Global Change and Tropical Forests: Photosynthetic Responses of Trees to Elevated CO_2

Alexander Ellis and Catherine Potvin, McGill University

Clear-cutting and slash-and-burn agriculture continue to exact a heavy toll on tropical forests, jeopardizing the future of both forest and people. Less clear, however, is the effect of another anthropogenic force, elevated atmospheric CO_2, that has resulted from the world's industrialization. This seemingly innocuous substance could play a considerable role in shaping the future structure and dynamics of tropical forests without chopping down a single tree. As the global atmospheric CO_2 concentration increases, it will likely have an effect on the photosynthetic rate and growth of trees worldwide. Therefore, one of the main thrusts of global change research has been to assess the potential physiological impacts of CO_2 on trees. Until recently, however, most elevated CO_2 research efforts were conducted under rigorously controlled laboratory or greenhouse conditions rather than under the naturally variable conditions of the forest. Furthermore, these research efforts focused chiefly on one or a few species rather than larger assemblages of species which could better represent the forest community. Even with the advent of field studies, most research has focused on temperate or wetland ecosystems. To address these gaps in knowledge, along with Dr. Stephen Hubbell of Princeton University, we are attempting to understand the physiological impact of elevated CO_2 on tropical forest species by recording the photosynthetic and water use responses of 21 neotropical tree species to elevated CO_2 on and around Barro Colorado Island (BCI), Panama.

The goal of our work has been to determine whether the physiological responses to a CO_2-rich atmosphere are detectable under the heterogeneous environmental conditions of the tropical forest. Many environmental factors such as light level, nutrient and water availability, and temperature fluctuate widely within the forest and are known to affect photosynthetic performance. Our approach sought to use this inherent environmental variability within a forest in order to obtain measurements that would be indicative of the effect of high CO_2 levels on the trees.

Many current forest models use functional groups or guilds of species with similar ecological characteristics as a means of simplifying the structure and composition of forests. To test whether functional groups indeed exhibit characteristic responses to elevated CO_2, we selected seven species from each of the three functional groups represented in the BCI forest (pioneer, intermediate, and shade tolerant), as determined by ecological characteristics derived from the BCI 50-ha Forest Dynamics Plot data.

Gas exchange measurements of the various tree species began in January 1995, the onset of the dry season in central Panama. Steady-state photosynthetic rates were measured at the leaf level, using an infrared gas analyzer and a cuvette to enclose a leaf, allowing us to artificially increase the CO_2 level around the leaf. Measurements of 10 minutes duration were taken at ambient and elevated CO_2 for a given tree in both the morning and the afternoon to account for daily changes in response due to temperature and water stress, carbohydrate buildup, and photoinhibition. Measurements on individual trees were subsequently repeated in the wet season to evaluate seasonal impacts on response. Light level, temperature, and humidity of the leaf and of the surrounding air were recorded concurrently as were soil moisture, pH, and successional status of the forest at each site. These measurements will be used in a factor analysis to identify environmental conditions under which the CO_2 fertilization effect is highest.

In-situ CO_2 measurements being taken on BCI using an infrared gas analyzer.

Our results indicate that there is a strong short-term, leaf-level photosynthetic enhancement in response to elevated CO_2 across all species. Thus, even when examined under heterogeneous environmental conditions, tropical trees show significantly increased photosynthetic rates at elevated CO_2. Furthermore, they exhibit a very strong species-specific response to elevated CO_2, that is, various species respond differently to the same stimulus. In response to elevated CO_2, *Swietenia macrophylla* (Meliaceae), commonly known as mahogany, and *Zanthoxylum belizense* (Rutaceae) exhibited the greatest increase in photosynthetic rate while *Palicourea guianensis* (Rubiaceae) and *Protium tenuifolium* (Burseraceae) experienced the smallest photosynthetic increase. However, when the species were lumped together into their predetermined functional groups, there was no longer any significant effect of CO_2, indicating that functional groups themselves do not react characteristically. This is an important result because it implies that the current approach of forest models, which view the forest as collections of species rather than individuals, will not produce accurate results. Our data also indicate a significant seasonal effect on species' photosynthetic rate. Although all species photosynthesize at a higher rate during the dry season month, the effect is especially evident at high CO_2, which may be important if the anticipated climatic changes accompanying the atmospheric CO_2 rise come to pass.

In this experiment, we used relative growth rate data from the BCI 50-ha plot to examine the relationship between photosynthetic rate and growth rate. We found a strong relationship between photosynthesis and growth at ambient CO_2, indicating that as the photosynthetic rate increases, so too does the growth rate. However, no such relationship exists between growth rate and photosynthesis at high CO_2. This underscores the need for experiments that can quantify both CO_2-fertilization effects and growth effects in the field.

Meanwhile, further data analysis is under way, as are plans to conduct expanded studies directly monitoring growth and photosynthesis under continuously enriched CO_2 conditions. We feel that these studies will enhance the findings of long-term research projects like the BCI Forest Dynamics Plot by integrating the existing ecological data with a better understanding of underlying physiological differences among trees. ■

Fungi Associated with Trees on BCI

Gregory S. Gilbert, Smithsonian Tropical Research Institute

The leaves, branches, trunk, and roots of every tree in a tropical forest harbor a diversity of fungi, hidden from our view for most, if not all, of their lives. Some of these fungi may cause disease in their hosts, whereas others function as nutritional mutualists or as decomposers of senescent or dead host tissues. Many fungi, including important pathogens, reproduce only after the host has died. The diversity of plant-associated fungi in the tropics is startling — up to dozens of fungal species may inhabit a single leaf, with many more in the wood and bark.

Understanding the natural histories of these organisms and the effects that fungi have on their tree host populations and the forest community as a whole requires finding and identifying large numbers of their widely-dispersed (and often dead) host plants, a formidable task in a diverse tropical forest. Working within the 50-ha Forest Dynamics Plot on Barro Colorado Island (BCI), Panama, has allowed me to overcome some of the inherent difficulties in working with plant-associated fungi in the tropics. Because all trees on the plot are mapped, it is possible to study the spatial distribution and epidemiology of tree diseases in a highly diverse tropical forest. Additionally, the plot data make it possible to identify the remains of any tree that has died since the initial census in 1982, permitting the study of host preferences among fungi that reproduce only after the death of the hosts.

I took advantage of the mapped trees within the Forest Dynamics Plot to examine the effects of a fungal canker disease found in various tree species of the family Lauraceae. My research revealed that the cankers, which form on the trunks and branches of both juveniles and adults, can double the host mortality rate. Both the incidence of cankers and the rate of mortality were greater for juveniles near conspecific adults than individuals dispersed far from the parent tree. This suggests that the disease spreads from mother to offspring and pest pressure should be highest among juveniles at high densities near the mother tree, conforming closely to the predictions of the Janzen-Connell density-dependence model for the maintenance of high tree diversity in tropical forests. This disease appears to be an important regulator of population size and spatial distribution among several species of Lauraceae on BCI.

In a separate long-term project, I am collaborating with Ms. Astrid Ferrer (SUNY College of Environmental Science and Forestry) and Prof. Julieta Carranza (Universidad de Costa Rica) to examine how the diversity of wood-decomposing polypore fungi (shelf fungi) is related to the diversity and structure of the tree community. We identified the fruiting bodies of polypores associated with all trees, dead or alive, in 2.5 ha of the Forest Dynamics Plot on BCI. The rarity of both hosts and fungi makes it difficult to assess host specificity. The more common fungi were all found on multiple host species. Yet, the majority of the fungal species were extremely rare, with two-thirds of the species found only once. Currently, we are completing more intense studies of the fungi associated with ten focal tree species to evaluate how host abundance affects the diversity of fungi associated with a host population. We are also investigating the strength of host preferences among various fungal species.

The next step of our research is to compare the structure of the fungal communities within the 50-ha Plot on BCI to other tropical forest communities in both low and high diversity forests elsewhere in Panama and Costa Rica. The data from these studies will help to, first, identify fungi that may be of particular importance in population dynamics of certain tree species and, second, help understand the overall role of fungi in tropical forest ecology. ■

Regeneration of Pioneer Tree Species

James Dalling, Smithsonian Tropical Research Institute

Pioneer trees are becoming increasingly abundant in the tropical landscape. Fast-growing and light-demanding, these species often occur along the margins of forested areas, and in degraded or abandoned land. In recent years, interest in the biology of pioneer species has increased as their utility in forest restoration and plantation timber production has become apparent. Yet, we still know little about the ecology of pioneer species in natural forests.

On Barro Colorado Island (BCI), Panama, recruitment of pioneers is largely confined to treefall gaps — holes in the forest formed by the death of one or more canopy trees. The occurrence of these gaps is unpredictable, and thus pioneer species need effective dispersal mechanisms to ensure that their seeds reach newly formed gaps. For most pioneers, dispersal in space is augmented by seed dormancy, which allows seeds buried in the soil to wait for gaps to form before germinating.

The 50-ha Forest Dynamics Plot on BCI provides an ideal opportunity to examine patterns of seed dispersal in pioneer species. In August 1992, in collaboration with Dr. Mike Swaine (University of Aberdeen) and Dr. Nancy Garwood (The British Museum), we began research on two of the most common pioneer species in the plot, *Miconia argentea* (Melastomataceae) and *Cecropia insignis* (Cecropiaceae). We set out to determine: 1) the size and shape of seed shadows produced by these species; 2) the persistence of seed shadows throughout the year and following the death of the parent tree; and 3) the factors responsible for seed loss in the soil.

Using data from the 1990 census of the 50-ha Forest Dynamics Plot, we located isolated reproductive adults of our focal species and collected soil samples at fixed intervals along transects radiating away from them. After exposing soil samples to the sun, in a screened growing house, we estimated the density of seeds in the soil by counting the emergent seedlings. We repeated our sampling seasonally and also at sites where reproductive-sized individuals had once lived and were recorded in previous censuses of the plot.

Our results indicate that both *Miconia* and *Cecropia* produce distinct seed shadows, with the density of seeds in the soil decreasing logarithmically with distance from the parent tree. However, these species produce such large quantities of seeds (up to 9000 seeds/m^2 in soil below the crown) that seed densities are measurable even 50 m from the nearest adult. Most seeds, however, do not survive

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for long periods in the soil. For both species, more than 90% of the seeds disappear within one year, and little or no residual "seed bank" remains after the death of the tree.

Finally, to examine the role of fungal pathogens as agents of seed mortality, we treated seeds with chemical fungicides, buried them in the soil for six months, and then compared the germination rates of treated and untreated seeds. Our findings indicate that fungi do indeed appear to be responsible for the majority of seed losses in the soil. The mortality of seeds treated with fungicide was reduced by up to 50%.

In the next phase of this project, in collaboration with Dr. Stephen Hubbell (Princeton University), we will examine how dispersal characteristics and differences in seedling establishment and growth requirements may permit the coexistence of 25 pioneer species on BCI. To assess which pioneer species contribute seeds to individual treefall gaps, we will combine information on the location of reproductive trees, the size and location of treefall gaps in the plot, and information on the dispersal characteristics of each species. Additionally, by experimentally growing seedlings under a range of light conditions simulating gaps of different sizes, we will compare species performance across different gap conditions to evaluate the degree to which pioneer species partition gaps. Combining information from the plot and from experiments, we should be able to predict which species will colonize gaps of a certain size and location. To test these predictions, we plan to record pioneer seedling establishment, growth, and mortality within a large sample of newly established gap sites within the 50-ha Forest Dynamics Plot. ■

ETHNOBOTANICAL VALUE OF PLANTS TO THE LAS PAVAS COMMUNITY

Salomon Aguilar, CTFS/STRI
(Translated by David Gruber)

Although there have been many studies on the use of the forest by indigenous communities, few studies have investigated the use of plants collected in the wild by non-indigenous communities living outside the forest. To document the importance of non-cultivated plants by non-forest dwelling people, I visited the community of Las Pavas (09° 06'N, 79° 53'W) to interview local people about plants collected in the wild and to observe which timber species were used to build houses.

The community of Las Pavas is located near the Panama Canal, immediately southwest of the Barro Colorado Nature Monument. The community, comprised of 247 residents, has neither running water nor electricity. The soils are poor and not suitable for intensive agriculture, and most of the land is under cattle pasture. Many farmers maintain small gardens, growing yucca (manioc), beans, and other crops. Local residents build their own houses and tools, primarily with local wood.

With the purpose of providing sound data on the use of native forest species, the Center for Tropical Forest Science (CTFS) has embarked on agroforestry and socioeconomic studies at this site. This program began with a study of tree resources that are used by the local inhabitants of Las Pavas. Local people accompanied us in the field — both pasture and farm land as well as forest — to point out and name useful plants. The main part of this work took place from July 1992 to September 1992, but on-site interviews continued through July 1994.

During this investigation, we recorded the use of 119 species, including 108 tree species, 3 shrubs, 2 herbs, 4 lianas, and 2 vines. Nearly all the species (115 of 119) were native to the area, but are never cultivated locally.

The construction of houses was the dominant use of forest plants, accounting for 71 species. According to the surveys conducted in Las Pavas and two adjacent communities in 1994, 67% of the houses had roofs made of leaves from *Scheelea zonensis* (Palmae); 60% of the walls are *Socratea exorrhiza* (Palmae) and 34% of the floors are of wood. Secondly, it was reported that 40 tree species were used for firewood. The desired characteristics when selecting fuelwood are slow-burning wood, radiating heat, and low levels of ash. Good fuelwood species include *Xylopia frutescens* (Annonaceae), *Trichilia tuberculata* (Meliaceae), and *Byrsonima spicata* (Malpighiaceae). Thirdly, it was reported that 27 tree species are used for making fences. Fences were made from the trunks or branches of trees 10 cm dbh. Also, live fences were made by directly planting trunks or branches 5 cm dbh of 13 species.

Most of the species (82 of 119) were collected in secondary forests near the community, while somewhat fewer (47 species) were collected in mature forest. The rest were taken from areas of cultivation and along river banks.

We conclude that even non-indigenous communities in tropical Latin America, living outside the forest, make frequent use of the great diversity of trees native to the region. The information obtained in this study adds to our knowledge concerning the value of native trees and enrich other research regarding the use of native trees in plantations on deforested lands around Las Pavas (see Morales, *Inside CTFS*, Fall 1995, p. 2).

We are thankful for the support of the Smithsonian Tropical Research Institute Herbarium and the University of Panama for identifying species that we were not able to recognize. ■

Table 1. Plants preferred by the Las Pavas community due to their desirable traits such as hard wood, resistance to termites and rot, and high local abundance.

Latin Name	Common Name	Uses
Anacardium excelsum (Anacardiaceae)	Espavé	walls
Byrsonima crassifolia (Malpighiaceae)	Nance	fences, firewood, fruit
Byrsonima spicata (Malpighiaceae)	Nancillo	roof material, firewood
Casearia commersoniana (Flacourtiaceae)	Coloraito	roof material, firewood
Cedrela odorata (Meliaceae)	Cedro	walls
Colubrina glandulosa (Rhamnaceae)	Carbonero	roof material, fences, firewood
Cordia alliodora (Boraginaceae)	Laurel negro	roof material, walls, arrows, wooden handles, fences, firewood
Coutarea hexandra (Rubiaceae)	Azulejo	roof material, firewood
Miconia argentea (Melastomataceae)	Papelillo, dos caras	fences, firewood
Phoebe cinnamomifolia (Lauraceae)	Sigua blanca	firewood
Pochota quinata (Bombacaceae)	Cedro espino	walls, living fences
Siparuna guianensis (Monimiaceae)	Pasmo hediondo	fences
Tabebuia guayacan (Bignoniaceae)	Guayacán	wooden handle, fences
Tabebuia rosea (Bignoniaceae)	Roble	walls, dead fences
Terminalia amazonica (Combretaceae)	Amarillo	roof material, dead fences, firewood

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ARTICLES ON BCI TREE POPULATION GENETICS BY J. HAMRICK, J. NASON, AND E. STACY

Sinharaja Forest Dynamics Plot: Some Reflections

Nimal Gunatilleke, University of Peradeniya

> THE VEGETATION SAMPLING AND MAPPING AT FIRST SEEMED A HERCULEAN TASK

As I prepare this report in the first week of March 1996, a message from the field team leader, Ajith Ethugala, arrives saying "everything here in Sinharaja is going well and we hope to finish the enumeration of the 25-ha Forest Dynamics Plot within another five days." Having inaugurated the Forest Dynamics Plot work back on 12th August 1993, in collaboration with Prof. Peter Ashton (Harvard University) and Dr. James LaFrankie (CTFS), it was indeed a most welcome and heartening message. At this point, it is well worth reflecting on how we accomplished this immense task.

From the outset, the Sinharaja plot was identified as a project to promote local capacity building in every aspect of its establishment and maintenance (*Inside CTFS*, Fall 1994, p.4). The initial phase of the project activity, gridding the plot, was carried out by field assistants and surveying students from the Faculty of Engineering, University of Peradeniya. Their mentor was the lecturer in surveying, Mr. Gamunu Gurusinghe, who transformed our need for a topographic grid into an academic exercise for engineering students. Their task was to prepare a mock design for the construction of a reservoir within the 25-ha plot, selecting the most suitable location across two streams to site a dam. The hilly terrain of Sinharaja was indeed a challenge amid the ever-present risks of tree falls, constant downpours, slippery footpaths, and leeches conducting their own surveys on the surveyors. Under these difficult conditions, the students set up and leveled the theodolite on steep slopes, took readings under poor light conditions, and dealt with high humidity misting up the lenses of the instruments — all without removing any plants along the path of vision. In all, about 30 engineering students from throughout Sri Lanka, most of whom had never been to a rain forest, participated at different times during this project.

The vegetation mapping and sampling at first seemed a Herculean task. However, we had the advantage of the long-standing experience from a core group of assistants, a local women's team, and vacationing students from nearby towns. Not only did these groups know the forest well, but they also had a very good rapport with the village youth, who actively assisted in sampling.

As the vegetation sampling progressed, the distance between the plot and field station increased, limiting the time available for field work. This compelled us to establish a satellite field camp, with the permission of the Forest Department, near the southern border of the plot. While this camp greatly facilitated the progress of the enumeration, it also provided some of the workers with a once in a lifetime experience of living inside a rain forest.

Identifying herbarium material and processing field data has been carried out at the University of Peradeniya. Each set of field data is entered twice using a computer program developed by Computer Science graduate students at the University of Peradeniya. By the end of July, we hope to complete the remaining herbarium identification, data entry, and further demarcate the Forest Dynamics Plot into 5 m x 5 m quadrats.

The collaborative effort has undoubtedly been worthwhile for the following reasons: First, the 25-ha plot is the only site within lowland, wet zone, Sri Lankan rain forest, where growth increment and productivity data for both timber and non-timber species is being recorded. Second, the plot has been the venue for field training of botany and engineering undergraduates. Recently, botany undergraduates at the University of Peradeniya participated in a 10-day field course which focused on plot enumeration, data entry, writing group reports, and presenting seminars based on their findings. The plot studies, along with other research at Sinharaja, is already built into the undergraduate and graduate curriculum in botany at the University of Peradeniya. Also, we hope to use the site for future field work, particularly for a proposed M.Sc. course in Wildlife Ecology and Management. Third, the plot has provided tropical rain forest experience for Sri Lankan and foreign undergraduates and graduates. For example, Harvard University undergraduates have studied the floristic composition of large canopy gaps in the plot and have monitored bird flock behavior in the regenerating forest along access roads to the plot. Botany and computer science graduate students from the University of Peradeniya have had the opportunity to pursue their post graduate training in a wide variety of plot related research.

What do we dream for the future? Until now, the field courses conducted at Sinharaja have been the effort of a few individuals. With the establishment of the plot and all the other interdisciplinary research activities in place at Sinharaja, it would be ideal to have a field education program for 2-3 weeks duration each year, for students in biology, wildlife ecology, and forestry. We also hope to see additional Forest Dynamics Plots established in differing forest types and climatic zones around Sri Lanka. Although Sri Lanka is relatively small, it is a highly diverse island with many different forest types. These plots would provide information imperative for sustainable management of these forest types, including their traditional use and conservation of their biodiversity.

The success of setting up the Sinharaja long-term Forest Dynamics Plot rests with many groups of people. We are deeply indebted to all who have participated in all stages. At this point, I would like to acknowledge the generous financial aid we have received from the MacArthur Foundation, the Smithsonian Institution, and the Norwegian Aid Agency to implement the plot work. We also extend our thanks to the Forest Department of Sri Lanka who permitted us to use the facilities at the field station at Sinharaja. ■

Singapore's Tropical Forests and Beyond

Shawn Lum, Ayesha Ercelawn, and Lee Sing Kong, National Institute of Education

Singapore's recent visibility in the international media has not focused much on its tropical forests. Admittedly, with only 30 km² of forest cover, Singapore is not the first country to come to mind when one thinks of the quintessential "rainforest." Nonetheless, the end of 1996 will mark four years since the Center for Tropical Forest Science (CTFS) and the National Institute of Education (NIE), part of the Nanyang Technological University, signed a Memorandum of Understanding. This vigorous collaboration has fostered ongoing administrative, research, and educational activities, bringing important attention to Singapore's forests. The administrative base for this collaboration is centered at the office of Dr. James LaFrankie, CTFS Asia Program Coordinator, at the National Institute of Education.

NIE and CTFS recently established a 2-ha Forest Dynamics Plot within the Bukit Timah Nature Reserve in eastern Singapore. The first plot census was carried out in 1993 by Dr. LaFrankie (CTFS) and Dr. Lee Sing Kong (NIE). In 1995, 14,629 individual trees, comprising 312 species and 60 families, were recensused within this plot. This recensus was supervised by Ms. Ayesha Ercelawn as part of her NIE-based M.Sc. research project. Ms. Ercelawn led a team of four undergraduate forest neophytes, who quickly became highly proficient at tree measurement and identification under her tutelage. The first analyses of the dynamics of this fragmented tropical Asian forest should appear by end of 1996. Ms. Ercelawn has already made a big impact on the CTFS-NIE research project, having collected, identified, and completed voucher specimens and untangled problematic data from the first census.

The CTFS-NIE collaboration has been particularly significant from an educational perspective. The National Institute of Education is Singapore's primary teacher-training center; every teacher in Singapore's public schools passes through its doors. Members of the Biology Division of the NIE regularly take future teachers to the 2-ha plot to acquaint them with forest flora and ecology, as well as to illustrate the value of long-term research and the need to understand the dynamics of the Bukit Timah forest, arguably Singapore's most important nature reserve.

The Bukit Timah site also has been used as a model and training ground for research methodology for the CTFS network. In November 1994, a course for Asian plot-based foresters was conducted at NIE by Dr. LaFrankie and Ms. Suzanne Loo de Lao of CTFS. Additional courses, workshops, and seminars in Singapore are also being planned by CTFS and the National Institute of Education.

Many readers of this newsletter may already be receiving e-mailed information on current happenings in Asian forests from the desk of Dr. LaFrankie. An example of recent electronic updates initiated by LaFrankie's network has been news of a mass flowering of trees in Malaysian Forest Dynamics Plots in the Peninsula and in Sarawak. If you would like to be added to this e-mail list, please contact Dr. LaFrankie at "ctfs@am.nie.ac.sg." ■

TREE FLORA OF PASOH FOREST

K.M. Kochummen, Forest Research Institute Malaysia

The establishment of a 50-ha Forest Dynamics Plot in Pasoh Forest Reserve, Peninsular Malaysia, and the enumeration of hundreds of thousands individuals has provided the opportunity to compile comprehensive descriptions of all living trees within Pasoh. In total, 335,240 stems ≥ 1 cm dbh spanning 814 species, 290 genera, and 78 families were recorded. Additionally, the surrounding forest flora outside the plot was also surveyed and additional species not present within the plot were identified. For each species, we gathered descriptive information such as buttresses, stilt roots, bole appearance (eg. fluted or cylindrical), bark types (eg. smooth or fissured), texture of inner bark, color of latex, smell of cut bark, and color of inner bark.

This work recently has been completed and compiled in a book entitled, *Tree Flora of Pasoh Forest*, and will soon be published by the Forest Research Institute of Malaysia (FRIM). This book will cover many aspects of the Pasoh flora including: a) vegetative characters useful for tree identification, including color photographs of different bark types and illustrations of leaf features; b) a key to some common species based on spot field characteristics; c) a key to species based on bole characteristics which have been divided into smooth bole, fluted bole, scaly bole and dippled bole and; d) a key to species based on leaf characteristics. Also included are descriptions of species, genera, and families.

Since FRIM has already published a general flora entitled, *Tree Flora of Malaya*, descriptive notes on families, genera, and species are given minimum treatment in *Tree Flora of Pasoh Forest*. The plan adopted here is to give a general description of the family; keys to the genera and species present within each family; short descriptions of each genus; and short field descriptions of all species ≥ 10 cm dbh. In large families like Annonaceae and Euphorbiaceae, it is difficult to key out the genera based solely on vegetative characters. Therefore, a key based on reproductive characters is included for all species within these families. This account also gives the distribution of species within the 50-ha plot including their ecological preferences and the number of stems ≥ 10 cm dbh recorded.

In other floras, taxonomic treatments of genera and families seldom contain information on bark and bole characters, despite their importance for identification in the tropics. Moreover, their reliance on reproductive traits can be problematic since flowering and fruiting are often erratic and unpredictable — sometimes occurring over intervals of several years. The *Tree Flora of Pasoh Forest* will fill this information gap for a large number of tree species in the Malaysian tropics and will be useful for monographers of plant families in the Malaysian region. This book will also serve as a plant identification guide for biologists, nature lovers, students of biology, and anyone interested in the tree flora of this region. Since the book contains descriptions of about a quarter of all tree species present in Peninsular Malaysia, most of which are also found in other Malaysian regions, the guide should be useful throughout the region.

Tree Flora of Pasoh Forest is expected to be published by the end of September 1996 as a Malayan Forest Record. It can be purchased by writing to: Publication Division, FRIM, Kepong, Selangor, 52109 Kuala Lumpur, Peninsular Malaysia. ■

NEWS SECTION

Colombia

A new 25-ha Forest Dynamics Plot has recently been established in La Planada, sponsored by Instituto von Humboldt. Located at an elevation of 1800 m, The plot is situated on flat terrain. La Planada receives around 4000 mm of annual rainfall with no pronounced dry season. Although the forest contains many tall trees, the canopy is mostly low and the undergrowth extremely thick. La Planada appears to contain mature forest, as evidenced by common "old growth" species.

Ecuador

Despite a serious setback caused by a car accident on route to Yasuní National Park, field teams are advancing admirably on the enumeration of a 50-ha Forest Dynamics Plot in Yasuní. Approximately one-third of the plot has been mapped and measured. Tree identification is proceeding more slowly — field identifications and collections were recently completed for 2 ha — due to the extremely high level of species diversity. It is expected that, once identifications are finalized, the first 2 ha will include approximately 700 species.

Puerto Rico

The University of Puerto Rico and the International Committee of the US Long-Term Ecological Research (LTER) Network hosted a workshop to promote the development of a LTER network in Latin America. In attendance were representatives from most Latin American countries, including CTFS partners from Puerto Rico and Colombia. Dr. James LaFrankie represented the CTFS network.

India

The second complete recensus of the 50-ha Forest Dynamics Plot in Mudumalai Wildlife Sanctuary is currently being carried out by field teams from the Centre for Ecological Sciences of the Indian Institute of Science. The annual recensus of mortality and recruitment in the large plot is now in its ninth year.

Philippines

Enumeration of a 8-ha Forest Dynamics Plot in Palanan Wilderness Area was completed in April 1996. At that time, the field identification and plant collection phase of the project was launched with a training course led by Dr. James LaFrankie. Species identification is expected to be completed by September of this year.

Isabela State University, Conservation International, and CTFS are currently working closely with PLAN International to implement a new project in Palanan aimed at biodiversity conservation through poverty eradication and rural development.

Thailand

Species identifications are due to be finalized this September, signifying the completion of the first census of the 50-ha Forest Dynamics Plot at Huai Kha Khaeng Wildlife Sanctuary. Mr. B. Sarayudh and Dr. James LaFrankie will soon begin preparing the first publication from this plot.

Mr. Patrick Baker, a graduate student from the University of Washington, is living in HKK and carrying out doctoral research on habitat specificity of dipterocarp seedlings.

Sarawak, Malaysia

A light general flowering around Lambir Hills National Park began in March of this year. Japanese colleagues responded in force, as dozens of students and assistants came to Lambir under the supervision of Dr. Tamiji Inoue of Kyoto University and Abang Hamid of the Sarawak Forest Department to record flower phenology and pollinator biology.

Lisa Delissio, a graduate student at Boston University, is working on seedling demography and is in residence at the CTFS research quarters through August of this year.

The first recensus of the 52-ha Forest Dynamics Plot in Lambir is scheduled to begin in 1997 through a partnership of Sarawak Forest Department, a consortium of Japanese universities, and CTFS.

Peninsular Malaysia

Forest Research Institute of Malaysia (FRIM) field teams will soon complete the second recensus of the 50-ha Forest Dynamics Plot in Pasoh Forest Reserve. Kalan Ickes, a graduate student at Louisiana State University, is currently in residence at Pasoh continuing his doctoral research on impact of wild pigs on forest dynamics and assisting the FRIM teams.

Cameroon

The Bioresources Development and Conservation Programme (BDCP) and CTFS are embarking on a project on medicinal plant development, monitoring, and conservation in Central and West Africa, sponsored by the International Cooperative Biodiversity Group (ICBG) Program. As part of this project, two Nigerians and two Cameroonians recently participated in a workshop in Front Royal, Virginia, on biodiversity monitoring and measuring, hosted by the Smithsonian Institution/Man and the Biosphere Program. Similar workshops will be held in Cameroon and Nigeria later this year and early next year. Initiation of a large Forest Dynamics Plot in Korup National Park, Cameroon, will begin later this year.

Zaire

Having completed the enumeration of four 10-ha Forest Dynamics Plots in the Ituri Forest earlier this year, botanists and field teams are engaged in the final phase of their first plot census: completion of species identifications and data entry. At present, the plots contain more than 400 species, though corrections to this list are still being made. The census is due to be completed this November.

A corrected version of a table from *Inside CTFS* (Fall 1995, page 14) appears below:

Table 1. Forest Dominance by DBH Size Class

		Percent stems/ha for DBH classes		
Plot	Principal Canopy species	≤10 cm	0-30 cm	≥30 cm
Lenda	*Gilbertiodendron dewevrei*	3.4	49.0	78.9
Edoro	*Cynometra alexandri*	3.2	14.1	38.2

THE CENTER FOR TROPICAL FOREST SCIENCE

OVERVIEW

The Center for Tropical Forest Science (CTFS) is a program within the Smithsonian Tropical Research Institute that joins together—through formal memoranda—a voluntary association of natural and social scientists and institutions around the world. The mission of CTFS is to promote and coordinate long-term biological and socio-economic research within tropical forests and forest-dependent communities, and translate this information into results relevant to forest management, conservation, and natural resource policies. To achieve its objectives, natural and social scientists associated with CTFS work with collaborators in forestry departments, universities, and non-governmental organizations to develop a network of long-term forest research programs. The primary involvement of CTFS is to coordinate and standardize research at different sites. CTFS also provides technical assistance and training to the extent needed at each site.

A unifying research tool shared by all CTFS research sites is the Forest Dynamics Plot. These are large (up to 52-hectares), permanent forest demographic plots that are situated in natural forests. All trees with a diameter at breast height of one centimeter or greater are mapped and monitored. An initial census and periodic recensuses yield long-term information on species growth, mortality, regeneration, distribution and productivity in relation to topography, hydrology, soils, climate and biotic factors. The plots, due to their large size, are capable of dealing with the high tree diversity of tropical forests.

The CTFS network of long-term forest research programs will soon be tracking approximately 2,500,000 individual trees of almost 3,000 species throughout the world's tropics. CTFS has initiated collaborative research programs in Barro Colorado Island (Panama), Luquillo Experimental Forest (Puerto Rico, USA),Yasuní National Park (Ecuador), La Planada (Colombia), Pasoh Forest Reserve (Peninsular Malaysia), Lambir Hills National Park (Sarawak, Malaysia), Sinharaja World Heritage Site (Sri Lanka), Huai Kha Khaeng Wildlife Sanctuary (Thailand), Mudumalai Wildlife Sanctuary (India), Palanan Wilderness Area (Philippines), Bukit Timah Nature Reserve (Singapore), Korup National Park (Cameroon), and Ituri Forest (Zaire).

CTFS received major core support from the John D. and Catherine T. MacArthur Foundation in 1991 in order to promote closer cooperation between participating programs. The CTFS Latin American program has received significant core funding from STRI. The CTFS Asia program has received significant core support from the Rockefeller Foundation, the John Merck Fund and STRI. Significant in-kind support is also contributed by CTFS partners in projects around the world. Many other donors, too numerous to mention here, have provided support to individual CTFS research programs. ■

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CTFS Partners are encouraged to send copies of all publications to the same address.

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