VISITOR'S GUIDE

Smithsonian
Tropical Research Institute

MISSION
To increase and diffuse knowledge about the past, present and future of tropical biodiversity and its relevance to human welfare.

Smithsonian
Tropical Research Institute

BIENVENIDOS

Welcome to the Smithsonian Tropical Research Institute (STRI, pronounced "stry") and thank you for your interest. STRI is the world leader in providing a global platform for tropical research and training the next generation of tropical scientists. Scientists at STRI have freedom to ask key questions in their disciplines and undertake fieldwork wherever those questions take them. Building on 100 years of Smithsonian science in Panama, researchers from STRI's vibrant scientific and support community rigorously explore the most biologically and culturally diverse region of our planet — the tropics. STRI's scientific community spans international borders, academic disciplines and generations. Our researchers take seriously the original mandate of James Smithson, the founder of the Smithsonian Institution, to increase knowledge and disseminate it as widely as possible, here applying it to the tropics. This is essential if we are to develop sustainable solutions to the myriad environmental problems of the 21st century. A STRI scientist, for example, analyzed his data on whale migration patterns and realized that there was a simple solution to the problem of whale-ship collisions by changing shipping lanes and slowing speeds during the migratory seasons. This policy was unanimously adopted by the International Maritime Organization and was implemented in 2014.

IN THIS GUIDE WE WILL ANSWER THESE FREQUENTLY ASKED QUESTIONS.

WHAT ARE **THE TROPICS** AND **WHY STUDY THEM?**

WHAT BROUGHT **STRI TO PANAMA** A **HUNDRED YEARS AGO** AND WHY HAS IT **STAYED?**

WHAT DOES STRI DO **THAT IS USEFUL TO SOCIETY?**

WHAT **FACILITIES** ARE **AVAILABLE FOR SCIENCE?**

HOW IS **STRI FINANCED?** HOW **CAN WE HELP?**

STRI RESEARCH PLATFORM:
THE ISTHMUS OF PANAMA

11 **RESEARCH FACILITIES** LOCATED THROUGHOUT PANAMA

2 **FOREST CANOPY** ACCESS CRANES

LABORATORIES WITH **MODERN SCIENTIFIC INSTRUMENTATION**

THE WORLD'S **MOST COMPREHENSIVE** SPECIALIZED LIBRARY FOR TROPICAL SCIENCES

25 **PERMANENT STAFF SCIENTISTS** who call Panama home. Dedicated to long-term research questions

400 **SUPPORT STAFF** committed to creating the world's best tropical research institute in Panama

1500 **VISITING SCIENTISTS, STUDENTS AND FELLOWS** each year who come for STRI's vibrant intellectual community, modern research infrastructure, and the deep knowledge of tropical science based on 100 years of study

WHAT ARE THE TROPICS?

"Tropikos" means "turning" in Greek. In the summer of each hemisphere, the sun appears each day to be vertically overhead further and further away from the equator. It then "appears to turn" and head back towards the equator to repeat the cycle in the opposite hemisphere. The area astride the equator between the two "turns" is called the tropics. The "turning points" come on June 21, at the Tropic of Cancer, 23.4 degrees to the north, and on December 21, at the Tropic of Capricorn, 23.4 degrees to the south of the equator.

SOLSTICE:
On June 21, the North Pole is inclined to the maximum towards the sun resulting in the longest day of the year in the Northern Hemisphere. At midday, the sun is directly over the Tropic of Cancer. Six months later, on December 21, the South Pole is maximally inclined toward the sun, resulting in the longest day in the Southern Hemisphere and the shortest day in the Northern Hemisphere, when the sun is directly over the Tropic of Capricorn.

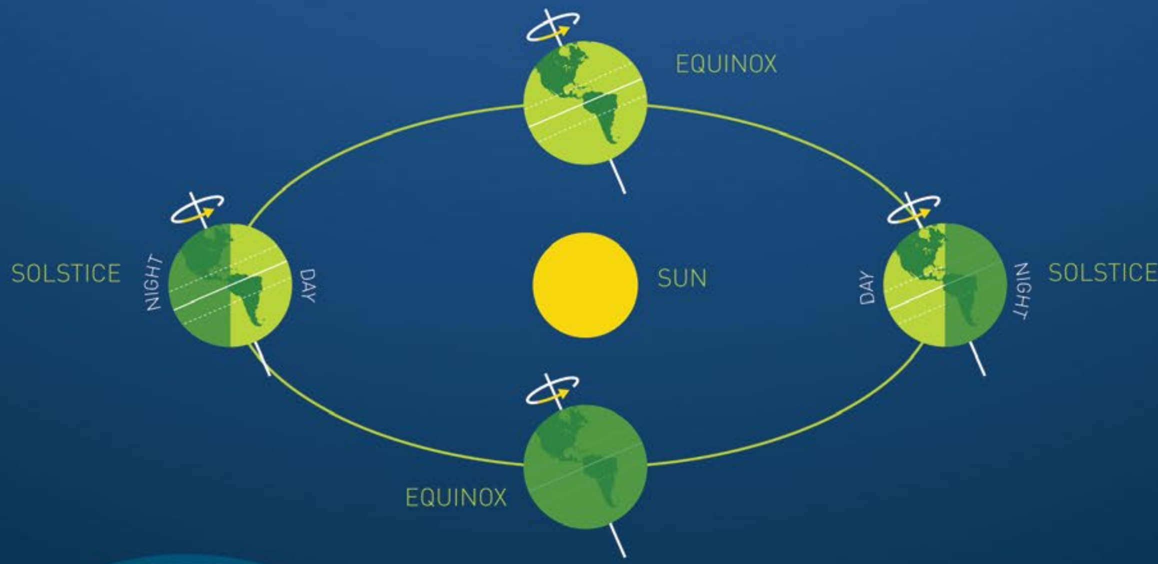
EQUINOX:
When the sun is directly above the equator the length of day and night are equal everywhere on Earth. This happens twice a year, on September 21 and March 21. At the equator the length of the day and night is always equal.

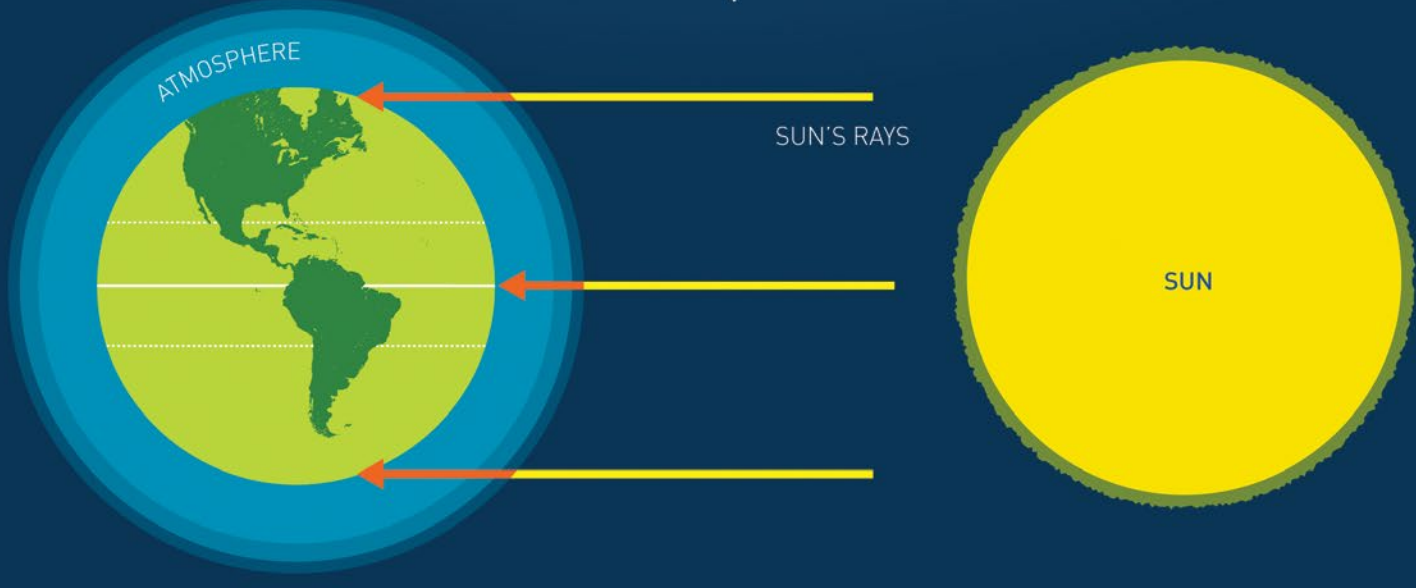
THE TROPICS ARE WARM:
The greatest amount of heat comes to the Earth in the tropics because here the sun's rays pass through the minimum thickness of the atmosphere in comparison to the temperate and polar zones, where they have a longer passage through the heat-absorbing atmosphere. This tropical heat is transferred to the higher latitudes via ocean currents and determines whether the Earth has an equable or extreme climate.

ABUNDANT LIFE IN THE CANOPY OF TROPICAL PANAMA

Photos by Christian Ziegler


TROPIC OF CANCER
EQUATOR
TROPIC OF CAPRICORN


EQUINOX
SOLSTICE
NIGHT
DAY
SUN
DAY
NIGHT
SOLSTICE
EQUINOX


ATMOSPHERE
SUN'S RAYS
SUN

TROPICAL RAINFORESTS AND **CORAL REEFS**
ARE **THE MOST DIVERSE ECOSYSTEMS** ON EARTH

WHY ARE THE TROPICS IMPORTANT?

ABUNDANT LIFE

Much of life on Earth depends on plants capturing energy from the sun. Plants use solar energy to convert carbon dioxide from the air into carbohydrates — the basic food source for everything from bacteria to humans. In the tropics, incoming energy from the sun is constant and abundant so plants can grow rapidly. Many fruit all year.

MEASURING TROPICAL BIODIVERSITY

BIODIVERSITY AND ENDLESS VARIATIONS ON RECURRING THEMES

The tropics are home to the vast majority of animals, plants, and fungi on Earth. For reasons that biologists still do not completely understand, the constant abundance of the sun's energy in the tropics, and thus the availability of food for organisms that can use it, has resulted in an overwhelming diversity of life forms that is far greater than in the temperate and polar regions. There are more species of trees and birds in Panama, a country the size of South Carolina, than in all of the United States and Canada combined.

Furthermore, the tropics are characterized by complex biological interactions. Groups of species are sometimes so closely co-evolved they depend completely on each other for their reproduction and survival, and so their struggle for existence is as a member of a cooperative consortium. Both consortia and individuals are engaged in a fiercely competitive world of escape or protection from predators and pathogens. Literally, it's "a jungle out there!" These biological interactions also make the tropics a treasure house of complex chemical compounds likely to be useful in the discovery of new drugs. The tropics have a staggering diversity of species, yet they are still the least known part of the planet, because the great majority of the world's contemporary scientific institutions are in the temperate regions of the world. STRI is marching to a different drummer.

Photos by Christian Ziegler (left)

THE AMERICAN TROPICS - PANAMA

In Panama there are only two seasons — wet and dry. This is because the weather in Panama is controlled by one of the most obvious features of the Earth seen from space, the Intertropical Convergence Zone (ITCZ), which forms a global band of clouds that marks the collision of the trade winds of the Northern and Southern Hemispheres. The hot sun and warm ocean water of the tropics heat the air, raising its humidity and causing it to rise. As it rises, it cools, releasing the accumulated moisture in a constant series of thunderstorms that move from east to west.

Image via NOAA

▲ THE ITCZ SEEN FROM SPACE

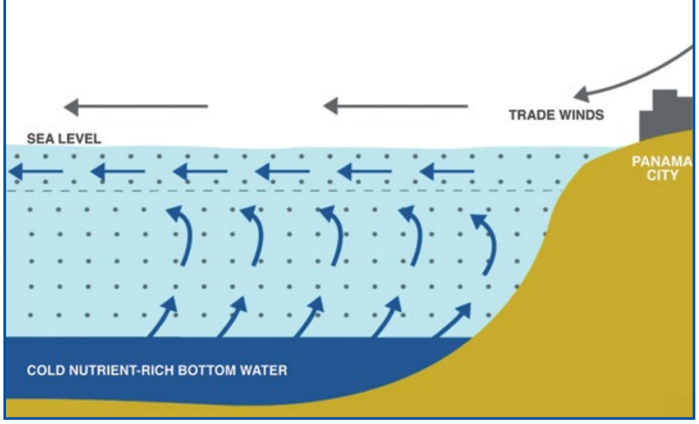
Wet season

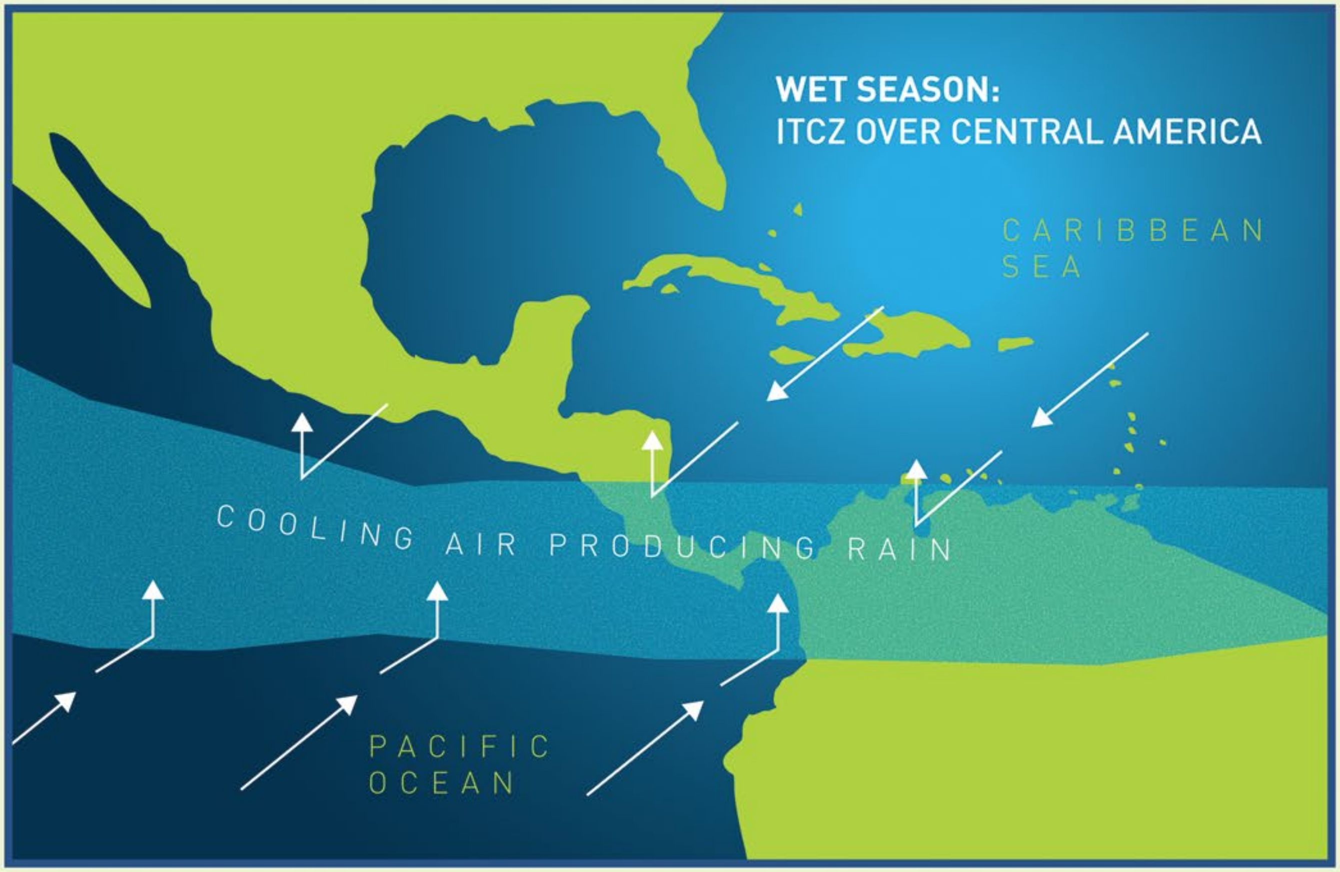
Between May and November the ITCZ's line of thunderstorms flows directly over Panama, creating the wet season as moisture comes in from the Caribbean. The Pacific side of the country, on the other side of mountains, receives less rainfall. When Caribbean hurricanes draw moisture off to the north of the ITCZ, Panama has unseasonably dry and sunny days during the wet season.

Dry season

In mid-December, the ITCZ is pushed to the south over Colombia so that the northeast trade winds blow over Panama creating dry conditions that last until April. Those same winds, at low topographic points along the Isthmus like the shoreline along the Bay of Panama, push surface waters out to sea causing upwelling of cold nutrient-rich water that triggers a burst of biological productivity, which provokes a feeding frenzy of marine life. In western Panama the mountains are higher along the Gulf of Chiriqui, blocking the trade winds, so there is no upwelling and seasonal patterns of sea-surface temperature and productivity are strikingly different. With easy access to the Atlantic Ocean and these two different Pacific sites, STRI's marine scientists have access to three different oceans.

UPWELLING IN THE BAY OF PANAMA



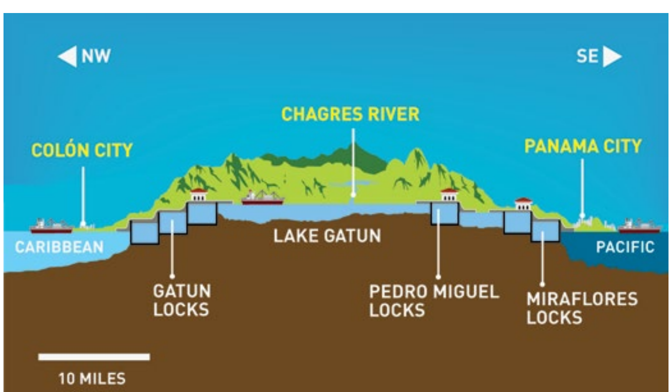

WET SEASON:
ITCZ OVER CENTRAL AMERICA
CARIBBEAN SEA
COOLING AIR PRODUCING RAIN
PACIFIC OCEAN


DRY SEASON:
ITCZ OVER SOUTH AMERICA
CARIBBEAN SEA
NORTHERN TRADE WINDS
COOLING AIR PRODUCING RAIN
PACIFIC OCEAN

WHY IS THE SMITHSONIAN IN PANAMA?

THE 1910 PANAMA BIOLOGICAL SURVEY

The presence of the Smithsonian in Panama is closely tied to the construction of the Panama Canal between 1903 and 1914. American engineers dammed the Chagres River near the Caribbean coast, creating Lake Gatun, 85 feet above sea level. Ships step up to lake level and then back down to sea level through a series of locks. This freshwater lake, topped up by Panama's enormous rainfall, carries ships for more than half their journey across the Isthmus. The 10-mile Culebra Cut, blasted through Panama's central mountains, connects the lake to the Pacific Ocean. Scientists were concerned that flooding the Chagres River Valley would threaten rainforest species and connection between the Atlantic and Pacific would allow invasive organisms to pass from one ocean to the other.



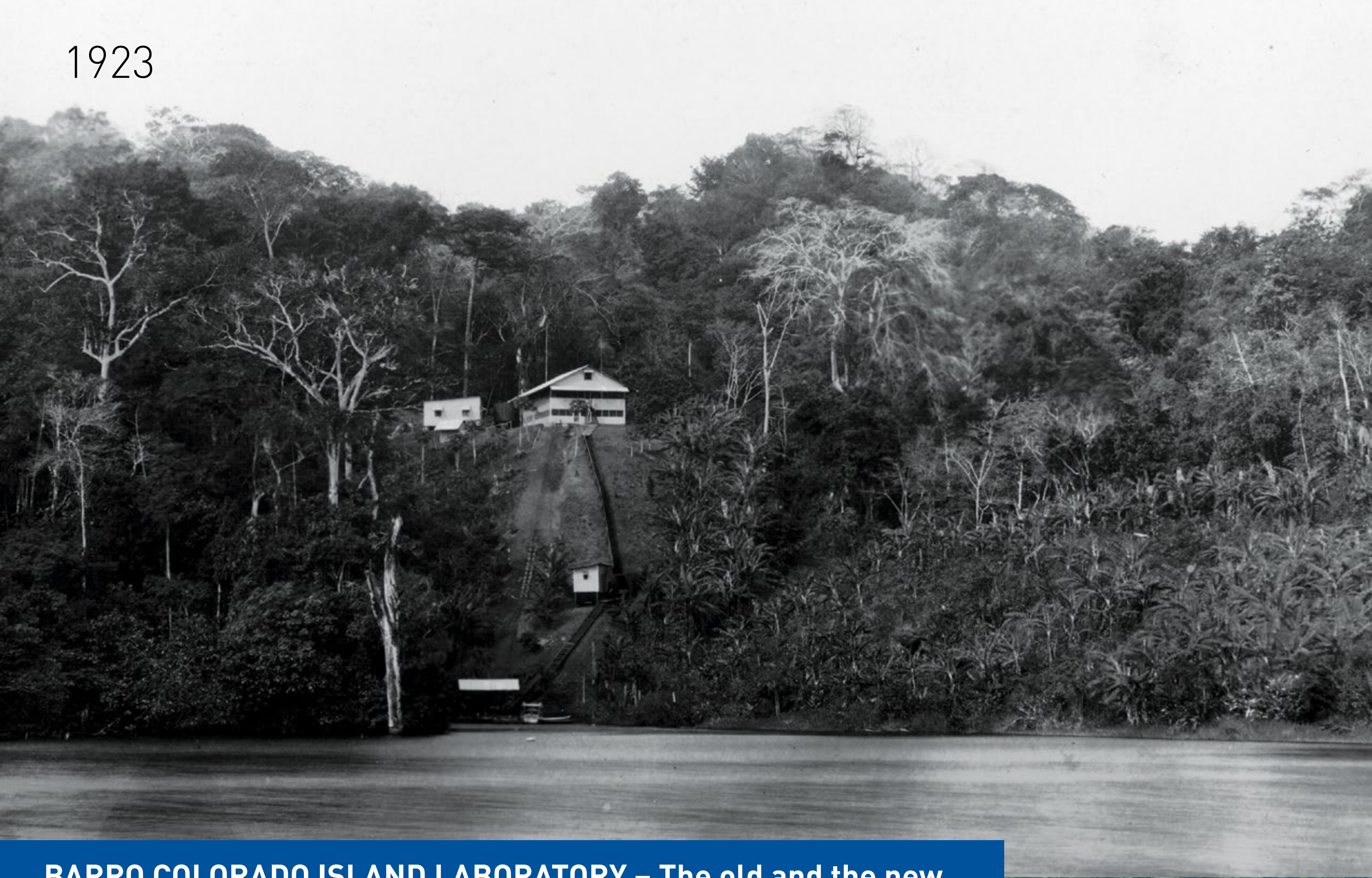
Profile of the Panama Canal

From 1910 to 1912, with President Taft's blessing, the Panama Biological Survey was launched. It was led by the Smithsonian and involved explorers from U.S. government agencies and museums. When President Pablo Arosemena of Panama was informed of the expedition, he not only welcomed it but also proposed that it be extended to all of Panama. As a result, studies in Darien, Azuero, and Bocas del Toro, as well as the Canal Zone, not only greatly added to the value of the scientific research but also launched a century of friendship and collaboration between the Smithsonian and the Republic of Panama.

Infographic courtesy of Panama Canal.

CROSSING LAKE GATUN IN 1928

AGUA CLARA LOCKS: New locks on The Caribbean entrance of The Panama Canal



BARRO COLORADO ISLAND LABORATORY – The old and the new

BARRO COLORADO ISLAND (BCI)

The U.S. effort in building the canal succeeded in part because before construction started authorities got a handle on why so many French workers had died of disease—malaria and yellow fever in particular. At the time, decision-makers were still following the belief that tropical diseases were caused by "bad vapors (mal aires)"– the delightful mist that embraces the tropical forest around sunrise, made all the more spectacular when the howler monkeys are greeting the dawn. It was not until Dr. William C. Gorgas, who knew that these diseases are borne by mosquitos, instigated practical disease-control methods that work on the canal was able to continue. As a result a large number of entomologists, who study insects, were working in Panama. These visionary scientists realized the value of a site protected for scientific research. They petitioned the governor of the Canal Zone, and in 1923 the biggest island in Lake Gatun became a scientific research station.

THE BARRO COLORADO NATURE MONUMENT (BCNM)
The central island, BCI, formed the original Canal Zone Biological Area (1923). In 1977 the surrounding peninsulas were added as part of the Torrijos-Carter Treaty. STRI was granted sole responsibility to act on behalf of Panama and the United States for the purpose of scientific research and for the protection of the BCNM.
The Agreement is pursuant to Article VI of the Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere signed Sept. 9, 1977.

Ornithologist Frank Chapman, who worked on BCI, wrote a book about his experiences called *My Tropical Air Castle,* a bestseller in the United States in 1929 that brought wide attention to the Island. In addition, the elite of American biological science came to visit. Scholars such as William Wheeler and Thomas Barbour of Harvard University gave credibility to the enterprise and kept the station afloat with personal donations. A long history of philanthropic support began with David Fairchild, a well-connected botanist from the U.S. Department of Agriculture. He attracted generous support to BCI from his friends Allison Armour and Barbour Lathrop. In 1940, the station became the Canal Zone Biological Area. At the end of the Second World War in 1946, the station was formally placed under the direction of the Smithsonian Institution. In 1966 the Smithsonian Tropical Research Institute was established to extend the scope of research to other sites in Panama and the world. Today STRI is legal custodian of BCI under an international treaty protecting reserves for scientific research.

Early visitors to BCI - Circa 1924

CONTINENTS CONNECTED
OCEANS DIVIDED

PANAMA CHANGED THE WORLD

When Panama emerged from the sea to create the Isthmus of Panama about three million years ago, it changed the world. It sparked the Great American Biological Interchange in which members of the cat, dog, pig, horse, rodent and elephant families migrated from North America to South America. Armadillos, sloths, anteaters, marsupials, giant birds, and porcupines travelled north. Following the exchange, most southern forms went extinct in the north but northern forms prospered in the south. Subsequently, the vast biological diversity of the Amazon spread to Central America.

The emerging isthmus divided a uniform tropical ocean into two parts, creating a perfect, natural Darwinian evolutionary experiment in the sea. The Caribbean side became warmer, saltier and deficient in nutrients — classic conditions for the spread of coral reefs. On the Pacific side, the seasonal upwelling of cold nutrient-rich water produced vast quantities of anchovies that each year feed a spectacular gathering of seabirds, whales, rays, sharks and fishes. These strikingly different marine environments helped drive many of the original forms to evolve into different species on either side of the Isthmus of Panama, making it a unique location to study how evolution works.

Further afield, the formation of the isthmus changed global ocean circulation which affected climate around the world, and perhaps influenced the development of an ice age and the evolution of humans in Africa.

Digging up the past.

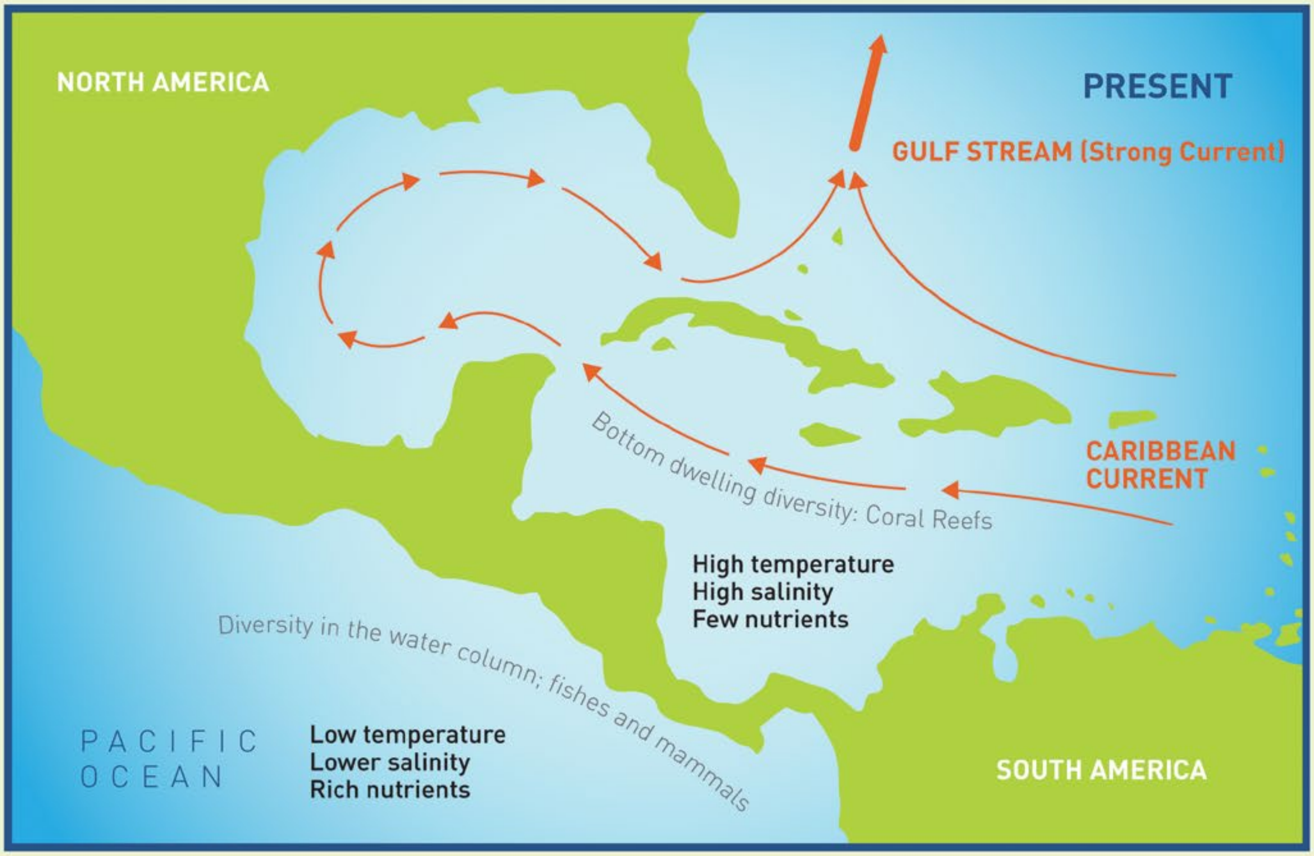
A BRIDGE BETWEEN CULTURES AND CONTINENTS

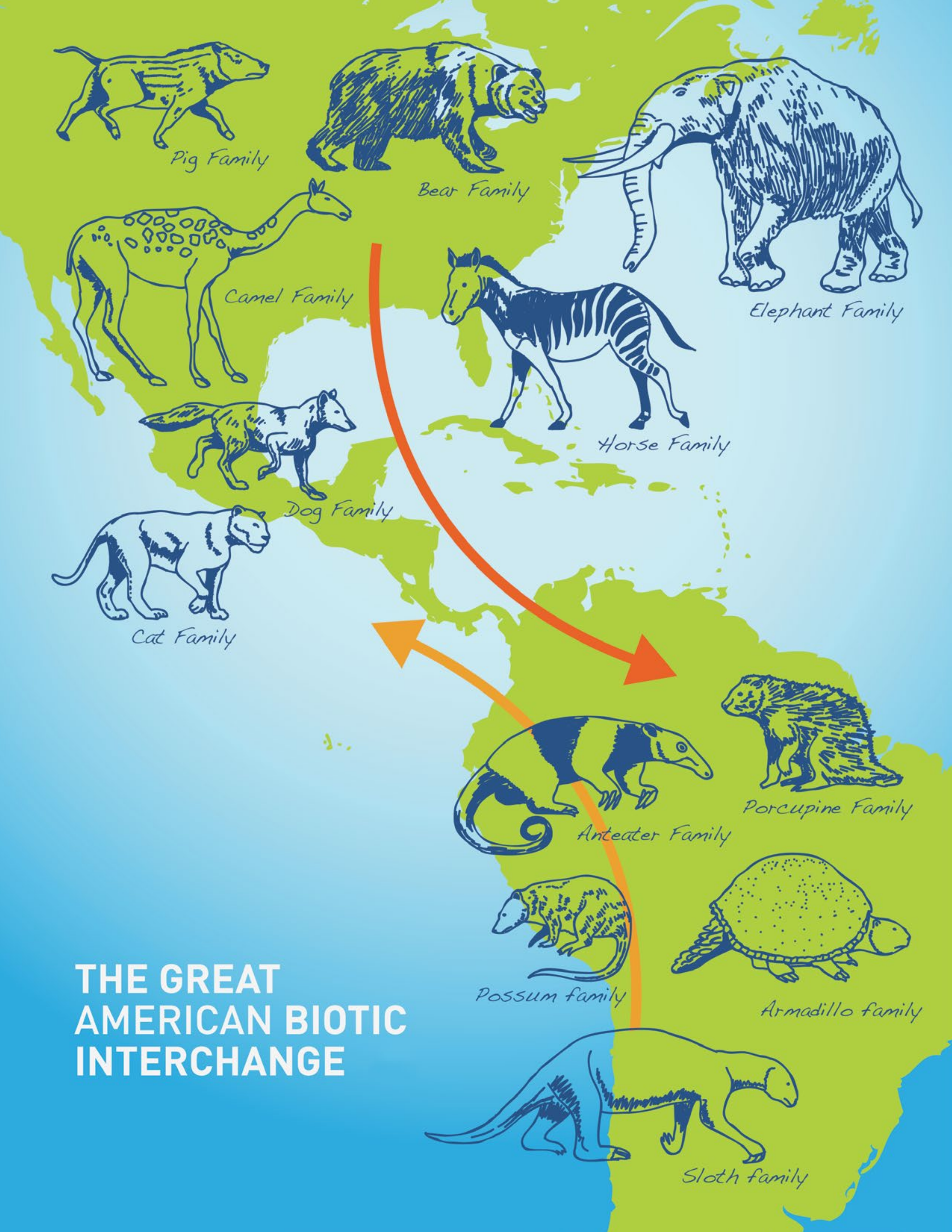
The staggering diversity of the tropics lies almost exclusively in countries where funding for basic research on the environment has to compete with economic development, in light of serious social and political needs and concerns. STRI is a rare example of a state-of-the-art scientific research institute headquartered in the tropics, for which we thank the generosity and on-going political support of the government and people of Panama, the United States and private citizens around the world.

94% OF THE TOP UNIVERSITIES IN THE WORLD ARE IN THE TEMPERATE ZONE

80% OF ESTIMATED PLANT AND ANIMAL BIODIVERSITY IS IN THE TROPICS


NORTH AMERICA
BEFORE
THE ISTHMUS FORMED
ATLANTIC OCEAN
WEAK CURRENT
A single tropical ocean
PACIFIC OCEAN
SOUTH AMERICA


NORTH AMERICA
PRESENT
GULF STREAM (Strong Current)
CARIBBEAN
CURRENT
Bottom dwelling diversity: Coral Reefs
High temperature
High salinity
Few nutrients
Diversity in the water column; fishes and mammals
PACIFIC
OCEAN
Low temperature
Lower salinity
Rich nutrients
SOUTH AMERICA


Pig Family
Bear Family
Elephant Family
Camel Family
Horse Family
Dog Family
Cat Family
Porcupine Family
Anteater Family
Possum family
Armadillo family
Sloth family
THE GREAT AMERICAN BIOTIC INTERCHANGE

A SAMPLING OF STRI RESEARCH

A WORLD OF TREES

WHY ARE THERE SO MANY SPECIES OF TREES IN THE TROPICS?

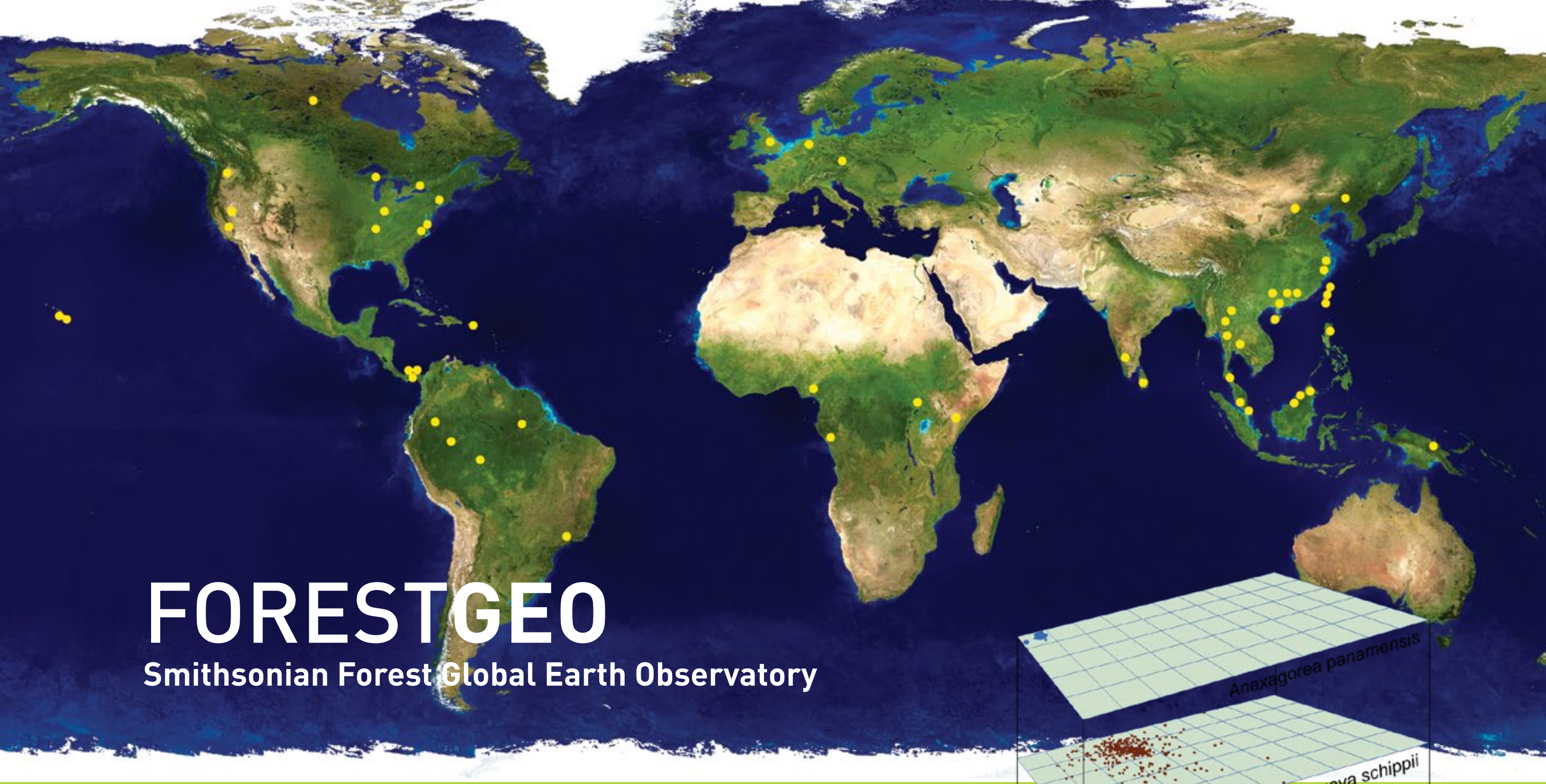
If you could identify all of the different trees in the Appalachian Mountains, a broad swath of some 1,200 miles along the eastern side of the USA, you would find no more than about 50 species of trees. In less than a quarter of a square mile of forest in Panama, there are more than 300 tree species, and in a plot only half that size in Ecuador, there are more than 1,000 species. To find out why, two scientists proposed in 1979 to set up a big forest-monitoring site on Barro Colorado Island in Panama. Although there are many different tropical tree species, many of them are rare so the only way to get a sense of all of the member species in a forest community is to set up a huge study site where at least a few individuals of most species are represented.
In 1980, STRI researchers on BCI located, identified, tagged and measured more than 200,000 trees in 50 hectares (about 120 acres). The plot has since been re-censused every five years.
For the first time, scientists have statistics on the birth, death and rate of growth of this vast array of tropical trees. It appears that mortality from pests when individuals become common, drives many species to be rare and thus difficult for pests to find them, allowing space for many other rare species, leading to high diversity.

So useful were these data that many other plots around the world have been implemented and integrated into a network that is coordinated by STRI's Center for Tropical Forest Science (CTFS). Today scientists are comparing tropical and temperate forests, as well as studying forest insects and mammals that pollinate the plants and disperse the seeds in a project called Smithsonian Forest Global Earth Observatory (ForestGEO). Because each plot uses the same system of measurements, researchers can compare data from different forests around the world and detect global patterns that would otherwise be impossible to recognize.

Photo by Christian Ziegler

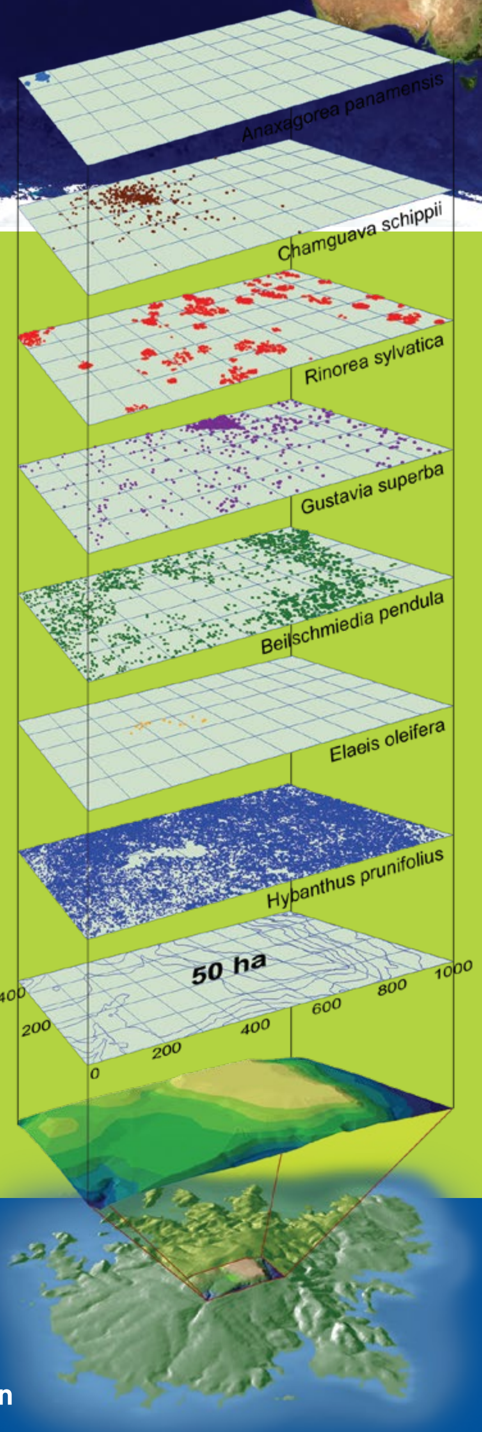
BIODIVERSITY CONSERVATION

Forested land supports an enormous diversity of both plants and animals that are currently going extinct at an unprecedented rate, mostly due to habitat loss. Many scientists believe that humans are causing a mass extinction equivalent to the scale of the famous episode that killed off the dinosaurs at the end of the Cretaceous Period. All forests, but especially those in the tropics, conserve an astounding range of biodiversity not only of plants but also of microbes and fungi to insects, birds and primates. Close monitoring not only enhances our understanding of forests but also our ability to detect threats to biodiversity, anticipate epidemic diseases, store carbon, and control soil erosion.



FORESTGEO

Smithsonian Forest Global Earth Observatory



66 plots (and growing)

26 countries

10,000 species
(about 15% of all tree species on Earth)

6.4 million living trees

15.6 million measurements

86+ partner institutions

The first 50 Hectare Plot Panama, 1980

Each species has a different pattern reflecting its unique distribution

HOW CAN WE ACCESS THE TREETOP CANOPY WHERE THE ACTION IS?

First-time visitors to tropical forests are surprised that there are so few animals and flowers at eye level, and soon learn to use binoculars to get a glimpse of life in the treetops. A STRI scientist came up with the novel idea of accessing tropical tree canopies with construction cranes. A 50-meter crane, with an equally long boom, lifts scientists in a strong metal cage into contact with the highest branches where they can measure how leaves cope with stress, take up carbon dioxide and use water. These repeated measurements seed understanding of the exchange of gases between the atmosphere and the forest and lead to a more precise understanding of the forest's role in global warming and climate change, and the complex web of interactions between trees and the organisms that eat them or help them reproduce.

Measuring gas exchange between the atmosphere and the forest.

The use of construction cranes revolutionized the study of forest canopies and revealed the astonishing diversity of insects, spiders and microbes that live there. Fourteen canopy cranes are now in operation worldwide and a whole new field of canopy biology has been created using methods pioneered at STRI. Given the diversity of the tropical forest, a crane carefully placed within it can cover a wide range of tree species in one revolution.

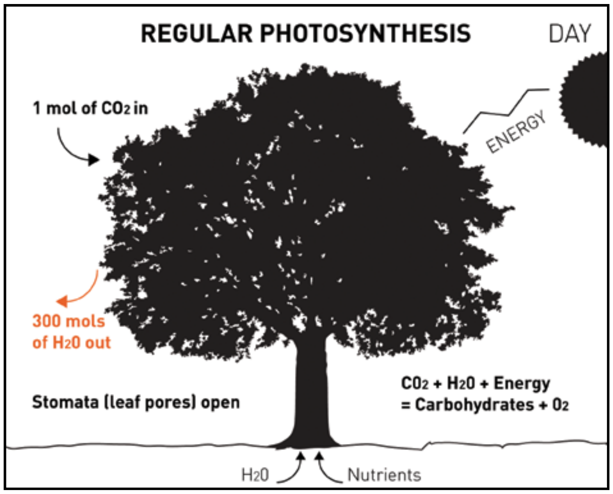
STRI'S FOREST CANOPY CRANE IN FORT SHERMAN NEAR COLÓN

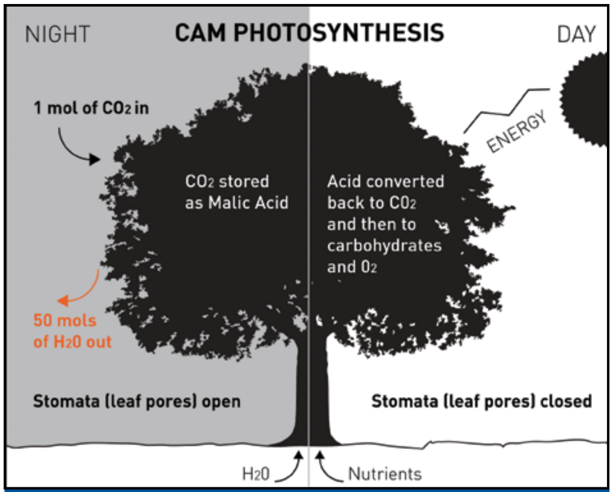
DOING IT IN THE DARK

To save water, some plants open their pores at night instead of during the day, absorbing carbon dioxide gas while losing only about one sixth of the water spent during daytime photosynthesis. About seven percent of all plants, including plants in the orchid, pineapple and cactus families use this method. Some tropical trees switch from regular photosynthesis to this system, called CAM photosynthesis, when they are stressed by drought.

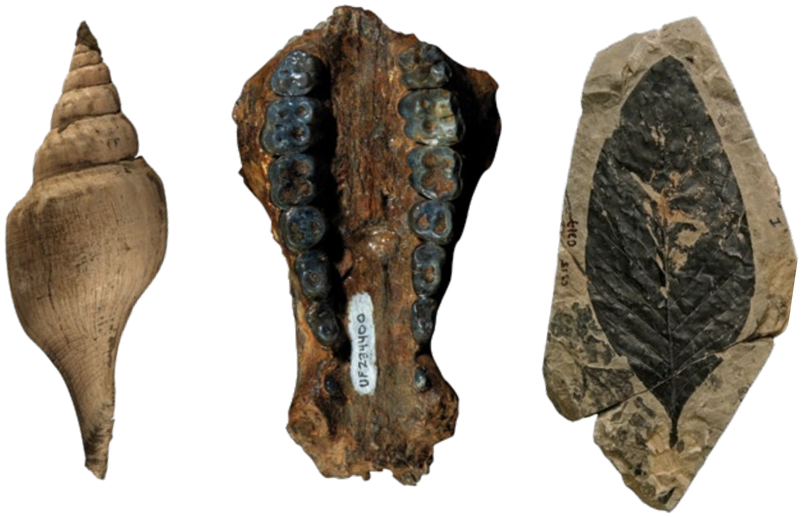
WHAT WILL HAPPEN IN A "GREENHOUSE" WORLD?

Since the Industrial Revolution the amount of carbon dioxide gas in the atmosphere has been rising, trapping the heat of the sun and resulting in the warming of the planet. Predicting that this trend will continue, STRI scientists grow plants and trees in chambers at increased levels of carbon dioxide predicted for the future. Increased growth of trees will still be more governed by availability of water and soil nutrients but in general less moisture will be transpired into the atmosphere and more conserved in the soil.





Strong sunlight and drought stress plants in the tropics. Most stress adaptations involve tradeoffs, as in the example of CO_2 uptake and water lost. The water lost must be replenished from the soil via the roots. CAM photosynthesis, by reducing water loss, is thus an adaptation to drought.



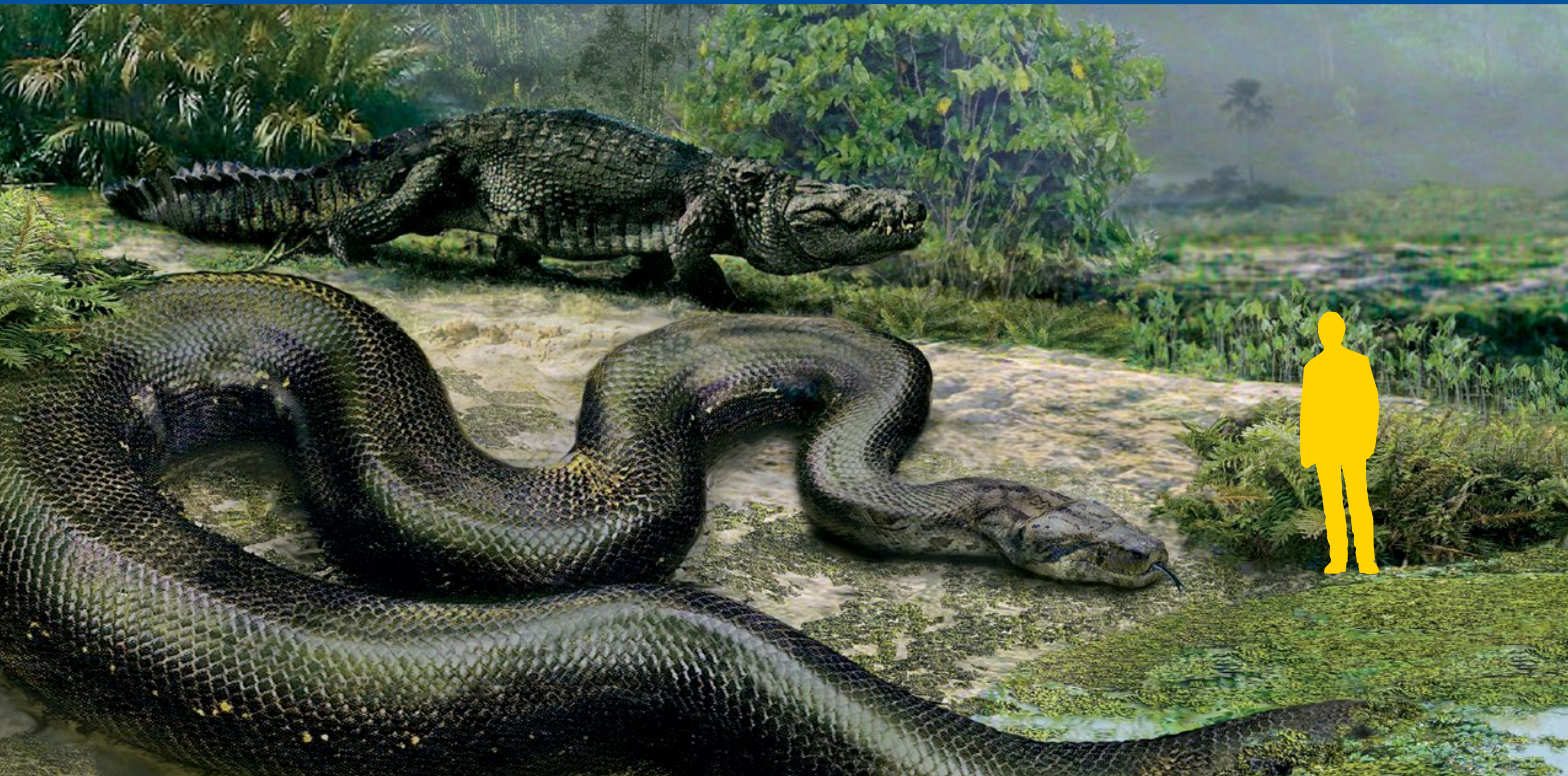
Fossils provide evidence of the environmental conditions in the past. Marine fossils reveal seawater temperature, productivity, salinity and seasonality of the oceans on either side of the Isthmus of Panama before, during and after its closure. Terrestrial fossils tell us about vegetation and thus climate on land, and in special cases about human migration and settlement and the onset of agriculture.

THE EARTH'S PAST

WHAT CLUES DO FOSSILS HOLD?

Research in paleontology at STRI has revealed the largest snake ever recorded – a boa that reached 43 feet long and more than 3 feet in diameter and giant turtles six to nine feet in diameter. Magnificent collections of plant specimens from a Colombian coal mine date from about 55 million years ago when the level of CO_2 and the temperature of the atmosphere was much higher than today. The fossils show that the forests of that era responded by increasing in diversity, an unexpected result that is very relevant to the climate change discussions of today.

THE WORLD'S LARGEST SNAKE, ***Titanoboa cerrejonensis*** **a 60 million year-old fossil from Colombia**



LIFE IN THE SEA

CORAL REEFS INCUBATE MARINE BIODIVERSITY

This Hawksbill turtle, like the Green Turtles, were vastly more numerous before the advent of humans.

Together with tropical rainforests, coral reefs are the most biologically diverse habitats on the planet. Coral reefs are important as a source of fish, tourism, pharmaceutically valuable products, and as protection of the coastline. Only found in or near the tropics, coral reefs have been the focus of the research of many STRI scientists. The deterioration of reefs generally receives less public attention and provokes less concern than that of forests because they are hidden from view, but they are seriously threatened.

The solid framework formed by the massive calcium carbonate skeletons of reef corals usually protects an expanse of quiet water called a lagoon which is floored by a carpet of the marine grass *Thalassia*. Sea grass beds are the marine equivalent of the grassy plains of the Serengeti and used to support vast populations, not of zebras and antelopes, but of turtles, queen conch, large herbivorous fish and manatees. Sea grass meadows generally grade landward into mangrove forests.

Coral reefs, especially in the Caribbean, have changed dramatically since the English pirate William Dampier, writing in the 18th Century, remarked that the crew of his ship was annoyed that their sleep was disturbed by the constant noise of green turtles bumping against the hull. He also records vast numbers of other marine animals that today are only spotted rarely on most Caribbean reefs.

Appropriate protection of reefs from human impact could still allow the return of some reefs to their original splendor. Several STRI scientists are undertaking basic research on coral evolution and ecology as well as on the reseeding of reefs, coral spawning and coral bleaching. Their work contributes to effective regulations for marine protected areas.

The trio of mangrove forests, seagrass meadows and coral reefs serve an extremely important function as the site for the development of juvenile marine animals, many of which subsequently head out to sea. These include numerous species that are commercially important.

MICROSCOPIC LIFE

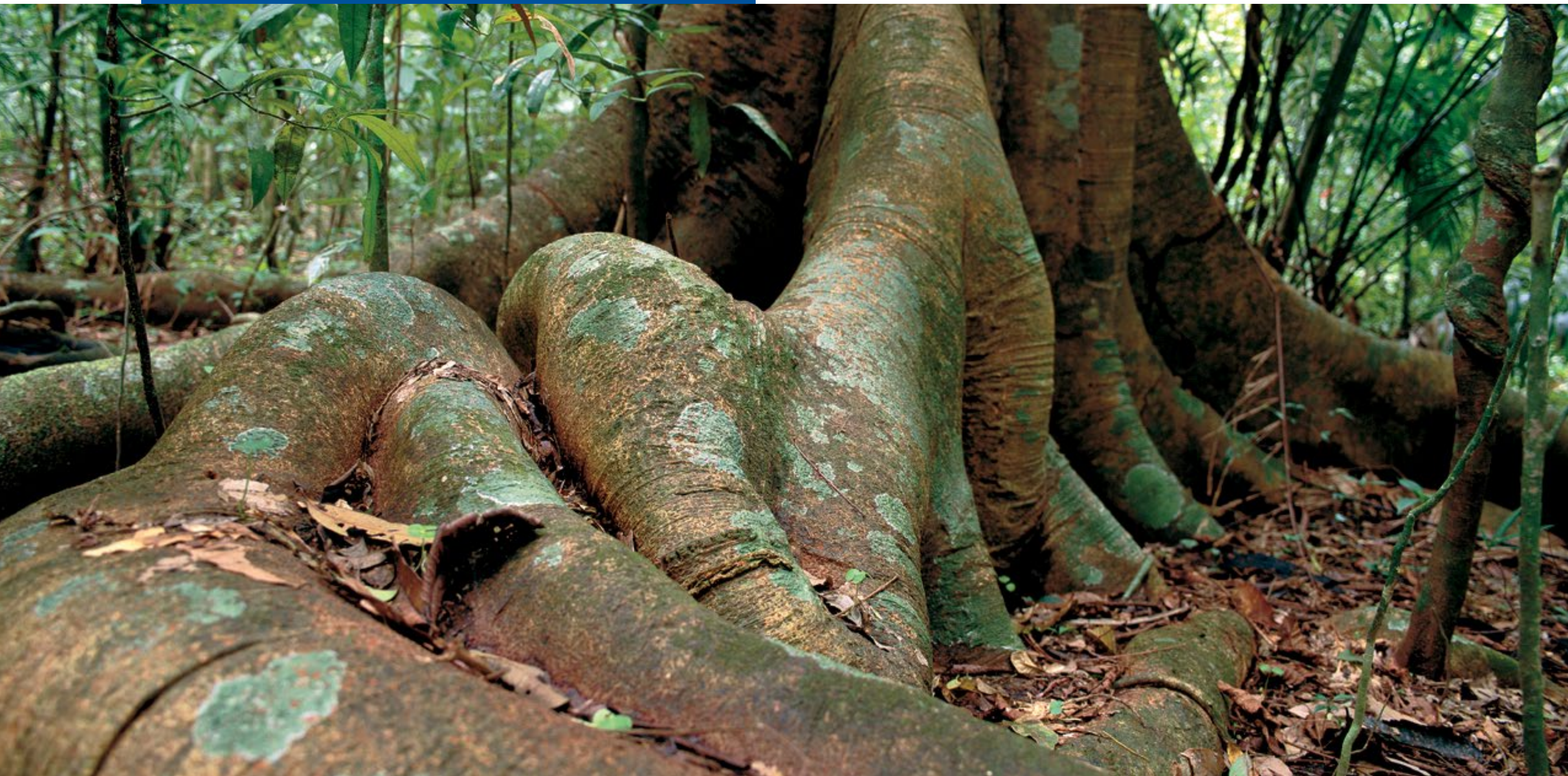
IS THERE MORE DIVERSITY THAN MEETS THE EYE?

One of the most important research programs at STRI concerns the role of bacteria and fungi in tropical forests and their interactions with diverse plant-eating animals, including the famous leaf cutter ants of the American tropics. Scientists have recently discovered that most tree roots, stems and leaves in the forest are loaded with thousands of species of minute fungi called endophytes. We do not know how many species there are, but they are major players in the health of their host plants and in the ecology of the forest. Spraying endophytic fungi onto the leaves of cacao plants, for example, can protect the plants from destructive pathogens. Thin strands of mycorrhizal fungi extend from plant roots out into the soil and increase the plants' abilities to absorb nutrients.

STRI Scientists sampling and cultivating endophytes

The growing recognition that plants are a chimera of plant and fungal tissues has profound implications. So intimate is the coevolution of the microbes and the plants that scientists may have confused some functions, chemicals and genes of one as the other.

Photo by Christian Ziegler



ANIMAL BEHAVIOR

HOW ANIMALS BEHAVE IS CRITICAL TO UNDERSTANDING THEIR ECOLOGY

When STRI was formally established in 1966, the first director placed a strong emphasis on the study of animal behavior. This tradition remains strong because what animals do — how and why they behave in a certain way — is critical to understanding ecological interactions and the complex interconnections among components of major ecosystems such as tropical forests and reefs. Most physical features have multiple functions. Behavioral scientists ask how these features have come to be used for different purposes and how their shape is selected as a compromise between the various functions.

Resident scientists at STRI study the behavior of such diverse animals as crabs, ants, wasps, beetles, butterflies, bats, birds, monkeys and humans. We will select one group as example – the ubiquitous leafcutter ants.

Original illustration by Martin Moynihan.

CUTTER ANTS: EARLY FARMERS THAT MADE PUBLIC HEALTHCARE WORK

In recent years, STRI scientists interested in social behavior have focused considerable attention on understanding social complexity in the fungus-growing ants. These farmers are best represented by the iconic leafcutter ants that are often seen on a visit to Panama as little rivers of green leaves flowing back to a nest, with each leaf being carried like an umbrella by a worker ant. The leaves are used in the nest as compost for gardens where the ants cultivate a certain species of fungus. This crop is the sole food source for their young. A colony contains several million ants and occupies a space underground the size of a good-sized room. The ants totally depend on the fungus for their survival, and the fungus cannot reproduce on its own, so it is totally dependent on the ants. Biologists call this kind of co-dependence "mutualism" and mutualism is a central and recurrent theme in much of tropical biology, and has been extensively studied by STRI scientists.

Four steps in the life history of cutter ants as they collect leaf fertilizer to farm the fungus that feeds them.

The ants also have a sophisticated public health care system. They fastidiously clean themselves and their young, and also clean up compost material before it enters the nest. The ants have a waste management system with a specialized group of workers that cart the garbage to a specific trash dump. They deploy teams of ants to work in the gardens, physically removing spores of bacteria and fungi that might threaten their way of life. Fungus-growing ants discovered that bacteria could be harnessed as antibiotics to combat disease about 50 million years before Sir Alexander Fleming discovered the value of penicillin in 1928. The ants culture "Actinomycetes" bacteria on special structures on their own bodies. Our own antibiotics—such as Streptomycin—come from these same kinds of bacteria. Other ant antibiotics come from glands where they synthesize a cocktail of antimicrobial compounds. Humans are still catching up to the ants, having discovered only recently that a cocktail of compounds administered at once is less likely to provoke the rise of resistant strains of pathogens.

STRI scientists take seriously the proverbial wisdom of King Solomon to "look to the ants." Their fantastically complex world of social interactions, compounded by myriad interactions with beneficial and detrimental microbes, and a degree of organizational sophistication in dividing labor that makes Henry Ford's assembly lines look primitive, suggests we might do well to reverse engineer some of the ants' ideas into our own societies.

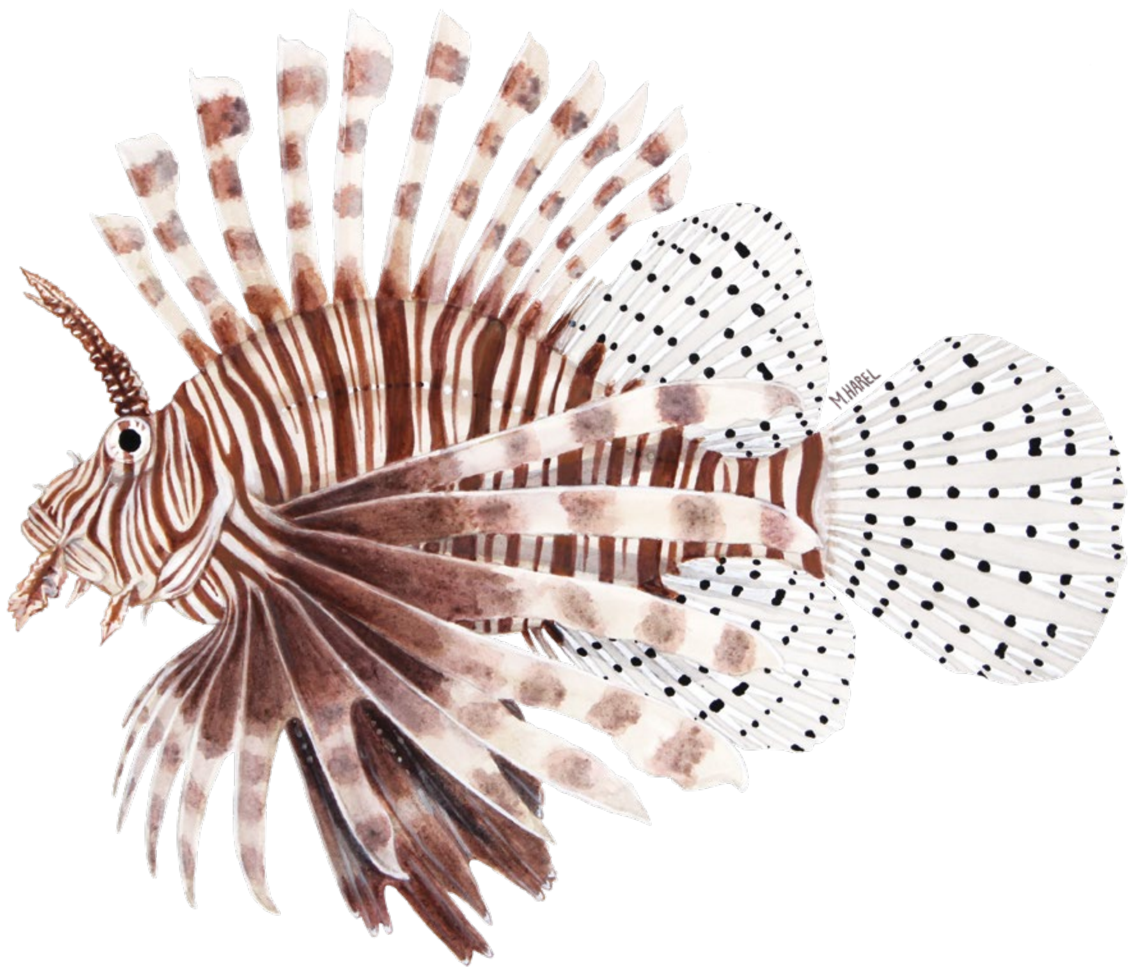
INVASIVE SPECIES

HOW DOES GLOBALIZATION INFLUENCE INVASIONS?

What happens when an animal or plant relocates in a new habitat where it has never been before? When it arrives in a new place, it may escape from its usual parasites and diseases and therefore may be able to out-compete local species. As humans alter the landscape of the Earth and economic globalization expands, invasive species are increasingly taking over the world's flora and fauna.

Panama is a potential hotspot for invasions by marine organisms. At least since the fifteenth century, and especially since the construction of the Panama Canal, the country has been a hub for shipping and world trade. Ships must empty their ballast tanks before crossing the Canal, but there is still a risk that tiny marine organisms can move from one ocean to the other.

Parasites and pathogens affect the success of all free-living organisms. Although they are often microscopic, they can kill more individuals than major predators. Their effects, while enormous, are often undetected. By integrating research on invasive species, parasites and disease, scientists contribute important biological information to policy decisions about how to manage biological problems that result from globalization.



The native Pacific Lionfish now invading the Caribbean. Watercolor illustration by Mayan Harel.

SOIL SCIENCE

WHY IS STRI GOING UNDERGROUND?

Soil is the living skin of the Earth. It contains the basic materials for all terrestrial life. It harbors far more carbon than forests and the atmosphere combined. And soil contains a staggering diversity of living organisms, many of which are fundamental to above-ground life. For example, fungal filaments associated with roots, called mycorrhizae, and nitrogen-fixing bacteria both allow plants to grow in places where they otherwise could not. Yet we know relatively little about the role tropical soils play in the ecology of either the biosphere or the atmosphere. Recent research has shown that the abundance of phosphorus in the soil controls the distribution of some forest tree species. Yet others manage to photosynthesize very actively even when the soils are extremely poor in phosphorus. Understanding how these plants thrive in nutrient-poor soils could help farmers worldwide by avoiding the need for the application of expensive fertilizers, which are, for example, required on newly cultivated high-yield rice varieties that do not flourish in low phosphorus conditions.

STRI scientists are seeking to understand how carbon and water cycle through tropical forests, how soil nutrients affect their ecology and how plants are affected by soil properties in Panama and in the Smithsonian Global Earth Observatory forest plots.

STRI scientists sample soils for chemical analysis in the laboratory. Using a Mass Spectrometer to determine the composition of forest soils, researchers can understand how soil nutrients affect the ecology of the rainforest.

MOLECULAR BIOLOGY

WHAT DO CODED MESSAGES TELL US?

By reading the genetic code, scientists can differentiate species and individuals even when they look very similar, much as the FBI can identify individuals at crime scenes based on their unique DNA.

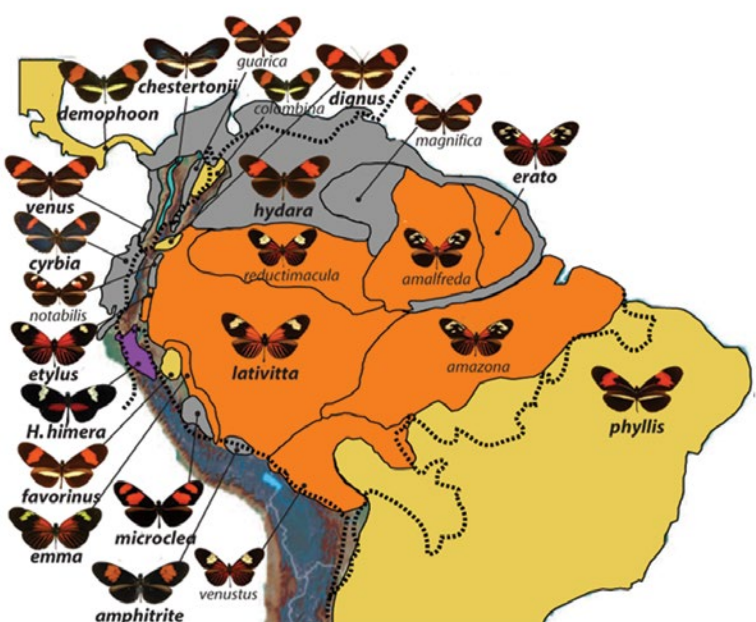
Researchers use genetic information to reveal the relationships between individuals, families and even very different organisms. This tells us about where they came from, and how they changed through time.

STRI is a member of the Consortium for the Barcode of Life in which all the DNA sequences for many species are catalogued in a computerized database accessible on the web to all biologists describing new species.

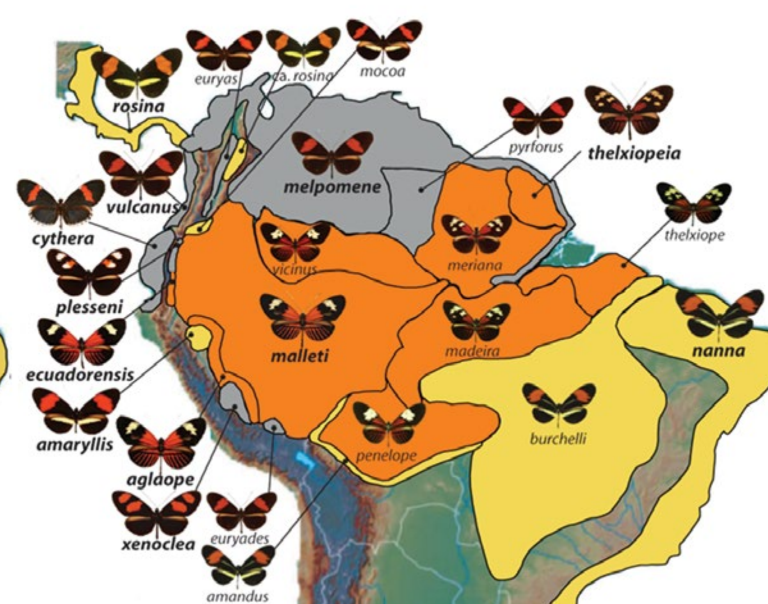
The barcoding initiative is a way of keeping track of genetic information and will allow us to tell whether the species of mosquito buzzing around your ears transmits disease, for example. Simple tests will reassure buyers at the fish market that they are not eating mislabeled or threatened species. STRI is making a major contribution to this initiative by providing samples of tropical species, by hosting teams searching for new species, and by using the molecular laboratories to read DNA barcodes.

In the Census of Marine Life, STRI scientists are attempting to catalogue all marine species in the region of Bocas del Toro on the Caribbean coast of western Panama. In the most comprehensive and sophisticated study of its kind, a STRI scientist has identified, photographed and provided maps for the distribution of 2,290 tropical shore fishes from the eastern Pacific and the Greater Caribbean, shared online in a Fish ID Guide App (free on iTunes).

Lineage *Heliconius erato*



Lineage *Heliconius melpomene*



Corresponding pairs of butterflies from the *H. erato* and the *H. melpomene* lineages are mimics of each other across their whole geographic range. By having a distinctive wing pattern *H. erato* and *H. melpomene* both signal to predators that they are unpleasent to eat. This protection against predators is even more effective when, in each place both species lineages have the same wing pattern. This is called Mullerian mimicry.

ANTHROPOLOGY & ARCHAEOLOGY

HOW DID PEOPLE SURVIVE IN THE PAST?

Anthropologists at STRI study how tropical societies or local communities interact with each other and with their natural surroundings. They focus on the relationship between culture and environment and how this determines modes of subsistence, patterns of trade, belief systems and ritual practices. The theories they have formulated reveal the complexity of the relations between the human and the natural world.

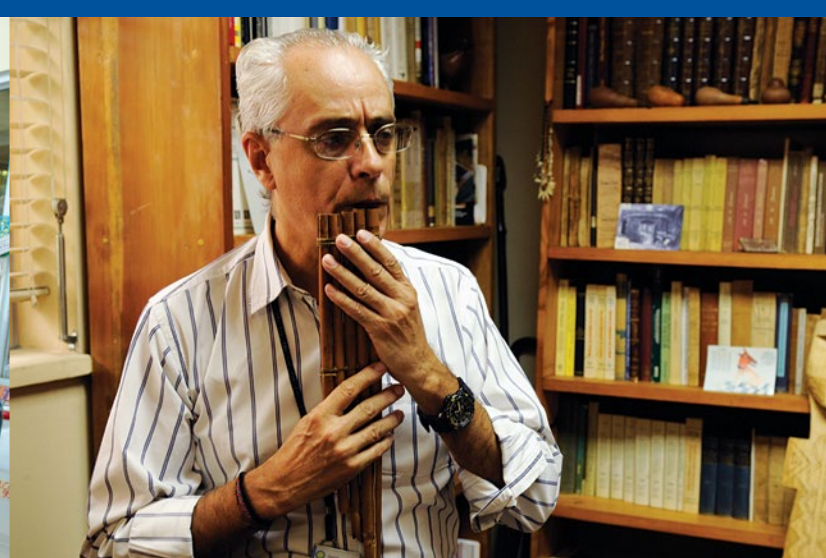
Traditionally, Central America has been viewed as a transit zone for people and their goods-- but STRI archaeologists challenge this paradigm. Based on various lines of evidence, we argue that ancient settlers across the Neotropics established vibrant communities with complex trade relations, political organizations, and artistic achievements.

Archaeologists at STRI have pioneered and continue to use a number of cutting-edge techniques in studying ancient cultures and environmental practices in the tropical Americas. For example, microscopic plant fossils known as phytoliths have revealed a great deal about how plant life changed with the arrival of human settlers, including information about the origins of crops such as squashes and maize. Other scientific approaches include the use of DNA and biochemical analysis in the study of human and animal bones to understand changes in ancient diet and nutrition and the role of animals in domestication and in rituals. Bones also reveal a great deal about the diseases that plagued early populations and about ancient cultural practices such as skull modification.

One of STRI's archaeological research sites focuses on the Pearl Island archipelago, which lies in the Bay of Panama, some 50 km south of Panama City. About 9,000 years ago, these islands gradually became isolated as sea level rose after the last ice age. Native Americans reached Pedro González Island about 6,000 years ago.

They were farmers who grew corn. They were also efficient fishers who used nets to catch small tuna, mackerel and even dolphins. Starting about 2,000 years ago, new colonists bringing pottery gradually settled all the inhabitable islands. A recently discovered gravesite produced the second-oldest examples of gold-work known from Central America.
When the Spanish conquered these islands in AD 1515 they marveled at the size and quantity of pearls worn by native chiefs and re-named the largest island "Isla Rica de las Perlas."

STRI ARCHAEOLOGISTS AND ANTHROPOLOGIST AT WORK



A COMMUNITY OF SCHOLARS & STUDENTS

THE PERFECT RESEARCH PLATFORM

The key to STRI's extraordinary scientific productivity is its ability to provide logistical support for 25 resident scientists and almost 1,500 visiting scientists every year. STRI helps with visas, collecting permits, transportation, housing, computing, library needs and mentoring. Researchers accomplish much more than if they had to make these arrangements unaided from abroad. The local support staff and the collaboration of the Government of Panama have fostered Smithsonian research in Panama for 100 years.

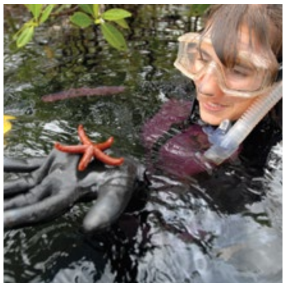
STRI maintains ten research laboratories and field stations distributed across the Republic of Panama, as well as two construction cranes for research on the forest canopy.

STRI'S OUTREACH AND EDUCATION IN ACTION

HOW BEST TO REACH THE NEXT GENERATION?
The Fellowship program - training scientists

Supporting and training the leaders of tomorrow is a priority for STRI. STRI regularly invests millions of dollars to support hundreds of students including interns, graduate students and postdoctoral fellows. They form a diverse community of scholars that typically represents close to 50 countries and greatly enhances STRI research. In particular, long-term international research collaborations subsequently often evolve among the scholars.

Among major themes, STRI fellows have performed fundamental research into the geological history of the tropics, the nature and origins of biodiversity, climate change, and the cultural heritage of Native American peoples. Moreover, most STRI scholars go on to prominent positions in education, research and government, broadly extending the immediate and long-term influence of our Fellowship and Internship Program.



STRI's young scientists, up to the level of Post-Doctoral Fellow, produce a significant amount of STRI's research. Attracting them will sustain STRI's cutting edge research into the future.

100,000 VISITORS

35,000 SCHOOLCHILDREN

EDUCATION AND OUTREACH

STRI offers educational and outreach programs at five sites across Panama, including Barro Colorado Island Research Station, Bocas del Toro Research Station, Galeta Marine Laboratory, Punta Culebra Nature Center, The Amphibian Rescue and Conservation Center at Gamboa, and our main office at Tupper Center in Panama City. The goals of these programs are to interpret STRI science, offer high quality informal science education and promote biodiversity conservation. Our offerings include school programs, science camps, exhibitions, teacher development programs, online and public talks and guided tours of our facilities for local and international visitors.

At our most visited center, Punta Culebra on the Amador Causeway, kids and adults alike journey through Panama's microcosm of natural worlds – from coral reefs of the Caribbean, marine animals of the Pacific to tropical dry forest. Hands-on activities and live animal encounters via our touch tanks, turtle pool and aquaria, and excursions to the nearby seashore and rocky tidal pools give invaluable hands-on experience. A new amphibian exhibit and education program showcases the research, conservation and education efforts of the Smithsonian Institution and partners to preserve one of Panama's natural treasures, the Panamanian Golden Frog.

The center receives support from the Smithsonian Institution Women's Committee and the Fundación Smithsonian, an association of Panamanian businesspeople committed to promoting science, education and the conservation of biodiversity.

Punta Culebra Nature Center on the Amador Causeway, Panama City.

STRI FACILITIES

THE EARL S. TUPPER RESEARCH, LIBRARY AND CONFERENCE CENTER

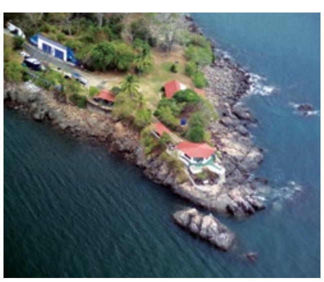
provides modern offices and laboratories for STRI staff and visiting researchers. The Center also contains a 176- seat auditorium, meeting rooms, a gallery for temporary exhibitions, and a tropical sciences library, containing more than 69,000 volumes and reference materials.

THE CENTER FOR TROPICAL PALEOECOLOGY AND ARCHAEOLOGY (CTPA)

in the Ancon Building, near the Tupper Center, is equipped to process samples of fossils and sediments and for geological mapping and stratigraphy. It also houses permanent research collections of pollen, phytoliths and marine fossils.

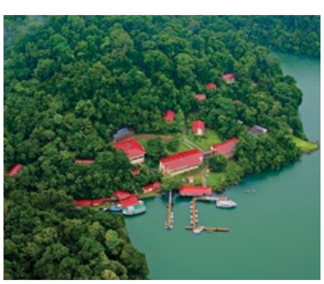
THE NAOS ISLAND LABORATORIES

near the Pacific entrance of the Panama Canal, include an extensive seawater system for research on marine organisms, a well-equipped molecular biological research facility and laboratories for both marine and archaeological research.



THE PUNTA CULEBRA NATURE CENTER

includes exhibits on Panama's coastal habitats and aquaria featuring species from the Pacific and the Caribbean. STRI's public education programs here increase understanding and awareness of Panama's marine environments.



THE BARRO COLORADO NATURE MONUMENT

STRI's primary site for the study of lowland moist tropical forest, provides modern, air-conditioned laboratory space, as well as accommodations for resident researchers. The island together with five mainland peninsulas forms the 5,400-hectare Barro Colorado Nature Monument.

GAMBOA

on the banks of the Panama Canal, has facilities that include housing for scientific visitors, field laboratories, an amphibian rescue center, a center for growing plants under elevated CO_2 and temperature, and a dock for boats servicing BCNM. There is also a school with classrooms and dormitories for advanced courses in tropical biology, and a major new Laboratory complex.

THE GALETA POINT MARINE LABORATORY

near the city of Colón and the Caribbean entrance to the Panama Canal, features a thriving outreach program. Long a site for marine environmental monitoring, Galeta has also been the focus of one of the most intensive studies ever conducted on the biological effects of a major oil spill, and is a center for research on mangroves.

THE FORTUNA FIELD STATION

is a rustic accommodation for researchers in the Fortuna Forest Reserve (20,000 hectares) in Chiriqui Province in Panama's western highlands. Located at 1,200 meters (4,000 feet) elevation, the facility provides access to spectacular wet montane and cloud forests.

THE BOCAS DEL TORO RESEARCH STATION

on the western Caribbean coast, provides laboratory facilities and accommodation for researchers. It offers access to a remarkable coastal lagoon system, numerous islands and reefs, lowland tropical forests, pre-columbian archaeological sites and an anthropological melting-pot.

RANCHERIA ISLAND

is located within the largest concentration of coral reefs in the eastern Pacific. Its location within Coiba National Park provides access to protected habitats and abundant fish populations.

AGUA SALUD

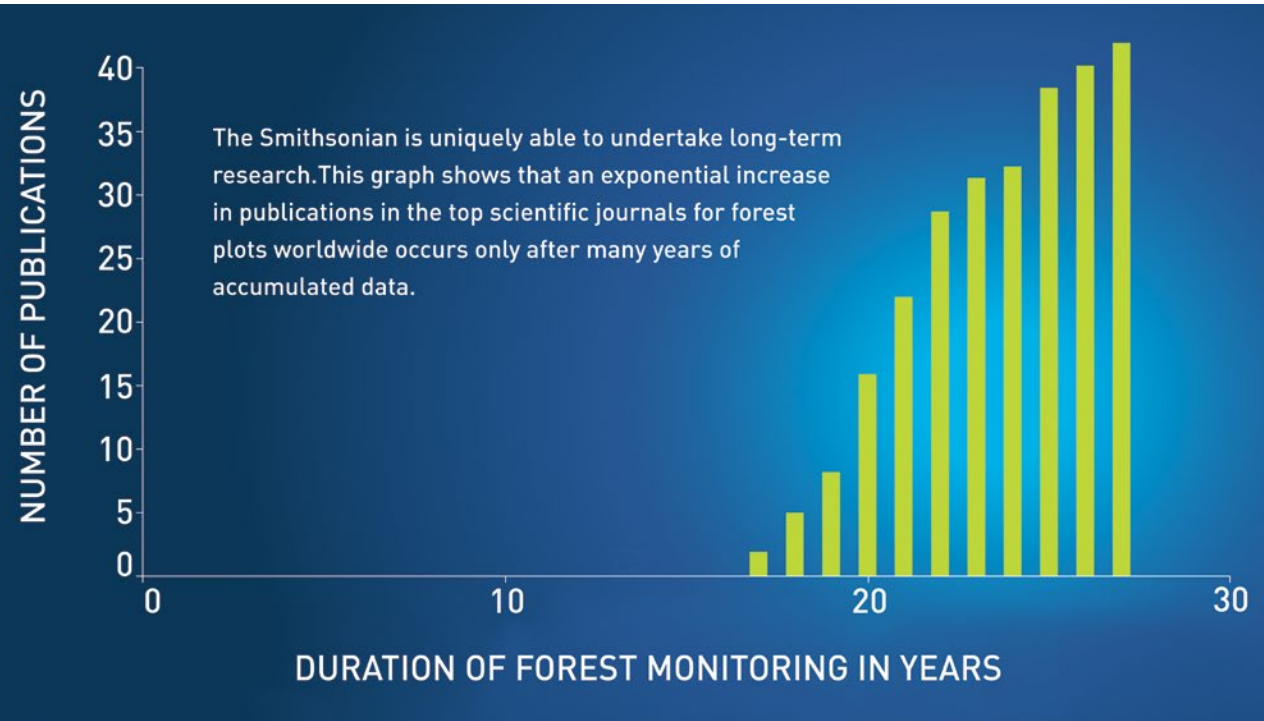
is a landscape-scale project in the Panama Canal Watershed that is at the leading edge of applied forest ecology and conservation. This land-use experiment is about the mechanics of **Smart Reforestation**™ and how it fits into optimum land use scenarios.

FUNDING, LEGAL STANDING AND SCIENTIFIC RATING

Many of you ask the question "From where does STRI receive its budget?" STRI is a unit of the Smithsonian Institution. The Smithsonian was established when the US Congress accepted a donation from the Englishman James Smithson. According to his will, the aim of the gift was to establish an institution for "the increase (research) and diffusion (education) of knowledge among mankind." The Smithsonian was thus established as an independent trust instrumentality, held by the US Federal Government. Today, STRI's annual budget comes from Federal Appropriations (about 64% of total), Smithsonian and STRI Trust Funds (12%), as well as grants and contracts (24%).

Private philanthropy and individual grants are crucial to STRI because most Smithsonian scientists cannot apply for funds to the National Science Foundation or the National Institutes of Health, the largest and most valuable sources of funds available to United States-based university researchers. They are therefore very dependent on non-governmental institutions and private donors to support their research programs. However, since much of scientific operations and facilities, including scientists' salaries, are covered by the STRI federal budget, private donations can be dedicated mainly to supporting the students and the field and laboratory work that new research projects require.

Another commonly asked question is, "How good is STRI and what does it produce that is useful?" In a recent external review by leading international scientists, STRI was evaluated scientifically. By examining how many publications had been written by STRI scientists (we have published over 13,000 scientific papers to date) and peer-assessment of their importance (citations by other scientists), it was determined that STRI was equal to the top one percent of biology and anthropology departments in the United States. STRI is one of few institutions that conducts fundamental research on the most diverse and least known region of the planet. This research can include long-time series beyond the capacity of most universities. Without the knowledge provided by this basic research, sound conservation policies and good land and marine management practices are not possible.



HOW YOU MIGHT HELP AND BECOME A FRIEND OF STRI?

We hope this guide helps provide a good sense of the range and importance of STRI's research, but we have only been able to cover a portion of all our activities — in Panama and around the world. For more detailed information please consult STRI's website, www.stri.si.edu. If you are interested in helping, we invite you to contact our Development Office which will assist you in arranging a personal visit to STRI where you can meet some of our scientists, see their laboratories, tour our facilities, and learn in greater detail about the varied on-going research projects at STRI.

Ideally, we would be delighted to have you become a friend of STRI and help us in our mission. Although the federal budget keeps the basic operation of STRI functioning there are three key areas in which we depend on the philanthropy of private donors and foundations.

1) The lifeblood of STRI is a constant source of young scientists at the undergraduate, graduate and postdoctoral level. We must attract students by a reliable supply of fellowships, which we cannot easily obtain through normal budget channels. We therefore depend on private donors to supply the means to train the future stars of tropical biology, archaeology, anthropology and geology. The unique experience and training they receive at STRI will also benefit univerities and government agencies to which these young researchers will bring new scientific knowledge.

2) STRI also needs private discretionary funds to be able to take advantage, at very short notice, of special time-sensitive research opportunities. For example, the sea urchins that controlled algal growth on reefs were devastated by a pathogen in 1986 and most died in a matter of months, during which the disease migrated from Panama to Bermuda. Current fossil excavation sites will reveal much about the neotropical deep past, but the opportunities to excavate are often temporary. Amphibian species in Central America are disappearing, exterminated by a lethal fungus disease. If we can react quickly enough by having the necessary funds available, these very important research opportunities can be seized; otherwise they will be missed in the course of normal budget cycles.

3) Any dynamic research center is constantly innovating so that new equipment has to be purchased and infrastructure kept state of the art.

Regents, donors and friends convene at STRI or meetings and to socialize.

If you chose to give a gift to STRI it can be mailed directly to our office in Washington, DC. Through the Smithsonian Institution, interested individuals are also able to establish a planned gift, including a Charitable Gift Annuity that can provide income to you during your lifetime and ultimately create a lasting legacy that will benefit research and educational programs in the tropics.

For further information on gifts of stock, corporate matching programs, bequests or other giving, please contact Jenny McMillan in our advancement office in Washington, D.C., at (202) 633-4088 (email: McMillanJ@si.edu) Thank you for your interest in becoming involved with STRI's work.

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Or simply log on to **www.stri.si.edu**, and click on "Giving" to make a donation with your credit card. Your donation is tax deductible in the United States, Panama, and the United Kingdom.

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