored training session. Second from right is Frank H. Wadsworth (c. 1968).

Letter received from Guadeloupe Forest Service requesting technical assistance for reforestation.

International Programs: The Beginning

Starting in the decade of the 1950s, the Luquillo Experimental Forest's professional staff members began to reach out to scientists at other tropical forests around the world. Following are some of the early extended programs:

- Teaching graduate-level tropical forestry in Venezuela.
- Teaching graduate-level tropical forestry in Costa Rica.
- Preparing a national watershed plan for El Salvador.
- Preparing a national forestry plan for Paraguay.
- Designing watershed management in the Dominican Republic.
- Documenting forest plantation growth in 16 countries.
- Analyzing forest research progress and needs in Latin America.
- Describing the forests of western Ecuador.
- Providing technical guidance on nursery practices in Jamaica.
- Providing technical guidance on mahogany silviculture in Mexico.

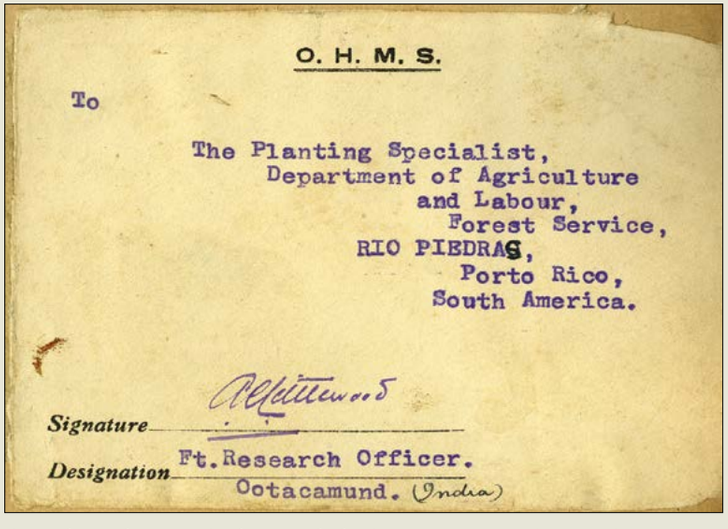
[Frank H. Wadsworth]

Temptations

In 1959, as a result of a request from the United Nations Food and Agriculture Organization Latin American Forestry Commission, three of us covered Latin America collecting data on the most successful forest plantations. In Chile, I was taken south along the coast to a plantation of *Pinus radiata* on a rainy site near Tomé. My driver personally knew the owner of the plantation and said he had planted it 17 years earlier when he bought the tract. When we got there, he pulled up to a tree almost a meter in diameter. I had an increment borer, but it was raining hard, so I questioned him. Again he assured me. I got out and took a core. That night from the hotel, I wrote to the Chief of the USDA Forest Service in Washington that, if I were not married, I would not come back to the United States.

Another time, the leaders of the Emberá of the Panamanian Darien had come together seated at a table in one of their straw shelters. A wizened elderly woman represented the Tribal Council. She asked for advice. She told how their ancestors had always told them never to cut the forest, which was their home. Then she said that now the Tribe is being offered $50 per tree and needs the money. What she wanted to know was how many trees they could sell without losing the forest. It was another tempting place for a forester from Puerto Rico. She was advised to send the two young agronomists in the meeting to forestry school in Costa Rica.

[Reminiscences of Frank H. Wadsworth]



O. H. M. S.

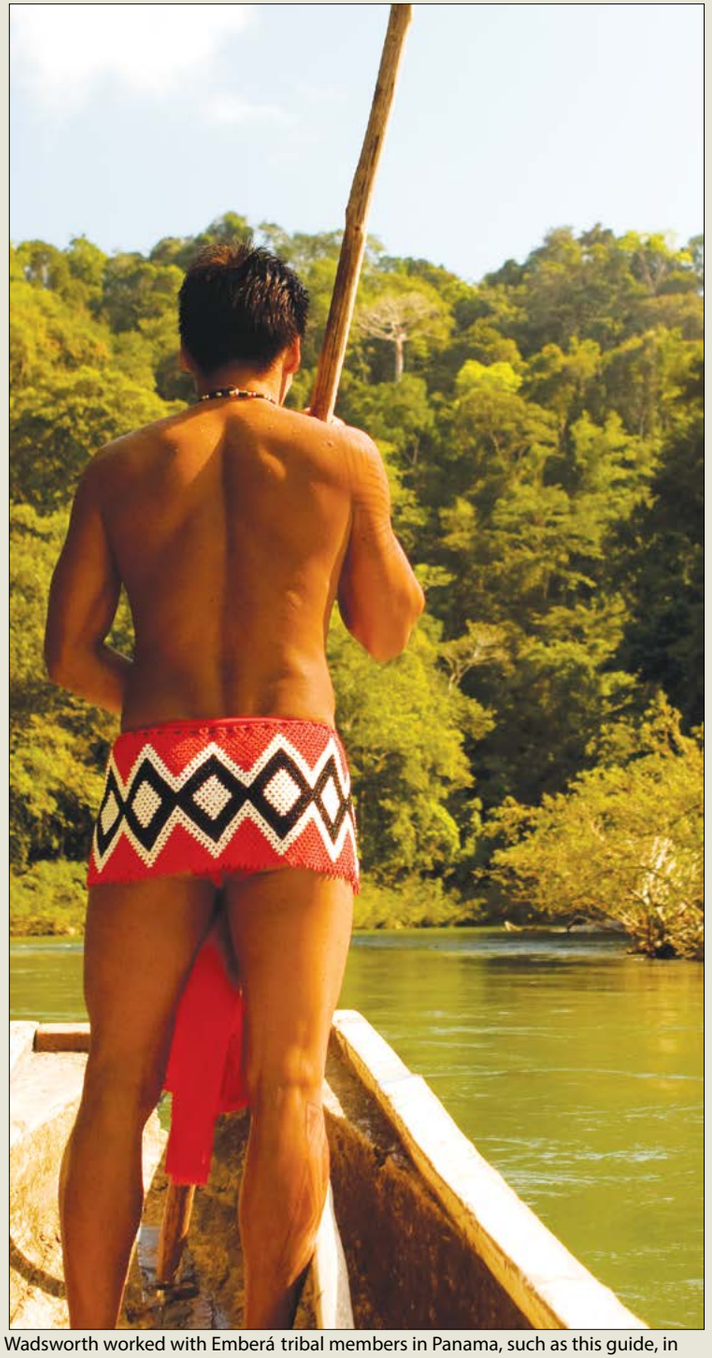
To

The Planting Specialist,
Department of Agriculture
and Labour,
Forest Service,
RIO PIEDRAS,
Porto Rico,
South America.

Signature A.H. Wadsworth

Designation Ft. Research Officer.
Ootacamund. (India)

Letter from a forest service forester of a foreign country requesting technical assistance from the Institute of Tropical Forestry in the 1930s.



Wadsworth worked with Emberá tribal members in Panama, such as this guide, in exploring the forest in the Panama Canal Watershed (2006).

A Tale of One Endangered Bird

The 70 *Amazona vittata* parrots found in the Caribbean National Forest in 1968 were all that was left of a population that may have topped a million when Columbus first approached the island. Although the birds began to decline after the arrival of the Spaniards, they remained in great numbers until the 1800s, when agriculture spread over much of the island. Lowland forests were destroyed, and the parrots, forced to feed on crops, became fair game for farmers' slings and guns. Slaughter by farmers continued into the early years of the 20th century. Periodic hurricanes wiped out large numbers, and the parrots could no longer rebuild their populations. Poor country residents collected young parrots to sell as pets: one parrot would fetch up to 2 dollars, a princely sum to the farmers. By the 1920s, the birds' original lowland habitat was reduced to isolated nooks in the karst country of northwestern Puerto Rico. Yet, after Hurricane San Felipe in 1928, no parrots could be found in the karst region. By the late 1930s, a census estimated some 2,000 remaining parrots, all in the Luquillo Mountains.

Yet, even within the protective boundaries of the forest, the birds continued to decline—200 counted in 1959, a single flock of 70 in 1966, no flocks at all by the end of the decade. A number of factors contributed to the startling decline. Several of them, easy to list in retrospect, took a tremendous amount of time and analysis to understand. Back in the 1930s, workers disturbed habitats while constructing trails and building a road through the forest. Local residents continued to hunt parrots to sell as pets, often destroying nests as they did so. Loggers removed trees for fuelwood, timber, and posts. Foresters cleared out old, decaying, cavity-ridden trunks: these trunks, biologists eventually learned, were favorite parrot nesting sites. Competition developed over who would use the limited remaining cavities: bees needed them to make their honey, and aggressive Pearly-eyed Thrashers tossed parrot eggs out of nests that appealed to them. Predators stalked the parrots, maggots lodged in the skin of chicks, hurricanes took their toll, and the military and radiation experiments may have affected the birds.

[Excerpted from the book The Parrots of Luquillo: Natural History and Conservation of the Puerto Rican Parrot, *by Noel F.R. Snyder, James W. Witey, and Cameron B Kepler.]*

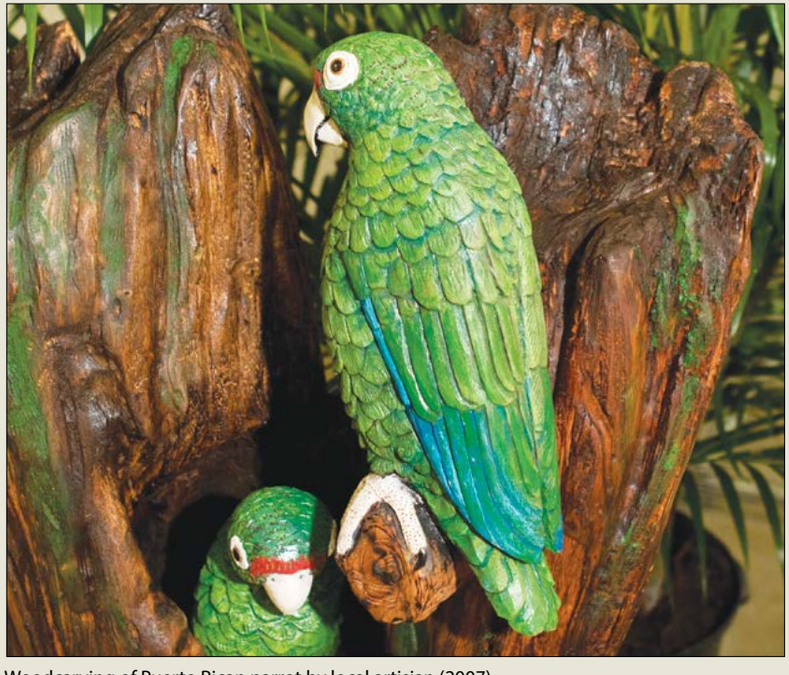
Another Part of the Tale

Ed Cliff was one of the USDA Forest Service's toughest chiefs. He was interested in the tropics and visited the Caribbean National Forest around 1965. By that time, I had noticed that the parrots were less common than they had been before. I told Ed that if the parrots were to disappear, the egg would be on the face of the USDA Forest Service because the bird was found only in the forest. This was the beginning of the parrot restoration program, using $25,000 that Ed had gotten from the USDA Forest Service, the U.S. Fish and Wildlife Service, and the National Wildlife Federation.

The biologists who have worked with parrot recovery have concluded that without their efforts the bird would now be extinct.

[Reminiscences of Frank H. Wadsworth]

José Vidal (in wheelchair), the first Puerto Rican to carry out a study of the Puerto Rican parrot, participates in the inauguration of the Iguaca Aviary in the El Yunque National Forest (2007).



Woodcarving of Puerto Rican parrot by local artisian (2007).

Then-USDA Forest Service Regional Forester Chuck Myers at the inauguration of the Iguaca Aviary (2007).

Sierra palm forest, El Verde Field Station (2006).

First Impressions

My first contact with the USDA Forest Service was in the summer of 1963. My duty station was the El Verde Field Station and I spent the summer working in the Rain Forest Radiation Experiment led by H. T. Odum. I had just graduated from the University of Puerto Rico and became a field technician for the radiation project. Although the field station was on national forest land and leased to the University of Puerto Rico by the USDA Forest Service, the presence of the agency was invisible to me. I was only aware of Pepe Lefebre, who was the USDA Forest Service field person in charge.

Later, my duty station was the basement of the institute's main building. I was an employee of the Nuclear Center and a master's degree student in the first graduate class of the Biology Department. Here, I became aware of institute scientists, Director Frank H. Wadsworth, and the library. I shared the basement with Peter Murphy, Carol Ogle (for a while), and a noisy printing press of the University Agriculture Experimental Station. Our quarters were a very small cage. From there, I observed scientists entering and exiting the building, but not a word was exchanged with me. The presence of institute scientists intimidated me.

My master's degree program and my job with Odum enabled me to spend a lot of time in the national forest, including meetings in what was for many years the parrot aviary. In all these visits to the field and use of the facilities, however, I was not aware of the USDA Forest Service as an agency. To me, the USDA Forest Service was Frank H. Wadsworth, institute scientists, and Pepe Lefebre.

When I was a 27-year-old professor at the University of Florida, I had my first significant encounter with the USDA Forest Service hierarchy. It was in the early 1970s and the Southern Region was interested in learning more about ecology. They contracted with the University of Florida to conduct weeklong sessions in ecology at Camp Oklawaha on the Ocala National Forest. I was one of the instructors, and spent the whole week at the camp. We eventually conducted two such trainings. My students were from the USDA Forest Service. Other than that, I had no idea who they were. I was aware, however, of how they reacted to my lectures, in a complicit, I-told-you-so mode, as some of them were wildlife-oriented and others were timber-oriented. I was a systems ecologist, and I gave them a lot of ecosystem science and even an early version of ecosystem management. These sessions were memorable, but I only realized how so later.

In 1979, I was a staff member at the Council of Environmental Quality in the Executive Office of the President in Washington, DC, and had just been appointed project leader at the Institute of Tropical Forestry in Puerto Rico. For my going-away party, the Chief of the USDA Forest Service was present. Chief Peterson was asked to say a few words, and he pointed out that I had been his teacher. I was puzzled. Later, I checked my files and found a picture of the course participants at Camp Oklawaha. Sure enough, the Chief (regional forester at the time of the class), was there.

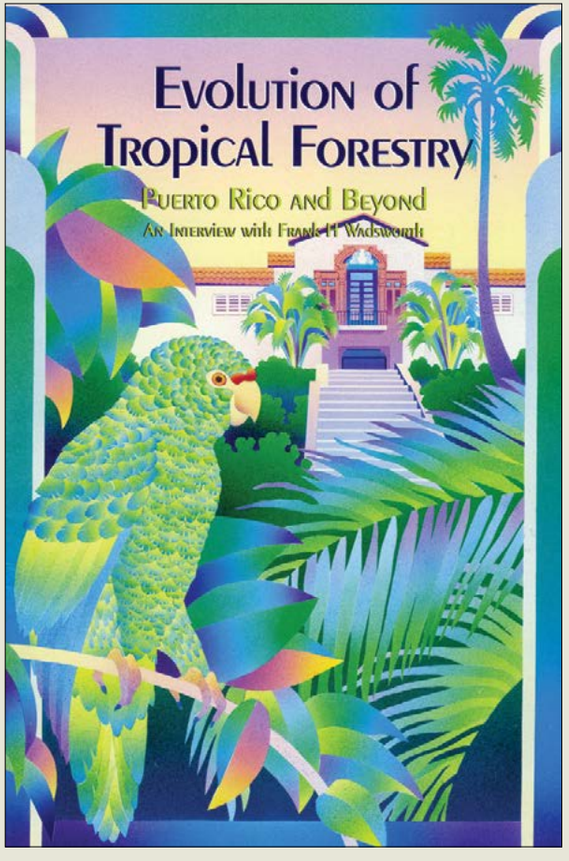
[Reminiscences of Ariel E. Lugo]

This Is His Life: Frank H. Wadsworth

Frank H. Wadsworth was born in Chicago, IL, in 1915. He attended the University of Michigan, earning B.S. and M.S. degrees, and later received a Ph.D. in forestry.

He came to the Tropical Forest Experimental Station in 1942 as a research forester. He later became the Institute of Tropical Forestry's Director and Supervisor of the Caribbean National Forest from 1956 to 1974 and remained in charge of the institute until 1979. He continued as a research forester and an international tropical forestry consultant until his retirement in 1999. He currently works as a volunteer at the institute.

Wadsworth received the USDA Superior Service award (twice) and the Fernow International Forestry award. He is a Fellow of the American Society of Foresters. He has published more than 100 scientific books and papers; his major work is a 600-page *Producción Forestal para América Tropical,* a text in use in the forestry schools of the region.



Lush vegetation along the Mount Britton trail in the La Mina Recreation Area in the Caribbean National Forest/Luquillo Experimental Forest (2008).

Alejo Estrada Pinto

When I met Alejo in 1962, he was already a leader at work and in his community. Alejo had grown up in the Luquillo Mountains; although he had very little formal schooling, he knew the forest as well as anyone. Starting as a teenager, he worked around 10 years for the Caribbean National Forest under the supervision of Pepe LeFebre.

In March, 1963, based on Pepe's recommendation, H. T. Odum hired Alejo, then 27 years old, and two others to work for the Rain Forest Radiation Experiment. Peter Murphy was their supervisor, although Alejo needed no supervision. He was the leader, and he took responsibility for daily activities at El Verde. More important, Alejo knew all the trees, the forest, and how to survive in the wild. He became the critical link between scientists and workers. He was the plant taxonomist without formal training. Robert Smith developed a key to translate Alejo's common names to scientific names of trees; and Alejo was usually the authority when a particular tree needed identification. Odum assigned Alejo the task of doing a phenology study, which required monthly visits to more than 150 trees along the trails of El Verde to see if they had flowers, fruits, or new leaves. Alejo is the single author of the article "Phenological Studies of Trees at El Verde," published in the *Rain Forest* book containing the results of the radiation study. This work on the phenology of tropical trees could be used in the future as a base to compare potential changes in tree phenology because of climate change.

Alejo was a "doer" and a leader not only in the rainforest study, but also throughout the rest of his career. After Odum left, Alejo continued to work at El Verde as an employee of the University of Puerto Rico and de facto leader of the El Verde Field Station. He retired in June 1992 after 30 years of service. One of his legacies to the USDA Forest Service of today is his son Carlos Estrada, who works for the institute as a forestry technician in the Sabana Field Station.

[Ariel E. Lugo]

Chapter VII

Rethinking the USDA Forest Service in Puerto Rico

1970 to 1985

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Rethinking the USDA Forest Service in Puerto Rico
1970 to 1985

Frank H. Wadsworth, Retired USDA Forest Service Employee, and Other Sources

In 1976, the Caribbean National Forest/Luquillo Experimental Forest was designated a Biosphere Reserve by the United Nations Environmental Program. The biosphere is the factory of life on Earth. Living organisms process and recycle the energy and nutrients available from the environment, and the biosphere's health is crucial to the future of our planet. The Luquillo Experimental Forest was one of the first biosphere reserves so designated. U.N. Biosphere Reserves are nuclei of virgin forests surrounded by reestablished forests; the reserves demonstrate preservation, research, tourism, rehabilitation, and traditional uses of the land. Several years later, Guánica Commonwealth Forest, a dry coastal forest on the island's south coast, was also designated a U.N. Biosphere Reserve.

The biosphere designations indicated scientists were emphasizing different aspects of managing forests.

1970 A.D.
The USDA Forest Service and the Commonwealth Department of Agriculture (Natural Resources Division) exchanged lands around the Luquillo Experimental Forest for the Toro Negro Forest.

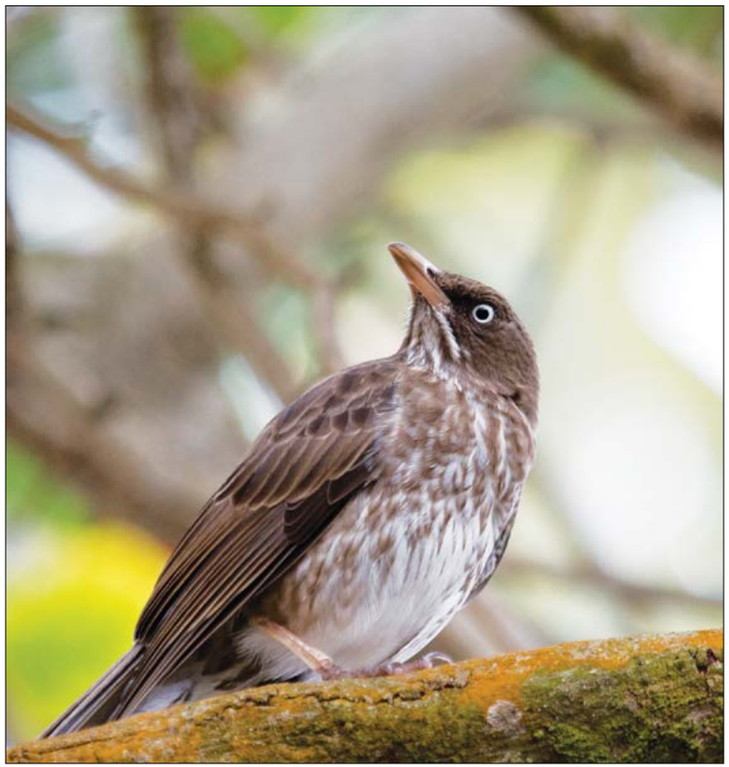
Road 191 through "El Yunque" was closed due to a major landslide. The highway remained closed because rebuilding plans were hampered by the existence of unstable sandy soils.

A Tropical Rain Forest, based on ecological studies begun during the early 1960s under the leadership of Howard T. Odum, was published. It includes 111 research papers totaling 1,645 pages.

1970 A.D.
The population of Puerto Rico was 2,712,000.

Ways of Thinking About the Forests

Over the centuries, people have focused on different characteristics of forests. To Taíno Indians, Luquillo may have been an abode of the gods; to runaway slaves, it was a place to hide and survive; to miners, it was a region to find gold. Spanish colonists found it exceedingly inaccessible, and only a limited amount of farming and lumbering took place. King Alfonso XII set aside the upper elevations as one of the hemisphere's first forest reserves. In the early 20th century, the USDA Forest Service focused primarily on the trees in the forest, replanting abused slopes, and preparing for sustainable timber management. By the middle of the century, the emphasis began to shift toward looking at the forest as an entire interacting community, in which the fate of a certain bird could affect the fate of a certain tree, and vice versa. Around the time of the designation of U.N. Biosphere Reserves, scientists began to look at Puerto Rico's forests as an interacting part of environments around the world, in which the dust of the Sahara could affect the plants in Guánica.



The Pearly-eyed Thrasher, a common bird in Puerto Rico and the Caribbean (2004).

Expanding Concerns

The work being done in forests in Puerto Rico during the 1970s and early 1980s reflected the new trends. The study of trees remained an important aspect of forestry. Researchers continued to study the habitat of the birdlife by recording dates of flowers and fruits of the forest trees. Also they extended the period of growth measurements of thousands of trees to relate them to weather changes. They developed a technique for extracting the tiny seeds of kadam *(Anthocephalus cadamba)* and successfully planted kadam, along with broadleaf mahogany, under secondary forest. They intensified reforestation efforts for mahogany along the forest's lower slopes. By 1978, the Institute of Tropical Forestry had conducted some 2,400 different comparative tests of forest regeneration and management practices, many of which are still providing new information. More than 450 tree species had been propagated, including more than 100 native species.

Forest wildlife also came under the spotlight. The numbers of native Puerto Rican parrots continued to decline, reaching an all-time low of 13 birds in the wild in 1972. Rescue efforts were greatly increased. In 1970, a professional decision to rear parrots in captivity to save the species created the need for an aviary. By 1973, the aviary was in place within the forest; it contained eight captive birds. The Sharp-shinned Hawk *(Accipiter striatus)* was also becoming rare in the mountain forests. Wildlife concerns became a top priority.

Rescue efforts for the parrots, some of which were downright ingenious, began to have success. One major reason for the parrots' continued decline was the Pearly-eyed Thrasher *(Margarops fuscatus).* An aggressive bird, the thrasher commandeered many of the scarce tree cavities used by the parrots for nesting, tossing out priceless parrot eggs in the process. Major habitat observation led to the conclusion that the thrashers actually preferred a shallow nest, and the parrot a deeper one. By deepening parrot nests and constructing shallow nesting structures for the thrashers near the parrot nests, biologists were able to stop the thrashers from harassing the parrots. Not only did they no longer enter the parrot nests, but their aggressiveness also served to protect the parrots from other predatory wildlife. The parrot slowly began to rebuild its numbers. In 1971, the ornithologist Cam Kepler and his wife, Kay, found a species of bird that had remained undiscovered longer than any other bird in the Caribbean, the Elfin-woods Warbler *(Dendroica angelae).* Ornithologists considered the discovery of the bird, which is

Elfin-woods Warbler, an endangered bird species found in the elfin woodland forest in the Luquillo Experimental Forest (1999).

endemic to the upper Luquillo Mountains, a positive sign that the forest remained healthy. The Keplers studied birds throughout the island and eventually published a comparison of the birdlife of the Luquillo Experimental Forest with that of the Guánica Commonwealth Forest.

Research was also expanding to biodiversity and ecosystem dynamics. A study of the Río Icacos watershed in the Luquillo Mountains found that only 10 percent of rainwater was intercepted for local use, primarily through evaporation and transpiration, while 65 percent tumbled down the mountainside as surface runoff. Fourteen scientists from the institute visited Isla de Mona, a small, ecologically rich, lima-bean-shaped island halfway between Puerto Rico and the Dominican Republic. They made an inventory of natural resources that became instrumental in a decision to abandon a proposed superport on Mona.

The Green Anole, a common lizard found throughout Puerto Rico (2006).

1971 A.D.
The Elfin-woods Warbler *(Dendroica angelae),* a heretofore undiscovered bird endemic to Puerto Rico, was discovered to exist at high elevations in the Luquillo Experimental Forest.

1972 A.D.
A tally of Puerto Rican parrots in the Luquillo Experimental Forest revealed 16 individuals remained in the wild.

A summary was published of the results of fence post longevity based on four preservatives and two treatments for 6,700 treated and nontreated posts, representing 70 tree species.

A summary was published of growth studies for 15 conifers and 16 hardwood species for use in 60,000 hectares (148,263 acres) of Puerto Rico's granitic uplands.

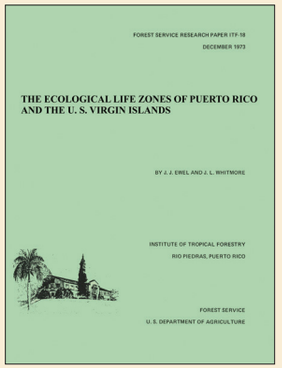
Princeton doctoral student John Faarborg began tagging migratory birds in the Guánica Commonwealth Forest in what was to become the longest data set on migratory birds in the tropics.

1973 A.D.

L.A. (Andy) Lindquist was appointed Interim Supervisor of the Caribbean National Forest/ Luquillo Experimental Forest.

A captive breeding program for the Puerto Rican parrot was established at the Luquillo aviary.

A map and text on the ecological life zones of Puerto Rico was published.



Administrative Changes

During this time, several administrative changes reflected the changing times. The administration of the Commonwealth forests was transferred from the U.S. Department of Agriculture to the recently formed Puerto Rico (Commonwealth) Department of Natural Resources (later, the Department of Natural and Environmental Resources). The administration of the Caribbean National Forest was separated from the Institute of Tropical Forestry, giving the institute greater autonomy. Eventually, the institute was placed under the Southern Forest Experimental Station in New Orleans. In 1982, the Luquillo Field Office was moved from its small quarters in the community of Sabana to the newly constructed Catalina Service Center off Road 191 at the northern edge of the forest.

Mahogany trees about 60 years old that were planted on abandoned land near El Verde, Luquillo Experimantal Forest (2007).

Reaching Out to Fellow and Future Foresters

Foresters and scientists at the Luquillo Experimental Forest continued their work in connecting with local and international communities. On the local front, the institute offered forestry training and technical assistance, such as a 2-day workshop on forestry effects, a competition for hurricane-resistant house designs, and support for 14 urban tree nurseries. It also offered programs similar to the Civilian Conservation Corps of the 1930s—namely, the Youth Conservation Corps and the Young Adults Conservation Corps, which provided Puerto Rican young people with experience in forestry work.

On an international level, the institute staff participated in activities with organizations such as the Anglo-American Caribbean Commission, the Food and Agriculture Organization's Latin American Forestry Commission, and the Tropical Silviculture Study Group of the FAO North American Forestry Commission (Canada/USA/ Mexico). In the 1980s, the institute hosted an international symposium on the role of tropical forests in the world's carbon cycle and 2 years later, initiated biennial Caribbean foresters' meetings.

Participants from the Caribbean islands attended a 9-week international forestry training program presented by the USDA Forest Service in collaboration with the U.S. Agency for International Development (1980s).

1974 A.D.

The Caribbean National Forest/ Luquillo Experimental Forest was administratively separated from the Institute of Tropical Forestry. Juan Muñoz was appointed forest supervisor of the Caribbean National Forest.

Mahogany reforestation efforts were intensified in secondary brushlands on the lower slopes of the Luquillo Mountains.

An environmental analysis and management plan for the proposed El Yunque Peak Electronic Site was prepared and implemented.

1975 A.D.
The Commonwealth of Puerto Rico passed a new forest law for the island, based on contributions by Forest Supervisor Juan Muñoz.

The Puerto Rican parrot population reached a low of 13 birds in the wild, the lowest point in the history of the species.

1975 A.D.
The population of Puerto Rico was 3,115,000.

1976 A.D.
The Luquillo Experimental Forest (Caribbean National Forest) was designated the Luquillo Biosphere Reserve as part of the United Nations International Network of Biosphere Reserves.

"El Yunque contains the largest patch of primary forest on the island. Primary forest means it does not have any evidence of human effects such as logging. It was the gift of King Felipe to Puerto Rico. Of the 12,000-odd acres of Crown Land, some 10,000 of it was primary forest. This was the heritage of the Mother Country to Puerto Rico. … So we are locating these original tracts and saying they should be left alone as the heritage of Spain to Puerto Rico … no new trails, nonmanipulative research, just leave it alone."

[Ariel E. Lugo, 2004]

Publicizing Research

Several important publications came out during this time. While her husband worked with the Puerto Rican parrots, Kay Kepler scoured the forest for ferns, locating around 150 species, which she studied and described in a book. A new booklet depicted the trees of the Caribbean National Forest. *The Ecological Life Zones of Puerto Rico and the U.S. Virgin Islands* mapped the various climatic zones, using the system developed by Leslie Holdridge. Recognizing the importance of urban forestry on a populated island, the institute published a bilingual bulletin on the use of 46 tree species in urban settings. In March 1980, the first issue of the quarterly newsletter for the International Society of Tropical Forestry was published, reaching more than 2,000 people in 128 countries. This publication ended in 2013 due to lack of funding. A bulletin summarized the forest resources of Puerto Rico. Three years later, institute librarians and scientists published an extensive bibliography of all works pertaining to forestry in Puerto Rico. With close to a thousand publications produced by the institute alone at that time, it proved a great help in orienting both local and international scientists.

Is Our Research Relevant?

Today's International Institute of Tropical Forestry has been conducting tropical forestry research since 1939. Its mission is to generate and disseminate knowledge for the sustainable management of tropical forests. The institute provides many services to society in the form of its library services, technical information, education, forestry consultation, and training. More than 2,000 science publications are among the major accomplishments of the institute. Are these publications relevant to the mission of the institute? Do they have a practical use? Have they solved any real world problems?

Science is under public scrutiny, and it is increasingly pressured to make its work relevant. Relevancy is the battle cry at the National Science Foundation, at universities, and in government. As an example, today's institute scientists are expected not only to publish scientific journals but also apply their science through public interactions and demonstrations on its applicability.

In 1985, 10,000 people demonstrated against a threat by the USDA Forest Service to harvest timber from the Caribbean National Forest, and harvesting was put on hold. Today, 23 years later, global carbon management is part of mainstream human activity, including the global Kyoto agreement that allows credits and profits for growing forests for carbon accumulation; a very practical outcome for a very basic research.

Science works on problems that others do not yet see as problems. Libraries contain the solutions for today's problems solved by science yesterday. When I explain this to lay audiences, they understand that part of the process of science is esoteric, but then something needs to happen after the research is done to make it relevant and understandable to the public.

Is research relevant? Yes, it is. We can find many examples in the Luquillo Experimental Forest. Tree and vine identification is fundamental knowledge for management and conservation activities. Reforestation techniques assure the success of tree-planting programs. Silvicultural treatment for cut-over or volunteer forests allows for the management of secondary forests for public use. Rehabilitation of landslides allows for the reestablishment of forests and the stabilization of hazardous slopes. Understanding how silvicultural practices influence wildlife populations, soil fertility, greenhouse gas emissions, and water yield enables humans to know the effects of manipulating vegetation, something that is becoming increasingly more prevalent. What we need to do is work on filling the gap between science and the public.

[Adapted from 2008 a paper by Ariel E. Lugo]

1976 A.D.

Numerous reports began concerning long-term monitoring of permanent plots in the tabonuco, palo colorado, elfin woodland, and sierra palm forests. They included studies of forest structure, dynamics, and the impacts and responses to hurricanes.

The USDA Forest Service established a tree nursery to provide seedlings for a reforestation program.

The Youth Conservation Corps (YCC) program began in El Yunque Forest.

1977 A.D.

The first silviculture examination and prescription of the Caribbean National Forest was completed.

1977 A.D.

The Institute of Tropical Forestry was transferred from the Office of the Chief of the USDA Forest Service to the Southern Forest Experiment Station (New Orleans) as the Tropical America Forest Research Work Unit.

1979 A.D.

Involvement in urban forestry began with a bulletin in English and Spanish on the use of 46 tree species in urban settings for Puerto Rico and the U.S. Virgin Islands.

Beginning in 1979, more than 4,000 hectares (9,800 acres) of forest were systematically sampled and analyzed for silvicultural conditions, including the determination of the tree size, age class, and species.

Frank H. Wadsworth was succeeded by Ariel E. Lugo as director of what will eventually become the International Institute of Tropical Forestry.

Designing a New Management Plan

In the 1970s, Congress passed two acts calling for the USDA Forest Service to assess its forests and provide a long-range management program, complete with an environmental impact statement, for each one. To comply, in the early 1980s, the USDA Forest Service in Puerto Rico began to fashion an environmental impact statement and a 50-year land and resource management plan for the Caribbean National Forest. Draft statements and proposed plans were published and distributed to a variety of interested parties, comments were made, hearings scheduled, changes approved, and, by the end of 1985, the USDA Forest Service put the finishing touches on the final version of its long-range plan—hundreds of pages of text, tables, facts, figures, glossaries, and maps.

The alternative preferred by the foresters favored continuation of multiple-use management, that is, balancing the uses of the forest's various resources. There would be selective commercial timber harvesting on some of the reestablished forests of the lower slopes. A wildlife management program would maintain healthy wildlife populations and aid in the recovery of endangered plants and animals. Road construction would be reduced, and recreational activities would become more dispersed throughout the forest. All this would be done without compromising the optimum production of water.

In early 1986, the plan was released to the public, attracting significant attention and causing debate about the conservation of biodiversity.

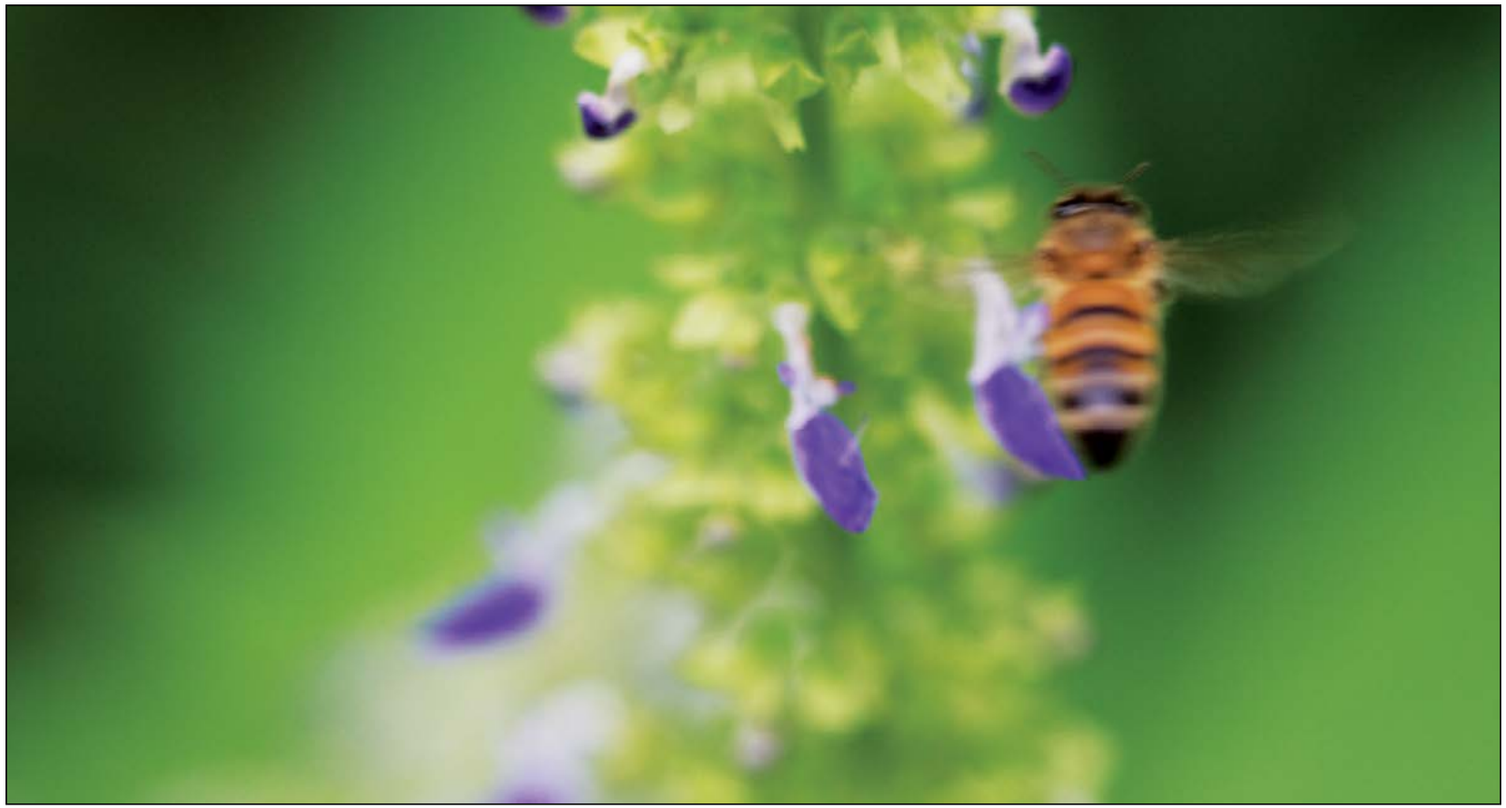
A sierra palm forest, Luquillo Experimental Forest (2008).

Is There Such a Thing as Too Much Success?

In response to claims from the Puerto Rico Medical Association, the institute and the Caribbean National Forest sponsored a symposium in 1977 on the ecological effects of plantations of alien trees in Puerto Rico. As an ecologist, I thought that I had a contribution to make to the response, because my main line of research at the institute was on the ecology of timber plantations.

I had to approve technician time to cut weeds in our plantations before measuring the tree diameters. I thought this requirement was excessive and questioned the practice. A technician dared me to measure diameters in an unweeded plantation. I accepted the dare, and when I was faced with the wall of green in the plantation understory, I realized that a major ecological value of these plantations was allowing the regrowth of native vegetation under the canopy of the alien trees.

[Ariel E. Lugo]



Honeybees are necessary to help pollinate plants and play and important role in maintaining the ecological balance in the tropical forest (2007).

1980 A.D.
An islandwide inventory of secondary forests on timberlands was initiated.

The Institute of Tropical Forestry Analytical Research Laboratory was established.

The Institute of Tropical Forestry hosted an international symposium on the role of tropical forests in the world's carbon cycle.

Editing and production of the quarterly newsletter of the International Society of Tropical Forestry began. This publication reached more than 2,000 recipients in 128 countries.

1981 A.D.
Construction of the Puerto Rico Telephone Company communication tower was completed on El Yunque Peak in the Caribbean National Forest.

United Nations Educational, Scientific and Cultural Organization designated Guánica Commonwealth Forest as the Guánica Biosphere Reserve.

1982 A.D.
The Caribbean National Forest Field Office was moved from Sabana to the newly constructed Catalina Service Center off Road 191 at the northern edge of the forest.

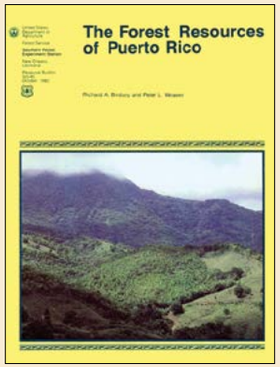
1982 A.D.

Information on the storage and production of organic matter in tropical forests and their role in the carbon cycle was published by the institute.

Biennial Caribbean foresters meetings were initiated.

Forestry in the Caribbean was published.

The Forest Resources of Puerto Rico was published.



1983 A.D.

The USDA Forest Service initiated collaborative research with the U.S. Department of the Interior National Park Service on the Cinnamon Bay watershed, St. John, U.S. Virgin Islands. As a result, the institute published papers on species occurrence, dynamics, and hurricane impacts.

The San Juan National Historic Site (El Morro) was declared a World Heritage Site by the United Nations.

Tabonuco trees in the Baño del Oro Research Natural Area (1987).

Right Makes Might

Río Mameyes is the last river in Puerto Rico with an uninterrupted flow, yet several years ago the Commonwealth Government proposed to dam the river. The institute and a group of citizens led the way in the opposition. Two anecdotes typify the environmental conflict. In 1995, when the first hearing was called, I showed up alone with the lawyer for the environmentalists. We were surprised to find in opposition about 20 corporate lawyers representing government agencies, the Tourism Company, and many private interests that would benefit from the damming of the river.

On another occasion in 1995, I was invited to debate the director of the Puerto Rico Aqueducts and Sewer's Authority in a public forum that would be carried by islandwide radio. I showed up alone and found that the debate would be in a *gallera* (an arena). The place was full, with people hanging over the rafters. The debate was in the ring. The director showed up with a dozen advisors, and he took heated questions from the town and callers to the program. After I made my case, I received no questions. All questions were addressed to the water company.

[Ariel E. Lugo]

Río Mameyes National Scenic River, El Yunque National Forest (2007).

1984 A.D.
Bibliography of Forestry in Puerto Rico was published.

1985 A.D.
A volume describing 150 vine species that grow in Puerto Rico, *Los Bejucos de Puerto Rico, Volumen I,* was published.

1985 A.D.
The population of Puerto Rico was 3,378,000.

This Is His Life: Ariel E. Lugo

Ariel E. Lugo was born in 1943 in Mayagüez, Puerto Rico. He earned his B.S. and M.S. degrees in biology from the University of Puerto Rico, subsequently obtaining his Ph.D. in plant ecology from the University of North Carolina at Chapel Hill. His professional experience has included service with the Puerto Rico Department of Natural Resources; the Center for Wetlands and the Deparment of Botany at the University of Florida at Gainesville; the Council on Environmental Quality, Executive Office of the President; and the Center for Energy and Environment Research, University of Puerto Rico. In the USDA Forest Service in Puerto Rico, he served as project leader, director, and supervisory research ecologist at the Institute of Tropical Forestry. When the institute's name changed to the International Institute of Tropical Forestry in 1992, he was acting director. Returning to Washington for a tour as Acting Deputy Chief of International Forestry, he subsequently returned to Puerto Rico as Director of the International Institute of Tropical Forestry.

Institute Director Ariel Lugo speaking with visiting U.S. school teachers at El Portal Rain Forest Center (2005).

Land snails commonly found in the Luquillo Experimental Forest (2006).

Chapter VIII

The USDA Forest Service Today

1986 to Present

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The USDA Forest Service Today
1986 to present

Peter Murphy, Professor of Botany, Michigan State University, East Lansing, MI, and Other Sources

In 1986, an event took place that, in the words of Director Ariel E. Lugo, "signaled a change in the philosophy of the USDA Forest Service in Puerto Rico." An attempt on the part of Caribbean National Forest administrators to implement a new land management plan that included harvesting in the reforested region of a dominant tree, tabonuco (*Dacroydes excelsa*), aroused concerns about the protection of the forest's primary stands. Although the potential benefits of some level of carefully managed harvesting was not at issue, a number of experts thought the plan inadequately ensured the protection of areas composed of fully mature, natural forest that were considered irreplaceable for their inherent ecological values. Eventually, public outcry in the form of demonstrations and newspaper commentaries, and even a lawsuit, forced a reorientation of the plan to include policy to protect primary forests. In many ways, this critical event, resolved through the process of communication and negotiation, was seen as the beginning of a new era of land management philosophy for the USDA Forest Service in Puerto Rico. Recreation, public education, and water production would continue to be the main management goals, and the production of timber would take a lesser role.

1986 A.D.
Bernie Ríos was appointed forest supervisor of the Caribbean National Forest.

The Institute of Tropical Forestry began long-term collaborative research with high schools in Utuado and Barranquitas. Eventually, the program would expand to include a total of six schools.

The El Yunque Ranger District was established and lasted until it was terminated 10 years later.

The forest plan for the Caribbean National Forest/ Luquillo Experimental Forest was approved by the regional forester. The plan, however, was appealed by 12 environmental/ recreational organizations, and, on November 19th, thousands marched on "El Yunque" to protest the proposed cutting of trees. The process of amendments, revisions, and public involvement continued through 1997, when the Revised Land and Resource Management Plan was finally approved.

Visitor entrance to the El Portal Rainforest Center (2005).

The Forests Endure

After more than a decade of amendments, revisions, and public involvement, the Revised Land and Resource Management Plan was finally approved (in 1997). In 1988, a Big Tree Registry was begun, and competitions in subsequent years have sent people all over the island to find the largest trees in a variety of species. Eight years later, in 1996, El Portal Tropical Forest Center opened its doors to the public at the northern boundary of the forest. The multimillion dollar center, designed to reflect the cathedral-like canopy of old-growth tropical rainforest, provides visitors with a forest documentary, exhibits that analyze Luquillo and other tropical rainforests, an interpretive path, gift shop, and information about hikes, conferences, and other forest activities. About a million people visit the Caribbean National Forest every year. Most of them crowd into the recreation area in virgin forest along the upper reaches of the mountains, where there are mini-visitor centers, observation towers, picnic areas, paths, pools, and trails. Locating El Portal at a lower elevation was the first major step in dispersing visitors to other parts of the forest. A popular restaurant

popular restaurant once located in the recreation area lost its roof to Hurricane Hugo in 1989; it was never rebuilt. A decade earlier heavy rains caused a large landslide along Road 191, the main road through the forest. Another controversy erupted over whether to rebuild the road, with environmentalists opposed and groups like the town of Naguabo on the forest's south side in favor. Eventually, the USDA Forest Service opted to keep the road permanently closed (see page 100). Today, foresters envision developing small pockets of recreational areas throughout the forest, including where Road 191 ends south of the landslide. In 1996, the antennas and buildings atop El Yunque Peak were greatly reduced, thus also reducing the amount of traffic involved in maintaining the communications equipment.

Of increasing concern to the USDA Forest Service is the extensive development in northeastern Puerto Rico, which is driving communities ever closer to forest boundaries. One solution has been to push for tougher Federal controls over forest resources. A good example is the Río Mameyes. The Mameyes is a beautiful stream that tumbles over boulders, into pools, and past unruly vegetation as it makes its way from cloud forests to the coast. Although it may be the only river in the Caribbean that remains untouched on its journey to the sea, a local water company had plans to dam it in the 1980s. Partly because of those plans, the USDA Forest Service petitioned that Luquillo's Mameyes, Icacos, and La Mina Rivers be designated as Wild and Scenic Rivers, and, in 2002, they were added to the Federal program. Another bill was introduced to the U.S. Congress to declare 9,000 acres on the southern side of the forest as the El Toro Wilderness Area; it was signed by President George W. Bush in 2005.

The past two decades have been marked with concerns and controversy, but also with hope. In 2001, a population of more than 1,500 orchids belonging to the species *Lepanthes eltoroensis* was recorded. This orchid grows only on El Toro Peak in the Luquillo Experimental Forest, nowhere else in the world, and its hardy population numbers surprised even the most optimistic botanists. More recently, the Puerto Rican Crested Toad, once found all over the island but now only surviving in the wild in Guánica Commonwealth Forest on the dry southern coast, took advantage of an unusual rainy spell. More than 600 toads were seen reproducing, by far the largest number since the animal was listed as endangered in the 1980s.

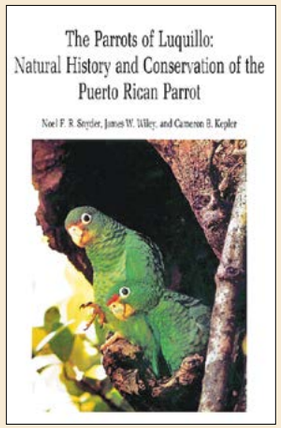
Visitors in the main hall of the El Portal Rainforest Center (2005).

1987 A.D.

A comprehensive study of the dynamics, structure, and composition of the palo colorado forest type in the Luquillo Mountains was begun by the Institute of Tropical Forestry.

Watershed research began in the Bisley sector of the Caribbean National Forest.

The publication of *Acta Científica*, a scientific journal for Puerto Rican science teachers, began.



The Parrots of Luquillo, a 20-year history of parrot research in the Luquillo Experimental Forest, was published.

A technical guide for the nursery management of the Caribbean pine was published.

1988 A.D.

A Big Tree Registry was begun to record the largest trees by species throughout the island and to increase local appreciation for forest resources.

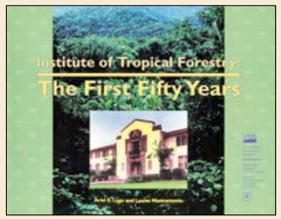
The Long Term Ecological Research Program of the National Science Foundation began in collaboration with the University of Puerto Rico.

Jose Salinas was appointed forest supervisor of the Caribbean National Forest.

Hurricane Hugo struck Puerto Rico in September 1989, causing heavy damage in the Luquillo Experimental Forest, as seen at the Palo Colorado Recreation Area (this page), the entrance to the forest on Road 191 (opposite top), and the Sierra Palm Visitor Center (opposite bottom) (1989).

1989 A.D.

Hurricane Hugo caused major damage to the island of Puerto Rico and to the Caribbean National Forest facilities, including the Catalina Service Center and the forest's recreational areas. As a result of the hurricane, the population of the Puerto Rican parrot dropped to a low of some 30 individuals in the wild. Hurricane recovery efforts resulted in watershed restoration efforts involving more than 120 hectares (296 acres).

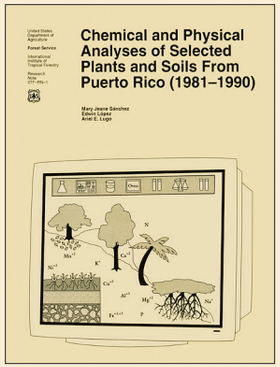


The Institute of Tropical Forestry celebrated its first 50 years with a symposium and published a book, *Tropical Forestry Management and Ecology*.

The Puerto Rican parrot Population Viability Analysis and Recommendations, a 2-day workshop, was conducted by the institute and attended by scientists from many disciplines, recovery program managers, and field technicians.

1990 A.D.

The population of Puerto Rico was 3,522,000.



1991 A.D.

A volume on the growth and site relationships of Caribbean pine was published.

A list of naturalized exotic species in Puerto Rico with information on their environmental requirements and estimated rates of spread was published.

The first fire crew trained in the Caribbean National Forest was dispatched to fight fires. A decade later, a recordbreaking 22 fire crews were dispatched from the forest to fight fires in the continental United States.

Scientists from the University of Puerto Rico collaborate with the institute scientists conducting a wildlife survey in Quebrada Sonadora, El Verde section of the Luquillo Experimental Forest (2006).

The Institute Expands

In 1989, the Institute of Tropical Forestry held its 50th anniversary celebration with a series of conferences and the publication of the book *Tropical Forest: Management and Ecology.* In 1992, the institute became known as the International Institute of Tropical Forestry as the focus of the work took on a more global approach. In addressing complicated and multifaceted research issues, the institute has focused on extensive collaborations with a multitude of other agencies and organizations, in both governmental and private sectors, locally, nationally, and internationally. Research partnerships exist with more than 50 institutions around the world, including virtually all of the nations throughout Central and South America, Mexico, and the West Indies. Although the institute's focus is on Latin America, the research product typically has relevance for tropical forests of many types throughout the tropical world.

Supporting the research programs are some of the most sophisticated facilities in the tropics, including a state-of-the-art chemistry laboratory with the capacity to process more than 50,000 plant, soil, water, and air samples per year, and various timber-handling shops and wood-product labs. Some of the plots under the jurisdiction of the institute, such as those established many years ago in the Luquillo Experimental Forest, have provided the potential for long-term studies unparalleled in the tropics. Equally important as a research asset is the institute library. In 1998, it was designated the Frank H. Wadsworth Library in honor of the former institute director and forest supervisor. Nothing compares to these facilities within the U.S. National Forest System.

Basic Research: What and Why

Research at the institute can be divided roughly into studies of basic biological and ecological processes and studies of a more applied nature. Basic research projects address questions and issues that actually underpin strategies for management, utilization, or protection of tropical forest ecosystems, including plant, animal, and water resources. Numerous studies have been done, papers written, and workshops attended, but several recent projects stand out.

In 1988, a research project funded by the National Science Foundation through its Long Term Ecological Research (LTER) Program was initiated in the Luquillo Experimental Forest. LTER, still in progress, is the best known work undertaken in the forest since the El Verde irradiation and ecology study in the 1960s. It has the collaboration of leading scientists and organizations on fundamental issues of tropical forest ecology. By establishing, managing, and monitoring long-term plots, some of which are subject to experimental manipulation, scientists can unlock answers to questions about long-term growth patterns and changes in the processing of energy and materials and assess the effects of global warming or other environmental changes. As part of the program, the watershed studies in the Bisley area of the forest are providing important information concerning the flow of water and nutrients through tropical forest ecosystems. In 1989, shortly after the LTER program got under way, Hurricane Hugo passed directly over El Yunque. It was the first major hurricane to cross the forest in some 60 years. Although Hurricane Hugo reduced the wild Puerto Rican parrot population, caused innumerable mountain landslides, and stripped most trees of their leaves and some of their branches, it also proved to be a great opportunity for the LTER scientists. Now they could also follow the growth cycle the forest goes through from one major hurricane to the next.

Another important project involves studies of the palo colorado forest type in Luquillo. Begun in 1987, it has had important implications for the ecology of the severely endangered Puerto Rican parrot populations, which largely roost in cavities of the *Cyrilla racemiflora* (palo colorado) trees. This forest type, occurring at mid-to-higher elevations, is thought to contain some of the oldest trees in the Caribbean, with the potential to add insights into changes in forest conditions over extended periods of time. Studies of cloud forest (elfin woodland) in Luquillo have been and continue to be among the most respected

for this category of ecosystem. A major cloud forest symposium was held in the early 1990s. The proceedings were published in 1994 and are now regarded as one of the landmark references on this topic. Soon afterward, the United Nations declared The Year of Tropical Cloud Forests, in recognition of their ecological importance and the peril that confronts them due to habitat alteration and climate change.

On the south side of the island, in the Guánica Commonwealth Forest, another long-term project is focusing on a dry forest, analyzing its structure, function, and recovery following such impacts as cutting and hurricanes. In addition to producing an array of pioneering publications on tropical dry forest ecology, it has served as a training ground for many graduate and undergraduate students and stimulated related studies in other regions.

Tropical dry forest in the Guánica Commonwealth Forest (2007).

The palo colorado forest type in the Luquillo Experimental Forest (2007).

1992 A.D.

The International Institute of Tropical Forestry was created by the Secretary of Agriculture as called for in the 1990 Farm Bill. The institute was designed to "serve as a gateway for collaborative efforts emphasizing forest research, demonstration forests, technology transfer, training, education, and networking." International forestry was formally recognized as a vital part of the institute's mission.

Supervision of the institute was transferred to the USDA Forest Service Washington [DC] Office. Ariel E. Lugo was appointed director.

1992 A.D.
The State and Private Forestry program was transferred to the institute from USDA Forest Service, Southern Region.

The institute hosted an international workshop on Natural Sinks of carbon dioxide.

After 22 years of continuous efforts to reopen Road 191, closed due to landslides between kilometers 13 and 21, the USDA Forest Service came to the conclusion that the soils in the area were highly unstable and withdrew any support to reopen the road.

The first Forest Interpretive Plan was completed in the Caribbean National Forest.

1993 A.D.
Pablo Cruz was appointed forest supervisor of the Caribbean National Forest.

The U.S. Postal Service issued a stamp to commemorate the 500th anniversary of Columbus's landing on Puerto Rico.

Applied Research: How

Applied research has a direct relevance to forest management, conservation, and resource issues. The institute's 60-year record of growth and stand structure for certain forest types, developed to estimate the potential of forest resources, is among the most comprehensive for any tropical forest in any region. These stands have been used in a variety of assessments, including studies of the resiliency of forests in recovering from hurricanes, three of which occurred in Luquillo between 1989 and 1998. One significant conclusion emerging from these investigations is that at least some tropical forests are more resilient than has typically been assumed, and, with proper management, could be used for resource purposes. This is a notable departure from the common view of tropical forest fragility and suggests that effective forest management is indeed within the realm of capability, even in tropical rainforest ecosystems.

Some of the institute's most interesting research has involved created systems, such as various types of plantations and secondary forests. The work has shown that these systems, in addition to producing food or fiber, have the capacity to support at least a component of the natural forest community while, at the same time, relieving natural systems from the pressures of use. In addition, long-term institute investigations of mahogany *(Swietenia macrophylla)*, the most valuable tropical timber tree in the Northern Hemisphere, have reoriented thinking on restricting the use and commerce of this increasingly scarce tree. Many of these research findings and recommendations were published in a special issue of *Forest Ecology and Management,* which was devoted to institute strategies for the restoration of biodiversity on degraded lands, and in a book that summarizes the state of the art in mahogany plantations and forests.

Applied institute research that will prove vital in future decades involves using tropical forest streams to provide water without damaging stream wildlife or long-term water productivity. Techniques such as new designs for water intakes and variable pumping rates synchronized with time of day, season, and streamflow rates have helped to ensure continuous system function even during times of drought.

Forester Jerry Bauer checking out a young mahogany enrichment planting in the Luquillo Experimental Forest (1993).

Researcher Samuel Moya collecting rainwater sample in the Bisley watershed, Luquillo Experimental Forest (2007).

Boas, Vines, and the Canopy Connection

As a federally listed endangered snake, the Puerto Rican Boa *(Epicrates inornatus)* is a species of special concern for managers in the Caribbean National Forest as well as in forested areas throughout Puerto Rico. The boa is widespread in a variety of habitats, from sea level to 400 meters, where its prey includes various invertebrates, lizards, rats, bats, and birds. Formerly common, the boa is believed to have declined in both population size and distribution due to deforestation of the island in the late 1800s. Given the species' endangered status and lack of knowledge of its basic biology, International Institute of Tropical Forestry researchers conducted a 4-year study of boa movements and habitat use in "El Yunque," using radio telemetry. Small radio transmitters were surgically implanted in the boas, enabling researchers to use radio receivers to locate each boa on a weekly basis for approximately a year. As luck would have it, Hurricane Georges struck the forest in the middle of the study, allowing the researchers to document the hurricane's effects on the boas. The boas responded to the hurricane by moving more frequently after the storm. Unfortunately, however, this upsurge in mobility also increased their risk to predation. Apparently, hurricane winds that strip leaves, branches, and vines from trees reduce cover for boas and limit access to arboreal sites for several years until regrowth brings about recovery, with increased vine growth. Both the study's discovery of more boas than expected (72 in 4 years) and the visual detection of boas at only 15 percent of the sites where boas were located with radios indicated that the boa is more abundant than generally perceived. As a result of the study, institute researchers devised methods for long-term monitoring of boa populations by "El Yunque's" wildlife managers.

The study's discovery that trees used by boas had more vines and greater canopy contact with neighboring trees than random trees was consistent with a hypothesis that some tropical forest birds avoid snake predation by nesting in isolated trees without vines and canopy contact with neighboring trees. The hypothesis was tested by a Jamaican collaborator, Dr. Susan Koenig, who measured vine cover and canopy contact and demonstrated higher rates of predation on Black-billed Parrot nests in trees with vines and canopy connection than nest trees lacking these traits in Jamaica. The closely related Jamaican Boa was implicated as the predator, and these findings led to a collaborative review of snake predation on parrot nests and management recommendations (including trimming the vines and canopy of nest trees) for endangered cavity-nesting birds. Although the Puerto Rican Boa is not a serious threat to the parrot in the Caribbean National Forest because most nesting occurs at high elevations where the boa is rare, reintroduction of the parrot to the island's karst region has been initiated in places where boa densities are highest.

[Excerpted from anecdotes by Joe Wunderle, International Institute of Tropical Forestry scientist]

Puerto Rican Boa (2007).

1994 A.D.

A Geographic Information System laboratory was established at the institute. It was later involved in summarizing the long-term plot information for Puerto Rico and the U.S. Virgin Islands and big-leaf mahogany studies in Central and South America.

The institute began research studies in Brazil.

The International Institute of Tropical Forestry published its 1,000th publication.

The Caribbean National Forest prepared and implemented a drought emergency planned that outlined plans to supply more than 3 million liters (792,516 gallons) of water per day from rivers and streams to surrounding communities.

The Society of Arboriculturists was established in Puerto Rico.

1995 A.D.

El Yunque Peak Electronic Site consolidation plan was completed, reducing 23 buildings and more than 200 permittees to 9.

1996 A.D.
El Portal Tropical Forest Center opened with 3,000 square meters (9,800 square feet) of exhibit space highlighting public education and demonstrating the importance of forest conservation.

The first annual meeting of urban foresters in the Caribbean area was held.

Hurricane Hortense struck the island on September 10th, killing five people and knocking out electricity to 85 percent of the island.

Young Puerto Rican children (above and right) benefit from the institute's outreach and educational programs (2007).

Education and Outreach: To Whom?

In the tradition of the USDA Forest Service, the institute has always made an effort to ensure that its research results are readily available to those who can use them. Over the years, publications have ranged from those of a basic or academic nature, placed in leading professional journals, to more practical material contained in field manuals, guidebooks, and brochures intended for widespread distribution. A technical guide published in 1987 contains information necessary for the cultivation of Caribbean pine, and a more recent book covers the silviculture of 102 tree species found in Puerto Rico and the U.S. Virgin Islands. More esoteric publications, primarily in scientific journals, concern such topics as the biogeochemistry of montane wetlands. In 1987, the institute began to publish *Acta Científica,* a journal for science teachers, placing special emphasis on topics and contributions of importance to Puerto Rico and the Caribbean region.

Recent workshops and conferences have covered a variety of contemporary issues—the endangered Puerto Rican parrot, urban forestry, the role of tropical forests in climate change, remote sensing, tropical stream dynamics, and Caribbean wildlife. In 1986, a program of long-term collaboration with high schools throughout Puerto Rico was started. Both teachers and students are learning to be more aware of environmental and resource issues and problems. In addition, undergraduate and graduate students are involved in institute projects, mentored by experienced members of the staff. Through these and many other efforts, the institute has acquired a reputation, in Puerto Rico and throughout the Caribbean, as being a place where the interested public can access information and expertise on a wide variety of environmental and resource-related matters.

The Third Branch of the USDA Forest Service: State (Commonwealth) and Private Forestry

Three branches of the USDA Forest Service receive funding—the forests themselves, which get up to 90 percent of funds; the research component; and State and private forests. The State and Private Forestry (S&PF) deputy area of the USDA Forest Service is based on the Cooperative Forestry Assistance Act. The act mandates State Forestry agencies and the USDA Forest Service to implement Federal programs targeted at State lands and private forest lands in a cooperative fashion. Research, technology development, field demonstrations, technology transfer, and financial assistance to State and private forest managers and landowners were important when the USDA Forest Service first became active in Puerto Rico, and they continue to be important today. State forests in Puerto Rico are often referred to as Commonwealth forests.

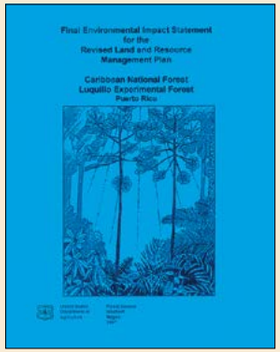
In the cooperative forestry programs, technical and financial assistance is provided to help sustain forests. The cooperative fire assistance program emphasizes improving fire planning and wildland fire techniques training for local fire agencies. The forest health protection program prevents, detects, and manages insects, disease, and invasive plants and manages forests to maximize their resilience in the face of severe storms and hurricanes. In the forest history program, forest historian Carlos Domínguez Cristóbal conducts research in local and international archives and libraries to identify events in the history of Puerto Rico that have affected forests and vegetation coverage throughout the island. The new Urban and Community Forestry in Puerto Rico program will assess current urban forest resources for the Commonwealth of Puerto Rico land areas and provide direction for future policies and program development based on protecting and restoring the urban ecosystem.

The conservation education program helps people of all ages understand and appreciate Puerto Rico's natural resources and how to conserve those resources for future generations. As part of this program, in 1986, the Institute of Tropical Forestry began a pilot project in which the principal goal was to assist in curricula and forest research development at the Pablo Colón Berdecía High School in the mountain town of Barranquitas. Training sessions have included information on weather monitoring, forest community dynamics, tropical soils and nutrient cycling, hydrology and stream ecology, dynamics of vertebrate populations, and natural history. The USDA Forest Service, University of Puerto Rico researchers, as well as LTER researchers from collaborating mainland institutions, have conducted training sessions. Students have held symposia, participated in science fairs, published articles, and developed profiles for nearby forests.

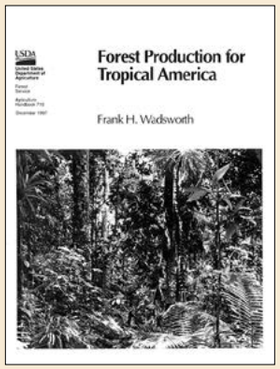
A certified arborist ascends a tree using all proper safety equipment to check for disease (2007).

1997 A.D.

The Caribbean National Forest Land and Resource Management Plan was approved.



A formal environmental education teacher training program was developed, in partnership with local schools, to enhance classroom experiences for middle and high school students and to complement the guided tours given by forest interpreters that the teachers and their students enjoy when visiting the forest.

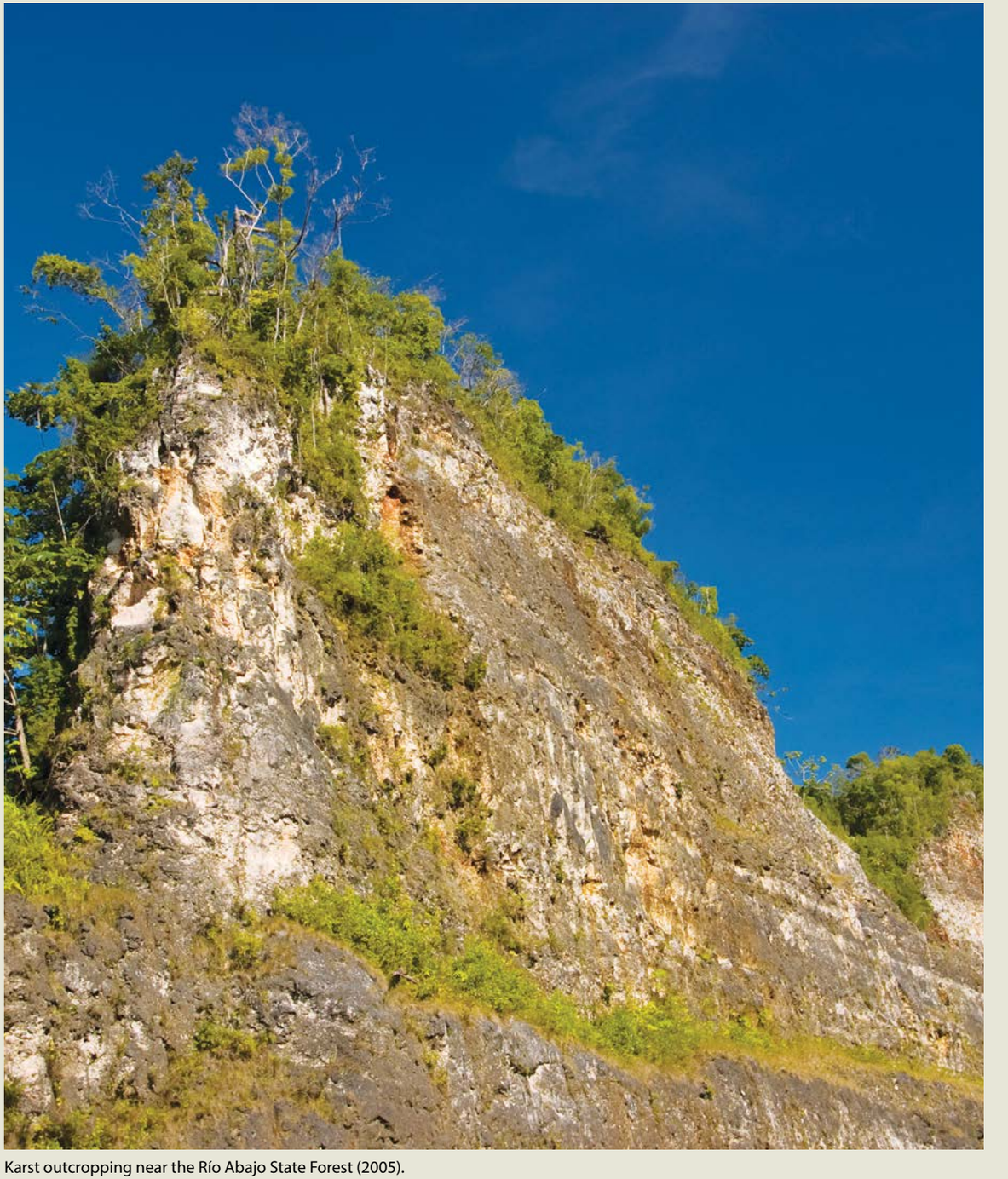


Puerto Rico's State Forests Are Unique

Active forestry during American administration of Puerto Rico began with a forest law passed by the local government in 1917. This law established the Puerto Rico Forest Service and provided for governmental proclamation of State (local) Forests for the production of wood and the protection of water and wildlife. It also provided for a silvicultural experimental station, a nursery for distribution of trees to the public, and an educational campaign to enhance public appreciation for forests. In the following year, with the arrival of the supervisor of the Luquillo National Forest, the administration of the local forest service under the Puerto Rico Department of Agriculture was passed to the Federal Forest Service supervisor, an arrangement that lasted for the ensuing 36 years. In the first 5 years following the 1917 forest law, the governor proclaimed two upland forests, Guánica and Maricao; the mangroves of Piñones as well as Ceiba, Aguirre, and Boquerón; and Mona Island. During this period, the Puerto Rico Forest Service relied on two sources of support: the Federal Government and the local government, with the latter subject to local as well as Federal approval. The result was a large component of direct assistance on State forest lands from the USDA Forest Service, a situation unique to Puerto Rico. This unusual level of assistance to the "State" included forestry practices in the State forests. State lands became excellent demonstration sites and are critical to technology transfer to this day.

[Frank H. Wadsworth]

Editor's note: After the establishment of the Commonwealth of Puerto Rico in 1952, these forests became known locally as Commonwealth Forests.



Karst outcropping near the Río Abajo State Forest (2005).

Making a Difference: Environmental Sustainability in the Turabo Valley

In 1997, I attended an urban forests conference in Atlanta, GA, on a trip funded by the State and Private Forestry (S&PF) Program of the USDA Forest Service's International Institute of Tropical Forestry. There, at a presentation by the late Gary Mason of the firm Wolfe Mason Associates of California, I became enthralled with the concept of biotechnical restoration of rivers and the possibilities offered for the much abused water bodies of Puerto Rico. Less than 2 months later, with funding from the USDA Forest Service and the cities of San Juan and Caguas, Gary traveled to Puerto Rico and led a workshop on ecosystems management and biotechnical river restoration.

Interest in the protection of streams and rivers in Caguas increased upon publication of "Caguas 2020," a strategic urban design study which called for "a continuous setback along the banks of … rivers [to] be preserved or reclaimed for a combination of ecological preservation, public access, recreational facilities, and linkages to the urban fabric." In subsequent years, projects to protect and enhance the natural values of the local Cagüitas River, to create a new botanical garden along the river, and to plant and inventory trees on the grounds of the local Universidad del Turabo campus were launched. These projects came about thanks to the combined efforts of Gary Mason, Robin Morgan, and Magaly Figueroa of S&PF; the U.S. Army Corps of Engineers; the Puerto Rico Department of Natural and Environmental Resources' Sustainable Forestry Initiative (funded by S&PF); the University of Turabo; and the city of Caguas. The projects are fine examples of what devoted public service can accomplish, and residents of the Valle del Turabo will be grateful for these efforts for a very long time.

[Excerpted from a report by Jeffrey Glogiewicz, forester working in the Caguas Botanical Garden]

El Jardín Botánico de Caguas, Magaly Figueroa (2012)

1998 A.D.

Hurricane Georges, with 120 mph winds, struck the island on September 21, killing 7 people and leaving more than 24,000 in shelters. Virtually the entire island was left without electricity (99.5 percent), most without water service (77 percent), and some without phone services (25 percent). It was followed by extensive hurricane recovery efforts.

A partnership with the University of Puerto Rico Institute 2000 and the Puerto Rico Department of Education was developed to allow teachers attending USDA Forest Service environmental education training sessions to qualify for continuing education credits. More than 400 teachers would benefit from these training sessions from 1998 to the present.

The new International Institute of Tropical Forestry library was designated the Frank H. Wadsworth Library.

1998 A.D.

The devastating pink hibiscus mealy bug was first discovered in the Caribbean National Forest. The Puerto Rican Department of Agriculture responded promptly with the introduction of a parasitic wasp to destroy the mealy bug.

The Caribbean National Forest World Wide Web site went on line.

1999 A.D.

Hurricane Lenny hit Puerto Rico.

The International Institute of Tropical Forestry celebrated its first 60 years with a symposium.

2000 A.D.

The Center for Aquatic Technology Transfer (CATT) performed a comprehensive inventory of aquatic species on the Río Espíritu Santo in the Luquillo Experimental Forest.

The first release of 10 Puerto Rican parrots reared in captivity into the wild was accomplished, followed by the release of 16 parrots in 2001, and 9 in 2002.

The institute published a book on the silvics of 102 native and exotic tree species found in Puerto Rico and the U.S. Virgin Islands.

International Cooperation

The International Institute of Tropical Forestry has been involved in international cooperation, commonly known as international forestry, since its start. The early years of the Tropical Forest Experiment Station in Río Piedras (established in 1939) included international activities throughout Latin America and the Caribbean region. In subsequent decades, focus on international forestry grew considerably as the station carried out trainings for students from throughout the tropics, and they, in turn, created requests for technical assistance on return to their home countries.

Given the established work of the USDA Forest Service in Puerto Rico, the island was considered an ideal location for training professionals from the Caribbean Basin.

Many identifiable similarities exist between Puerto Rico and other countries in the region—diversity of ecosystems and land formations; a wide range of forestry issues and historical uses; and, perhaps most importantly, Puerto Rico's comparably advanced states of deforestation and agricultural and urban expansion that served as windows into the future for many less developed or deforested countries in the region, which were unmistakably moving down a similar path. Training programs have covered topics such as tree identification, site selection, forest nurseries, planting, cutting methods, mensuration, aerial photometry, research methods, timber grading and classification forest legislation, and forest administration. These programs have led to improved knowledge and experience with plantation forestry, tropical forest products, tropical species taxonomical descriptions, and long-term monitoring of natural and planted forests.

As greater emphasis has been placed on the sustainability of natural tropical forest management in recent decades, the institute remains a center for technical training, providing courses in tropical forest management. The Caribbean Foresters Meetings (CFM), started during the early 1980s, continue to be held today. At these meetings, leaders in the forestry and natural resource sectors assemble, and many of the most significant and timely issues pertaining to natural resource management are brought to light, studied, debated, and acted upon. From watershed management and forest recreation to biodiversity protection and fire management, the meetings have provided an opportunity for forestry leaders and topic specialists to share practical experiences and discover ways in which forest use can become more sustainable and natural resources within the region can be conserved.

Learning To Live Together

As the International Institute of Tropical Forestry continues to contribute to forestry issues in the Caribbean Basin and the American Tropics, it almost certainly needs to reconsider the relationships between native, naturalized, and nonnative species, now characteristic of many forests in the region. More than 70 years after near-complete deforestation, Puerto Rico represents a valuable window into the mechanics and characteristics of forest recovery and conditions for environmental change—information important for a changing world. Studies have shown and described the emergence of new forest types in Puerto Rico that encompass native, nonnative, and naturalized species. These new forests arise naturally on abandoned and often degraded agriculture lands, conditions that are found throughout the tropics and that exhibit both positive and negative traits. As forest fragmentation, degradation, and land use change continue to occur and increase in the tropics, observations and lessons learned from Puerto Rico's emerging new forest types will lend important information to the development of management and conservation strategies for existing and diminishing primary forests in the tropics and the new forest types that are likely to emerge around them.

Within this expanded scope in the international arena, the institute has increased cooperation and technical assistance with the U.S. Agency for International Development (USAID) missions. Continually, since 1989, the institute has had staff members placed on long- and short-term assignments in Central America and the Caribbean within USAID missions as mission and regional environmental and forestry advisors.

Today, significant evidence of the institute's long history indicates positive impacts in the region. For example, long-term research and monitoring of the mahogany tree has provided significant contributions to the international debate on mahogany's conservation status as well as developments on technical guidelines for mahogany's sustainable management. Other long-term monitoring and collaborative research on wildlife populations in the Caribbean Basin has shown noted declines in many neotropical migratory species over the past quarter century. Continued monitoring will provide valuable comparative data for questions relating to human impacts on forests and wildlife, as well as possible changes in the global climate. In addition to monitoring carried out by institute scientists, the USDA Forest Service has provided extensive training on long-term vegetation and wildlife monitoring to countries in the Caribbean Basin and beyond.

(Left to right) U.S. Ambassador to Nicaragua Paul Trivelli with institute scientist Wayne Arendt and biologist Marvin Tórrez looking at bird checklist in Montibelli Wildlife Reserve, Nicaragua (2008).

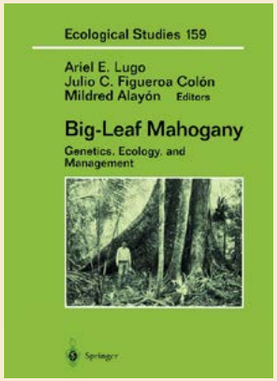
2000 A.D.
The population of Puerto Rico was 3,808,600.

2001 A.D.
A Caribbean National Forest transportation study was completed. It recommended a mass transit system for Road 191.

A population of more than 1,500 elfin forest orchids *(Lepanthes eltoroensis)* was recorded in the elfin woodland forest.

2002 A.D.
The first *Caribbean National Forest Interpretive Site Guides* were published in English and Spanish.

The institute published a book on the big-leaf mahogany.



2002 A.D.

The Caribbean National Forest Wild and Scenic Rivers Act of 2002 amended the Wild and Scenic Rivers Act to designate Río Mameyes, Río de la Mina, and Río Icacos of the Caribbean National Forest of the Commonwealth of Puerto Rico as components of the National Wild and Scenic Rivers System.

Construction was completed on a new chemistry laboratory for plant, water, and soil analyses at institute headquarters.

The Catalina tree nursery was reestablished.

The official *Caribbean National Forest Soil Survey* was published.

Alexis Massol-González of Casa Pueblo in Adjuntas received the Goldman International Environmental Award for Excellence in Protecting the Environment for more than 20 years of efforts to protect the natural and cultural resources of Puerto Rico's Cordillera Central (Central Mountains).

A Bridge to the U.S. Virgin Islands

Although the people of Puerto Rico and the U.S. Virgin Islands have different languages and cultures, the islands themselves are quite similar when it comes to vegetation and wildlife. A mere 10,000 years ago, when the oceans were lower, the land mass of Puerto Rico extended to today's British Virgin Islands, which is why these islands share many of the same species. Most descriptive books chronicling Puerto Rico's natural resources also include the U.S. Virgin Islands, and the USDA Forest Service has long worked closely with Virgin Island foresters.

For more than 10 years, the Virgin Islands Resource Conservation and Development (VIRC&D) Council has enjoyed and benefited immensely from a very successful partnership with the USDA Forest Service, in particular from the International Institute of Tropical Forestry. This partnership has played a major role in the growth and effectiveness of the VIRC&D Council, and 20 programs and projects have been completed with financial assistance from the USDA Forest Service.

Among the education and outreach initiatives in 2003, the USDA Forest Service funded a student outreach program that sent six Virgin Islands students to participate in the Natural Resource Conservation Conference in Georgia; a Virgin Islands Forest Products Outreach program that sent five Virgin Islands artisans to the 8th Caribbean Urban Forestry Conference in Ponce, Puerto Rico; and the farmers and landowners Agricultural and Natural Resources Conference held in the Virgin Islands.

The VIRC&D's showcase project, partially funded with $11,000 from the USDA Forest Service, is the Estate Adventure Nature Trail. This project was the idea of Paul Johnson, Chief of the USDA Natural Resources Conservation Service (NRCS) in 1995 after Hurricane Marilyn. He was the first NRCS Chief to visit the Virgin Islands. Local high school students have been involved in the design and preparation of signs and literature and in researching and collecting information to produce a brochure. In collaboration with VIRC&D volunteers, members of the St. Croix Hiking Association, and The Nature Conservancy, walkways and bridges were built to access the trail. The trail was officially inaugurated in 2004.

VIRC&D joins all others in this opportunity to acknowledge and celebrate 100 years of true service provided by the USDA Forest Service in its mission to sustain the health, diversity, and productivity of our forests and grasslands to meet the needs of present and future generations.

[Excerpted from a testimonial by the Virgin Islands Resource Conservation and Development Council, Inc.]

Fungi—Unique and Colorful

Some of the most interesting organisms in the tropics are fungi, commonly referred to as mushrooms. Numerous and colorful, they are noticed primarily in the forest by their whimsical shapes, and the more innocuous varieties often enhance a leafy salad or a sizzling steak. Other varieties of fungi, however, can be very poisonous to eat or cause serious plant infections

Microfungi are short lived, with about 95 percent of the species growing in and on live leaves and being replaced by other species within a few weeks. Most of the microscopic fungi that grow in decomposing leaves on the forest floor show strong 'preferences' for leaves of different tree species, and these preferences are related to their rates of decomposition. Macrofungi, on the other hand, are long lived and are the dominant decomposers in much of the forest floor. Scientist have monitored some individual fungi for more than 20 years in the Luquillo Mountains.

Rounding out this quintessential group of organisms are about 250 species of plant parasitic rust and smut fungi; about 450 species of mushrooms and other fleshy-stalked fungi; about 300 species of shelf fungi and flat-surfaced fungi; and approximately 150 species of puffballs, jelly fungi, coral fungi, tooth fungi, and other miscellaneous subgroups.

In Puerto Rico, about 1,800 species of fungi have been recognized. Between 1990 and 2007, through the efforts of Dr. Jean Lodge and her associates, more than 50 new species and 8 genera of fungi were described on the island, and an additional 50 species are in the process of being described. The total number of fungi, however, is unknown, because the majority of species has yet to be discovered.

Regardless of whether they are edible or poisonous, shaped like pert parasols or flat globs, fungi play a vital role in sustaining plants and animals, nutrient recycling, and the health of forests as well as other natural environments.

[Excerpted from anecdotes by Jean Lodge, botanist-mycologist for the Northern Research Station]

2003 A.D.
The first Biological Corridor in Puerto Rico was established through the community initiative of Casa Pueblo in Adjuntas. Known as the Conservation of Sensitive Areas in Adjuntas and Adjacent Municipalities, the corridor united the Bosque del Pueblo Forest in Adjuntas with the forests of Toro Negro, Tres Picachos, La Olimpia, and Guilarte.

2004 A.D.
The geographic information system (GIS)/Global Positioning System (GPS) laboratory was renamed the "International Institute of Tropical Forestry GIS and Remote Sensing Lab," and a new state-of-the-art facility was inaugurated, allowing for expanding geospatial analysis, cartographic production, training, and technology transfer activities.

2005 A.D.
Approximately 10,000 acres of the Caribbean National Forest was designated as El Toro Wilderness Area. El Toro, named after the highest peak (3,524 feet) in the forest, is the only tropical wilderness in the U.S. National Forest System.

2007 A.D.
A new Puerto Rican parrot aviary was opened in the Caribbean National Forest.

A historic release of 22 Puerto Rican parrots was made in the Río Abajo Commonwealth Forest in the Karst region of Puerto Rico, marking the first time in 70 years that Puerto Rican parrots fly free over the Karst region.

The Caribbean National Forest was renamed the El Yunque National Forest.

The Governor of Puerto Rico designated the Northeast Ecological Corridor in Puerto Rico by executive order.

2007 A.D.
The population of Puerto Rico was 3,944,259.

Modern-day Foresters in the Caribbean

In the Caribbean, policies for the protection and sustainable use of forests have not, for the most part, had the desired impact. These policies have often failed to address the underlying factors that cause deforestation—industrial-scale agriculture, urban development, and, to a lesser degree, fuelwood consumption. Also, they are rarely supported with sufficient financing, technology, personnel, and training. In recent years, however, environmental groups and institutions have grown stronger by acquiring increased leverage in the policy arena and stimulating a greater environmental consciousness in the public arena. Consciousness-raising activities include a growing number of major educational campaigns for saving natural resources, reducing wasteful practices, promoting recycling, and using nonpolluting products.

Of great importance are the Caribbean Foresters Meetings. These meetings assemble leaders in the forestry and natural resource sectors to provide an opportunity for the exchange and distribution of information. Since May 1982, the International Institute of Tropical Forestry has sponsored and organized, in collaboration with other organizations of the region, a biennial meeting that brings together foresters and other government officials who work in forest and natural resource management at the national level in the Caribbean region. Following are the year, place, and theme for each meeting held.

Institute Director Ariel Lugo presenting an award to Gabriel Charles from the Santa Lucía Forest Service.

Caribbean Foresters Meetings

Year	Country	Theme
1982	St. Lucia	Forestry in the Caribbean
1984	St. Vincent	Watershed Management in the Caribbean
1986	Guadeloupe	Forest Recreation in the Caribbean Islands
1988	Dominica	Wildlife Management in the Caribbean Islands
1990	Trinidad	Wetlands Management in the Caribbean and the Role of Forestry and Wetlands in the Economy
1992	Martinique	Toward Sustainable Forest Resource Management in the Caribbean
1994	Jamaica	Economics of Caribbean Forestry
1996	Grenada	Protected Areas Management
1998	Dominican Republic	Biodiversity in the Caribbean Management and Benefits
2000	Guyana	Possibilities and Approaches Toward Community Forestry in the Caribbean
2002	St. Thomas, U.S. Virgin Islands	The Future of Trees in the Caribbean Biology, Planning, and Management Possibilities
2004	Puerto Rico	Wildland Fire Management and Restoration
2006	Jamaica	Possibilities and Approaches to Idle Lands in the Caribbean
2008	Dominica	Linking Conservation, Tourism, and Sustainable Development in the Caribbean
2010	Guadalupe	Climate Change and Its Link in Forest Management and Biodiversity
2013	Dominican Republic	Forest Management, Climate Change, and Biodiversity: Advancing Understanding of Caribbean Forest Dynamics and Creating Long-Term Networks

[Excerpted from a report by Kathleen McGinley, International Institute of Tropical Forestry scientist]

Foresters from 17 countries attended the 14th Caribbean Foresters Meeting held in Dominica (2008).

2008 A.D.
Rosa Hilda Ramos received the Goldman International Environmental Award for Excellence in Protecting the Environment for her efforts to mobilize the local communities around the Las Cucharillas Marsh in Cataño to halt factories from polluting the wetlands and mangroves that provide important habitats for aquatic and migratory birds as well as flood protection and open space for local residents.

Institute Historian Carlos Dominguez completed a book on policies affecting mangroves in Puerto Rico during the 19th century.

Foresters from 17 countries attend the 14th Caribbean Foresters Meeting held in Dominica.

This Is His Life: Pablo Cruz

Pablo Cruz was born in Fajardo, Puerto Rico. He attended the University of Puerto Rico, where he received a B.S. in civil engineering. Since his graduation, he has dedicated his entire professional career to public service. He was project engineer for the USDA Soil Conservation Service and joined the USDA Forest Service as a civil engineer in California. He spent 11 years with the USDA Forest Service, including tours in national forests and the Washington Office. He returned to Puerto Rico in 1989 as part of the Incident Command Team after Hurricane Hugo. In 1990, Cruz became the Caribbean National Forest's district ranger and was appointed forest supervisor in 1993.

Sign at the entrance to El Portal Rainforest Center (2003).

The elfin woodland forest and communications towers on El Yunque Peak, Luquillo Experimental Forest. Notice to the right the urban development encroaching on the lower slopes of the Luquillo Mountains (2005).

2009 A.D.

A study, "Incorporating Remotely Sensed Tree Canopy Cover Data Into Broad Scale Assessments of Wildlife Habitat Distribution and Conservation" is published by various scientists, including institute researcher W. Gould.

2010 A.D.

The institute becomes custodian to two new properties that were transferred from the USDA Farm Service Agency. These properties became the Guayama Experimental Forest and the Manati Experimental Forest.

Study by Geographer Tania del Mar reveals that urban areas around El Yunque increased by 21 percent from 1998 to 2010.

2011 A.D.

Recognizing the need to provide educational opportunities for kids, the Natural History Society of Puerto Rico applied a grant from the USDA Forest Service More Kids in the Woods Program and brought students from public schools to discover the Santa Ana Forest.

2011 A.D.
The institute worked with a number of other Federal and local agencies to establish the Caribbean Landscape Conservation Cooperative, which was initiated as part of a national network of 22 landscape conservation cooperatives.

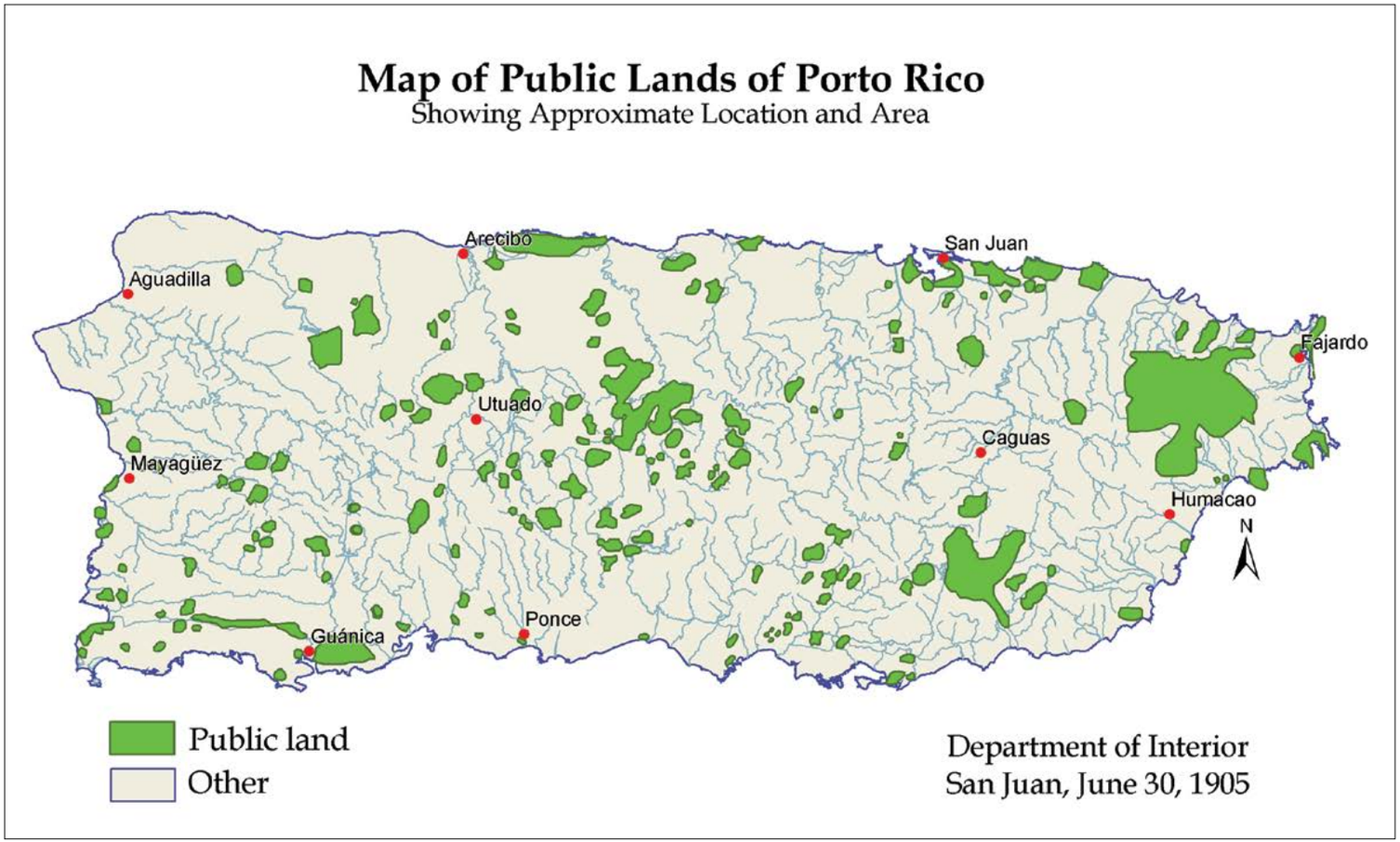
2012 A.D.
USDA Forest Service published "The Luquillo Experimental Forest: Research History and Opportunities" by N.L. Harris, A.E. Lugo, S. Brown, and T. Heartstill Scalley.

The Renovated Headquarters Building and Sabana Field Station are inaugurated with a visit from Thomas L. Tidwell, Chief of the Forest Service.

The institute prepares to celebrate its 75th Anniversary in 2014.

Land Use Around Luquillo Experimental Forest

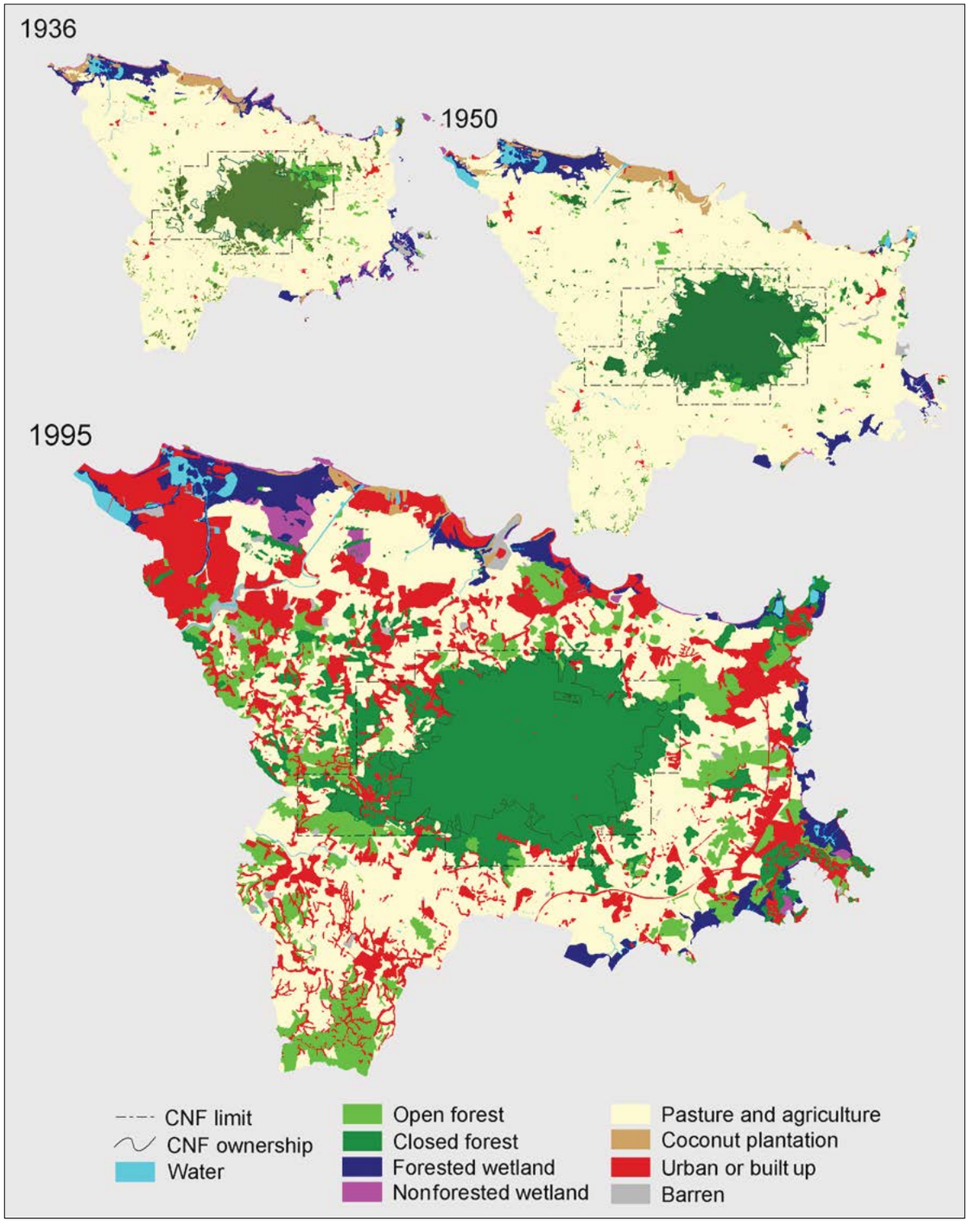
Land use around the Luquillo Experimental Forest has drastically been altered by human activity in the last century. These maps show the decrease in pasture and agriculture land use and the increase in urban-built-up and open forest land areas.



Map of Puerto Rico Public Lands in 1905.

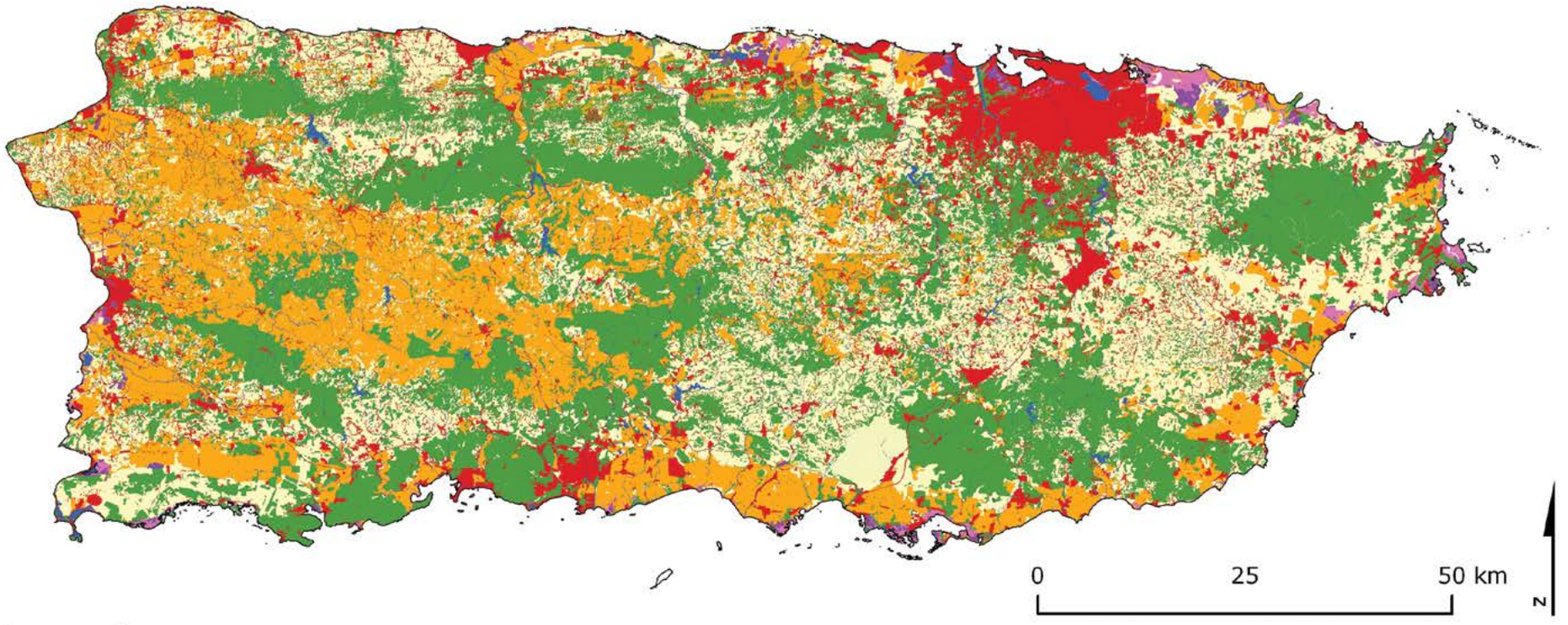
Map of Public Lands in Puerto Rico

Early in the twentieth century, the need for public land and conservation was recognized. Many forested areas around the island were set aside for the long-term needs of the general public.



Map of land use around the Luquillo Experimental Forest in 1936, 1950, and 1995.
CNF = Caribbean National Forest.

Land Cover of Puerto Rico in 1977–1978



Legend

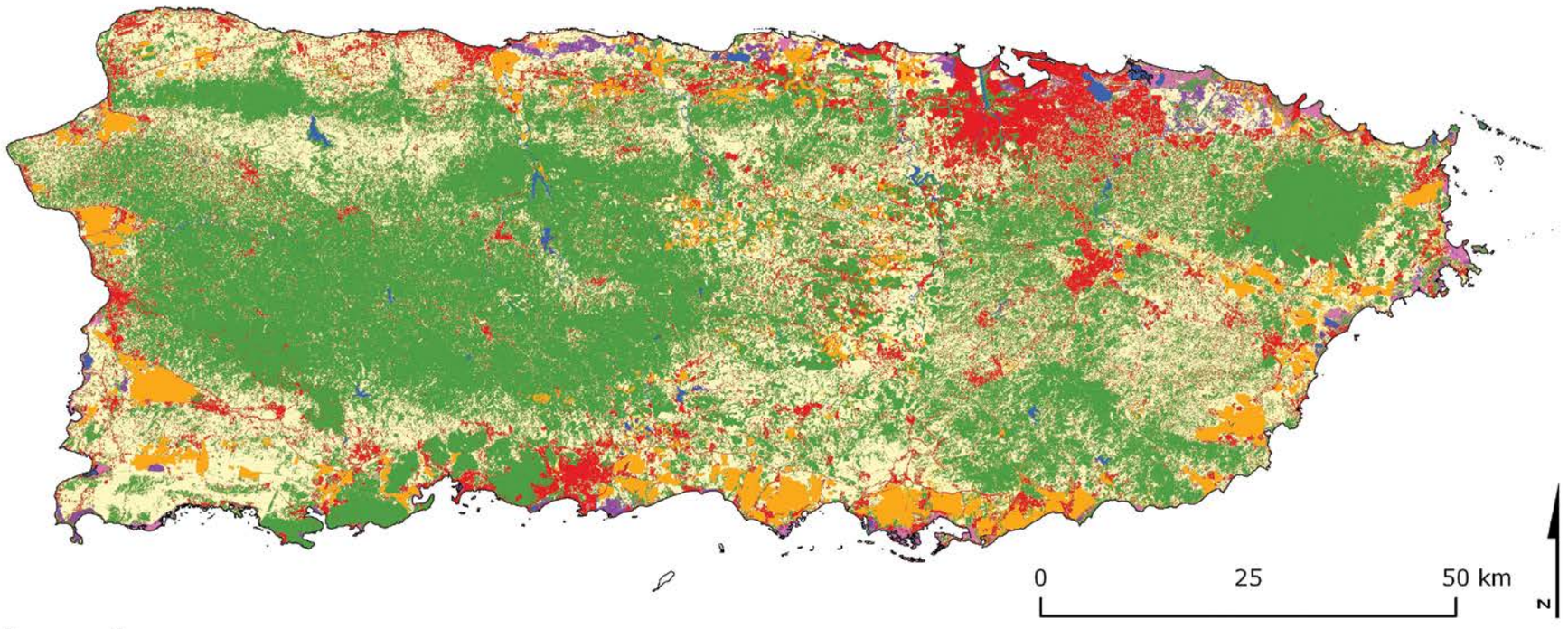
- Agriculture
- Barren
- Forest and shrubland
- Urban
- Mangrove
- Pasture
- Water
- Wetlands

This is the first cartographic product of the IITF GIS and Remote Sensing lab. The map is a generalization of a Puerto Rico land use map developed by the Puerto Rico Department of Natural Resources and digitized by the US Geological Survey Caribbean Water District.in Puerto Rico. The original dataset was created through aerial photo interpretation of 1977 and 1978 photos of the island.

Reference: Ramos, O.; Lugo, A.E. 1994. Mapa de la vegetación de Puerto Rico. Acta Científica 8 (1-2): 63-66.

Puerto Rico land use map in 1977–1978.

Land Cover of Puerto Rico in 1991–1992



Legend

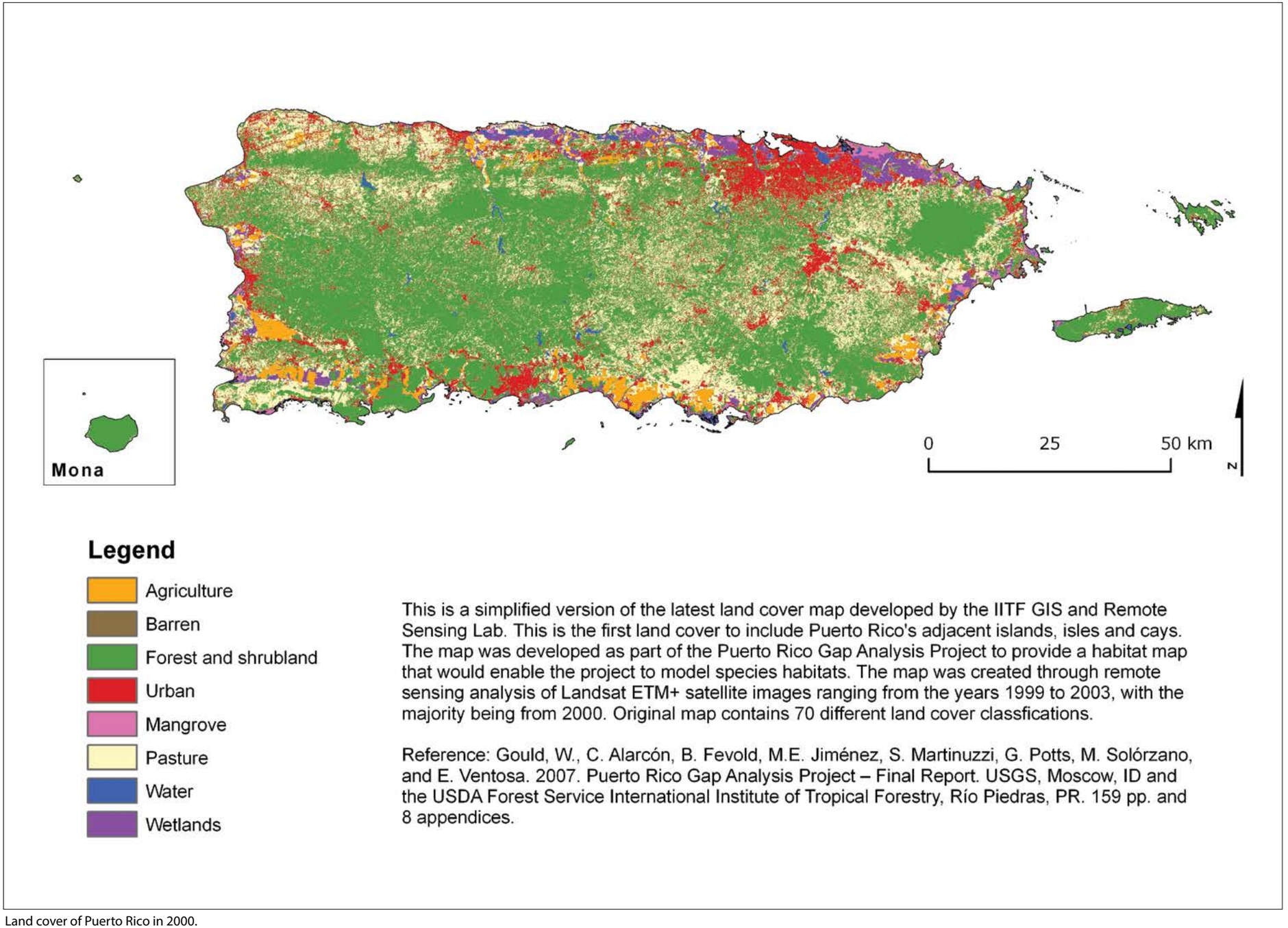
- Agriculture
- Barren
- Forest and shrubland
- Urban
- Mangrove
- Pasture
- Water
- Wetlands

This is a simplifed version of the 1991 to 1992 land cover map of Puerto Rico developed by the IITF GIS and Remote Sensing Lab. The map was created through remote sensing analysis of Landsat TM satellite images ranging from 1991 to 1992. Original map contains 31 different land cover classifications.

Reference: Helmer, E.H.; Ramos, O.; del Mar Lopez, T.; Quiñones, M.; Diaz, W. 2002. Mapping forest type and land cover of Puerto Rico, a component of the Caribbean biodiversity hotspot. Caribbean Journal of Science 38: 165-183.

Land cover of Puerto Rico in 1991–1992.

Land Cover of Puerto Rico in the Year 2000



Land cover of Puerto Rico in 2000.

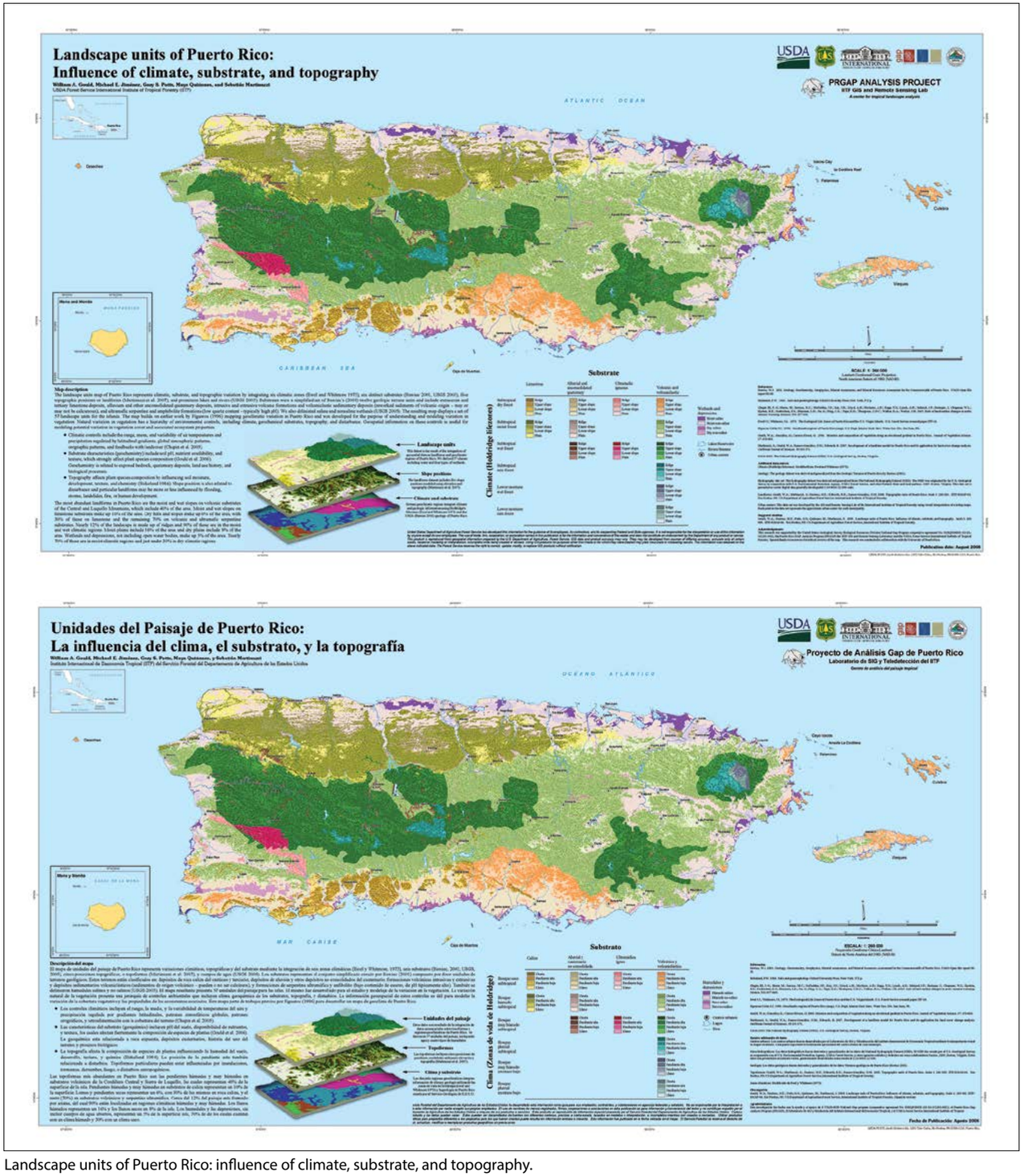
Landscape Units of Puerto Rico

As an initiative of the institute, the USDA Forest Service created a national publication series to allow for the publication of research map products developed by its research scientists and collaborators. The primary purpose of the series is to publish maps that convey new geospatial information derived from USDA Forest Service research.

The first four maps in the series were published in November 2008. They depicted various aspects of the Puerto Rican landscape and population dynamics.

The maps were published in both English (top) and Spanish (bottom).

The maps came folded inside an envelope with a description of the map inside.



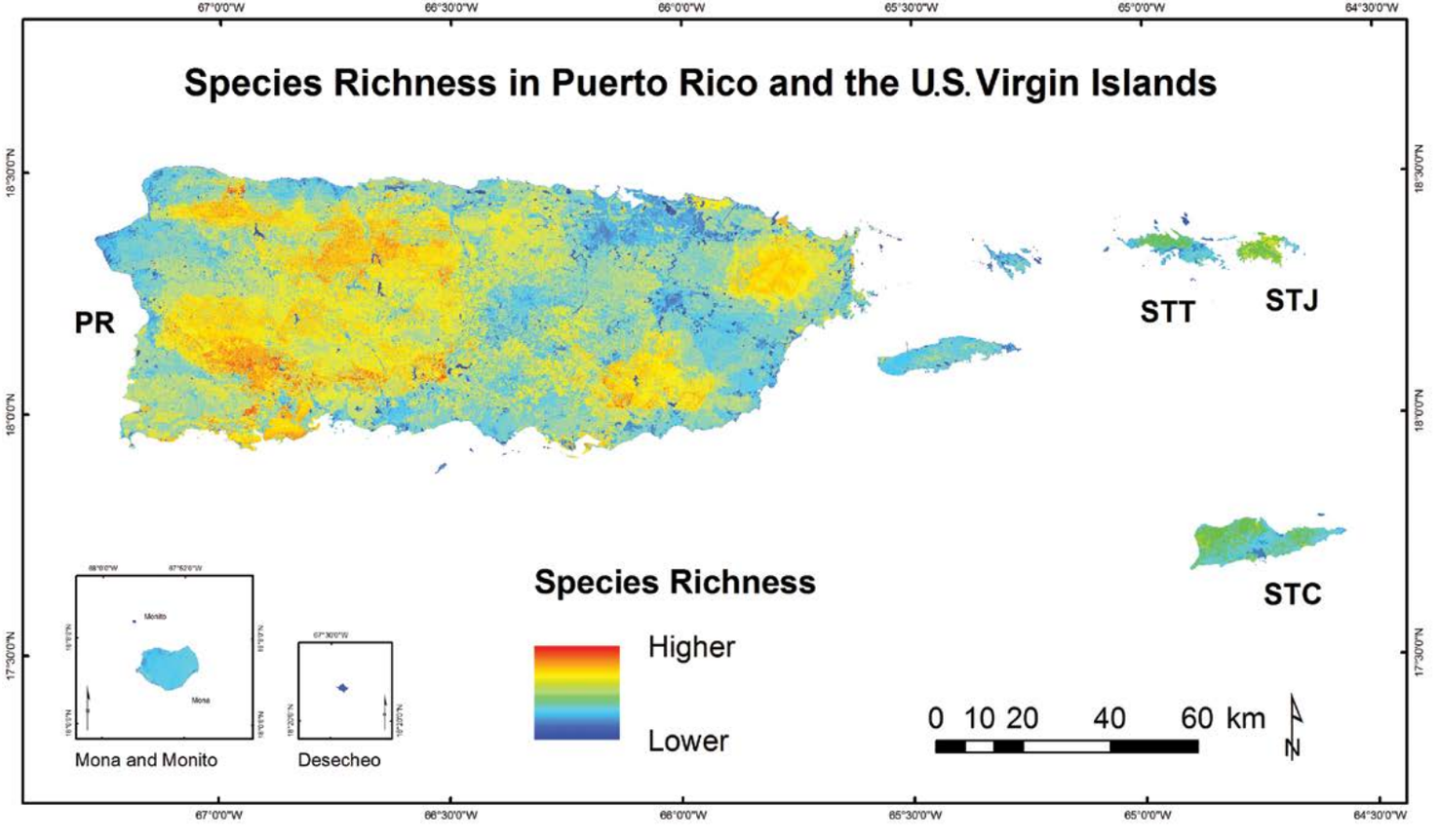
Landscape units of Puerto Rico: influence of climate, substrate, and topography.

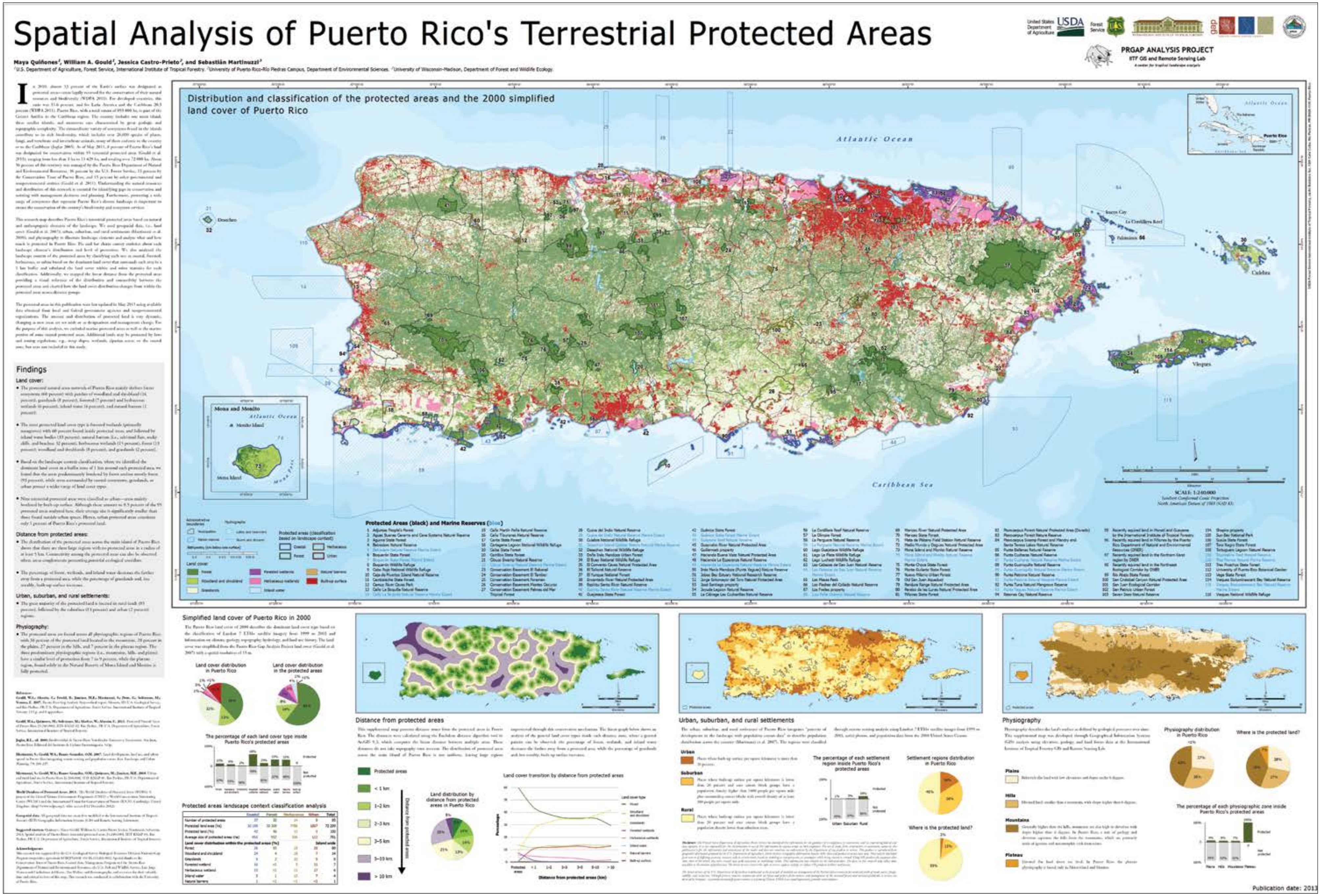
The Puerto Rico Gap Analysis Project

The Puerto Rico Gap Analysis project was first funded in 2002 through the U.S. Geological Survey Biological Resources Division National Gap Program cooperative agreement at the institute GIS [Geographic Information System] and Remote Sensing Laboratory. The main goal has been to assess the distribution of animal species and habitats in relation to protected areas and conservation. Since the project began, a number of modifications, collaborations, and continued efforts have built on the work and become known collectively as the PRGAP project. In 2006, the project expanded to include the terrestrial U.S. Virgin Islands and later in 2009 to include the analysis of aquatic environments and species in both territories. The project maintains an extensive database of species occurrences, spatial information on species distributions and protected areas, and continuing efforts mapping landcover and habitats for the area.

The PRGAP Analysis project findings and products have supported government planning decisions in the islands as well as continued research in various fields, including ecology, herpetology, conservation and protected areas management, and scientific publications, including USDA Forest Service technical reports. It has been pivotal for the institute GIS and Remote Sensing Lab in providing continued funding that allowed hiring, training, and supporting new employees, contractors, and students at the lab. The Web site developed for the project provides a portal for accessing this valuable set of information and findings (http://www.prgap.org).

The following two maps are products from this effort.

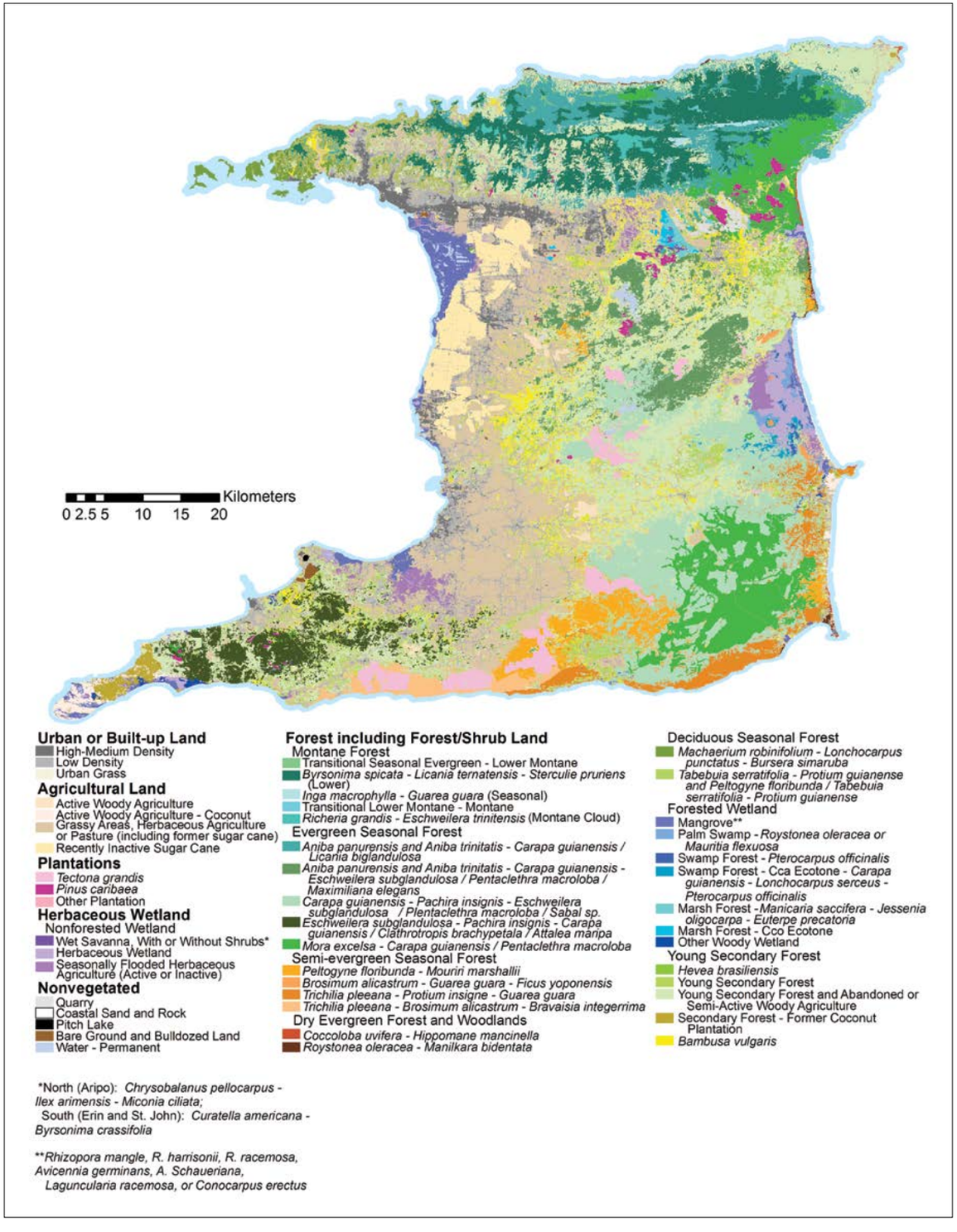


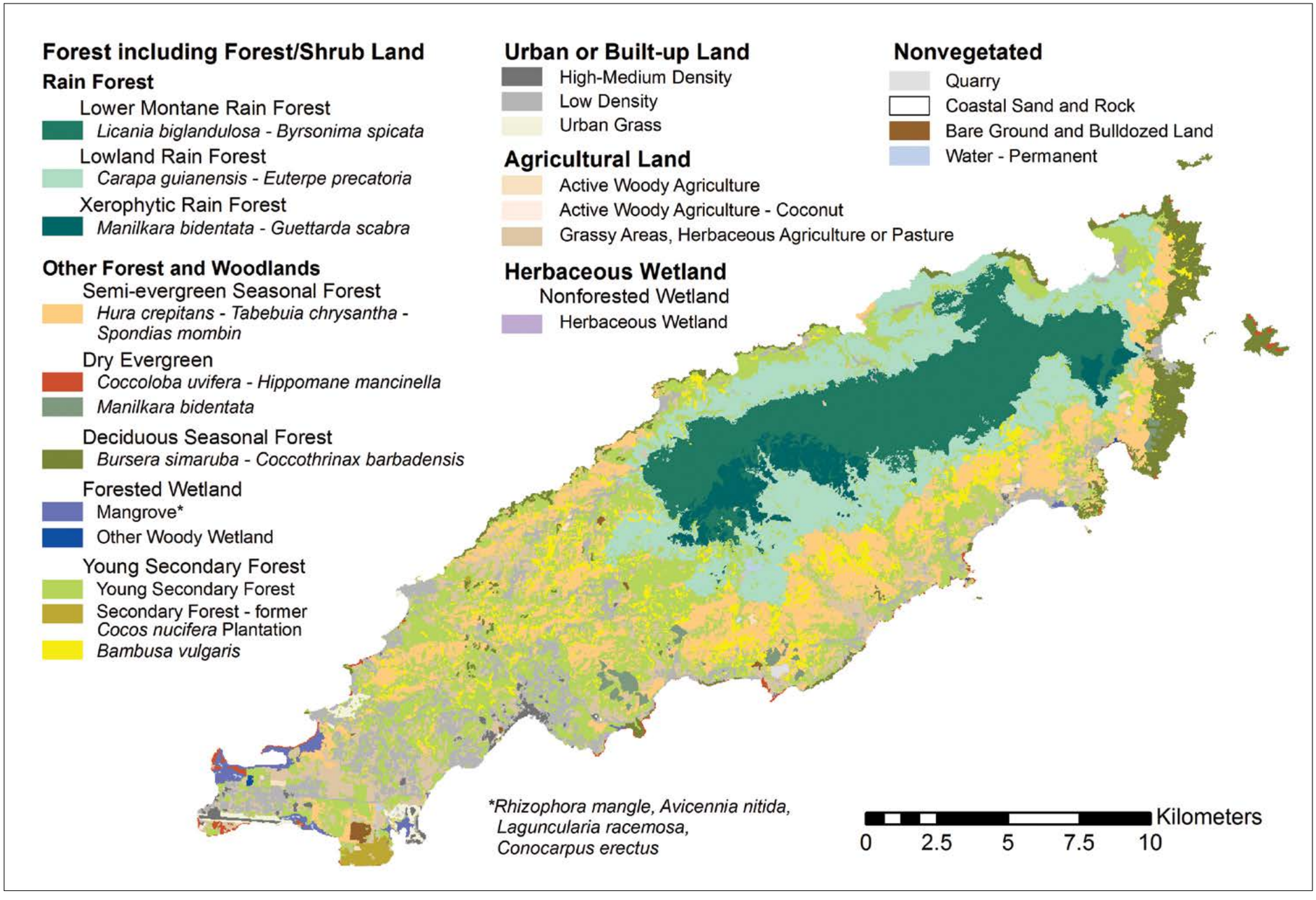


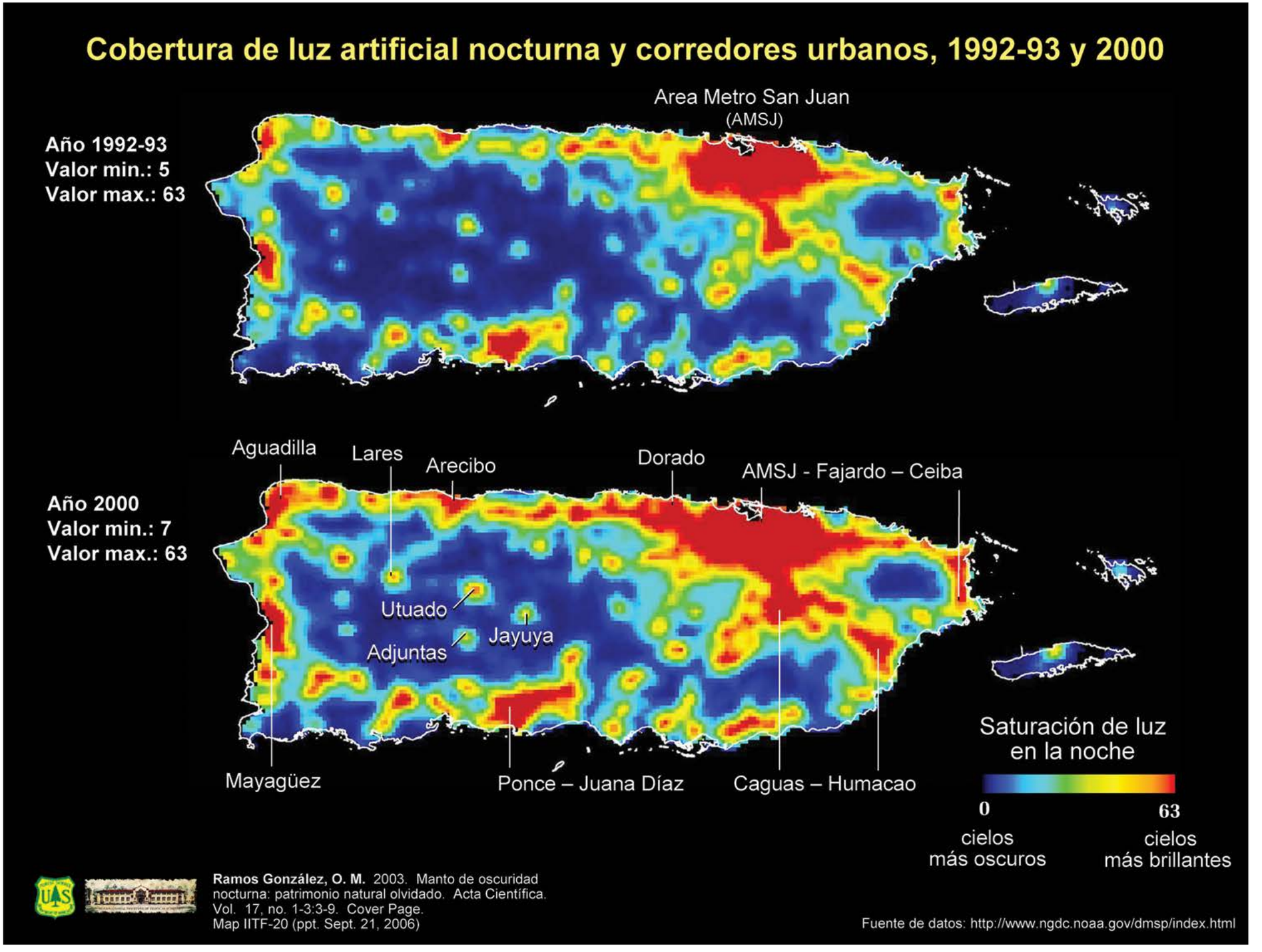
Spatial Analysis of Puerto Rico's Terrestrial Protected Areas
Maya Quiñones[1], William A. Gould[1], Jessica Castro-Prieto[2], and Sebastián Martinuzzi[3]
[1]U.S. Department of Agriculture, Forest Service, International Institute of Tropical Forestry. [2]University of Puerto Rico-Río Piedras Campus, Department of Environmental Sciences. [3]University of Wisconsin-Madison, Department of Forest and Wildlife Ecology.
PRGAP ANALYSIS PROJECT
Distribution and classification of the protected areas and the 2000 simplified land cover of Puerto Rico
Atlantic Ocean
Caribbean Sea
Mona and Monito
Vieques
Culebra
Findings
Land cover:
Distance from protected areas:
Urban, suburban, and rural settlements:
Physiography:
Protected Areas (black) and Marine Reserves (blue)
Simplified land cover of Puerto Rico in 2000
Protected areas landscape context classification analysis
Distance from protected areas
Land cover transition by distance from protected areas
Urban, suburban, and rural settlements
Physiography
Publication date: 2013

Trinidad and Tobago Forest-Type and Land-Cover Maps

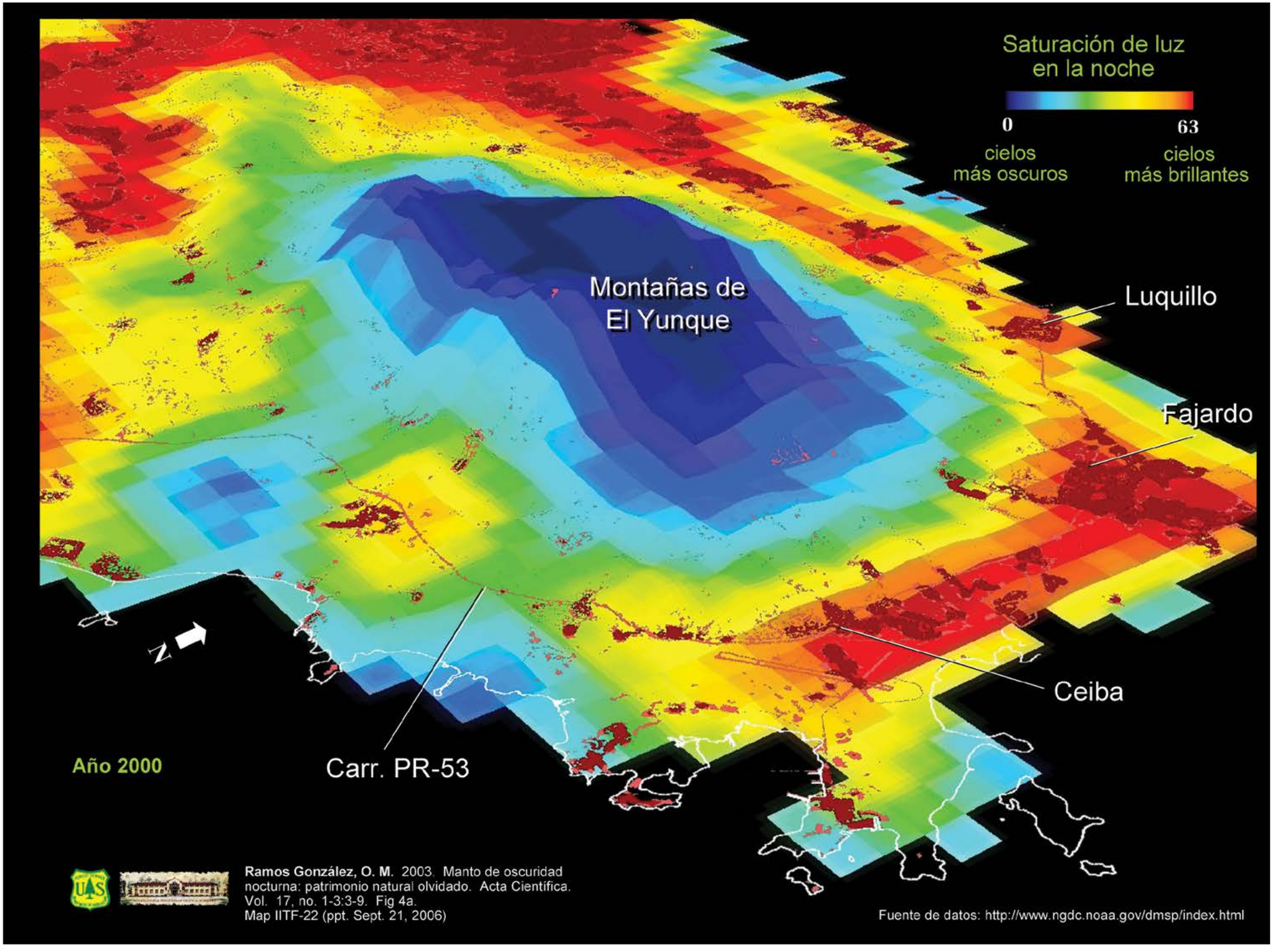
The Caribbean Forest Inventory and Analysis Program (Caribbean FIA) monitors tropical forests from stand to landscape scales with ground-based inventory plots and remote sensing technologies. Working with local forestry agencies, Caribbean FIA combines forest inventory or lidar data with satellite imagery to map forest types, aboveground carbon storage (biomass), height, foliage height profiles, and tree species richness and species composition, as well as land cover and land-cover change, all of which are important for REDD+ monitoring. The program has produced the most consistent set of forest type and land-cover maps available for several Caribbean countries. It is conducted jointly by the USDA Forest Service International Institute of Tropical Forestry and the Southern Research Station. These maps of forest type and land cover for Trinidad and Tobago are products of the program (Helmer and others 2012).




Forest including Forest/Shrub Land
Rain Forest
Lower Montane Rain Forest
Licania biglandulosa - Byrsonima spicata
Lowland Rain Forest
Carapa guianensis - Euterpe precatoria
Xerophytic Rain Forest
Manilkara bidentata - Guettarda scabra
Other Forest and Woodlands
Semi-evergreen Seasonal Forest
Hura crepitans - Tabebuia chrysantha - Spondias mombin
Dry Evergreen
Coccoloba uvifera - Hippomane mancinella
Manilkara bidentata
Deciduous Seasonal Forest
Bursera simaruba - Coccothrinax barbadensis
Forested Wetland
Mangrove*
Other Woody Wetland
Young Secondary Forest
Young Secondary Forest
Secondary Forest - former Cocos nucifera Plantation
Bambusa vulgaris
Urban or Built-up Land
High-Medium Density
Low Density
Urban Grass
Agricultural Land
Active Woody Agriculture
Active Woody Agriculture - Coconut
Grassy Areas, Herbaceous Agriculture or Pasture
Herbaceous Wetland
Nonforested Wetland
Herbaceous Wetland
Nonvegetated
Quarry
Coastal Sand and Rock
Bare Ground and Bulldozed Land
Water - Permanent
*Rhizophora mangle, Avicennia nitida, Laguncularia racemosa, Conocarpus erectus
Kilometers
0 2.5 5 7.5 10



Extent of light pollution in the islands of Puerto Rico, Vieques, and Culebra, 1992–1993 to 2000. Global data source accessible from the National Oceanic and Atmospheric Administration National Geophysical Data Center, Earth Observation Group, Defense Meteorological Satellite Program (USDA Forest Service 2008).



Extent of light pollution in the islands of Puerto Rico, Vieques, and Culebra, 1992–1993 to 2000. Global data source accessible from the National Oceanic and Atmospheric Administration National Geophysical Data Center, Earth Observation Group, Defense Meteorological Satellite Program (USDA Forest Service 2008).

Conclusion

The Next Hundred Years: What the Future Might Hold

Conclusion

The Next Hundred Years:

What the Future Might Hold

Ariel E. Lugo, Director,
International Institute
of Tropical Forestry

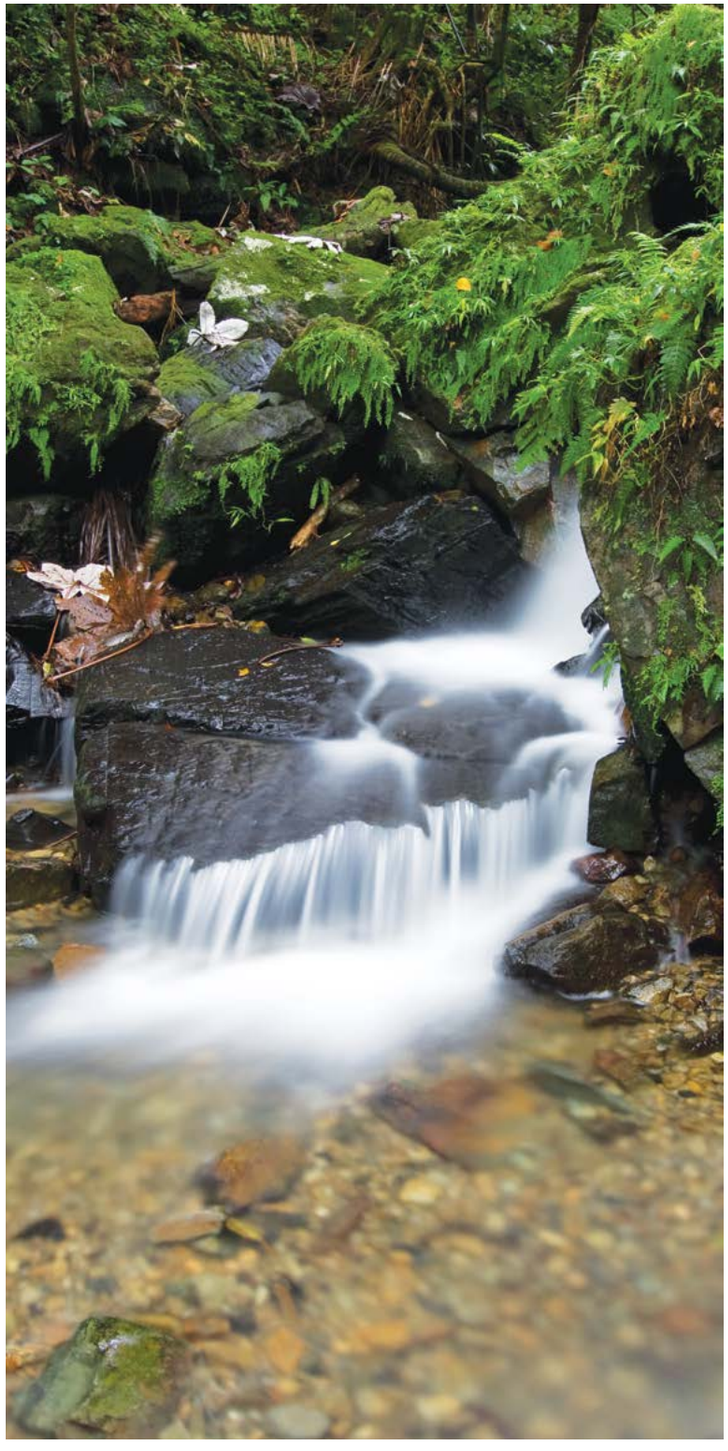
It is impossible to predict the future and it is particularly difficult to predict what the future might hold for the conservation of the forest resources of Puerto Rico. Over the next 100 years, at least four different scenarios will influence forest stewardship in Puerto Rico, each with different implications to conservation. To make predictions more difficult to articulate, more than one or all of these scenarios are likely to occur, which means that the opportunities for synergy are likely. The four scenarios are changes in land cover, climate change, a change in political status for the island, and the decline of the availability of fossil fuel supplies that power the Puerto Rican economy.

The land cover of Puerto Rico over the past 100 years resulted in more than 50 percent forest cover and about 25 percent under urban influence. The future proportions of forest, urban, and agricultural cover are uncertain. If the island continues with urban sprawl, it will affect forests and reduce the capacity to grow food. A concentration of urban populations would release land for agriculture and allow forests to supply clean water for future populations. To have one-half of the island under forest cover is a sound goal for sustaining quality of life over the next 100 years.

Climate change is the most uncertain of the three scenarios. Mean air temperatures and precipitation might change, and the climate might become flashier with perhaps more frequent hurricanes. Those changes would certainly influence forests, but the changes are not unprecedented, because the biota has experienced climate change before, and the processes of succesion and adaptation will allow the biota to cope. Continuing research and observation will enable scientists and land managers to understand climate change and adjust management procedures to mitigate its effects.

A scenario involving political change will affect the island as a whole. Some political scenarios project a return of the El Yunque National Forest to the Government of Puerto Rico. In that case, negotiations between the Federal Government and the Government of Puerto Rico will determine the institutional framework under which the El Yunque National Forest will be managed. I assume, however, that the forests of the Luquillo Mountains and other public forests will continue to be protected, because the people of Puerto Rico are likely to demand it. Moreover, El Yunque, along with 22 other sites, was considered for inclusion in the designation of the top 7 natural wonders of the world, and that alone justifies its permanent conservation.

The unavailability of fossil fuels to power the economy (either because of price increase or exhaustion of global supplies) is a more serious threat to forest conservation because it might force the government into increasing the agricultural output and use of forests for fuelwood. This possibility is a back-to-the-future scenario, which was characterized by high rates of deforestation and overexploitation of forests. One big difference in the future is that we would have a greater reservoir of knowledge to manage forest land. The island, however, will also be more populated, which would complicate the conservation situation. Clearly, sustainability under a reduced fossil fuel supply scenario would be very difficult, and this scenario might be the greatest challenge facing conservationists, scientists, and government in the next 100 years.



Stream with crystal-clear water originating in the El Yunque National Forest (2008).

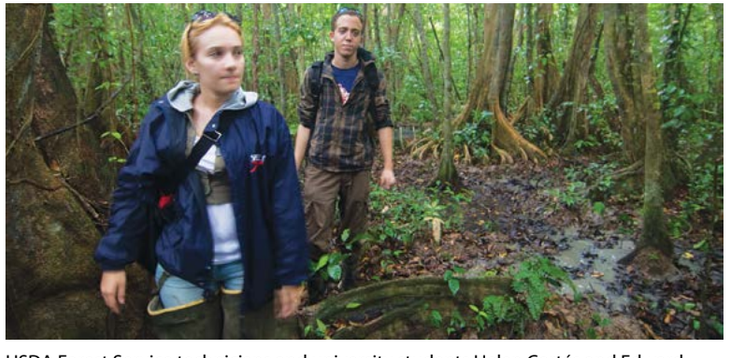
Beetle in the Luquillo Experimental Forest (2007).

In the National Forest

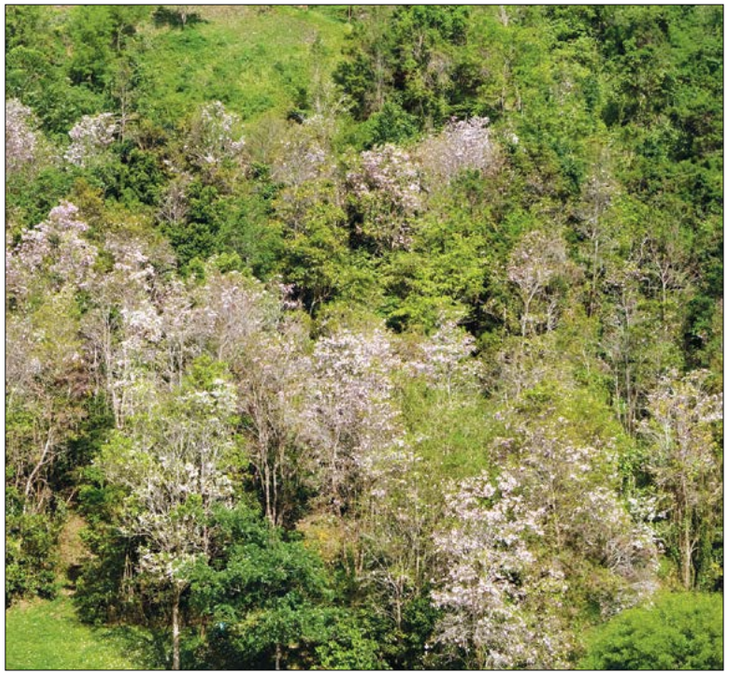
The National Forest is starting out the new century with a new name, El Yunque National Forest. The forest will continue to provide vital services to Puerto Rico, with water becoming one of its most important services to the island's growing population. It will also continue to harbor pristine open spaces on the island and the richest concentration of plants, animals, and biotic resources. Vehicle access to the forest will be controlled to minimize air pollution and congestion in the increasingly popular recreation areas. Forest management will be increasingly protective of the natural resource base, as evidenced by the designation of El Toro Wilderness Area and Wild and Scenic Rivers. The rivers within the forest will continue to be unique in the Caribbean due to the health and quality of their waters and biotic resources. The greatest threats to the forest will continue to be the systematic urbanization of its surroundings and potential global climate scenarios. Scientists believe that any changes in climate will cause the vegetation types of the forest to shift along the elevation gradient. A reduction of rainfall could result from expanding urban areas in the lowlands of the Luquillo Mountains.

In Research

The research program of the USDA Forest Service in Puerto Rico will continue to evolve to maintain its innovative excellence. Although scientists will continue to measure tree growth and study endangered species and other wildlife, their research will also include new studies addressing problems that transcend the boundaries of the national forest. In the future, the conservation of natural resources will be affected by global and large-scale phenomena with complex temporal dimensions and interactions. Examples of these phenomena include potential changes in climate, higher frequency of hurricanes, fluctuating conditions leading to extreme drought or flooding events, invasions of alien species, and rapid changes in land use and land cover. These problems will drive scientists into new areas of research. In anticipation of these events, International Institute of Tropical Forestry scientists are now focused on the global role of the tropical forests and analyzing the changes induced by deforestation and logging. The institute is now focused on soil biology, a new ecological frontier. Soil organisms regulate the processes of decomposition and nutrient cycling of tropical ecosystems. The conservation of landscapes requires innovative research applications of new remote-sensing technologies coupled with computer modeling and geographic information systems. Modern chemistry laboratories allow the study of nutrient cycling and chemistry of tropical forests. The Luquillo and Estate Thomas Experimental Forests (on St Croix, U.S. Virgin Islands) will network with other experimental forests in the region and the United States to help understand large-scale gradients of environmental change and adaptation and to monitor how the Earth is responding to the activities of human beings. Studies of the socio-ecological systems of cities will become more prevalent.



USDA Forest Service technicians and university students Helen Cortés and Edward Camacho assisting with research data collection in the pterocarpus forest in the Humacao Nature Reserve (2006).



New forest of oak growing on recovered agriculture land (2008).

Research technicians from the University of Puerto Rico collecting data at El Verde, Luquillo Experimental Forest (2007).

In State and Private Forestry

The formation of partnerships and coalitions among government and private citizens, communities, and nongovernmental organizations will greatly increase in the future. Society will realize that government alone cannot solve the problems of conservation and sustainable development. Public empowerment is necessary with the government acting as facilitator or enabler and a center of knowledge. A good example is the interaction between the institute and Casa Pueblo, a nongovernmental organization in the central mountains of Puerto Rico. Through a partnership with the institute, Casa Pueblo is leading hundreds of landowners in a land-care movement by which private initiative takes the lead in achieving environmental quality and sustainable conditions for communities. Institute scientists collaborate by conducting research on the value of services rendered by natural ecosystems. State (Commonwealth) and Private Forestry programs focus resources on this effort and attract other State and Federal Government agencies into collaborating with Casa Pueblo. The expectation is that the effectiveness of government programs will increase because the efforts are focused on the interests of those who receive the services.

Lagoon and mangrove forest surrounded by urban gowth in the San Juan metropolitan area (2007).

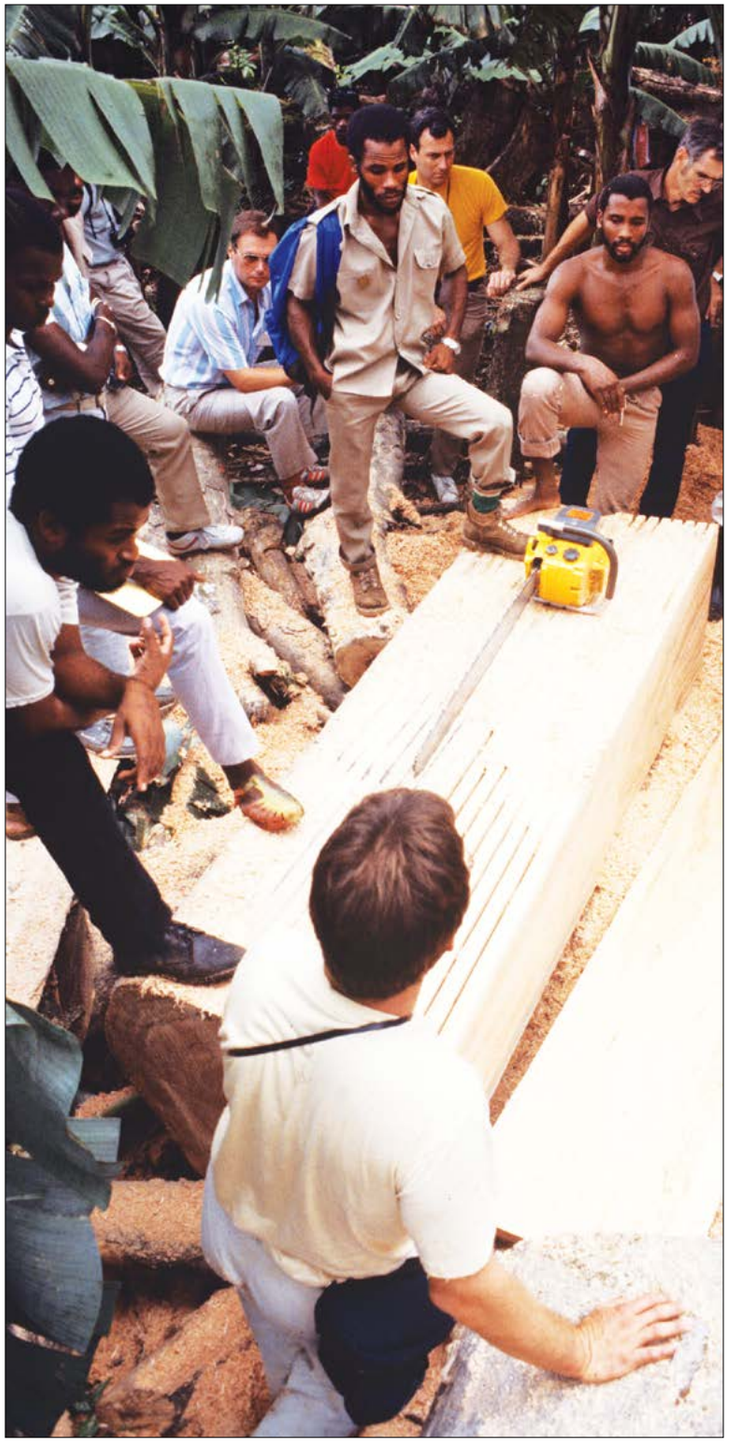
Puerto Rican Flycatcher (2007).

Smokey Bear helps carry the conservation message to local youth (2007).

International Cooperation

The International Cooperation (IC) unit at the institute will expand as more demand for its expertise increases in such areas as technical assistance, research, and technology transfer. The institute will continue to be recognized as a global leader in conservation, serving the people, and as a unique unit within the USDA Forest Service as the only field unit dedicated to tropical and international conservation issues. The IC unit will continue to develop partnerships with global clients in both the public and private sectors and to coordinate international activities with institute scientists. In addition to providing expertise to U.S. Government agencies, such as the U.S. Agency for International Development (USAID) and U.S. Department of State, the unit will also work closely with international donor organizations, such as the World Bank and Organization of American States; international not-for-profit organizations; and local communities. Unit staff will continue to work on long- and short-term assignments with USAID, broadening their scope in several areas, and will continue to provide technical support for international seminars, conferences, and meetings, such as those hosted by the Caribbean Foresters, the Mesoamerican Society for Biology and Conservation, and the Mesoamerican Ecotourism Alliance Conference. IC technical assistance will be demand driven, emphasizing current trends and needs, while foreseeing and preparing for future obligations in areas such as climate change, watershed protection, and invasive species and in connecting youth and communities to the natural world.

The institute's International Cooperation unit provides technical assistance throughout the Caribbean and Latin America. Here, they help small farms on a rural road project in Guatemala (1990).



Here, they observe local farmers making use of downed logs in Dominica (1990).

In the Forests of Puerto Rico

The Puerto Rican forests of the future will be different from the forests of today, just as today's forests are different from those of the past. Three main reasons for this future scenario are, first, environmental conditions continue to change as humans expand the scope and intensity of their activities. Forests respond to these changes. Second, most forests in Puerto Rico are secondary forests—forests that are still young (less than 100 years) and are still changing and maturing. Third, the introduction and naturalization of species (plants and animals) change the species composition of forests and form new forests different from those of the past. These introductions and naturalization phenomena will continue into the future and thus cause forests to change.

Mona Island Commonwealth Forest (1987).

Guánica Commonwealth Forest at sunset (1987).

Anole lizard (2007).

A flock of Great Egrets flying along the Puerto Rican coast (2006).

Overall

The future is usually exciting: it is difficult to anticipate, and we always hope for the best. It is clear today, however, that the future will have a characteristic that has been accelerating throughout the 100-plus-year history of the USDA Forest Service in Puerto Rico—the rate of change. We know that the future will bring us change in environmental conditions, change in forest types, change in the levels of human activity—in short, changes in almost any parameter we choose to measure. These changes mean that, more than ever, research will be critical for our success in the conservation of forests. Through research, we can anticipate the consequences of change. Change also implies that we need to be in a state of mind that is flexible and anticipatory so that we can be as successful in caring for the land and serving people in the next hundred years as we were in the past hundred years.

Tree fern and Cecropia leaves dominate the overstory view in open, sunny spots in the Luquillo Experimental Forest (2007).

Recommended Reading List

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Photography Credits
(in alphabetical order)

Ariel Lugo: p. 136 (right).

Edward Camacho: p. 101, p. 129, p. 156 (right).

Frank H. Wadsworth: p. 32, p. 53, p. 68, p. 75, p. 95 (bottom), p. 97 (left), p. 111, p. 113.

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