

THE CENTER FOR TROPICAL FOREST SCIENCE



Smithsonian Tropical Research Institute

An international survey team maps trees in the Tropical Forest Dynamics Plot on Barro Colorado Island. By remeasuring individual trees every five years, foresters can identify fastgrowing species suitable for reforestation programs.



Around the world, tropical forests are disappearing rapidly. Darien Province, Panama.

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*Understanding tropical forests for conservation
and sustainable management*

Dr. B.D.
The world's tropical forests are rapidly disappearing under the pressure of powerful economic and political forces. Many tropical countries have tried to improve the lives of their people through development of their forests. But often, hoped-for economic gains have turned out to be illusory. Forest harvest or conversion

***Why we need a
better understanding
of tropical forests***

can have many unforeseen liabilities: soil degradation, erosion, flooding, cultural and social disruption, the loss of biological diversity, and climate change. Frequently, valuable forests are cut for a fraction of their real worth, only to be replaced by marginal agricultural lands or eroded wastelands. Economists and policy makers are beginning to realize that wise management of tropical forests could provide far greater economic returns over the long run than converting them to other uses.

A unique value of tropical forests is their extraordinary biological diversity. A single square mile of Amazonian rain forest harbors more tree species, and almost as many bird species, as all of temperate North America. These forests are a potential source of thousands of useful products, including foods, fibers, resins, chemicals, and medicines. Many of these still await discovery



Timber represents only a small part of the real value of tropical forest. Darien, Panama.

by scientists, although they may be well known to local people. Tropical forests contain a large percentage of the world's total store of genetic information; these genes may provide us with ways to cope with future disease epidemics, crop pests, and economic needs. As a further economic benefit, the biological diversity of tropical forests attracts a growing number of nature tourists to tropical countries every year.

The phenomenal diversity of tropical forests, however, complicates the task of understanding them. Our ignorance of the details of this diversity, and of how these myriad plant and animal species interact with one another, is profound. We know little, for example, about the basic biology of most tropical trees: what light, water, and soil conditions they need to survive and grow; what animals pollinate their flowers or disperse their seeds; what animals depend on them for food; what disease organisms attack them. We also know very little about the real economic value of tropical forests —especially the value of their non-timber resources. We don't know how local people use the resources of tropical forests, what role these products play in local economies and cultures, or what level of exploitation they can sustain.

We will not be able to manage and conserve tropical forests successfully until we acquire a basic understanding of how they work. Because we lack adequate knowledge of the growth, reproduction, and ecological dynamics of tropical trees, we are unable to harvest them in a sustainable way. Because we do not understand fundamental interactions between forest plants and animals, we cannot predict how alternative management programs will affect them. A deeper understanding of forest dynamics will also be essential to preserve the biological diversity of parks and reserves as they become isolated by the destruction of forests around them. Current policies to manage and conserve tropical forests, constructed in the absence of basic knowledge, have little chance of success.

THE CENTER FOR TROPICAL FOREST SCIENCE

The Center for Tropical Forest Science (CTFS) is dedicated to meet the critical need for better understanding of tropical forests and their interactions with man. The Center was established by the Smithsonian Tropical Research Institute (STRI) in 1990, in cooperation with faculty members at Princeton and Harvard Universities,



In Panama guayacán trees (Tabebuia guayacan), an important timber species with extremely hard wood, flower after heavy rains that interrupt the dry season. Very little is known about the reproductive ecology of most tropical trees.

***The mission of
the Center for Tropical
Forest Science***

and is based at STRI's headquarters in Panama City, Republic of Panama. In 1991, the CTFS received major support from the John D. and Catherine T. MacArthur Foundation. The Center's activities are international and pantropical, and it collaborates with leading organizations throughout the world engaged in tropical forest research.

The mission of the Center is to:

- Promote programs of long-term, interdisciplinary research in the natural and social sciences aimed toward understanding plant, animal, and human interactions in natural tropical forests;

- Translate this information into results relevant to forest management, conservation, and natural resources policy, and communicate these results in a timely fashion through publications, workshops, conferences, and data-sharing networks.

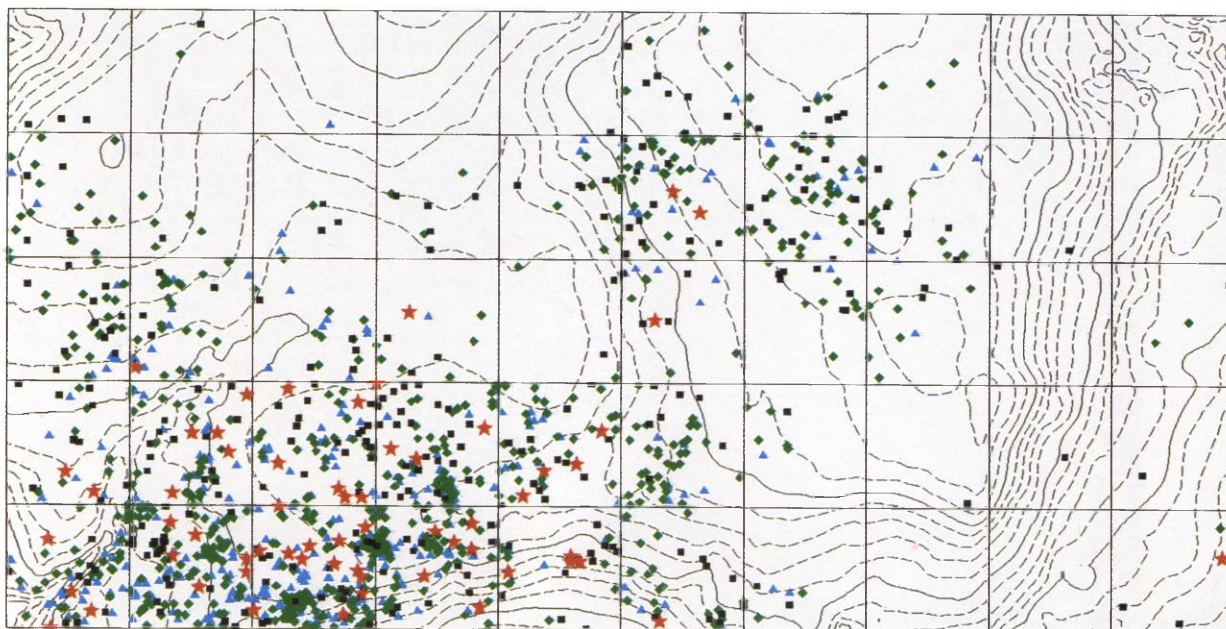
To meet the first objective, the CTFS, in collaboration with local institutions, links a growing number of long-term tropical forest research sites around the world. These sites are the focus of comprehensive, integrated research programs including scientists from a broad range of disciplines. An important function of the CTFS is to facilitate standardization of research methodologies among sites, so that results can be rigorously compared.

To meet the second objective, the CTFS analyzes and interprets the information derived from these research programs to address problems of forest management and conservation. The results of basic research are often ignored by resource managers, because they are presented in a way that obscures their significance for management. The CTFS provides the critical “missing link” of information exchange between tropical forest research and management. The Center promotes coordination between research sites and communication of results through technical and nontechnical publications, training workshops, and international conferences, and also develops data storage and analysis systems and data sharing networks. The CTFS will provide better access to existing information on natural tropical forests, and generate new data when the necessary information does not exist.

*The unique role
of the Center*

TROPICAL FOREST RESEARCH

The CTFS serves as a global center for promoting and coordinating research on the ecology and management of natural tropical forests. The Center presently links seven research sites in Asia and Latin America, and eventually will incorporate

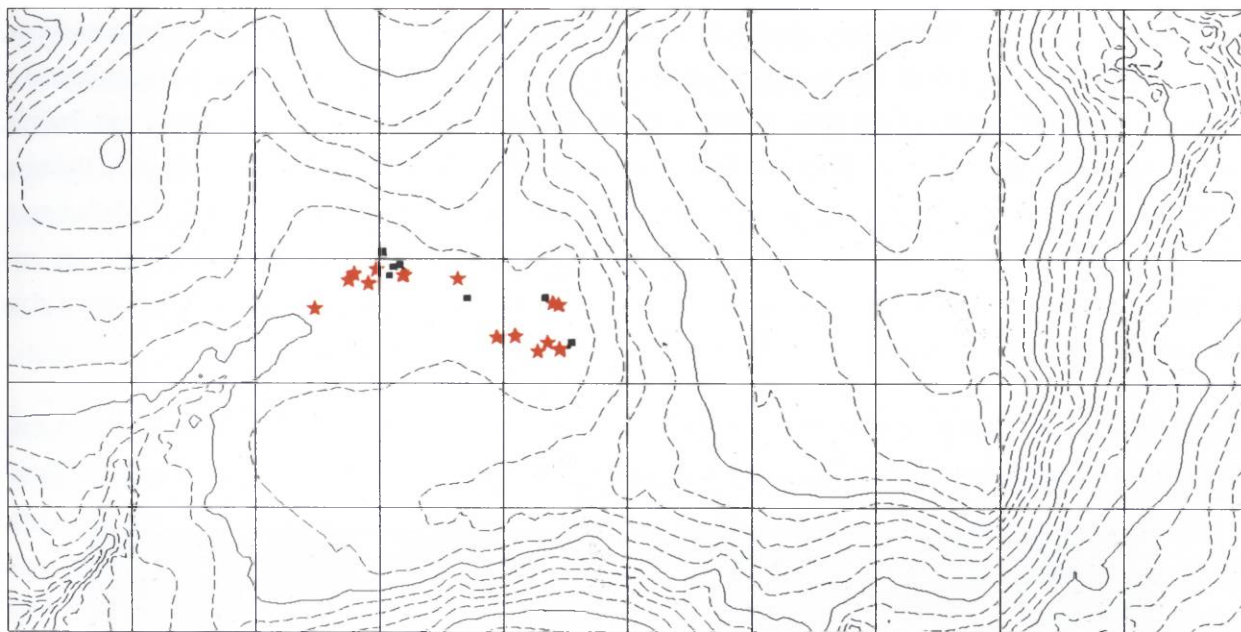


1982 Size Classes: ▲ 1-2cm ◆ 2-8cm ■ 8-Adult ★ Adults **PRIC**

*Although cativo (*Prioria copaifera*) is one of the most important timber trees in Panama, we lack basic information on its growth and reproduction. Data from the Forest Dynamics Plot on Barro Colorado, shown on this map, will help develop models for sustainable management of this species.*

sites in all major tropical forest regions. Individual sites and local research programs are administered by a variety of national and international organizations. The research programs at sites cooperating with the CTFS, however, share many critical features. This commonality of approach provides the Center with four special strengths: scope, focus, standardization, and scale:

■ **Scope.** CTFS research programs take a holistic approach to understanding how tropical forests work as ecological communities, and how management and other human activities may affect them. CTFS research is interdisciplinary, and incorporates studies of the role of animals, pathogens, and other organisms in forest ecology, and of human uses of the forest. Tropical forest management will only be successful if the mutual interactions and dependencies among species, as well as traditional human uses of the forest, are taken into account.



1982 Size Classes:

▪ 8-Adult

★ Adults

ELAO

The corozo palm (Elaeis oleifera) has a very localized distribution in the Barro Colorado Forest Dynamics Plot. It is an important forest resource for indigenous groups in Panama, and is used for construction, food, cloth, fiber, medicine, and cosmetics.

■ **Focus.** CTFS research focuses on natural tropical forests and on the development of sustainable management strategies for them, an area that has been seriously neglected to date. Most tropical forestry today is focused on development of a very small number of fast-growing, multiple-use species for plantation forestry. Such plantations can be a productive use for land that has previously been deforested. But plantations, especially of exotic species, are biological deserts compared to the original native forest. Managed natural forests have the potential for producing a wider range of products than plantations, while still retaining their value for biological diversity and their role in the traditional economy and culture of local communities.

■ **Scale.** The CTFS provides comparative information on tropical forests on a far larger scale than has ever been attempted before. At three fully-implemented research sites in Panama, peninsular Malaysia, and

India, more than half a million individual trees, representing more than 1,000 species, are under continuous, long-term study. This is more than twenty times the number of tropical tree species currently under intensive study for plantation forestry. Four more research sites, in Thailand, Malaysian Borneo, Sri Lanka, and Bolivia, are currently being implemented. Additional sites in India, Thailand, China, the Philippines, Indonesia, Panama, Ecuador, Zaire and Brazil are being planned, and the Center will eventually include sites in Madagascar and New Guinea as well. By 1995, the CTFS database is expected to include several million trees and several thousand tree species. Within the next decade, the Center's goal is to obtain forestry-relevant data on virtually all major tree groups (genera) and all major forest types in the tropics.

■ **Standardization.** A unique strength of the CTFS is the international standardization of research and data management protocols at all sites, so that results can be rigorously compared. At present, tropical forest



Survey teams tagging and measuring trees in Forest Dynamics Plots on Barro Colorado Island, Panama (left) and in Pasoh Forest Reserve, Malaysia.

research sites employ a wide variety of methodologies, including various sizes of study areas, tree size classes, and measurement techniques. Data are collected, stored, and analyzed in many different formats. As a result it is difficult to compare information from different sites in a meaningful way. Standardization is especially useful for coping with the enormous diversity of tropical forests. For example, by using standard methods we can compare the growth and performance of closely related tree species in different forests. We can then acquire an idea of how related species perform at other sites. In this way we can reduce to a more manageable size the nearly impossible task of studying every species individually —a task for which there is neither sufficient time nor resources.

Forest Dynamics Plots are a major research tool at CTFS sites. In these plots, all trees over one centimeter in diameter at breast height in a 50-hectare gridded plot are mapped, tagged, measured, and identified to species. The large size of the plots and the inclusion of small-diameter stems permits collection of adequate data for a very large proportion of the tree species present in the area. Plots are recensused at least every five years, yielding information on species growth, mortality, and regeneration. These data permit detailed analysis of species distribution in relation to topography, hydrology, soil types, and biotic factors, and of forest dynamics in relation to long-term environmental changes, both natural and man-made. Such complete information on the distribution of trees provides a framework for sophisticated studies of the ecology of other plants and animals as well. In addition to yielding basic information on forest diversity, structure, and dynamics, these plots provide essential controls for management programs in nearby areas.

INTERNATIONAL PARTNERSHIPS AND TRAINING

The CTFS seeks long-term partnerships with institutions and researchers of tropical forest countries, to assist research and education programs that promote better forest management and conservation.

To promote such partnerships, the Center:

- Establishes collaborative programs with local institutions for research on tropical forests;
- Facilitates visits between participating sites, and attendance at workshops and conferences.

The Center assists local institutions in setting up and maintaining long-term, interdisciplinary research programs that advance the Center's mission. Through a program of fellowships and grants, the CTFS will sponsor short and long-term research and training visits by staff and students from participating institutions, both to the Center itself and to other sites. The CTFS will provide follow-up support to help participants initiate and maintain programs of research, education, and training in their home countries, and will also furnish support for researchers, students, and resource managers to attend workshops and conferences. This active interchange between participating sites will help to ensure that research programs maintain comparability.

COMMUNICATION

Poor communication between scientists, resource managers, and policy makers has significantly limited progress in the development of sustainable management programs for natural tropical forests. The CTFS will make the results of basic research accessible to resource managers and policy makers by publishing results in terms relevant to management issues. The Center will also bring natural and social scientists together with resource managers and policy makers, to find lasting solutions to problems of tropical forest management and conservation. The resulting solutions must be both environmentally valid and economically and socially workable.

The Center will promote communication on issues relevant to tropical forest management by:

- Making research results available in both technical and non-technical publications, and in English and regionally appropriate languages
- Sponsoring workshops and hosting regional and global conferences on tropical forest ecology, conservation, and management

INFORMATION SYSTEMS

Arriving at an adequate understanding of the complex interactions of species-rich tropical forests requires the ability to store, handle, and analyze enormous data sets. The Center for Tropical Forest Science provides customized computer software for tropical forest research, including database management and mapping systems and standardized statistical programs. These systems are designed to make it easier for scientists, field workers, and managers, regardless of computer skills, to access information and analyze data from their field sites. Standardized database formats and analytical programs permit easy comparison of information throughout the Center's network of research sites.

The Center maintains and continually updates large computer databases on tropical trees and forests. Micro-computer databases presently maintained by the Center include:

- Site-specific growth and survival data for more than 500,000 individual trees at the Center's long-term research sites;
- Summary data on more than 1,000 species, including abundance, mean growth rate, and survivorship. Information on the known or potential economic value of each species is currently being added to the database.

The Center also plans to develop a comprehensive bibliographic database on worldwide tropical forest research and management.

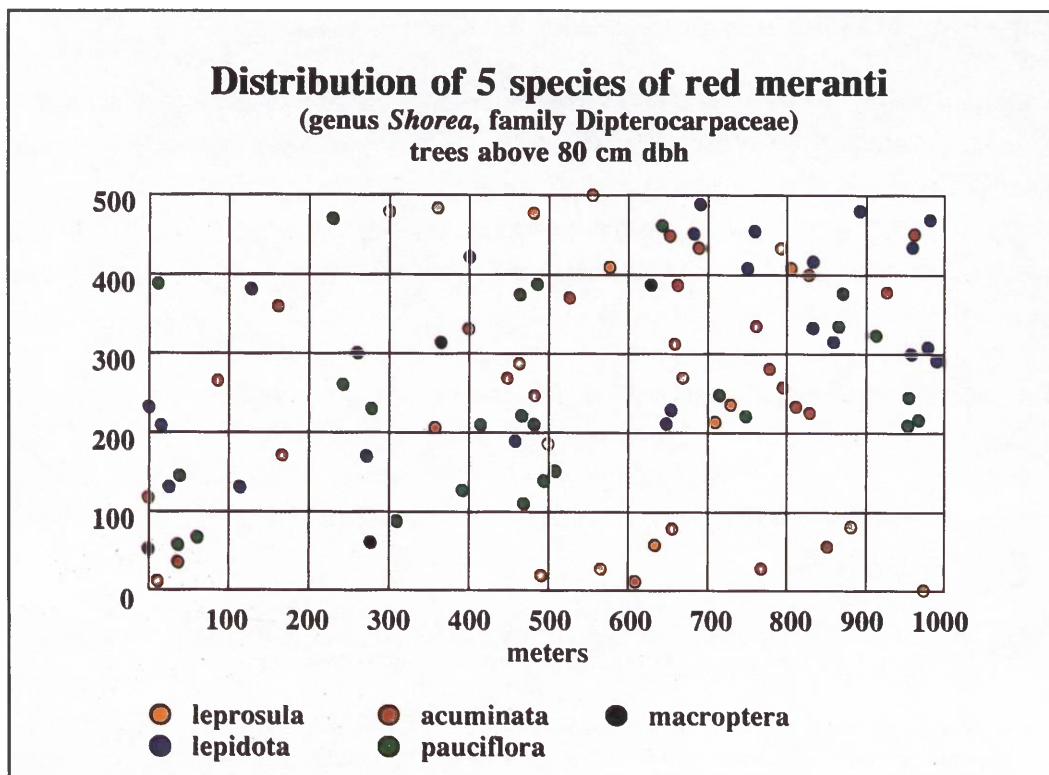
LONG-TERM RESEARCH SITES

The Center for Tropical Forest Science presently links the following long-term research sites:

Barro Colorado Island, Panama. Barro Colorado Island (BCI), STRI's principal field site for study of lowland tropical moist forest, has been the focus of intensive biological research since 1923. STRI established the first Forest Dynamics Plot here in 1980, as part of its comprehensive research program in forest biology, which includes plant physiology, canopy biology, and animal ecology. Recensuses of the plot in 1985 and 1990 revealed the remarkable dynamism and instability of tree populations on BCI. Turnover is very fast by temperate forest standards: the average residency

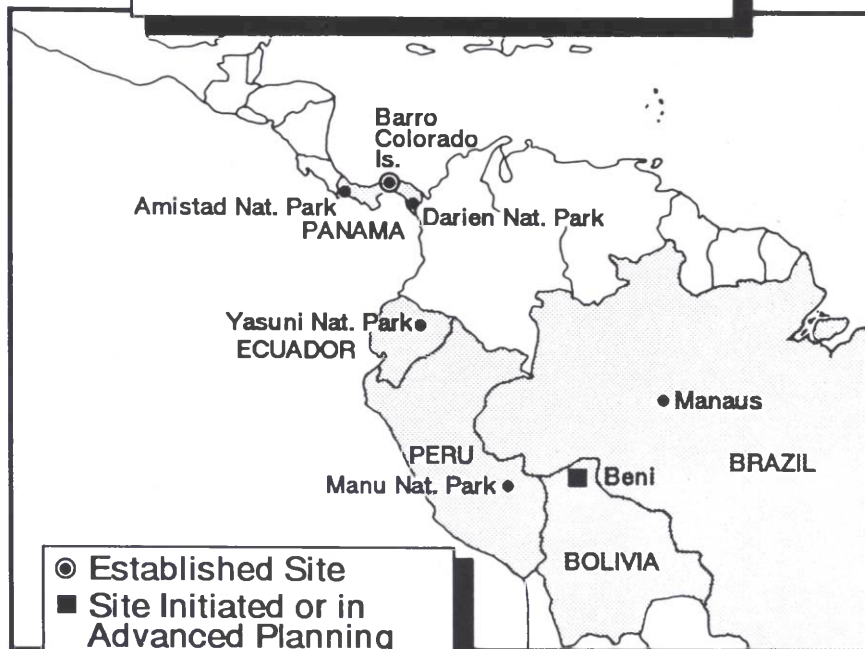
time of a tree in the canopy layer is only about 45 years. Between 1982 and 1985, 40% of the 306 tree species in the plot changed by more than 10% in total abundance. This was apparently the result of a severe drought in 1982 that elevated death rates to up to twenty times those of non-drought years. In addition, studies of canopy cover suggest that forests of central Panama are changing due to a long-term decline in rainfall. These discoveries indicate that tropical forests may be much more vulnerable to global climate change than has previously been supposed.

Pasoh, Malaysia. Pasoh Forest Reserve, in peninsular Malaysia, is a long-term research site of the Forest Research Institute Malaysia (FRIM). The Reserve is located in lowland dipterocarp forest, a type of evergreen tropical moist forest. In 1986, the second Forest Dynamics Plot was initiated there in a collaboration between FRIM, the Arnold Arboretum of Harvard University, and STRI. The first census was completed in 1989, and a recensus was undertaken the following year. The Pasoh plot is highly diverse, containing more than 800 species and 340,000 trees. Many commercially important species are under intensive demographic study, and an analysis of the human uses of the Pasoh forest and an economic valuation of forest resources are now under way.



This map depicts the distribution of five species of red meranti (Shorea species), important timber trees, on the Forest Dynamics Plot at Pasoh Forest Reserve, Malaysia.

FOREST DYNAMICS PLOTS



Mudumalai, India. Mudumalai Game Reserve is located in the eastern foothills of the Western Ghat Mountains of southern India, and contains seasonal semi-evergreen lowland forest typical of the subcontinent's dry teak forest. The third Forest Dynamics Plot was set up here in 1988, by the Indian Institute of Science in Bangalore in cooperation with STRI. Mudumalai's open-canopy woodland with grass cover is subject to nearly annual fires and to browsing by large herds of elephants. A major research focus, with significance for forest management practices throughout much of India, is how fire and elephant browsing affect forest regeneration.

Huai Kha Khaeng, Thailand. The Huai Kha Khaeng Wildlife Sanctuary, a World Heritage Site in western Thailand, contains a mosaic of dry evergreen dipterocarp and moist mixed deciduous forest. The Reserve's abundant large game depends on each forest in different ways and in different seasons. Dry evergreen dipterocarp forest is a critically endangered habitat in the region, and often becomes converted into deciduous forest through degradation and fire. In 1991 a Forest Dynamics plot was initiated at Huai Kha Khaeng by the Royal Thai Forest Department in collaboration with Kasetsart and Mahidol Universities, and the Arnold Arboretum of Harvard University. The plot crosses a steep soil moisture gradient and forms a transect between evergreen and deciduous forest. Understanding the dynamic relationship between these two forest types will be fundamental to the conservation of both and of their wildlife.

Lambir, Malaysia. The mixed dipterocarp forest of Lambir National Park in Sarawak, Malaysian Borneo, is characterized by high endemism and contains possibly the richest diversity of tree species in the Old World. The Park is now a small isolated forest surrounded by plantations and shifting agriculture. A Forest Dynamics Plot was set up here in 1991 by the Sarawak Forest Department, the Arnold Arboretum of Harvard University, and the Plant Ecology Laboratory of Osaka City University, Japan. The plot crosses an abrupt change in soil types that results in a more than 60% change of species composition within 50 meters. Projected research includes wildlife survival in an isolated forest with limited food resources; silvicultural research aimed at restoration of logged areas; and anthropological research on the relationship between local shifting agriculturalists and the Park.

Sinharaja, Sri Lanka. The forests of Sri Lanka display low diversity but very high endemism. A Forest Dynamics Plot is scheduled for installation in 1992 at the Sinharaja World Heritage Site in central Sri Lanka, sponsored by the Sri Lanka Forest Department and funded by the Rockefeller Foundation, with major input from the University of Peradeniya. Research issues at Sinharaja include silvicultural management for diverse forest products including hardwoods, forest restoration, and the biological stability of forests of low biological diversity.

Beni, Bolivia. A Forest Dynamics Plot is scheduled to be initiated in the Beni region of Bolivia in 1992, in lowland deciduous tropical forest rich in valuable timber species such as mahogany (*Swietenia*) and tropical cedar (*Cedrela*). This project is a collaboration between the National Herbarium of Bolivia, International Tropical Timber Organization, U.S. Agency for International Development, Smithsonian Institution, Princeton University, and Harvard Institute of International Development.

THE SMITHSONIAN TROPICAL RESEARCH INSTITUTE

The headquarters of the Center for Tropical Forest Science is in Panama City, Panama, at the Smithsonian Tropical Research Institute. The laboratories, computer and information resources, and conference facilities of STRI's Earl S. Tupper Research and Conference Center provide outstanding support for CTFS activities. STRI's Tropical Sciences Library, with more than 40,000 volumes and 1,000 journal subscriptions, is one of the most comprehensive resources in the world for tropical biology and conservation.

STR^I has a distinguished history of tropical forest research, beginning in 1923 when a biological laboratory was established on Barro Colorado Island in Lake Gatún in central Panama. The Smithsonian Institution took responsibility for custodianship of BCI in 1946, and the island and surrounding lands were guaranteed status as a permanent nature reserve by Panama in 1979. Today BCI is the most thoroughly studied tropical forest site of its size in the world, and more than 1,500 books, scientific papers, and theses have been written on its flora, fauna, and ecology.

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For More Information:

Additional information about the Center for Tropical Forest Science and its programs is available from the Coordinator's Office, Center for Tropical Forest Science, Smithsonian Tropical Research Institute, Box 2072, Balboa, Republic of Panama.

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Browsing by elephants has a major impact on forest regeneration at the Mudumalai Game Reserve, India.



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