

40th Anniversary



Tropical Science for the 21st Century

■ Symposium

April 3, 2003

University of Costa Rica

San José, Costa Rica

where science and nature converge



Organization for Tropical Studies

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Symposium schedule

- 7:30** buses depart hotels (Tournón and Radisson) for UCR
- 8:00** **Gary Hartshorn, President and CEO of the Organization for Tropical Studies**
Welcome
- 8:15** **Abel Pacheco, President of the Republic of Costa Rica [invited]**
Official Opening of Science for the 21st Century Symposium
- 8:45** **Gabrial Macaya, Rector of the University of Costa Rica [invited]**
Welcome Remarks
- 9:15** Coffee Break
- 9:45** **Edward O. Wilson, Harvard University**
The Future of Tropical Biology
- 10:45** **Sally Horn, University of Tennessee**
Understanding Historical Effects: Paleoecology of Costa Rica
- 11:35** Lunch Break (lunch available throughout this time)
12:10 & 12:30 Guided walks to site of new OTS facility
12:00 – 1:00 Poster Session
- 1:00** **Pedro León, University of Costa Rica and CENAT**
Molecular Biology's Impact on Field Ecology
- 1:50** **Cynthia Neal Spence, Spelman College and UNCF/Mellon Programs**
The Imperative to Transform the Academy: The Minority Recruitment and Retention Agenda
- 2:40** Coffee Break
- 3:00** **Deborah Clark, University of Missouri-St. Louis**
Tropical Rain Forests and Global Climate Change: Big Impacts on the Horizon
- 3:50** **Harry Greene, Cornell University**
Keeping Organisms a Central Focus in Biology
- 4:40-6:00** Poster Session
- 5:00** Reception
- 7:00** buses return to hotels



Message from the Chairperson and President

In the late 1950's and early 1960's many biologists in the U.S. and Costa Rica recognized the need for graduate-level, science-based field courses in the tropics. Graduate students were not being exposed to field research in one of the most complex environments on earth and home to nearly 70% of the world's biodiversity. (In fact, the term biodiversity had yet to be coined.) After several years of meetings and conferences these biologists persevered in 1963. With the help of the U.S. National Science Foundation they formed the Organization for Tropical Studies (OTS) as a university consortium dedicated to graduate training in tropical biology. The OTS consortium has evolved in size and scope in 40 years and now stands as a consortium of 64 universities and research institutions from seven countries on four continents.

Soon after the first courses were in the field, the need for protected areas with permanent facilities and equipment was recognized. Over the next decade OTS established three biological stations in Costa Rica in contrasting ecosystems: La Selva, Las Cruces and Palo Verde. Then, and now, researchers came to these protected sites to conduct their research and consequently, have served tirelessly as lecturers and resource people in OTS courses, helping the consortium to train the next generation of scientists and environmentally-aware leaders. Partnerships with the communities surrounding the stations on environmental issues, conservation and employment, have established OTS as an active and responsible corporate citizen. Today, we work with the Costa Rican government to conserve more than 100,000 hectares of tropical ecosystems and their biodiversity.

OTS was fused together by three core principles: science, education and conservation. Our perennial training program is vital to ensure scientific discovery that enables sound conservation decisions. In the words of Baba Dioum, "In the end, we will conserve only what we love. We will love only what we understand. We will understand only what we are taught."

We dedicate Tropical Science for the 21st Century events to all the eternal students — seeking knowledge from nature, from each other and from the human potential inside us. We hope you enjoy the multiple events celebrating OTS' 40th anniversary.



Pedro E. León A., Ph.D.
OTS Chairperson



Gary S. Hartshorn, Ph.D.
OTS President and CEO



OTS timeline

40 Years of Education, Research and Conservation in the Tropics

1963 Consortium Founded

Dan Janzen
Student in
Fundamentals
Course



1968

La Selva
Biological Station
Purchased

Jack Spencer
Named
Executive Director

First NSF
Research Grant
Awarded
for Comparative
Studies at
La Selva and
Palo Verde

Founders:

Norman Hartweg,
University of Michigan

Stephen Spurr,
University of Michigan

John De Abate,
University of Costa Rica

Rafael Lucas Rodríguez Caballero,
University of Costa Rica

Henry Leigh,
University of Miami

Eugene Man,
University of Miami

James Bethel,
University of Washington

Ray Noggle,
University of Florida

Reed Rollins,
Harvard University

Edward O. Wilson,
Harvard University

Leslie Chambers,
University of Southern California

Jay Savage,
University of Southern California

Bill Argersinger,
University of Kansas

1965

Dan Janzen and
Norman Scott
Reformat
Graduate Courses
into a
Problem-Oriented
Field Biology
Program

1964

Bill Hatheway
First Executive
Director

Fundamentals
Course Led
by Les Holdridge,
Bill Hatheway
and
Dan Janzen

1965

Tropical Forest
Ecology Course
Led by
P.W. Richards

Steve Preston
Named
Executive Director

1967

Jorge Campabadal
Hired as
Resident Director
in Costa Rica

1969

Palo Verde
Biological Station
Leased



Charter Universities:

University of Michigan

University of Costa Rica

University of Miami

University of Washington

University of Southern California

University of Florida

Harvard University

University of Kansas

University of California



1972
Ken Turnbull
Appointed
Executive Director

1974
First
Graduate Course
in Spanish
Led by Gary Stiles,
Doug Robinson
and Sergio Salas

1976
RIAS Fellowship
Program Began
◆
First NSF Grant
for La Selva
Operations



1982
Stone Bridge
Constructed
at La Selva

1973
Las Cruces and
Wilson Botanical
Garden Acquired
◆
Chip Taylor
Coordinated
73-1 Course

1975
First Course
in Agroecology



Don Stone
Becomes
Executive Director

◆
North American
Headquarters
Relocates from
University of
Washington to
Duke University

1979
UNA Joins
Consortium

1980
First Andrew
W. Mellon Grant
Awarded to Support
Graduate Courses
◆
Deborah and David
Clark Become
La Selva Station
Co-Directors

1982
Zona
Protectora
La Selva
Decreed to
Connect
with Braulio
Carrillo
National Park





1984

La Selva Initiates Environmental Education Program in Local Communities



1987

Wilson Botanical Garden Dedicated at Las Cruces Biological Station

1986

Peter Raven Becomes President

Road to Palo Verde Completed

1988

Gordon Orians Elected President

1983

Recognized by Costa Rica as an "Institution of Public Benefit"

First Lab Built at La Selva

Costa Rica Natural History Published

1985

Awarded John and Alice Tyler Prize for Environmental Achievement



1988

25th Anniversary Celebration and Symposium; University of Miami and Museo Nacional, Universidad de Costa Rica

First Environmental Science and Policy Courses: U.S. Decision-Makers and Latin American Decision-Makers Courses

1992

Palo Verde Biological Station, part of Rafael Lucas Rodríguez Caballero Wildlife Sanctuary, incorporated into Palo Verde National Park

Board of Visitors Established

1986

Costa Rican President Monge Declares the Zona Protectora Part of Braulio Carrillo National Park, connecting La Selva to the park

Luis Diego Gómez Appointed Las Cruces/Wilson Garden Director



1993

Palo Verde Declared Ramsar Site (a wetland of international importance)

1996

Gary Hartshorn Becomes Executive Director

Eugenio González Named First Director of Palo Verde Biological Station



1999

First Graduate Course in Perú

Minority Scholarship Program Initiated

2003

40th Anniversary Marked by Symposium, Banquet and "Boot Camps" in Costa Rica

2002

Successful Completion of A.W. Mellon \$2.5 million Challenge for Endowments

1994

La Selva: Ecology and Natural History of a Neotropical Rain Forest Published



Las Cruces Fire

1997

First Undergraduate Semester Abroad Program

Pedro León, First Costa Rican Elected Chair of the Board



2000

ESA Award of Special Recognition and Merit

1999

James Cook University (Australia) Joins the Consortium as the First Old World Member

Electricity Installed at Palo Verde

2002

Funding Received to Initiate Undergraduate Program in South Africa

First Graduate Course Offered in South Africa and in Perú's Manu National Park

1998

Jorge Jiménez Appointed Director in Costa Rica

Bob Matlock, Jr. Named Scientific Director of La Selva Biological Station



OTS timeline

40 Years of Education, Research and Conservation in the Tropics

speakers' abstracts

EDWARD O. WILSON, HARVARD UNIVERSITY

The Future of Tropical Biology

I will review the scope of global and particularly tropical biodiversity, along with estimates of on-going species extinction rates and what is known about the causes of extinction. I will also make the case for a global all-species inventory as a key enterprise in future tropical biology.

SALLY HORN, UNIVERSITY OF TENNESSEE

Understanding Historical Effects: Paleoecology of Costa Rica

Is there a future in studying the past? Why, as we enter the 21st century, is it useful for tropical ecologists to look backward in time as well as forward? In this presentation I describe how paleoecological analyses of lake and swamp sediments and soils in Costa Rica are helping to elucidate the “natural” conditions and dynamics of tropical ecosystems and to document the ways in which they have been altered by past and present human activity and by climate variability and change. Drawing upon more than a decade of research at OTS stations and other research sites ranging from near sea-level on both coasts to the country’s highest peaks, I will describe what we know now, and can in the future hope to learn, about the long-term history of Costa Rican ecosystems — and why it’s worth our time to pursue this knowledge.

PEDRO LEÓN, UNIVERSITY OF COSTA RICA AND CENAT

Molecular Biology's Impact on Field Ecology

The XX century saw the expansion of the life sciences from a minor bucolic science, to an impressive construction of ever expanding symbiotic relations between “science” and “technology”; theories and the instruments to test them. Darwin and Mendel laid the basis for the XX century biology and early into the century fruit-flies revealed the existence of mutations to allow for a theory of evolution that brought Darwin and Mendel into consilience. After Watson and Crick's revelation of the structure of DNA, a snowball effect quickly led to a coherent explanation of cell function as protein synthesis, replication, transcription became understood. Sequencing of the DNA molecule yet again led to a rush of new knowledge, as precise phylogenies could now be proposed using diverse approaches, and genomes could be cloned and analyzed. Thence the genome projects for many bacteria and some 6 eukaryotes including humans, now publicly available, a huge store of mineable data for anyone with a computer and an internet connection.

Not unexpectedly, extensive sytheny between related genomes is widely encountered, particularly among higher eukaryotes (plants, mammals, insects). Comparative sythenic studies may soon provide a new source of information for phylogenetic reconstruction as more genomes are sequence and more powerful tools of analysis emerge. It is possible that precise explanations for many macroevolutionary processes will become available, as intermediate genomes are sequenced at appropriate sites. Loss of limbs in caecilians, snakes and other reptiles may have straight forward explanations, such as mutation of regulatory sequences (i. e. *hox* genes), deletion of these genes, mutation in coding regions, mutations on regulatory pathways or insertion of silencing elements around important regulators sites are only some of these possibilities. With the new tools many other mechanisms may be explained, such as the eye rotation in the head of flatfish, the emergence and evolution of sex chromosomes and the rise of genomic parasites in animals with very large genomes. Ultimately the process of embryogenesis with its myriad pathways and synergisms, will be understood.

The new tools of molecular biology, including the astonishing process of the polymerase chain reaction (PCR), makes it feasible to study individuals from populations of soil bacteria to social insects, trees, birds and small mammals. With PCR, minute amounts of tissue sample are sufficient so that populations studies of large animals is usually feasible. OTS has taken notice, and last year we offered the first field course on molecular techniques in field studies, relaying extensively on the PCR. Thirteen students from the USA, Costa Rica, Colombia and Brazil participated and actually got results! The basic structure is in place at La Selva, and we hope this approach continues, providing important baseline data that can be stored in digital form for future comparisons. Many opportunities are now open and we hope researchers from member universities take notice.

CYNTHIA NEAL SPENCE, SPELMAN COLLEGE AND UNCF/MELLON PROGRAMS

The Imperative to Transform the Academy: The Minority Recruitment and Retention Agenda

Higher Education has been and continues to be dominated by faculties and staffs that do not reflect the global society that characterizes the “real world.” Scholars of European descent dominate bibliographic references for prominent scholars in all disciplinary areas, with the exception of African American Studies and various versions of Diaspora Studies. In some disciplinary areas, the presence of non-Asian persons of color with advanced degrees is almost non-existent. This is particularly true in the sciences. As we look across the U.S. higher education community and throughout the world where persons of color reside, one among many commonalities is the fact that the major universities and academic disciplines do not reflect their presence. There are a number of reasons to explain this phenomenon. The contention of this paper is that the primary reason for the limited representation and/or absence of persons of color in the academy is because of historical and institutional impediments to access to quality education at all levels.

The most significant purveyors of knowledge and transformation within the academy are the faculty. According to the *Minorities in Higher Education 2001-2002 Nineteenth Annual Report*, African American, Hispanic and Native Americans represent less than 10% of all faculty. In the U.S., non-Asian persons of color earned approximately 5% of all Ph.D.'s. African Americans, Hispanics and Native Americans continue to lag behind their Asian counterparts and are totally dwarfed by their European descendant counterparts. In the scientific fields, the representation of African Americans, Hispanics and Native Americans is less than 3% of all Ph.D. degrees earned. The absence of these voices in the academy and other research communities is problematic.

These statistics point to a very serious deficit in the generation, exploration and declaration of knowledge in the academy and the external research community. The absence of persons of color in the academic enterprise compromises scholarly discourses in all areas. The 21st century demands that we respond to and reflect the diverse environments of our existence. Diversity within the higher education community is celebrated because of the richness and texture it adds to the curricular and co-curricular environment of the academy. Diverse ideas and experiences converge to form new ways of knowing and examining social and scientific phenomena.

One of the most valued characteristics of education at any level is its ability to transform individuals and knowledge. Programs designed to generate a pipeline of minority scholars are vital to the sustainability of a system of higher education that seeks to examine and interrogate social and scientific constructions of reality. Early identification and recruitment programs targeting persons of color serve to challenge notions about the place of minorities in the academy. Partnership programs with minority serving institutions are essential to the creation of a cadre of young minority scholars who will join their European-descent brothers and sisters in the transformation of the academy and the transformation of knowledge.

DEBORAH CLARK, UNIVERSITY OF MISSOURI-ST. LOUIS

Tropical Rain Forests and Global Climate Change: Big Impacts on the Horizon

Recent research findings from Costa Rica, along with data from other parts of the tropics, indicate large negative impacts on tropical rain forests from the on-going changes in global climate. Forest-wide rates of tree growth showed strong declines in the warmer years of the last decades, and there were large increases in tree mortality in the record-hot 1997/98 El Niño year. A new analysis of the year-to-year changes in atmospheric carbon dioxide levels has revealed very large CO₂ emissions from the terrestrial tropics in warmer years. These discoveries have large implications at the global scale. If higher temperatures were causing an increasing imbalance between photosynthesis and respiration in tropical rain forests, the net impact would be a positive feedback on the rate of global warming. This new understanding of strong connections between forest health in the tropics and the rate of climate change is built upon the results of some exceptional long-term studies. There is an urgent need to develop and maintain such long-term monitoring in tropical rain forests around the world.

HARRY GREENE, CORNELL UNIVERSITY

Keeping Organisms a Central Focus in Biology

Theories tell us what to measure, where to look, and what we don't know, and they encapsulate the current state of science; experiments help us confirm, refute, and refine theories. I will emphasize, however, that discoveries of new organisms and new things about organisms reset cycles of hypothesis testing and thus lead to new research directions. Organisms — not theories and experiments — are the functioning arenas for morphological, behavioral, and physiological systems; organisms are the fundamental packages in which life persists, varies, and reproduces, and they are the building blocks of populations, communities, and ecosystems. Theories and experiments are essential to good science, but organisms themselves, their patterns of diversification, and their environments should continue to be a central focus of tropical biology.



poster
abstracts

Poster 1

Reforestation planning in the West Usambara mountains of Tanzania

James J. Halperin, Theodore Shear, Heather Cheshire, Thomas Wentworth and Panteleo Munishi

Department of Forestry, North Carolina State University, USA

Faculty of Forestry and Nature Conservation, Sokoine University of Agriculture, Tanzania

Rural reforestation planning is critical to the success of many conservation initiatives in the humid tropics. Although often neglected, careful planning can have a profound impact on the success or failure of such initiatives. The first step in developing a conservation initiative is to accurately quantify existing forest resources for prioritization of areas for intervention efforts. Next, planners must consider the interaction of people and environment to develop site specific plans that maximize potential sustainability. Here we develop a reforestation planning methodology for communities adjacent to mountain forests in Tanzania. The forests within this 2,200 km² mountain range harbor many endemic species and provide critical water catchment protection. First we quantify forest distribution using LandSat7 ETM satellite image data for one of the more significant ranges in the Eastern Arc Mountains, the West Usambaras. We then describe forest fragmentation using a variety of landscape metrics. The planning process then focuses on one watershed, the Mkolo River drainage in the southeastern West Usambaras. Using GIS and remote sensing techniques, we incorporate environmental needs assessments, forest regeneration potential, and socioeconomic requirements of local communities to account for the varying services that tree planting provides. We account for these services in a spatially explicit forestry intervention need index (FINI). This multi-stage assessment of natural resource distribution and use develops a procedural methodology that is critical in planning and implementing reforestation projects in species-rich tropical regions.

Theodore Shear ■ ted_shear@ncsu.edu

Poster 2

Testing corridor efficacy with forest birds in the tropical dry forests of Costa Rica

Cameron S. Gillies¹, Colleen C. St. Clair¹ and Arturo Sánchez-Azofeifa²

¹Department of Biological Sciences, University of Alberta, Edmonton, Alberta, T6G 2E9, Canada

²Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Alberta, T6G 2E3, Canada

Tropical forest destruction and fragmentation may be disrupting the movement of forest birds. Corridors have been widely advocated and implemented as a way of mitigating these impacts in the tropics and elsewhere. To test the efficacy of riparian corridors and fencerows in facilitating movement, we translocated territorial individuals of two species of forest birds 0.7 to 1.9 kilometers in three treatments: along riparian corridors, along fencerows, and across open fields. We then closely followed their return with radio-telemetry. This research was carried out near Liberia, in northwestern Costa Rica.

Returns of both species were more likely and quicker over shorter distances. The two species differed, however, in their response to the three treatments. Returns of the moderately forest dependent *Campylorhynchus rufinucha* (Rufous-naped Wren) did not differ among treatments. In contrast, the returns of the more forest dependent *Thamnophilus doliatus* (Barred Antshrike) were more likely and faster in translocations along a riparian corridor than translocations across open fields. Returns in fencerows were intermediate. There was also an important difference between these two species in how they returned to their territories. *C. rufinucha* translocated along fencerows frequently used these fencerows in their return, whereas the *T. doliatus* that returned in fencerow treatments always did so via longer routes in more continuous forest and rarely used fencerows. These results suggest that 1) riparian corridors do facilitate the movement of forest-dependent birds through fragmented areas and that 2) fencerows are not sufficient to facilitate such movement and it is likely that substantial forested corridors are required for the movement of the most forest-dependent bird species in the Guanacaste region of Costa Rica.

Cameron Gillies ■ cgillies@ualberta.ca

Poster 3

Conservation of tropical hardwood species by private sector organizations

William Woodbridge

CAMCORE, North Carolina State University, Raleigh, NC USA

Background Throughout the 20th century, tropical forests have been degraded and reduced in area by harvesting and conversion to other uses. Such activities harm the environment and reduce the genetic diversity within species. The *in situ* conservation of these forests is often impossible due to demands for forest products and land. An alternative strategy is *ex situ* conservation. A major obstacle is finding organizations that have the motivation and resources to make seed collections, establish *ex situ* plantings, and maintain plantings to reproductive maturity and beyond. CAMCORE is comprised of forest products companies and governmental forestry agencies. Since the early 1980's, CAMCORE has made seed collections in threatened forest stands and established *ex situ* plantings of 40 species, including 13 tropical hardwoods, mostly from Central America.

Objectives To demonstrate that the private sector has an important role to play in tropical forest species conservation through *ex situ* planting.

Methods

1. Using maps, show the extent of provenance collections made for 13 tropical hardwoods.
2. Using maps, reports, and site visits; demonstrate that populations have been reduced since the date of collection.
3. Document establishment, survival, and growth of *ex situ* conservation plantings
4. Assess long-term prognosis for *ex situ* plantings and determine potential for seed production and reintroduction into the countries of origin.

Results CAMCORE's role is to collect seeds for *ex situ* conservation plantings, analyze data from the trials, and publish information on adaptability and productivity of the various provenances tested. Since 1980, the Cooperative has established 2500 hectares of field trials in 15 countries. The success of *ex situ* plantings depends on the level of interest in the species, the technical expertise of the organizations maintaining the plantings, and the nature and performance of the species.

This poster would focus on results of *ex situ* conservation efforts of four different broadleaf species native to Central America and other tropical regions.

William Woodbridge ■ woodbridge@ncsu.edu

Poster 4

Comparative natural history and feeding ecology of two closely related ants, *Pachycondyla apicalis* and *P. obscuricornis*

Amy Savage

Western Washington University, USA

Pachycondyla apicalis and *P. obscuricornis* are two ponerine ant species that are morphologically and behaviorally very similar. They are common and abundant throughout Central America and often occur sympatrically. This study examined the nesting characteristics, daily cycles of activity, prey size distribution, composition of prey items, and proportions of incoming materials for colonies of *P. apicalis* (n=5) and *P. obscuricornis* (n=4). All of the *P. obscuricornis* colonies and 60% of the *P. apicalis* nests were located in rotting wood on the forest floor. The remaining *P. apicalis* colonies were located in tree buttresses. All nests appeared to have only one nest entrance, and *P. obscuricornis* workers consistently blocked the entrance to their nests with debris after foraging ended for the day. *Pachycondyla apicalis* did not display this behavior. Daily activity cycles were strictly diurnal, with crepuscular peaks at some nests. Eighty percent of the foragers returning to the nest at the end of the foraging day were not carrying anything. Prey was mostly insects, and the size of prey was significantly larger (nested ANOVA, $p < 0.001$) for *P. apicalis* than for *P. obscuricornis*. This study provides information about the natural history of these ants that was previously unknown. The results of this study are similar to those found in other studies about generalist tropical ponerine ant foraging characteristics. However, the nest entrance blocking behavior, diurnal cycles with crepuscular peaks in activity, significant differences in the size of incoming prey, and foraging efficiency are not found in all studies of tropical ponerines.

Amy Savage ■ savagea@cc.wvu.edu

Poster 5

Extrafloral nectary mediated ant-plant interactions in coastal Veracruz, México: Plant richness and seasonality and ant foraging patterns

Cecilia Díaz-Castelazo¹, Victor Rico-Gray¹, Paulo S. Oliveira² and Mariana Cuautle¹

¹ Departamento de Ecología Vegetal, Instituto de Ecología, A.C., Veracruz, México

² Departamento de Zoología, Universidade Estadual de Campinas, Brasil

We studied the extrafloral nectary (EFN)-mediated ant-plant interactions in the coastal vegetation of Veracruz, Mexico. We determined the richness and abundance of interactions (spatial and temporal), and the proportion and correlation of participating species and groups. To determine the abundance of EFN-bearing plants and ants in vegetation physiognomies, plant linear covers and ant species at honey baits were estimated during three seasons. We surveyed plant physiognomies for EFN-bearing plants visited by ants, during day and night, for two years. We recorded plant species, nectary location and ant individuals/species. 48 plant species (in 25 families) presented EFNs; its covers were larger during the wet season. 66% of the EFN-bearing plant species (largely Leguminosae) were visited by ants. 31 ant species of 18 genera were found in 208 associations with EFNs. 84% of the recorded ant species visited plants. Ant species composition differed between day and night; species richness was higher during day, although abundance was the same between periods. Neither ant nor EFN abundance differed among vegetation types but they did differ within vegetation types. Abundance of EFNs was positively correlated with ant species richness during the rainy season, and inversely correlated with ant abundance during the dry season. Seasonality in the use of extrafloral nectar could be the result of higher availability of EFNs during the rainy season. The proportion of EFN-bearing plants (16.5%) was generally higher than reports from other tropical and temperate habitats (5-15%), which indirectly enhances the importance of EFN-mediated plant protection by ants in coastal communities of Veracruz.

Cecilia Díaz-Castelazo ■ castelaz@ecologia.edu.mx

Poster 6

Plant protection and dispersion in *T. ulmifolia*: A multiple interaction approach

Mariana Cuautle and Victor Rico-Gray

Instituto de Ecología, A.C., Veracruz, México

Turnera ulmifolia is a plant with extrafloral nectaries (EFN), which are visited by ants and wasps, and elaiosome-bearing seeds, dispersed by ants. The objectives were (1) To evaluate the effect of EFN-visiting wasps and ants on the reproductive success on *T. ulmifolia*, and (2) to describe its dispersion system, in a sand dune in Mexico. For the first objective, we selectively excluded wasps and ants using a two-factor design (Wasps, Ants), both factors with two levels (Absent, Present). A significant greater number of reproductive structures were produced in plants with wasps. However, there was a significant Wasp*Ant interaction on herbivory levels and unripe fruit production. This is the first demonstration of a positive effect of wasps associated with EFN. For the second objective, a transect was divided in 10 rectangles (2x18m), all plants inside were marked. Under each plant, a dish with seeds was placed, and in an eleven minute period any kind of ant-seed interaction was registered and assigned a category from 0 to 5, being 0 no interaction and 5 a seed taken to a nest. This was done for the three seasons of the year. For each rectangle the interaction intensity was obtained as the sum of categories and balanced by plant number. The number of seedlings was also registered. A significant correlation ($r=0.82$, $p=0.003$) between interaction intensity and number of seedlings was found. These results show the importance of using a multiple interaction approach: no-ant visitors may be important plant defenders, and organisms may play more than one role (protection and dispersion).

Mariana Cuautle ■ cuautle@ecologia.edu.mx

Poster 7

Effect of ovule position within the pod on the probability of seed production in *Bauhinia unguolata* (Fabaceae)

Jorge I Mena-Ali² and Oscar J. Rocha¹

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²Dept of Biology, The Pennsylvania State University, University Park, PA USA

Abstract: Here we describe the effect of ovule position within the pod on the probability of seed abortion and seed production in *Bauhinia unguolata*, a tropical dry forest tree. Fruits were collected during the dry seasons of 1999, 2000 and 2001. The number of ovules as well as its position within the fruit (from the stylar to the basal end of the ovary) was recorded. Each ovule was classified into one of the following categories: non-fertilized, early aborted, lately aborted, damaged seed or mature seed. Nearly 30% of the ovules were not fertilized in 1999, but this percentage dropped to 5% the following two years. Seed abortion (50%) and seed damage (15%) were similar during the three years of study. Only 15% of the initial number of ovules developed into a mature seed in 1999, but this percentage increased to 35% in 2000 and 2001. However, these patterns of seed production were affected by the position of the ovule within the pod: non-fertilized and early aborted ovules were found most of the times near the basal end of the ovary; this could be due to differences in the vigor of pollen tubes. Late abortion was more common in stylar positions, which might be related to resource depletion along the vascular system of the fruit. Mature seeds were more likely found in the stylar half of the fruit, where ovules were fertilized by strong pollen tubes and have access to more resources than stylar ovules; frequency of damage was not affected by position. These findings suggest that the seeds produced within a fruit would differ in their vigor.

Jorge I Mena Ali ■ jim123@psu.edu

Poster 8

Cottage industries in Costa Rica: The case of butterfly farms and herpetariums

Erika Deinert and Mahmood Sasa

Undergraduate Semester Abroad Program, Organization for Tropical Studies, Costa Rica

Parallel to the development of the tourist industry in Costa Rica, there has been an increase in cottage industries that exploit natural resources through exhibition, management, reproduction and sales. In collaboration with USAP class of Spring 03, we analyzed the biological and socioeconomic impact of two such industries in the country: butterfly farms and herpetariums. Several farms and exhibitions were visited throughout the semester, and our students interviewed the owners and personnel in charge. The students asked for information about history, administrative management, biological management, and potential impacts of each activity.

Live exhibits and reproduction programs are the most important economic activities of both industries, but some differences were noted. Butterfly farms are more numerous and widely spread across the country. Initial investment costs are low and the centers can be managed by a few personnel. There are 5 licensed exporters, who not only produce pupae themselves but also act as brokers for smaller producers. Herpetariums are mainly designed to exhibit snakes and amphibians, required higher technical knowledge and a higher initial investment. Only two centers export the products of their breeding programs, both directly. None of the people interviewed considered butterfly or herpeto-farming a growth industry. This is a first attempt to analyze these cottage industries in Costa Rica, and as an academic exercise the study motivated our undergraduate students to consider the feasibility of linking conservation and development through the sustainable use of diversity.

Erika Deinert ■ deinert@ots.ac.cr

Poster 9

Monitoring amphibian populations in La Selva: The first year

Mahmood Sasa^{1,2}, Randall Valverde² and Marco Barquero²

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² Instituto Clodomiro Picado, Universidad de Costa Rica, San José, Costa Rica

Population decline or extinction of over 26 species of anurans had been reported from pristine environments of Costa Rica. Despite this fact, very few projects have been established to monitor long term changes in amphibian communities in the region. Here, we present data for the first fifteen months of one such project conducted at La Selva Biological Station. Visual encounter surveys were established once per month in two transects: Cantarrana (150 m length) and Holdridge trail (1000m). Both sites include breeding places for swamp dwellers, and a proportion of primary forest. In 14 visits, we recorded 707 individuals of 11 genera and 27 species of amphibians, a figure that represents 54% of the species known to the station. Composition and abundance of species are different at each site, probably reflecting their structural differences. Fluctuations in species abundance observed during this period are discussed in terms of seasonal rainfall pattern and forest flooding. Long-term monitoring programs are necessary to understand the complex dynamics of amphibian populations, as well as to establish null models to compare fluctuations of suspected declines. We suggest that long term monitoring projects should be incorporated as exercises for students in the academic agenda of OTS.

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Poster 10**Consequences of time of fruit production for secondary dispersal and establishment of three palm species at La Selva, Costa Rica****Evan Notman and Ana C. Villegas**

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We investigated the consequence of seed production during different seasons on germination and survival of seeds for three species of palms in lowland forest of Costa Rica. We documented patterns of germination and seed survival during periods with different rainfall and community fruiting. Specifically, how timing of fruit production influenced; (1) time to germination (2) post-dispersal seed mortality (3) secondary dispersal by vertebrates (4) relative importance of different mortality sources (pathogens, invertebrate, and vertebrate). Seeds of *Welfia regia*, *Socratea exorrhiza*, and *Iriartea deltoide* were placed individually along transects in four replicate plots and in two treatments (1) protected from vertebrates (2) unprotected, but attached to a thread to follow seed movement. Fresh seeds of *W. georgii*, were put out in February, May, August, and November 2001. Seeds of *S. durissima* and *I. deltoide* were put out in three and two of these periods respectively. Levels of seed movement differed between species, but not between seasons. Survival of seeds protected from vertebrates was greater for all species and differed between species but not season. Survival of unprotected seeds differed between species and season. Time of germination differed between season for *W. georgii* and *I. deltoide*. Seed survival was higher during the period of community-wide fruit scarcity. Differences in survival between seasons appear to be due to how vertebrates treat seeds (consumed or cached) and not to vertebrate abundance.

Ana Villegas ■ anavi@cro.ots.ac.cr**Poster 11****Genetic diversity of the green and black poison dart frog (*Dendrobates auratus*) in Costa Rica using ISSR and RAPDs****Lisa D. Patrick and Mahmood Sasa**

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Among the species of poison dart frogs (family Dendrobatidae) known for Costa Rica, the chocolate-mint poison dart frog, *Dendrobates auratus*, has the widest distribution. It occurs disjunctly along the Caribbean and North versants, and in the South Pacific of the country, from sea level to 800m in elevation. *Dendrobates auratus* is a common frog in most of its range, and can survive well in disturbed environments. Introduced populations are known to exist in Florida and Hawaii, and a suspected introduced population is established in La Virgen de Sarapiquí, Costa Rica. Using Inter-Simple Sequence Repeats (ISSR) and RAPDs, we describe the molecular variation among seven populations of *D. auratus* in Costa Rica, and evaluate the affinities of the suspected introduced populations in La Virgen. Our preliminary results suggest that depth divergences occur among populations located at each side of the central mountain cord that divides the country, but populations within each versant are undistinguishable. La Virgen populations seems to be have the same level of variation and fixed loci as other populations in the Caribbean.

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Poster 12

Distance-dependent effects on patterns of secondary seed movement, infestation and predation of two neotropical palms

Lisa Patrick, Ana C. Villegas and Evan Notman

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Although studies of seed predators have frequently found evidence for distance and/or density dependent seed predation, little is known about how these factors might influence secondary dispersal. This study investigated patterns of secondary seed dispersal and its subsequent influence on insect infestation and mammal predation for two species of palms (*Welfia regia* & *Iriartea deltoidea*) in lowland primary forest at La Selva Biological Station in Costa Rica. The relative importance of different mortality sources (vertebrate vs. invertebrate) and the interaction of mortality source with distance from the parent tree were quantified. Ten fruiting individuals of each species were chosen as focal trees and 20 seeds were placed around each tree, 10 in wire cages (vertebrate enclosures) and 10 unprotected, but attached to nylon thread in order to follow seed movement. Seeds were also placed 10 m from each focal tree in the same treatments. Seeds were checked weekly for movement, predation (mammal or insect) and germination. After twelve weeks, significantly more seed movement was found within 10 m of the focal tree for both species. Moved seeds from below the parent tree were also found to experience greater mammal predation than seeds moved from the 10 m distance treatment. Neither the number of seeds infested, nor the number of beetle holes were related to distance. Beetle activity appears to be related to the presence of a fungal pathogen.

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Poster 13

Disappearance of insectivorous birds from tropical forest fragments

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Determining the impact of forest disturbance and fragmentation on tropical biotas is a central goal of conservation biology. Among tropical forest birds, understory insectivores are particularly sensitive to habitat disturbance and fragmentation, despite their relatively small sizes and freedom from hunting pressure. Why these birds are especially vulnerable to fragmentation is not known. Our data indicate that the best determinant of the persistence of understory insectivorous birds in small fragments is the ability to disperse through deforested countryside habitats. This finding contradicts our initial hypothesis that the decline of insectivorous birds in forest fragments is caused by impoverished invertebrate prey base in fragments. Although we observed significantly fewer insectivorous birds in smaller fragments, extensive sampling of invertebrate communities (106,082 individuals) and avian diets (of 735 birds) revealed no important differences between large and small fragments. Neither habitat specificity nor drier fragment microclimates seemed critical. Bird species that were less affected by forest fragmentation were, in general, those that used the deforested countryside more, and we suggest that the key to their conservation will be found there.

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Poster 14

The impact of seed predators and herbivores on palm population dynamics

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This study was conducted to describe patterns of seed survival and seedling recruitment relative to the distances and densities of conspecific adults for three species of neotropical palms, *Welfia regia*, *Socratea exorrhiza*, and *Iriartea deltoidea*. It also examined the potential of density/distance-dependent seedling herbivory as a mechanism regulating seedling survival and recruitment. I mapped all adult palms of the three species in four plots 50 x 100 meters. At each plot, seeds of those palms had been placed singly at twenty stations along transects at three different times the year before (Notman and Villegas unpublished). At each station one seed was exposed (control) and one seed covered with a wire cage (exclosure) to separate the effects of vertebrate and invertebrate seed predators on mortality. I measured distances and density to conspecific adults within 10-m radius from stations; marked all naturally occurring seedlings within 1.5-m radius and visually estimated missing leaf area (herbivory) and leaf toughness from each seedling leaf. Mortality due to insects (exclosure) was not associated with adult distance or density for any species. Mortality due to mammals (control) increased significantly with shorter distances and higher densities- of conspecific adults for *Iriartea* and *Welfia*. *Socratea* seed mortality due to mammals was nearly complete at all distances and densities of adults. Seedlings density increased significantly with increasing conspecific adult density and decreasing adult distance for all species. Levels of seedling herbivory were not significantly related to distance or density of adult conspecifics for any given species, but increased significantly with palm density. There was not a relationship between seedling leaf toughness and herbivory. Although density-responsive vertebrate seed predators significantly influenced seed survival and herbivory levels increased with the density of palms, they did not change the spatial patterns of higher seedling recruitment near the parent tree.

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Poster 15

Application of 0.7 and 2.8 m resolution Quickbird satellite data to studies of tropical rain forest tree demography and forest ecology

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Previous studies at the La Selva Biological Station near Puerto Viejo, Costa Rica, have shown that 1 m and 4 m resolution IKONOS satellite data can be successfully used to study tropical tree demography and forest ecology. Here we present preliminary results from the next generation of higher resolution satellites, using 0.7 m panchromatic and 2.8 m multispectral data from the Quickbird satellite. We also compare results from analyses of an August 2000 IKONOS image with a June 2002 Quickbird image. We georeferenced the Quickbird image using crowns of distinctive emergents surveyed to a ground grid network (root mean square error of the rectification = 3.50 m). Change in crown area over a two year period is being evaluated by locating individuals that can be clearly identified in both the IKONOS and Quickbird images, and comparing the digitized crown area on both images. We are using trees under demographic study for these analyses to relate changes in crown area to diameter growth rates. Using ground data from on-going studies, we are analyzing the Quickbird image to determine what percentage of the deaths of canopy-level trees can be detected using satellite data. We are also analyzing the Quickbird data to determine its potential for estimation of forest canopy cover, landscape biomass, and land use discrimination, particularly of old secondary forests and selectively logged areas. Although the work is ongoing and our results preliminary, it is clear that Quickbird data have enormous potential to extend landscape-scale study of tropical trees and forests.

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Poster 16

Optimality and allometry in nectar foraging of the orchid bees (Apidae: Euglossini)

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The rate of nectar intake plays an important role in many aspects of nectarivory, including flower selection, flight patterns, and competitive behavior. Theoretical models focusing on the mechanics of nectar intake predict a single optimal sugar concentration for all nectar feeders, but more integrative models predict a shift in this optimum as cost of transit increases relative to total foraging cost. I studied nectar feeding in 19 species of euglossine bees to determine how intake rate scales with metabolic demands during flight. If intake rate scales in direct proportion to flight metabolic rate, then relative feeding and transit costs will be independent of body size. Intake rate of 35% sucrose solution scales as body mass raised to the 0.64 power (95% CI, 0.51 - 0.76), and flight metabolic rate scales with the power 0.56. Consequently, relative transit and feeding times are likely to be body size independent, and nectar preferences should be shared among species of different sizes. A field study at three lowland sites in Costa Rica (La Selva, Manuel Antonio National Park, and Santa Rosa National Park) demonstrates that euglossine crop nectar concentrations fall between 34-42% and are independent of body size. Interspecific differences in nectar collection may be related to factors such as habitat use or floral access. Indeed, bees with long tongues (>25 mm) collect significantly more concentrated nectars than bees with shorter tongues, suggesting that floral access may be more important than forager preferences in regulating nectar collection in the wild.

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Poster 17 The role of insectivory in Costa Rican *Carollia* (Chiroptera: Phyllostomidae)

Heather A. York

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Frugivorous bats are well known to consume various non-fruit items, such as insects, pollen, nectar, and floral structures, in addition to fruits. However, it remains poorly understood whether the inclusion of such foods serves as a dietary substitute when fruits are scarce, as a dietary supplement to meet nutritional requirements, especially during times of reproductive activity, or a combination of substitution and supplementation. To elucidate the role of insects in frugivorous bat diets, I considered the presence or absence of insect matter in fecal samples from mist-netted individuals of four species of *Carollia* (Chiroptera: Phyllostomidae) to compare diets between the wet and dry seasons in both an aseasonal wet forest (La Selva Biological Station, Caribbean lowlands) and a seasonal dry forest (Palo Verde National Park, Pacific lowlands) in Costa Rica. Preliminary results show that frugivorous bats eat more insects at Palo Verde than at La Selva and that insectivory does not vary by season, as would be expected if dietary substitution were occurring (Fisher's exact test, $p = .3723$). Site (dry forest vs. wet forest) was the overwhelming factor in determining insectivorous behavior, both independently (Fisher's exact test, $p = .0063$) and in combination with sex, season, and reproductive condition. The implications of these findings for food preferences and for relationships between diet and reproduction currently are being investigated.

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Poster 18 Spatial and temporal estimation of below-ground carbon pools and fluxes in a neotropical rain forest, La Selva Biological Station, Costa Rica

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Estimates of carbon pools and fluxes in tropical forests are important in the current discussion on the world's carbon balance of forests. The overall goal of this study was to determine the below-ground carbon dynamics as a function of climate variability. This project was part of the La Selva 'CARBONO' project. The main objectives of the present study were (i) to quantify and compare the soil CO₂ efflux rates on two dominant soil types, (ii) to estimate CO₂ production rates as a function of depth and (iii) to evaluate how soil and environmental factors control CO₂ production and soil CO₂ efflux. Three plots on 'old alluvium' soils and three plots on 'residual' soils were selected. Pools of carbon were estimated at a single time on a plot basis. Soil CO₂ efflux was monitored bi-weekly since April 1998 using a portable infrared analyzer. At the same time-intervals CO₂ concentration in soil air, soil temperature and soil water content were measured at 0.05, 0.2, 0.4, 0.75, 1.5, 2.5 and 3.5 m depth. In 'old alluvium' sites 210 Mg C ha⁻¹ and in 'residual' sites 330 Mg C ha⁻¹ carbon were stored between 0 and 3 m depth. Soil CO₂ efflux rates ranged from 11 Mg C ha⁻¹ yr⁻¹ ('old alluvium') to 14 Mg C ha⁻¹ yr⁻¹ ('residual'). Temporal variability in soil CO₂ efflux could be explained by variations in soil water content. The main CO₂ production (80-95 % of total soil CO₂ efflux) occurred in the top 0.5 m of the soil. Carbon dioxide production rates in deeper layers (2.0-3.0 m depth) were temperature sensitive.

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Poster 19

The ECOMAPAS Project

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The ECOMAPAS Project focuses at ecological data collection and mapping of the distribution ecosystems and their vegetation in the Costa Rican Conservation Areas.

Immediate Objectives: To map the distribution of ecosystems and their vegetation;

To collect ecological data in the field and analyze these data;

To develop a Geographical Information System for planning and decision-taking directed at sustainable use of biodiversity;

To develop a plan to monitor changes in biodiversity along a time gradient.

Printed and digital maps of ecosystems distribution and their vegetation generated by ECOMAPAS at a semi-detailed scale, are serving as tools, not only for biodiversity conservation and sustainable use in the Conservation Areas (one of the main activities of SINAC), but also as an efficient planning of the activities of the National Biodiversity Inventory (one off the main activities of INBio).

An ecosystem classification system was developed on basis of the International World Vegetation Classification System elaborated by the UNESCO (1973). This ecosystem classification system is a hierarchical system that can be used at multiple scales and that implies different levels of classification, among which the physiognomical, floristic, climatological, hydrological and anthropogenical levels prevail.

Maps display the distribution of ecosystems and land cover types as established by well-defined parameters. By now, three Conservation Areas are mapped and catalogued: Osa, La Amistad Pacifico and Pacifico Central. All the information is available in printed ecological guides as well as in the Internet address <http://www.inbio.ac.cr>.

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Poster 20

CARBONO TOWERS — Understanding interannual net ecosystem carbon exchange variability in tropical rain forest: A new research program at La Selva

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Strengths of tower-based flux measurements are their focus on net ecosystem C exchange and the relatively large forest footprint measured. It is clear, however, that major issues need to be addressed with respect to eddy covariance measurements, particularly in tropical rain forests. A fundamental limitation is the prevalence of still-air conditions at night, preventing accurate assessment of nighttime ecosystem respiration by this technique. To evaluate the validity of the eddy covariance estimates of net ecosystem C exchange (NEE) in terms of their sign, magnitude, and climatic variation, eddy flux studies need to be compared to on-site ground measurements of the key processes in forest C cycling. Because of the large within-landscape spatial variation in tropical forest structure and function (200+ tree species, for example), spatial stratification and replication are needed to scale up plot-based estimates to the landscape level.

In a new research program at La Selva, Costa Rica, we will directly address these challenges to move toward assessment of tropical forest carbon flux and how it is likely to respond to on-going climate change. We will compare independent estimates of whole-forest photosynthesis, autotrophic and total ecosystem respiration, and NEE obtained by direct and indirect approaches: 1) highly replicated direct measurement of forest structure and function across the landscape, 2) process-based modeling of daytime uptake and NEE based on these ground data, 3) intensive cross-comparison of these data and model results with a 3-yr eddy covariance dataset over strongly contrasting climatic conditions, including the 1997/98 mega-ENSO.

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Poster 21

INBio

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The National Biodiversity Institute (INBio) is a non-profit and private Costa Rican institution. Its mission is to promote a new awareness of the value of biodiversity, and thereby achieve its conservation and to improve the quality of life of people. All activities are linked together by the institutional core process: capture and generate information, process and catalogue it and disseminate it.

The Program for Biodiversity Education looks to contribute to the process of bioliteracy of students and teachers, so that they become conscious and informed users of the value and natural richness of Costa Rica and promotes a change in behavior towards nature. BioPark is a tourist, recreational and educational complex that seeks to integrate education, scientific research and open-air spaces. The INBioPress helps popularize knowledge on biodiversity as part of this bioliteracy process as well.

INBio conducts research in collaboration with investigation centers, universities and national and international companies. The agreements take into account up-front and future benefits to be reinvested in conservation. Examples of bioprospecting projects are ChagasSpace, INBio-IDB Agreement for support of local industry, INBio-Merck, INBio-INDENA S.P.A., and INBio-University of Guelph. INBio has inventoried over 15,000 species of fungi, plants, mollusks, insects, nematodes and arachnids.

INBio also created the parataxonomist program (people from rural communities of Costa Rica, near protected areas, that receive an intense practical course at a vocational level). Workshops and training sessions are also carried out.

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Poster 22

Is cycasin in *Eumaeus minyas* (Lepidoptera: Lycaenidae) a predator deterrent?

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Sequestration of defense compounds from host plants may require particular physiological adaptations by larvae to ingest, accumulate, and store them. Defense compounds are used for various purposes, particularly against predators, where chemical defense reduces the risk of predation. Cycasin is a secondary metabolite present in cycads (Cycadales), which are host to *Eumaeus* (Lycaenidae). Cycasin is sequestered by the aposematic butterfly *E. minyas* from its host plant *Zamia loddigesii* (Zamiaceae), and used as chemical defense. Using laboratory and field experiments we assessed the presence of cycasin in all stadia of *E. minyas*. Using palatability experiments in the laboratory, we established that pure cycasin deterred a potential predator (*Solenopsis geminata*, Formicidae) of *E. minyas*, and assessed that cycasin in egg, larva and adult extracts deterred the same predator. To assess the efficiency of this chemical defense for eggs and larvae in natural conditions, we accomplished a predator exclusion experiment. Using survival analysis we showed that the number of surviving eggs and larvae were significantly higher in the exclusions. This suggested that the protective function of cycasin in natural conditions is not totally effective against natural predators. This is the first study including experimental testing of the protective function of cycasin in natural conditions. We suggest that cycasin in the aposematic butterfly *E. minyas* has a defensive function against predators; however, its populations may be regulated by the negative effect of its predators (which apparently circumvent the chemical defensive barrier) and by cannibalism.

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Poster 23

Sustainable mahogany management: regeneration within anthropogenic canopy gaps in the subtropical moist forests of Belize

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Big-leaf mahogany (*Swietenia macrophylla* King) is currently being depleted throughout its range because selective logging of adults removes seed trees when advance regeneration is not present in the understory. This study asks whether enrichment plantings within the gaps created from selective logging could ensure mahogany regeneration, and seeks to answer these questions by evaluating, two years after enrichment, the survival and growth of seedlings and seeds sown in logging gaps in Belize. The objectives of this study were: 1) to determine whether survival and growth varied with the size of the logging gap; 2) to compare the survival and growth from sown seeds and planted seedlings; 3) to evaluate whether levels of shoot-borer attack, ant damage, or lianas vary with the size of the logging gap, and to what degree they affect growth in the enrichment plantings. Growth from planted seedlings and sown seeds were, on average, 0.42m and 0.5m, respectively. Growth seemed to have been greater in gaps that were larger at the time of planting, but establishment and survivorship did not vary significantly with gap size. The percentage of seedlings surviving (66%) was three times the proportion of seeds (22%) that yielded a surviving seedling. Though gap size was significantly associated with growth, predictive power of relationships between growth and gap size was poor. Seedlings within these gaps have yet to show significant impact by pests or vines. Continued monitoring of the enrichment plots in this study should shed more light on the usefulness of this management method.

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Poster 24

Species regeneration response to clearing size: A *Swietenia Macrophylla* King harvested forest in northern Belize

Carissa Wong

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Swietenia macrophylla King (common name: big-leaf mahogany) is cited as a catalytic species in the destruction of American forests. Its regeneration requires the catastrophic forest disturbance associated with hurricanes, fire, and flood, and its management may be incompatible with the preservation of overall biodiversity, or alternative economically valuable timber species. This study investigates the impact of clearing size on natural tree species regeneration in the Belizean subtropical moist forest of the Rio Bravo Conservation and Management Area. Using height-frequency distributions, I classified 32 out of 68 identified species according to light tolerance with a literature and expert verified accuracy of 91%. Analysis of Variance (ANOVA) of relative height and percent density for shade tolerant and intolerant trees does not show significant trends with increasing patch-cut size. A Shannon-Wiener index of diversity varies significantly ($p = 0.047$) between only the intermediate 1000 and 2500 m² patch sizes. Insufficient variation in light levels between the patchcuts is a likely explanation for the lack of significant species performance and diversity responses to variations in gap size.

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Poster 25

The effect of ecology on aggressive interactions in White-faced capuchin monkeys, *Cebus capucinus*, in a Costa Rican dry forest

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Aggressive interactions in the context of feeding are more common when resources are sparse and/or more patchily distributed (Janson 1985; Barton & Whiten 1993; Sterck & Steenbeek 1997; van Schaik & van Noordwijk 1988). Several studies have analyzed the effects of resource distribution and abundance on the frequency of dyadic interactions, but no studies to date have related the severity of aggression to food resource characteristics. I studied two levels of dyadic aggressive behavior (active and passive) as well as polyadic aggressive behavior during feeding in white-faced capuchins, *Cebus capucinus*. This study addresses whether resource quality, quantity, and distribution have an effect on the type and quantity of competitive interactions observed. I evaluated the importance of nine ecological and behavioral variables that may influence food related aggression during a 15 month period. Focal feeding trees ($n=700$) were observed from the beginning to end of a feeding bout and all dyadic and polyadic aggressive interactions were recorded. These types of aggression are likely to be associated with different risks of further escalation and subsequent costs of time and possible injury. Preliminary analysis indicates that frequency of food-related aggression can be predicted by the amount of fruit available, the number of alternative resources of the same species within the group spread, and the number of adult females feeding in the tree. The type of aggression appears to be influenced mostly by the crown volume, the number of competitors in the feeding tree, and the feeding bout length. These results agree with previous studies on capuchin monkeys and extend our understanding of the role of ecology in affecting primate social structure to coalitionary as well as dyadic aggression.

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Poster 26**Resident and migratory aquatic birds: Use of the natural marsh (Palo Verde lagoon) and artificial marsh (Bagatzi rice fields)****Johanna Hurtado Astaiza**

Programa Regional en Manejo de Vida Silvestre, Costa Rica

This research was conducted in Palo Verde National Park and surrounding areas between July 2002 and January 2003. Its primary goal was to determine bird habitats in Palo Verde natural marsh and artificial marsh, specifically, the agroecosystem of contiguous rice fields from Bagatzi to the National Park. The Palo Verde marsh was first characterized by different cover types, including floating vegetation, emergent vegetation, Palo Verde trees, tifa, water holes and exposed ground. Next, they were defined as components of the rice field habitat. Different stages of the crop cycle and variables like water depth, plant heights and the percentage of ground water were recorded. A total of 48 species of birds was registered for the rice fields, which were related to some of the phases of the crop. For the Palo Verde marsh, 31 bird species were recorded. The birds made use of the different types of cover. The represented orders and the wealth of species were superior or similar to those documented for natural marsh ecosystems in Costa Rica and the rice fields of other regions of the world, specifically Cuba, China, and the United States. The species with the greatest numbers in both marshes were *Dendrocygna autumnalis* and *Ardea alba*.

Johanna Hurtado Astaiza ■ jhurtado@una.ac.cr**Poster 27****Proposal for changing the use of the soil in a coastal region of the Gulf of Mexico, based on the natural potential of the land****Ana Cecilia Travieso Bello, Angel Priego Santander and Patricia Moreno-Casasola**

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Changes in the use of the soil are generally produced by the increase in agriculture and cattle ranching activities. Very seldom are they based on the natural aptitudes of the territory. Sustainable development requires evaluations to define the activities that can take place in a region. This project evaluates spatially the natural potential for cattle ranching activities in the region of La Mancha-El Llano in the county of Actopan, Veracruz, in the Gulf of Mexico. This coastal area is characterized by high species and ecosystem diversity. A GIS was developed including biophysical data (type of geomorphological relief, horizontal and vertical dissection of the relief, soil types, degree of soil humidity, vegetation and soil use) as well as agronomic data (ecological requirements of the grass species used in the region). A map of the natural potential of the territory was generated. The actual soil use was compared with the natural potential map. Based on this comparison a proposal was made for changing the soil use. Results show that incompatible and partially compatible uses are dominant, and these were modified in the proposal. Protection, conservation or restoration is proposed for those areas with very low or null potential for this activity. Cattle ranching is proposed for those areas with medium, high and very high potential for cattle ranching. Recommendations were included in the work. This proposal is being discussed with the local people and the governmental authorities as well as the academic institutions in the area.

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Poster 28**Hummingbirds as vectors of fungal spores in *Moussonia deppeana* (Gesneriaceae):
Taking advantage of a mutualism?****Carlos Lara¹ and Juan Francisco Ornelas²**¹Departamento de Ecología y Comportamiento Animal, Instituto de Ecología, A.C. Xalapa, Veracruz, México²Laboratorio de Ecología y Evolución de Comportamiento, Centro de Investigaciones Fisiológicas, Universidad Autónoma de Tlaxcala, Mexico

Hummingbirds act as vectors of *Fusarium moniliforme* spores on protandrous flowers of *Moussonia deppeana* (Gesneriaceae). The resulting interactions between the pathogen and plant-pollinator interactions were investigated in a 4-yr study to determine the pathogen's impact host flowering phenology, flower longevity, nectar production, and seed production. We also evaluated hummingbird behavior on healthy and diseased plants and its effectiveness on spore transmission. Individual plants expressed the disease from year to year, and new infected individuals were detected every year. A fraction of the flowers in a plant expressed the disease, and this varied among and within years. Diseased plants produced more inflorescences, buds, and open healthy flowers than did healthy plants. Further, diseased plants bore proportionally fewer pistillate flowers than did healthy plants when considering only healthy flowers. Nectar nor fruit production differed between healthy and diseased plants, but healthy plants produced more seeds. Infected flowers were retained longer than uninfected ones, producing an additional 2 mg μ l per flower of nectar sugar. Hummingbirds visited more flowers on diseased plants than they did on healthy plants, regardless of number and sexual phase. Most pollen and spores were deposited within plants. These behavioral outcomes may promote geitonogamy and limit fungal spore mixing.

Carlos Lara ■ laracar@garza.uatx.mx**Poster 29****Community involvement in sea turtle research: Education makes a difference****Julie Osborn and Scott Pankratz**

Ecology Project International, Moab, UT USA

Illegal egg harvest from sea turtle nesting beaches is a major threat to the survival of sea turtle populations (Spotila et al, 1996). Many research programs desire local residents participation in conservation efforts, but involving the public extends beyond the expertise and time of many scientists (Brewer, 2002). For three years, Ecology Project International has successfully integrated local residents in conservation research at a high-density nesting beach for Leatherback sea turtles (*Dermochelys coriacea*) on the Caribbean coast of Costa Rica. In 2002, 17 student groups totaling 272 participants served as research assistants during 51 nights of the peak Leatherback nesting season. Local high school students collected biometric data, augmented the frequency and duration of patrols, contributed to habitat restoration of the nesting beach, and provided energy and inspiration to resident researchers. In February, 2003, Ecology Project International applied this model of community involvement at a Green turtle (*Chelonia mydas*) monitoring program in Galapagos National Park, Ecuador. In the first partnership of its kind on the Islands, local Galapageños students patrolled critical nesting beaches with Charles Darwin Research Station biologists.

Roxana González Chaves ■ Roxorchid@hotmail.com

Poster 30**International long-term ecological research (ILTER) towards sustainable land use and biodiversity in a mosaic of agriculture and tropical forest in Costa Rica****Bruces Haines and Chris Peterson**

Plant Biology Department, University of Georgia, Athens, GA USA

The human population is rapidly growing but the size of planet earth remains the same, thus material resources to support each additional person continue to decrease. Local dieback of human populations is a repeated theme in our history. Are we managing the human and life support resources for sustainable quality of life? What alternative spatial arrangements of land uses might facilitate sustainability? Long-Term Ecological Research, integrating the physical, ecological, economic and social sciences facilitates ecological forecasting. We are working at one of the Costa Rican ILTER sites to develop a package of field measurements, remote sensing and model simulations that will enable resource managers to explore spatially explicit alternative resource uses that may enhance sustainability. Here we describe our multi-phased long term research goals and our Phase I findings. In Phase I we are determining the time required to convert from abandoned cattle pasture back to forest and the biophysical controls to this forest regeneration. From our studies (1996 to 2002) we conclude that seed dispersal is the main limitation. Our general approach when coupled with knowledge of human economics and sociology can provide a valuable outreach program to help local decision makers balance their population size with resources to provide sustainable quality of life and sustainable civilizations for themselves and their descendants.

Bruces Haines ■ haines@dogwood.botany.uga.edu**Poster 31****Fady and botany biodiversity along the Fiherenana River, SW Madagascar****Sarah Stewart Johnson**

Magdalen College, Oxford, United Kingdom

Botany data were collected in two analogous forests in the Fiherenana River Valley in SW Madagascar. The study centered on investigating the effect of different fady, local taboos governing land use in the Malagasy culture, on botany biodiversity. Two sites were selected: Site One near the village of Anjamala at 23° 10.605 S, 043° 57.640 E and Site Two near the village of Fotivolo at 23° 01.237 S, 043° 08.751 E. Site One had significantly more restrictive land use policies than Site Two, largely predicated by local fady about ancestor burial. 25m by 25m quadrants were set up for sampling at each site; all trees >5 cm DBH were identified. Results include Site One: species richness of 16 and 53 total trees in gallery forest/species richness of 32 and 70 total trees in dry forest, and Site Two: species richness of 16 and 40 total trees in gallery forest/species richness of 21 and 44 total trees in dry forest. Despite the abundance of trees types at Site One, the Shannon's equitability was similar in the dry forest at both sites, 0.93 (Site One) v. 0.94 (Site Two), and in fact slightly higher in the gallery forest at Site Two, 0.87 (Site Two) v. 0.79 (Site One). It appears that the permissive system of fady at Site Two, including allowing disturbance from zebu grazing and the use of several trees for house and coffin construction, did not negatively impact the botany biodiversity.

Sarah Stewart Johnson ■ sarah.johnson@magd.ox.ac.uk

Poster 32**Systems of life based on biodiversity: The sustainable use of agro-biodiversity in highland forests of Ecuador****Selene Baez and Henrik Balslev**

Department of Systematic Botany, Institute of Biological Sciences, University of Aarhus, Risskov, Denmark

This study focuses on the upper Andean Zone of northern Ecuador. The objective is to build a knowledge base of the local systems of learning dedicated to sustainable production. The project plans to increase the agrobiodiversity and reduce the destruction of the last remaining natural forest of the northern Ecuadorian Andes. These forests belong to the last stretches of old Andean forest. The original cover of the forest is being replaced by intensive production of Popes and milk. This requires environmental investments, economic and human. These and other historical and socioeconomic factors disconnected people from the biodiversity of the region. This research project evaluates the biodiversity and the socioeconomic situation of the inhabitants of the forests, as well as the present and potential use of the agrobiodiversity on the part of the rural communities. Additionally, the project looks to fortify and to expand systems of learning through experimentation in alternative production systems, the project will stimulate local people and decision-makers to study and debate possible political instruments that they impel or they prevent these new productive systems. We give special attention to the similarities and differences that the area shares with other zones of upper Andean forests where the experiences of the zone could be adopted. The program requires intense participation of local organizations throughout all the phases of the research.

Selene Baez ■ selenebaez@mail.com

Poster 33**Production of tomato (*Lycopersicon esculentum* Mill) using compost prepared with residues of undergrowth, tomato, papaya and pig feces.****Juan Martin Cruz Campos¹, Manuel de J. Soria Fregoso², Lizette del Carmen Borges Gómez², and Gaspar Martin Pereyda Pérez².**¹ Tizimín, Yucatan Mexico² Conkal, Yucatan Mexico

In the state of Yucatan, 90% of the soil is stony, characterized as very thin and permeable. The excessive use of chemical fertilizers are causing pollution of the phreatic mantle, principally the nitrates. In the search for alternative nutrition we evaluated the response of the tomato to the effect of 10 composts and a control. The control was prepared with 70% bagasse of henequén and 30% soil. The culture was fertilized with the treatment 100 - 75 - 150. The Hybrid tomato 882 was used in its specific habitat. A design was used completely at random. For the analyses of the variables, were used description and statistics (SAS). The evaluated variables of the tomato plants were the diameter of the plants stems, plant height, fruit production dry and fruit biomass and fresh fruit biomass. Degrees Brix of the fruit, and extraction of N, P and K. The experiment was established inside a Structure Protected from Intensive Production (EPPI) of 9 x 12 meters, with a roof and walls of fabric antiáfidos. The substratum 5RT6kg produced the highest yield with 72 t. The substratum made from undergrowth produced the best quality fruit with regard to sweetness and solid soluble with 5.5 Degrees Brix. The foliate analyses they indicates that the plants with the substrata 7RP (0, 1ME6kg and 3RT (0), presented the major (bigger) content of Nitrogen, Phosphorus and Potassium with 2.6, 0.46 and 1.7% respectively.

Juan Martin Cruz Campos ■ yucatan2228@hotmail.com

Poster 34**One fish two fish: Using fish biodiversity in the Cahaba and Amazon rivers to link human impacts on local and global riparian systems in the secondary environmental science curriculum****Janet Ort**

Environmental Science, Hoover High School, Hoover, AL USA

The Cahaba River in Alabama has the highest fish biodiversity per square mile of any un-dammed river on the North American Continent according to the Nature Conservancy, and other studies. The supporting watershed, in conjunction with the Alabama River's, is highly impacted by urban development and decreasing permeable surfaces. By comparing the two river systems through classroom and field investigations, and using qualitative data from workshops in the Peruvian Amazon, Napo, and Sucasari Rivers' watersheds, students make cognitive and behavioral links between local and global environmental issues. The individual impacts cross learning styles and abilities to engage and enlarge the students' awareness as global citizens.

Janet Ort ■ JOrt@hoover.k12.al.us

Poster 35**When OTS independent projects work, they can lead to exciting new areas of research: Signal differences between courtship and territorial aggression behavior in the common anole, *Norops polylepis*****John E. Steffen**

Department of Biology, Auburn University, Auburn, AL USA

Norops (i.e. Anoline) lizards perform a dewlap display as a communicatory signal in courtship and territorial contexts. Previous studies have concluded that the dewlap display in Anoline lizards is predominantly shaped by intrasexually selective forces (i.e. via territoriality). These conclusions assume that courtship and territorial displays are similar in structure, but have highest fitness consequences in territorial contexts, despite a) the paucity of research on courtship displays, and b) the absence of research comparing the display in territorial and courtship contexts. The objective of this OTS Independent Project was to investigate similarities and differences in courtship and territorial dewlap display behaviors in *Norops polylepis*. Observations were performed to view differences in dewlap display behavior of the common anole, *Norops polylepis*, in Corcovado National Park, Costa Rica. Ten components of dewlap display behavior were measured in courtship and aggressive interactions to investigate potential differences in display behavior. Observations revealed that dewlap display duration was different between courtship and aggression interactions (Wilcoxon sign rank test, $X_2 = 3.7$, $p = 0.05$, $N = 8$). Mean duration of the aggressive dewlap display was seven seconds, and was longer than the mean duration of the courtship dewlap display (3.5 seconds). Furthermore, regression analyses of display components for aggressive and courtship interactions resulted in different significant relationships between components. For instance, in aggressive interactions, more displays per individual led to shorter duration of each dewlap display ($R_2 = 0.82$, $p = 0.012$, $N = 5$). In courtship interactions, the time between each successive dewlap display decreased with increased duration of display ($R_2 = 0.986$, $p = 0.07$, $N = 3$). Results show that there are specific differences in duration of dewlap display between courtship and territorial contexts. Furthermore, different temporal components of the display varied significantly with duration of display in different contexts. New research investigating the selective forces that shape this extravagant display is warranted because previous conclusions about the predominant role of intrasexual selection in shaping the display are unfounded; past assumptions of courtship and territorial display similarities are shown to be incorrect, and courtship displays require more investigation.

John E. Steffen ■ steffe@auburn.edu



graduate education

Students learn about science in the field through intensive courses that travel to various ecosystems. These courses are coordinated by experienced tropical scientists and include lectures, fieldwork and independent research. An overwhelming number of alumni cite their course experience as one of the most important factors in their professional success. More than 4,000 professionals are working to address global environmental issues through their leadership roles in governmental, academic and research institutions and grassroots, regional, national and international nonprofit organizations. Currently courses are offered in Costa Rica, Peru, Brazil, Panama and

Mexico on topics including ecology, tropical biology, plant systematics and marine ecology.



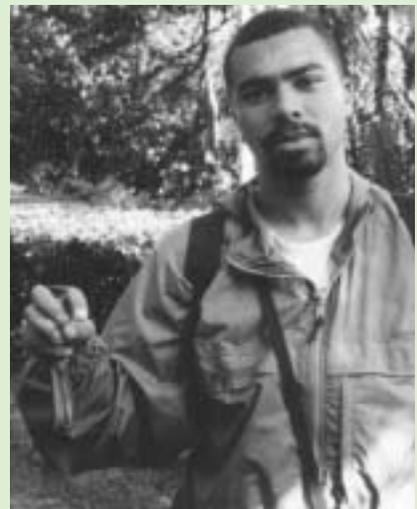


undergraduate education

The Undergraduate Program has trained more than 400 students in semester and summer programs. The fifteen-week semester program gives students the opportunity to learn the fundamentals of tropical biology, to conduct field research, to study first-hand Costa Rica's unique history in environmental policy, and to strengthen their understanding of Spanish and Latin American culture. Field Tropical Ecology and

Introduction to Field Ethnobiology are rigorous short courses offered in the summer. Advanced undergraduate biology students may also participate in the NSF-funded Research Experiences for Undergraduates program at La Selva. Starting in Spring 2004, the highly successful model developed for Undergraduate Programs in Costa Rica will be applied to the opening of a new semester program in South Africa. For almost all of its programs, OTS awards

scholarships to students from groups underrepresented in the sciences. Together, OTS undergraduate field courses help students define career objectives and provide a solid training in science and environmental policy in an international setting.



environmental science and policy

This program trains individuals whose policies have profound impacts on the natural environment. The hands-on, total immersion experience in tropical environments that is



the organization's trademark in education highlight the interdependence of social, economic, and ecological dimensions of environmental choices. Currently, this program offers training to enhance the understanding of environmental issues among present-day policy makers and training to strengthen the skill set of Latin American wildlands managers. This program has trained more than 600 people from 18 countries through the decision-maker courses and more than 90 people from 13 countries in the wildlands courses.



Las Cruces Biological Station and Wilson Botanical Garden

Las Cruces is located on Costa Rica's southern Pacific slope and is OTS' 266-hectare reserve of mid-elevation rain and cloud forest. Las Cruces is also home to the Robert and Catherine Wilson Botanical



Garden, a 10-hectare managed area consisting of one of the most important living botanical collections in Central

America. This site hosts approximately 6,500 students, researchers and natural history visitors annually. More than 480 scientific papers based on research done at Las Cruces have been published.





La Selva Biological Station



With its state-of-the-art laboratories, on-line geographic information system, extensive trails and large forest reserve bordering Braulio Carrillo National Park, La Selva is one of the world's most important sites for tropical forest research. La Selva is located in the Caribbean

lowlands of Costa Rica and comprises 1,516 hectares of old and secondary growth forests, plus experimental habitats. This site hosts approximately 8,700 students, researchers and natural history visitors annually. More than 2,200 scientific papers based on research done at La Selva have been published.





Palo Verde Biological Station



Unique in its landscape richness and wildlife, Palo Verde National Park contains one of the most extensive marshes and some of the oldest patches of dry forest remaining in Central America. The organization's facilities are in the heart of the Palo Verde National Park, located in the northwest lowland of Guanacaste Province. This site hosts approximately

2,300 students, researchers and natural history visitors annually. More than 460 scientific papers based on research done at Palo Verde have been published.



research



Palo Verde
Marsh
Restoration
OTS and MINAE

Nearly 200 research projects are conducted at the organization's biological stations in Costa Rica annually. Fellowships totaling more than \$70,000 each year are awarded to researchers in the early stages of their careers. These research facilitation activities, combined with efforts in helping researchers identify collaborators, secure funding and process required permits, are vital to increasing the world's knowledge of tropical ecosystems.

Researchers are:

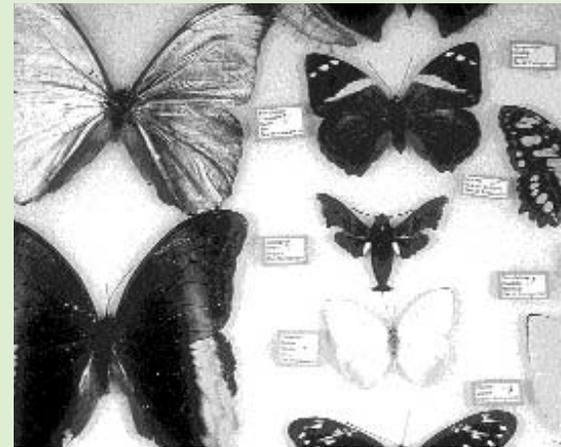


Current and future carbon budgets for tropical rain forests: a cross-scale analysis
David Clark
(U. Missouri, St. Louis),
Deborah Clark
(U. Missouri, St. Louis)
and Steven Oberbauer
(Florida International University)

- learning about tree seedling survival in the dry forest, which will provide vital information to land managers involved in restoration, plantations and agroforestry.
- working with local communities to restore degraded wetlands and protect the area from floods.



The effects of forest fragmentation on forest insectivorous birds
Cagan Sekercioglu
(Stanford University)



Arthropod diversity in a lowland tropical rain forest
Robert Colwell
(U. Connecticut)
and Jack Longino
(Evergreen)

- analyzing how tropical forests interact with carbon dioxide in the atmosphere to buffer the global warming effects of burning fossil fuels.

- studying how forest fragments impact survival of bird species.
- discovering the astonishing diversity of arthropods in the rainforest.

ensuring the **next** 40

The Campaign for OTS



THE CAMPAIGN FOR OTS is a \$30 million endowment and

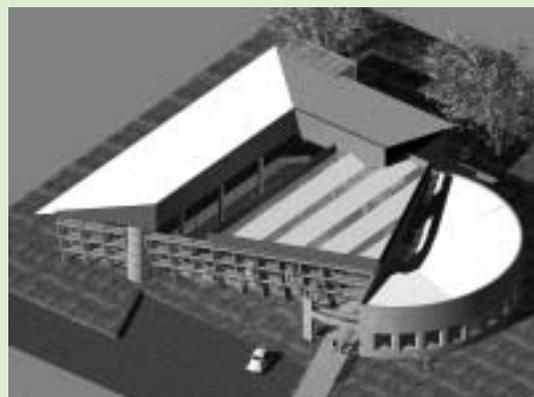
capital campaign to ensure the future of the consortium. The goals of the Campaign are \$20 million in endowment support, \$5 million for an education reserve fund to secure our core education programs and \$5 million in infrastructure support to significantly enhance our facilities and physical operations. Capital improvements at our research stations include classrooms, researcher and staff housing, laboratories, greenhouses and a visitors' center.

The Campaign also includes the \$1.2 million Richard H. Simons Center, named in memory of a Florida philanthropist to recognize the lead gift of his estate to this project. Construction on this new academic and administrative center on the research campus of the University of Costa Rica will begin in June and is slated for completion in June 2004. U.S. and Latin American students will benefit from the classrooms, library and technology center focused exclusively on tropical studies.

years:

In addition, politicians, corporate executives and community leaders will participate in an open exchange of ideas, and scientists from throughout the world will engage in a dialogue on the issues facing the tropics.

The Campaign for OTS is a bold vision of the future where core programs and key operations are financially robust through endowment funding and where infrastructure improvements benefit students and researchers. It is a vision worthy of the founders of the consortium. These pioneering biologists created field-courses that influence thousands of students and researchers. They built field stations that play a significant role in the world's understanding of tropical ecology. The Campaign for OTS will ensure that the work of these pioneering biologists continues, that the cornerstones of the consortium are secure and that the expectations for the 21st Century are fully met.



For information on the Campaign for OTS, how you can help with the Simons Center or ensure OTS' next 40 years, contact Jonathan Giles at (919) 684-6188 or write to <jgiles@duke.edu>.

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Tropical Science for the **21st Century** ■ Symposium