

**THE YALE INSTITUTE FOR BIOSPHERIC STUDIES
ANNUAL REPORT
JULY 2003 – JUNE 2004**

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THE YALE INSTITUTE FOR BIOSPHERIC STUDIES

ANNUAL REPORT – 2003/2004

INTRODUCTION

The Yale Institute for Biospheric Studies (YIBS), founded in 1991 with an extraordinary gift from Edward P. Bass, '72 Art A, was created to bring together a community of scholars and utilize the strengths of the University in the basic sciences which inform environmental issues; to draw on the knowledge embodied in the Faculty of Arts and Sciences and in the graduate and professional schools of the University, particularly the School of Forestry & Environmental Studies; and to encourage the reintegration of the natural history collections of the Yale Peabody Museum of Natural History into faculty and student research, thus drawing on the past to inform the present and enlighten the future. The YIBS mission is to build on the strong foundation of University resources to advance the understanding of the biosphere and develop relevant approaches to environmental issues of national and global importance.

Since its inception, YIBS has succeeded in cultivating a standard for university-based environmental research and education by establishing itself as a catalyst for interdisciplinary collaboration through its research centers, and most recently through its weekly seminar series held in the Class of 1954 Environmental Science Center, which serves as the hub of this interdisciplinary activity.

In addition to specific advances in research and education, a principal achievement has been in fostering a shared vision among multiple academic units. As a result, Yale's considerable intellectual resources continue to be most effectively brought to bear on solving environmental problems.

DIRECTORSHIP OF YIBS

- 1991 to 1996 - Biology Professor Leo W. Buss
- 1996 to 1998 – Geology & Geophysics Professor Elisabeth Vrba
- 1999 to 2003 - Sterling Professor of Geology & Geophysics Karl Turekian
- 2004 - Geology & Geophysics Professor Derek Briggs serves as the current Director of YIBS

STUDENT PROGRAMS

ENVIRONMENTAL STUDIES PROGRAM (EVST)

CHAIR: JEFFREY PARK

TOTAL PROGRAM SUPPORT - \$41,666

TOTAL UNDERGRADUATE SUMMER INTERNSHIP SUPPORT - \$53,501 FROM EVST FUNDS; \$10,000 FROM THE DEPARTMENT OF ECOLOGY & EVOLUTIONARY BIOLOGY

Through the support and hard work of Yale alumni, professors and staff, the Environmental Studies Program (EVST) was created as a stimulating interdisciplinary major for Yale undergraduates. In 2004 EVST's graduated its first class of seniors, a cohort of ten women and men whose senior research essays ranged from wildlife conservation to government fuel-economy policy.

The program has been successful under the Chairmanship of Geology & Geophysics (G&G) Professor Jeffrey Park, and the efforts of Professor John Wargo of the School of Forestry & Environmental Studies (F&ES). Jointly appointed in the Political Science Department, Professor Wargo is the program's Director of Undergraduate Studies (DUS).

John Wargo and Jeffrey Park co-taught the program's junior seminar in Spring 2004, a course that exposed EVST majors to interdisciplinary research methods in the environment.

In the 2003-2004 school year, EVST hosted the second year of Dr. Richard Marcus' term as a postdoctoral associate and lecturer. With the funding support of Yale's Center for the Study of Globalization, Dr. Marcus taught two courses, *Global Issues in African Conservation and Development*, and *Comparative Politics of Water Resources*, both cross-listed with the Political Science department. Between teaching and advising research projects in both Yale College and F&ES, Dr. Marcus initiated a book project on comparative water-resource politics.

Undergraduate Summer Internships 2004

With the generous support of the Gaylord and Dorothy Donnelley Foundation, the William Bingham Foundation, the Montgomery Family Fund and Yale's Department of Ecology and Evolutionary Biology (EEB), EVST awarded 27 Environmental Summer Internships for 2004 totaling \$63,501 to Yale undergraduates. The breadth of these internships expresses the remarkable diversity of student interest in environmental issues. Topics ranged from malaria-vector abatement in Africa, to efforts by multinational corporations to reduce environmental degradation in China, to fieldwork in the Yale-Myers Forest to study species dispersal among microscopic aquatic organisms.

The following 27 students received support for their summer projects. The students' descriptions of their experiences can be found on the website <http://www.yale.edu/evst/>

Aravinda Ananda, EVST '05

Shrimp Aquaculture in Ecuador: NGO Success in Improving Local Environmental Sustainability

Antasia Azure, English (writing concentration) '05

Study of the Culture of the Australian Aborigines and Their Relationship to the Great Barrier Reef in Cape Ferguson Region of Australia

Cara Berkowitz, EVST '05

Hands-On Environmental Education: Bridging Deficits in Holistic Educational Methods and Awareness of Environmental Issues

ENVIRONMENTAL STUDIES PROGRAM (EVST) continued

Bhart-Anjan Bhullar, Biology (Ecology & Evolutionary Biology Track) '05
Paleontology and Comparative Anatomy of Squamates: Field Work, CT Data Processing and Descriptions of Gerrhosaurid Skulls

Deepali Dhar, Undeclared '07
Climate Change Internship with Environmental Defense in New York City, NY

Genevieve Essig, Psychology '05
Summer Internship with Environmental Law Institute

Alexandra Freeman, History Of Science / History Of Medicine '05
The Recent History of Bioprospecting; An Ecological and Medical Investigation in the Republic of Panama

Shani Harmon, EVST / Anthropology '06
Potato Park Agrobiodiversity: Impact of Globalization on Indigenous People in Peru

Laura Hess, EVST '06
Internship with CHIRAG (Central Himalayan Resource Action Group)

Caroline Howe, EVST or Environmental Engineering '07
Study of Sustainable Agriculture on an Organic Farm and Field Research at Yale Myers Forest

Laura Jeanty, Physics '06
Internship on Electrical Industry with TERI (The Energy and Research Institute) in New Delhi, India

Lucas Knowles, EVST '05
Case History of the King Salmon Military Dump Site in Alaska

Beth Kochin, Biology (Ecology & Evolutionary Biology Track) '07
Impact of Anadromous and Landlocked Alewife on Inland Water Quality and Food Web Structure

Maya Kotas, Biomedical Engineering '05
Study of Malaria Intervention Techniques at Ifakara Health Research and Development Centre, Ifakara, Tanzania

Erica Larsen, Biology (Ecology & Evolutionary Biology Track) '06
Rotifers in Space: Testing a Spatially Explicit Model of Metacommunity Coexistence

Danielle Larson, EVST '05
Field Study in Wrangell-St. Elias National Park and Preserve

Flora Lichtman, EVST '05
Regulating Underwater Sound: A Case Study (Research at SACLANT Undersea Research Center on the Northwest Coast of Italy)

ENVIRONMENTAL STUDIES PROGRAM (EVST) continued

Melanie Loftus, EVST '05

What are the Institutional Challenges to Regional Environmental Planning in the Washington, DC Metropolitan Area?

Erica Machlin, Biology (Ecology & Evolutionary Biology Track) '05

Speciation in Mouse Lemurs (Working in Yoder Lab at Yale)

Madeleine Meek, Anthropology '05

Assessment of Healthcare Initiatives in Ranomafana Integrated Conservation-Development Project

Megan O'Connor, EVST Studies '05

Animal Care at The Second Chance Wildlife Center in Gaithersburg, Maryland

So YeonPaek, Molecular Biophysics & Biochemistry '05

Infectious Eye Diseases and Public Health Initiatives in Humijbre, Ghana

Vicente Undurraga Perl, Biology (Ecology & Evolutionary Biology Track) '06

Landlocked Alewife and Implications of Dam Removal or Fish Ladder Construction In Connecticut

Sarah Jane Selig, EVST and International Studies '06

Research on Mesoamerican Reef Health in Akumal Mexico

Leanna Sudhof, EVST And International Studies '06

Bacterial Larvicides as a Malaria Vector Control Method at International Centre of Insect Physiology and Ecology (ICIPE) in Nairobi, Kenya

Mary Elizabeth Young, Biology '06

Development of a Non-Invasive Molecular Sexing Protocol for the Endangered Amur Tiger

Xizhou Zhou, EVST '05

Case Study of Shell/Petro China Pipeline: Environmental and Social Impacts with the United Nations Development Program (UNDP)

**YALE INSTITUTE FOR BIOSPHERIC STUDIES GRADUATE STUDENT SUPPORT
TOTAL SUPPORT \$120,000**

SCHOOL OF FORESTRY & ENVIRONMENTAL STUDIES (\$30,000)

Anastasia Rose O'Rourke

Developing Policy for Sustainable Environmental Business

Cristina M Balboa

International Non-governmental Organizations: The Accountability of a New Force in Resource Policy and Management

Elizabeth Jones

Small mammals in Papua New Guinea's rainforests: Examining murid community dynamics through seed predation patterns

Alexandra Ponette

Matrix Quality, Microenvironment, and Seedling Survivorship in Tropical Montane Cloud Forest Fragments

Jennifer Balch

Fire Frequency Effects on Sources of Regrowth and Dispersal in the Brazilian Amazon Rain Forest

Shafqat Hussein

Environmental Discourse and Development of Environmental Policy in Pakistan

DEPARTMENT OF ECOLOGY & EVOLUTIONARY BIOLOGY (\$30,000)

Benjamin Kirkup

Genetic approaches to developmental evolution focusing on character identity
Advisor: Margaret Riley

Caroline Obert

Population genetics and molecular evolution of Australian enteric isolates
Advisor: Margaret Riley

Saverio Vicario

Reconstruction of ancestral ecological states based on patterns of molecular evolution using a marker under selection in Leptodirini beetles
Advisor: Jeffrey Powell

Erika Edwards

Systematics and water relations of basal cacti
Advisor: Michael Donoghue

Casey Dunn

The evolution and development of Siphonophores
Advisor: Günter Wagner

YALE INSTITUTE FOR BIOSPHERIC STUDIES GRADUATE STUDENT SUPPORT continued

Sang-tae Kim

Plant Systematics and Evolution

Advisor: Michael Donoghue

ENVIRONMENTAL ENGINEERING (\$30,000)

Jane Hill

Working on fate of phytate in natural waters with implications for eutrophication of receiving water bodies. Emphasis is on microbial breakdown of phytate.

Alexis de Kerchove

Working on transport and fate and transport of nano-biomolecules in natural and engineered aquatic systems, with implications for the fate of genes and DNA in soils and for biofouling of membranes used for wastewater reclamation.

DEPARTMENT OF GEOLOGY & GEOPHYSICS (\$30,000)

Jerome Neufeld

Study of the dynamics and thermodynamics of newly forming sea ice in a theoretical and experimental setting as well as through field studies

Erik Thomson

Within the Ice Physics group led by John Wettlaufer, study of the condensed matter and fluid physics governing polycrystalline ice.

YALE STUDENT ENVIRONMENTAL COALITION (YSEC)

TOTAL SUPPORT: \$3,000

Conference Participation (\$1,500)

Support for YSEC members who attended Interfaith Alliance for Environmental Justice conference in Hartford; the Envirocitizen Conference in Boston; and the Northeast Environmental Conference - a summit intended to foster idea-sharing with environmental groups based all over New England - at Brown University.

Campaigns focused on climate change (\$750)

- **Climate Campaign**

A collaborative effort of the six major student environmental networks in the northeast to make our schools and our states lead the way in the fight against global warming. YSEC will pressure Governors to pass state climate action plans and to pressure our university administrations to make strong commitments to reduce greenhouse gas emissions.

- **Energy Campaign**

Members of YSEC are currently working with the Yale administration to reduce on-campus energy consumption. Students have been working to construct a detailed energy audit, which will then be used to determine how energy can be conserved most cost-effectively. Students are also drafting a concrete energy plan for the university.

Increased outreach (\$750)

YSEC's goal is to influence the day-to-day actions of students in the hopes that by living sustainably as individuals, Yale students can contribute to a more sustainable campus community. Last year, YSEC created banners and table signs encouraging Yale students to consider the environmental impact of their actions. This year, YSEC distributed double-sided "How to be Environmental at Yale" flyers to all of the freshmen suites; by doing so, YSEC simultaneously influenced student choices and did crucial outreach work. They hope to revive the YSEC coffee mug and create a YSEC shopping tote in an effort to decrease packaging waste on campus.

GAYLORD DONNELLEY ENVIRONMENTAL POSTDOCTORAL FELLOWSHIPS
TOTAL SUPPORT \$249,619

From July 2003, through June 2004, the Gaylord Donnelley Postdoctoral Environmental Fellowship supported seven postdoctoral fellows:

Dr. Jenney Hall – working with Sterling Professor Karl Turekian in the Department of Geology & Geophysics (fellowship from August 1, 2002 through July 31, 2004)

Dr. Klaus Meiners – working with Professor John Wettlaufer in the Department of Geology & Geophysics (Fellowship from January 1, 2003 through December 31, 2004)

Dr. Stephen Meyers – working with Assistant Professor Mark Pagani in the Department of Geology & Geophysics – (Fellowship from November 1, 2003 through October 31, 2005)

Dr. Susanna Remold – working with Assistant Professor Paul Turner in the Department of Ecology & Evolutionary Biology (Fellowship from October 1, 2002 through September 30, 2004)

Dr. Amy Russell – working with Associate Professor Anne Yoder in the Department of Ecology & Evolutionary Biology (Fellowship from July 28, 2003 through July 27, 2005)

Dr. Benjamin Twining – working with Professor Gaboury Benoit in the School of Forestry & Environmental Studies – (Fellowship from August 11, 2003 through August 10, 2005)

Dr. Jeremy Redman – worked with Professor Menachem Elimelech in Environmental Engineering – (Fellowship from September 1, 2001 through August 30, 2003)

YIBS POSTDOCTORAL ENVIRONMENTAL FELLOWSHIP
TOTAL SUPPORT \$20,893 FROM YIBS; \$21,000 from the Provost's Office

Dr. Linda Puth – working with Professor David Skelly at the School of Forestry & Environmental Studies (Fellowship from August 1, 2002 through December 31, 2004)

POSTDOCTORAL FELLOWSHIP AT THE SCHOOL OF FORESTRY & ENVIRONMENTAL STUDIES TOTAL SUPPORT \$25,000

Dr. Neung-Hwan Oh - Postdoctoral Fellow in F&ES Assistant Professor Peter Raymond's Laboratory (Fellowship from September 1, 2003 through August 31, 2004)
One time request from the School of Forestry & Environmental Studies for one half support for Dr. Oh.

EDWARD P. BASS DISTINGUISHED VISITING ENVIRONMENTAL SCHOLAR PROGRAM
NO APPOINTMENTS WERE MADE DURING THE PERIOD BETWEEN SEPTEMBER 2003 THROUGH JUNE 2004

In July 2002, The Edward P. Bass Distinguished Visiting Environmental Scholar program was endowed by its namesake to bring scholars, who are active researchers in the area of the environment, to Yale for an extended period.

Scholars, who are premier scholars in any field dealing with the study of the environment past or present, are to be nominated through the Yale Institute for Biospheric Studies (YIBS) Faculty Council.

The scholar will be in residence for a three to six month period in one of the two semesters of the academic year. There are no formal teaching requirements but the scholar will give seminars, interact with students and research groups, and participate in the life of one or more academic units.

The scholar's institution or designated unit will be compensated for his/her time at Yale. YIBS will provide housing and transportation for the Scholar and his/her spouse to and from Yale and a car will be available during the length of the visit.

The nominator will submit a CV and Bibliography, as well as a one-page reason for the appointment.

The choice of scholars will be made by a committee chosen by the Director of YIBS and normally will be made up of the Chairs or Deans of the units represented on the YIBS Faculty Council as well as a representative of the Provost's office.

An office at Yale will be provided by the host unit of the University.

The number of scholars will be determined by the behavior of the endowment. Individual university units may extend the visit of the Scholar through dedicated funds but that will not be the basis for the choice of candidates by YIBS. Any funds in excess of those needed for the appointments made in a given year may be held over for subsequent appointments or redirected to other YIBS programs.

YIBS AFFILIATES

NO FUNDS WERE REQUESTED FROM YIBS AFFILIATES IN 2003-2004

CENTER FOR BIODIVERSITY, CONSERVATION AND SCIENCE

Director, Oswald Schmitz

Professor & Director of Doctoral Studies at the School of Forestry & Environmental Studies and
Professor of Ecology & Evolutionary Biology

GENOCIDE STUDIES PROGRAM

Director, Benedict Kiernan

A. Whitney Griswald Professor of History

CENTER FOR SOLAR AND SPACE SCIENCE

Director, Sabatino Sofia

Professor of Astronomy

SPONSORED ACTIVITIES

G. EVELYN HUTCHINSON CELEBRATION (\$21,000)

On Saturday, October 25, 2003, Yale celebrated the 100th anniversary of G. Evelyn Hutchinson's birthday with an all-day Memorial Symposium and related exhibits in the British Art Center and Peabody Museum of Natural History highlighting Hutchinson's achievements in ecology and limnology and his interests in art and literature. The symposium was sponsored by the Yale Institute for Biospheric Studies.

The day began with remarks by Yale President Richard Levin, followed by presentations by Sharon Kingsland (Johns Hopkins) - *The Beauty of the World: Evelyn Hutchinson's Vision of Science*; Earl Werner (Michigan) - *Community Ecology and the Legacy of G. E. Hutchinson*; Lillian Randall (Emerita, Walters Art Museum) - *Scientific Rules Made Plain in Art of the Gothic Era and Beyond*; Peter Vitousek (Stanford) - *Nutrient Cycling and Limitation in Terrestrial Ecosystems: Interactions across Time Scales from Minutes to Millions of Years*; David Schindler (Alberta) - *A Modern View of Eutrophication*. Oswald Schmitz (Yale) - *Evolutionary Ecology: The Theatre and The Play*; David Skelly (Yale) - *The Central Idea of Ecology*; David Post (Yale) - *From Individuals to Ecosystems and Back Again - How Food Webs Integrate Across Levels of Biological Complexity*; Karl Turekian (Yale) - *Geochemical Paleoecology*; and Michael Donoghue (Yale) - *Experiencing Green Pigeons: G. E. Hutchinson on Natural History Museums*.

OLIN-BAYER-NEW HAVEN PUBLIC SCHOOLS' SCIENCE FAIR (\$650)

Contribution to support the Olin-Bayer-New Haven Public Schools' Science Fair. This Program supports a Kindergarten-through-grade 12 hands-on investigative science activity in the New Haven school system, which culminates in a City-wide Science Fair at Yale Commons. Almost all New Haven public schools participate, and over 9,000 students were directly involved in doing investigative research projects.

YIBS FACULTY SUPPORT

YIBS ASSIGNED THREE JUNIOR FACULTY EQUIVALENTS (JFE) SLOTS TOTAL SUPPORT - \$94,172

Support to the Department of Geology & Geophysics for Assistant Professor Mark Pagani – five-year commitment of support from one third of the income from the YIBS Faculty Support Fund. Term of support is from July 1, 2002 to June 20, 2007 and represents one of the YIBS JFE slots (\$47,086)

Support to Environmental Engineering for Assistant Professor William Mitch – five-year commitment of support from one third of the income from the YIBS Faculty Support Fund. Term of support is from July 1, 2003 to June 20, 2008 and represents one of the YIBS JFE slots (\$47,086)

One YIBS JFE slot has been held to support a position in the area of population. There were two unsuccessful searches for this position conducted by the Department of Epidemiology & Public Health (EPH). This slot has been released and will be reassigned. (\$0)

YIBS FACULTY CHAIR POSITIONS – 4 JFE SLOTS

Two YIBS JFE slots support the Edward P. Bass Professorship, currently held by Professor Stephen Stearns in EEB (July 2000- June 2005)

Two YIBS JFE slots support the G. Evelyn Hutchinson Professorship, currently held by Michael Donoghue in his position as Professor of Ecology & Evolutionary Biology (July 2000- June 2005). In January 2003, Michael Donoghue was named the Director of the Peabody Museum of Natural History, which is also an endowed position and of this date a portion of this JFE slot income has been returned to YIBS to use for Program Support.

YIBS RESEARCH CENTERS:

YIBS CENTER FOR EARTH OBSERVATION

TOTAL SUPPORT - \$25,000 AND \$5,000 FROM GENERAL REINSURANCE CORPORATION

Introduction

The Yale Center for Earth Observation (YCEO) is a resource center for environmental scientists using satellites to monitor the earth. Founded in 1992, it provides world-class computer hardware, software and field equipment to Yale faculty, staff and students users, enabling them to use digital satellite imagery in their research. As anticipated in 1992, the rate of broad-scale observable environmental change has accelerated over the last decade and satellites, as a tool to monitor these changes, have moved to center stage. Today, a significant fraction of international research results on global change have a remote sensing component, including studies of climate, forests, deserts, water resources, agriculture, ocean currents, ozone, haze and dust, glaciers and sea ice. Government agencies are investing over three billion dollars annually in environmental satellite technology. No leading university can ignore this exploding area of earth science.

The changes in remote sensing technology since 1992 are astounding. The number of environmental satellites in orbit has more than doubled and the sensors on these platforms have increased their spatial, temporal, and spectral resolution by factors of two or more. Several more satellites with new capabilities are launched each year. The compounding of these “doublings” implies that the data stream from satellites to earth has grown by orders of magnitude. Luckily, computer technology for data analysis has kept pace. YCEO has passed through three generations of computers and remains at the cutting edge with its ability to process and interpret large image data sets. Due in part to its excellent staff, the Center remains technologically competitive with larger centers around the world.

One way to visualize the role of YCEO on campus is shown in Appendix 1. The box in the upper left represents the wide variety of satellite systems and data archives maintained primarily by government agencies. The box in the upper right represents the advanced image analysis software developed and supported by private companies. The Center box is YCEO, with its computers, expertise and access to data and software. The lower box is the Yale student or researcher with an environmental problem to be studied. All the ingredients come together at YCEO. YCEO is the campus focal point for global environmental change studies using satellites.

YCEO’s interaction with students begins with the annual course “Observing the Earth from Space” (see below). The course is well attended and its “graduates” have applied their knowledge in various related careers (Appendix II). The class projects cover an impressive range of important issues (Appendix III). As technology has advanced, more students are able to carry out change studies successfully, clarifying the way that physical and ecological systems on earth respond to human inputs and natural fluctuations.

Interaction with the faculty begins with the YCEO Steering Committee (Table 1). Their advice has kept the Center broadly focused and able to support student and faculty projects from all sides of campus. YCEO has also assisted numerous faculty in writing grant proposals (see below). Often, a small remote sensing component can broaden the scope and improve the quantitative content of a research proposal.

YIBS CENTER FOR EARTH OBSERVATION continued

Table 1: Steering Committee Members

Member	Department /School	Academic Field
Ronald B. Smith	G&G	Atmospheric Science
Frank Hole	Anthro.	Middle East Archeology
Mark Ashton	F&ES	Forest Ecology
Durland Fish	E&PH	Landscape epidemiology

One campus development was not anticipated. It was expected that Yale academic departments might add faculty in the remote sensing area as global change studies grew in importance. This growth has happened at other universities, but not here. While the students of Yale faculty use the Center, the teaching, research and expertise in remote sensing remains almost entirely within the Center. Little is done in the various departments. On the one hand, this speaks to the wisdom of the efficient centralized YCEO model. But, it carries with it the danger of lack of knowledge and commitment from the schools and departments that use and are asked to fund the Center. They have focused their growth elsewhere, perhaps assuming that the Center will take care of all the environmental monitoring needs. This puts a burden on the faculty most closely allied to the Center. As other universities grow in this area, Yale needs to have a more aggressive coherent strategy to stay competitive.

1. Activities and Resources of the Center

The resources of the center are:

- File Server with terabyte disk array
- Staff expertise (One FTE)
- 12 high-end graphic workstations
- Industry-leading satellite image analysis and GIS software
- Extensive Landsat and MODIS data archives
- Portable hyperspectral spectrometer and GPS units
- Training
- Ease of access to agency image archives

These resources are available for three types of activities: teaching, funded research and unfunded research. The most intensive commitment each year is the course “Observing the Earth from Space” (ARCG 362a, G&G 362a/562a, F&ES 506a, EMD 548a). The enrollment typically reaches the cap of 35 students. With its fast lecture schedule, detailed laboratory exercises and required student projects, the course fully engages the staff and resources of the Center. Many of the “graduates” of the course stay involved with the Center while they are at Yale, carrying out thesis research in remote sensing (Appendix IV).

YCEO also supports funded research. The largest grants have dealt with landscape changes in the Middle East, West-central Africa, and the Alps. Current work includes climate patterns in Oregon and Patagonia, heat wave in Europe and hydrology in the Tigris Euphrates watersheds. The staff who carry out this research are funded directly from the grants. YCEO base funds are not used for this purpose. Research staff in the Center often assist in the course and advise students with their thesis projects. Thus there is a synergy between the research and teaching activities of YCEO. YCEO frequently consults with faculty

YIBS CENTER FOR EARTH OBSERVATION continued

writing grant proposals (Appendix V). Typically, the proposals include a letter of support from YCEO.

One recurring problem at YCEO is a lack of sufficient staff to support the “walk in” user. Faculty, students and staff often ask YCEO to analyze images for them, as they themselves do not have the expertise to do this. Such requests are usually declined or YCEO links the requestor with former students from our course that have the needed expertise. The lack of capability in this area is unfortunate, as sometimes a small assistance of this type could lead to significant improvement in research results.

Further information about the YCEO activities and resources can be found at the website <http://www.yale.edu/ceo/index.html>.

2. Annual Budget for YCEO

The annual budget for YCEO is divided into two parts. The base budget includes the maintenance of the Center’s hardware, software, and archives and base staff salary so that the Center can play its role in teaching, the support of unfunded research and the assisting of grant proposal writing. The annual cost of these items is about \$120,000 per year (see Table 2); growing by about 5 % per year.

The second component of the budget is external funding, supporting the extra staff, images, software and expendables associated with particular funded research projects. Over the past ten years, this external funding has varied from \$200,000 to \$500,000 per year, averaging about \$300,000. These funds come from government agencies, mostly NASA, and provide full cost recovery (i.e. overhead) for Yale University. A “YCEO grant” is loosely defined as a grant for which the idea for the proposal arose at the Center and in which Center staff plays a critical role. Usually these are interdisciplinary projects involving faculty from different departments. Other grants in which the Center plays only an assisting role are not included in this definition.

Table 2: Typical annual Base costs

Item	Annual cost
DNO Port Charge	\$6,000
Workstation Support	\$2,000
Backup fees	\$2,200
Software (4 packages)	\$10,000
Hardware maintenance	\$5,000
Salaries (1 FTE)	\$48,000
Benefits	\$23,000
Travel and Training	\$5,000
Supplies	\$9,000
Images	\$6,000
Total	\$117,200

The synergy between on-campus and external funding is helpful in sustaining remote sensing activities at Yale. Students trained in the YCEO course and in small projects are available to help faculty with funded research projects. Research scientists hired under grants elevate the knowledge base in the Center and assist in teaching and advising students. Images purchased under grants remain in the YCEO archive for use by students.

YIBS CENTER FOR EARTH OBSERVATION continued

For the first ten years of the Center, the base funds came directly from YIBS each year and were allocated in “5-year plans” so that long term planning was simple and effective. The Center grew and flourished under this plan. Currently, YCEO operates under a shared “matching plan” in which on campus units donate annually and the total is matched by the Provost. Last year, the contributions received were:

- Annual contributions from YIBS (\$25,000); F&ES (\$25,000)
- Matching from Provost up to \$45,000 (reviewed in 04-05)
- One time gifts (EVST, YIBS, Gen Re)

The advantage of the new plan is that each campus unit is kept aware of the needs of the Center by the annual request for funds. The disadvantage is that each year’s budget depends on the generosity of multiple units. The paperwork and uncertainty are considerably greater, and there is little possibility for long range planning. Also, the current annual base funding falls about 25% short of YCEO needs.

A suggestion has been made that YCEO institute user fees to support itself. Such a model is used by chemical, DNA and Isotope labs in ESC. This approach may be problematic for the remote sensing Center however. YCEO services do not come in “sample units”, but rather take the form of consultation, hardware and software used by the scientist herself, and archive access. For funded research, funds are often transferred from grants to the Center by putting YCEO staff temporarily on the grant payroll. This is appropriate when YCEO staff contribute many days or weeks to a particular grant. These transfers are sporadic however, and cannot replace the base funding from Yale.

A current problem is that funds do not exist to allow consideration of promotions for Center staff. Another potential problem is that funds are not set aside for replacing our computer equipment periodically. Typically, computers must be replaced every 4 to 5 years to prevent obsolescence. In the past, YCEO has attracted off-campus and on-campus funds for these renewals.

The idea of a YCEO endowment has been put forward. Discussions with the Yale development office have just begun on this issue. Annual funds from an endowment would stabilize the budget and allow more aggressive plans for growth.

3. Future of the Yale Center for Earth Observation

After consultation with the YCEO Steering Committee, a set of priority initiatives for the next few years has been developed. These initiatives are listed below. Most would require additional funds.

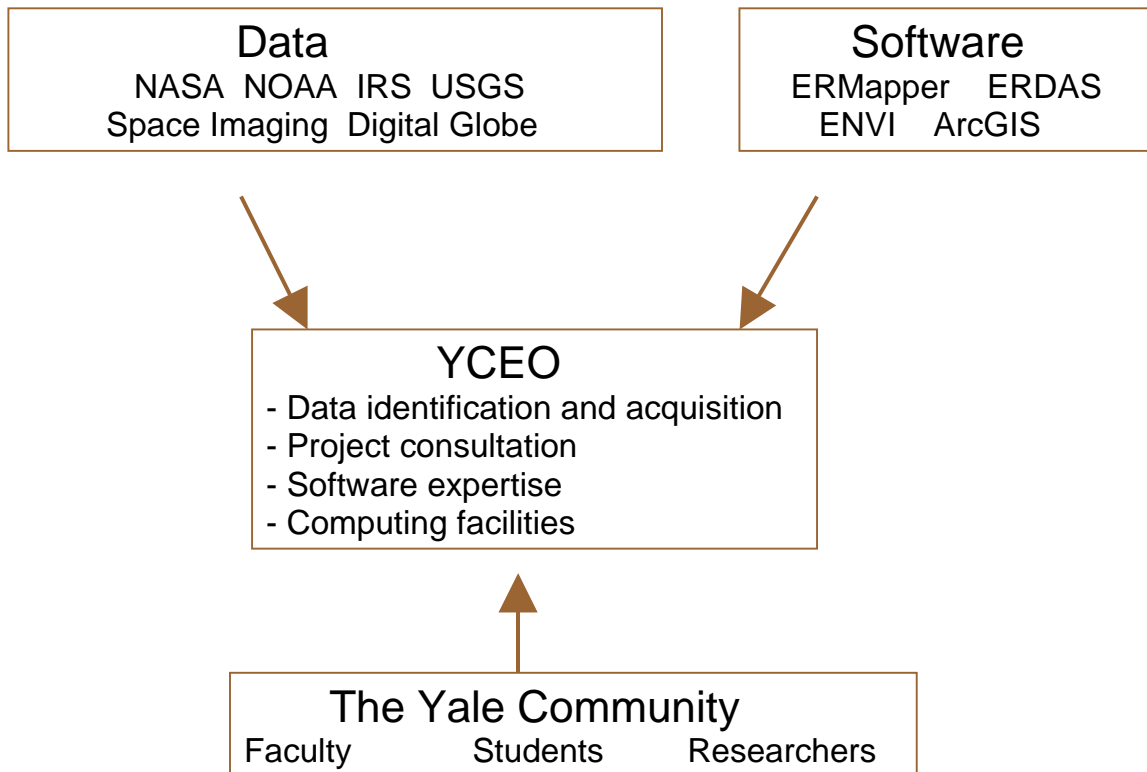
- Renew as a YIBS Center to take full advantage of their fund-raising and communications activities.
- Seek a new base funding model that is more stable, and with growth potential.
- Work with YIBS and Yale Development to attract donations from off campus.

- Redirect training activities, image archive growth and software development to attack a range of “Change Detection” projects (e.g. high-latitude warming, glacier retreat, mid-latitude heat waves and drought, rangeland degradation, forest cutting, urban sprawl, and insect, bird and animal habitat).

YIBS CENTER FOR EARTH OBSERVATION *continued*

- Strengthen the infrastructure of the YCEO (e.g. increase staff level and training, advanced computer hardware and software, expand image archive).
- Enable growth in quantitative environmental research at Yale using the international investment in environmental satellites
- Initiate group activities for students and faculty from different departments interested in earth monitoring.
- Improve assistance to faculty in student recruiting and grant support.
- Expand the quantitative teaching programs in environmental science.
- Expand assistance to geoscience and ecology programs. These programs have been underserved by YCEO.
- Increase international visibility of the activities at YCEO through a visitor program. Assist in hosting Rita Colwell (spring 2004) and other visiting remote sensing experts.
- Support additional faculty, staff, and students projects.
- Produce a seminar on global change analysis.
- Develop a workshop on natural hazard and risk analysis.
- Create an advanced course in remote sensing.
- Support a summer internship program.

Appendix I: Schematic of YCEO's campus role



YIBS CENTER FOR EARTH OBSERVATION continued

Appendix II

Student Career Paths

- Nick Kouchoukos- University of Chicago - using and teaching remote sensing in archeology
- Jeff Albert - Brown University - teaching GIS and remote sensing in hydrology
- Sarah Parcak - Cambridge University - using remote sensing to locate study sites for her Ph.D. program and teaching RS to Egyptian archeologists
- Doug Morton - NASA grant looking at Amazonian fires at U. Maryland
- Ben Silberfarb - The Lyme Timber Company - use RS to monitor the Pingree Forest Partnership
- Mark Wishnie - Project Director - Panama Native Species Reforestation Project (PRORENA)
- Art Gleason- PhD student at U. Miami in satellite oceanography
- Jane Foster - University of Maryland - Center for Environmental Science - Faculty Research Assistant in Remote Sensing

Appendix III

Student Course Projects from Spring 2004

Landscape Change Detection	7 projects
Forest Issues	7 projects
Ecosystem Mapping	4 projects
Atmosphere	4 projects
Urban Sprawl	3 projects
Epidemiology & Public Health	3 projects
Examining Environmental Events	3 projects
Elevation Impacts on Vegetation	2 projects
Climate	2 projects
Geology	1 project

Appendix IV

Examples of unfunded research:

- | | |
|--------------------------------------|-----------------------------|
| ■ Kyla Dahlin (Masters thesis) | Forest Management |
| ■ Tara O'Donnell (Senior Essay) | L.I. Sound temperatures |
| ■ Helen Mills (PhD Thesis) | Fire in the southwest |
| ■ Julie Valesquez-Runk (PhD Thesis) | Panama Land use |
| ■ Karina Yager (PhD Thesis) | Sacred Valley of Peru |
| ■ Christiane Ehringhaus (PhD thesis) | Land Use in the Amazon |
| ■ Deborah Liptzin (Senior Essay) | Alaska's shrinking glaciers |

YIBS CENTER FOR EARTH OBSERVATION continued

Appendix V

Recent Consultations on Research Proposals

Lead P.I	Dept	Agency or Program	Subject
M. Ashton	F&ES	NASA	Carbon Cycle
S. Stearns	E&EB	NSF IGERT	Ecology and Disease
R.B. Smith	G&G	NASA	Water cycle
P. Raymond	F&ES	USDA	Carbon and Rivers
T. Gregoire	F&ES	USFS	Biological invasions
G. Benoit	F&ES	NSF IGERT	Watersheds
X. Lee	F&ES	NASA	Ecosystem Carbon
B. Kiernan	History	YIBS, State Dept.	Genocide
T. Graedel	F&ES	Mining Industry	Mining impacts

YIBS EARTH SYSTEM CENTER FOR STABLE ISOTOPIC STUDIES
TOTAL SUPPORT - \$55,000

The YIBS Earth System Center for Isotopic Studies was established with the completion of the stable isotope facility in the Class of 1954 Environmental Science Center (ESC). This Center is devoted to the study of the environment, using the latest technology and ideas in light stable isotope research, and also serves as a meeting point for both Yale and external scientists to exchange ideas and develop new approaches to the study of the environment.

The goal is to make the Center a hot bed of research that not only will interact with the other inhabitants of ESC, but also with the rest of the Yale community, and to create a steady flux of visitors to the laboratory who will utilize the Center's state of the art equipment and participate in intellectual exchange.

Most aspects of the environment can be studied using light stable isotopes. For example, the isotopic compositions of animals and plants reflect the physical and chemical characteristics of the environment in which they live. As such, fossil components can be used to document past environmental change while living biota carry isotopic information regarding animal migration, metabolic pathways and environmental influences.

Light stable isotopes can also be used to study long-term cycles that influence Earth's climate such as CO₂ cycling within the Earth's interior, as well as placing constraints on the flux of volatiles through the Earth's crust.

The stable isotope facility in the department of Geology & Geophysics (G&G) has made many contributions to environmental studies. However, with new premises and instrumentation, the Center is positioned to greatly impact future research and scientific discourse. The Center has studied the dynamics of cloud formation and the effects that clouds have on global warming, and found that how clouds form and where they form can impact global warming both positively and negatively. Collaborations with the Department of Anthropology involved the study of wheat in the Middle East, when and where irrigation became important, and when and where drought conditions have been predominant. Collaboration with Fred Richards, Professor and Research Scientist in Molecular Biophysics and Biochemistry, investigated protein functions by using ¹³C as a marker of active sites. Stable isotopes in corals have been used to infer changes in recent ocean circulation, while isotopes derived from *Nautilus septa* constrain their early life history. Ruth Blake is active in developing oxygen isotopes of phosphates as environmental indicators and her studies may facilitate the recognition of life in ancient rocks and possibly on Mars.

The Earth System Center for Stable Isotopic Studies is housed in a 2,000 square foot facility in the ESC. The facility opened with an existing Finnigan MAT 251 mass spectrometer and a number of gas and chemistry lines to support the instrument. In the late part of 2002 a state of the art Finnigan MAT 253 was acquired as part of center member Mark Pagani's start up package. This instrument can be used to analyze isotopic compositions of extremely small samples of everything from water to compound specific organic molecules. The instrument came with a gas bench, a hydrogen device and a GC front end. A particularly exciting aspect of the instrument is that it is the first instrument that is able to analyze hydrogen isotopes on compound specific organic molecules. Early in 2003 a Finnigan Delta XP mass spectrometer was added specifically set up with automated devices for phosphate, sulfate, and organic carbon, analyses. This instrument was acquired as part of center member Ruth Blake's start up package. In late 2003 we added a Finnigan Delta Advantage as an elemental analyzer. The instrument was purchased as a four-way split between Geology, YIBS, Forestry, and EEB (the provost's office), The YIBS portion was

YIBS EARTH SYSTEM CENTER FOR ISOTOPIC STUDIES continued

\$35,000. Like all of the instruments it will have wide use but was purchased to satisfy the needs of center members David Post (EEB) and Peter Raymond (Forestry). All the instruments are of the same make and all peripherals are interchangeable, making the facility extremely flexible. The Finnegan MAT 251 is a very fine instrument but it is now 10 years old. As it is the main “workhorse” for ordinary isotopic analysis we plan to replace it in the near future. We intend to acquire the instrument through the normal government grant procedure, which will require university-matching funds.

The strength of the Center includes the expertise of the individuals who operate the instruments, and the Center’s mission is to bring together a group of scientists with stable isotope expertise that encompass a broad spectrum of environmental science disciplines. The current group includes: Ruth Blake, Gerald Olack, Mark Pagani, Danny Rye and Karl Turekian from the Department of Geology & Geophysics; David Post from the Department of Ecology & Evolutionary Biology; and Gaboury Benoit and Peter Raymond from the School of Forestry & Environmental Studies. Our range of expertise encompasses various disciplines including geochemistry, bio-geochemistry, paleo-ecology, ecology, micro biology, and forestry. The Center also intends to develop close ties to anthropology and engineering.

The Center has one full time PhD level staff member, Dr. Gerald Olack, who provides day-to-day management, assists users and instructors, and works with others from both within and from outside of Yale who wish to use the facility. He also has his own projects within the Center and Dr. Olack has brought a high standard of professionalism and scientific knowledge to the Center.

Some users and projects:

Ruth Blake:

- Yuhong Laing, Deren Dogru, Aleksandr Surkov: TC/EA: ^{18}O in phosphate, e.g. DNA from bacteria grown at different temperatures.
- Aleksandr Surkov, James Greenwood: TC/EA: ^{18}O in sulfate, e.g. sulfate isolated from different parts of water column.
- Yuhong Laing: Water vessels: ^{18}O in water via equilibration with CO_2 , e.g. growth media for bacteria.

Mark Pagani:

- Brett Tipple: GCC: compound specific ^{13}C , e.g. from alkanones and alkanes, extracted from different cores.
- Work with David Hodell, Florida: H-device: ^2H water: brine solutions.
- ^2H compound specific studies.

David Post:

- Gaku Takimoto: Costech EA: ^{15}N and ^{13}C from plant and animal material, e.g. Bahama study, insects.
- Undergrads: Costech EA: ^{15}N and ^{13}C from plant and animal material, student's hair for a class, seeds for senior project.

Peter Raymond:

- Kari Mull: Costech EA: ^{15}N and ^{13}C from organic matter in filtered river water.
- DIC and DOC--working on methods.

Danny Rye:

- Ephraim Taylor: MAT 251: ^{13}C and ^{18}O from carbonates from carbonate shale sequence – characterizing long term flow patterns. Using carbonate vessel with phosphoric acid. Project related to fate of CO_2 and H_2O in rocks.

YIBS EARTH SYSTEM CENTER FOR STABLE ISOTOPIC STUDIES continued

Gaboury Benoit:

- Rebecca Barnes: TC/EA: ^{18}O in nitrates.

Forestry Student:

- Fulton Rockwell: Costech EA and TC/EA: ^{13}C , ^{15}N and ^{18}O in plant material.

Chemistry:

Gary Brudvig

- Hongyu Chen: ^{18}O in O_2 and CO_2 from photosystem II studies.

Other facilities:

Vacuum lines to prep samples--offline techniques and roasting samples for continuous flow techniques. UV lamp, for sample digestion (phosphate release). Deltech furnace, for offline phosphate analysis. Muffle furnace for cleaning glassware (small), drying samples at high temperatures. Vacuum oven for drying samples at lower temperatures. Dental drill, for sample preparation. The Center is also the liquid N_2 and dry ice supplier to ESC (people billed for cost).

The Center's future needs include a Finnegan MAT 253 with peripherals to replace the MAT 251. As the operation grows the Center will need additional staff - at least one and most likely two people to run instruments on a daily basis. The Finnegan Mat 253 with peripherals, including a laser system for analyzing very small silicate samples, costs \$413,500. At present the staff is supported through fees and University resources. In past years half of Dr. Olack's salary and benefits were paid by the university. That practice ended in July of 2003. During the start up time when it was very difficult to generate any fees the operation was heavily subsidized by the Department of Geology and Geophysics. This year YIBS has contributed \$20,000 to the operation. With expected revenues for services and money from grants a \$25,000 deficit is projected this year that will be covered by G&G. This is clearly not an acceptable long-term solution to running the facility.

YIBS ECOSAVE CENTER

TOTAL SUPPORT - \$20,000 AND \$4,054 FROM GIFT FROM COLEMAN BURKE

Faculty members: Adalgisa Caccone, Michael Donoghue, Jacques Gauthier, Jeffrey Powell, Elisabeth Vrba (director), Anne Yoder

(superscripts refer to explanatory endnotes below; the 2003 Yale Environmental Newsletter has additional details on the programs)

Emphasis of EC funding ¹:

- field exploration, discovery, collection, and documentation of new and little-known living and fossil forms
- international, especially third world collaborations, and exchange of scientists and students
- seed money towards projects that find additional and continuing funds elsewhere

Requests and Special Needs during 2004-5:

TRAVEL (fieldwork, museum studies, visiting scholars); LABORATORY STUDIES; SYMPOSIUM; EQUIPMENT PURCHASES

Caccone and Powell, iguanas and tortoises, (Galapagos); malaria (Africa)	2
Donoghue, botanical field trip (Japan)	3
Gauthier, museum fossil study (U.S.A., Germany); fossil collection (Canada)	4
Vrba, fossil study (Ethiopia); <i>pO₂</i> experiments (Yale); carnivore growth (U.S.A)	5
Yoder, trip of Malagasy scholar to Yale; molecular systematics symposium	6

EXPLANATORY ENDNOTES

¹ **From Elisabeth Vrba, EC director:** EC support will emphasize exploration and discovery of new and little known living and fossil forms. We envision that this is where the cutting edge will be in future. International and especially third-world collaborations in research and exchange of scientists and students will be emphasized. Third-world countries contain a large proportion of Earth's undescribed species. Yet their poverty, high population growth, and low level of education imply a greater risk of future extinction. We are motivated not only by the will to serve the educational and research efforts of those countries, but also by Yale's interests. These partnerships will be equal ones with benefits for us, ranging from access to foreign sites, collection programs, and specimens, through the newsworthiness of scientific announcements on exotic biota, to influence on policy. In our view the globalization of science is on the march at Yale and elsewhere, and EC should be a part of that globalization.

The requests in endnotes ²⁻⁶ below were selected from a larger set of requests, and most of the budget amounts proposed on page 1 represent seed money or partial funding towards these selected objectives. The proposals are preliminary. Nearer the appropriate times there will be further justifications and discussions on what is needed and what other funds have been or can be raised.

² **From Gisella Caccone and Jeffrey Powell:** GALAPAGOS IGUANA PROJECT.

Understanding the effects of human induced pollution: a case study on marine iguanas and the genetic

YIBS ECOSAVE CENTER continued

consequences of the Jessica oil spill, Galapagos Islands

Project Description: In this project we want to analyze levels of genetic variation in two populations of marine iguanas, one of which has been exposed to severe pollution due to a major oils spill, the other which has not been subjected to such event. For both populations we have blood samples from 50-100 individuals, which were collected before the oil spill, as part of a sampling carried out to understand the levels of genetic differentiation between populations from different islands. We also have the possibility of sampling for the same populations museum samples dating to 1906. Thus, we are in the unique position to be able to carry out a study that directly compares levels of genetic variation before and after the oil spill in the same populations. To our knowledge there is no other study where this has ever been done before. We know that the oil spill was responsible for at least 60% mortality in the population that was impacted. What we want to understand with this project are two general aspects that directly relate to the long-term impact of pollution events. These types of questions are relevant to all species that experience this type of stress, but could never be addressed in a rigid scientific framework because samples before the pollution event were not available. The main questions addressed by this project are: 1. Did the oil spill affect all the different genotypes in the population similarly or did particular genotypes were more affected or more resistant than others? 2. Did the drastic reduction in size experienced by the population that was affected the oil spill translated in a reduction of levels of genetic variability, affecting its potential to cope with future environmental challenges?

Benefits:

1- Environmental studies impact: This study is the first to evaluate in a rigorous and controlled fashion the genetic consequences of pollution by taking advantage of samples from wild populations before and after the an oil-spill. The results will be of interest not only to the people working on this species but to all environmental agencies, park managers, and scientists that want to have data and information on the long term effect of dramatic pollution events on wild populations.

2- Conservation impact: This study will be a very valuable help in managing the populations of these marine iguanas. Let me emphasize that these are the only marine iguanas existing in the world. Thus, losing some of the population has very far-reaching impacts on the survival of this unique lineage.

3- Training impact: The genetic work will be carried out by undergraduate and graduate students interested in the use of molecular techniques for conservation and environmental studies.

Additional Funding and Budget Justification:

1- Travel and field expenses: I have recently received a National Geographic grant that will cover only the costs of the field and travel expenses to carry out an extensive collecting trip to sample blood from 50-100 individuals of all the populations of marine iguanas in the Galapagos (\$16,500). We need funds to go to the California Academy of Science (San Francisco, CA) and the Smithsonian (Washington, DC) to sample museum specimens from the same population we will collect. This will allow us to evaluate changes in genetic diversity over a century, and will help to tease apart changes probably linked to the oil spill from the ones linked to natural causes, such as ENSO events.

2- Personnel: Dr. Sebastian Steinfartz will join the lab this April for one year to work on this project thanks to a fellowship from Germany that covers his salary. No funds are requested.

3- Consumables for genetic work: We need funding to carry out the genetic analyses and to database the blood and DNA collection, which will be deposited in the Peabody Museum Cryolab and made available to the scientific community.

DNA analyses of 200 individuals from four populations: DNA extractions, PCR and DNA sequencing of a variable DNA fragment for the mitochondrial DNA region, and microsatellite analyses of 15 loci.

From Gisella Caccone and Jeffrey Powell: GALAPAGOS TORTOISE PROJECT.

Immortalize endangered Galapagos tortoise cell lines: YIBS, through ECOSAVE, has financed considerable research on the endangered Galapagos tortoises. In anticipation (hopefully not realized) that

YIBS ECOSAVE CENTER continued

some species may go extinct in the near future (as has already happened to three), we propose to obtain tissue samples in a manner, which allows cell culturing. We are collaborating in these efforts with Dr. Oliver Ryder (San Diego Zoo) who is an authority on tissue culturing exotic species. These efforts will require a collecting trip to Galapagos.

From Gisella Caccone and Jeffrey Powell: MALARIA PROJECT.

Malaria in Africa: We also intend to continue our work on the most important vectors of malaria in the world, the *Anopheles gambiae* complex in sub-Saharan Africa. As a distinguished former director of the Tanzanian Medical Research Council (our equivalent of NIH) stated: "malaria is a cause of poverty in sub-Saharan Africa and not vice-versa. Effective malaria control is essential for Africa's renaissance." (Kilama, 2001). It is well known that the economic well being of countries is crucial in determining the resources they can contribute to "luxuries" such as conserving their unique biota. Thus our work to possibly alleviate the horrific effects of malaria in sub-Saharan Africa is central to the aims of ECOSAVE.

Despite decades of research, many aspects of the natural history of insect vectors of disease remain unknown. For example, it is poorly understood how the major vectors of malaria in sub-Saharan Africa (*Anopheles gambiae* s.l.) survive the annual dry season, especially in West Africa where the dry season is most severe. This greatly affects the population genetics, size, and stability of populations. We intend to address these fundamental deficiencies in understanding malaria transmission dynamics in Africa. We need funds for field work in the summer 2004 to collect samples from the beginning of the wet season and at the end of the wet. This will allow us to use genetic data to test whether the population expansion that occurs in the transition between dry/wet seasons starts from a small number of mosquitoes that survive the dry season in low numbers in the villages, or from migrants from nearby areas where permanent pools allow breeding to occur all year long. This will have profound impacts on the development of strategies to control malaria by controlling the vector populations. We are submitting a large NIH grant to address this problem over a 5-year period. However, we will not have funds from this grant until December 2005. The funds from ECOSAVE will serve as "seed money" for this project. This money will also contribute to the training of a graduate student in EEB who intends to do her dissertation research on these mosquitoes.

3

From Michael Donoghue: In general, and in keeping with the mission of YIBS and its centers, I view any EC funding as "seed money" to jump-start a project for which I intend to seek outside funding. Often in my career it has proven extremely useful to carry out a preliminary field trip before launching a major effort. I have been working in the eastern Himalayas of China, but would like to extend my studies to Japan in future NSF grants. The idea is to address the major biogeographic questions that have been motivating a lot of my research these days. I will briefly outline the project below. It would provide excellent preliminary data, and the exact timing depends on many other factors.

Japan. Our work has focused on relationships of plant groups around the Northern Hemisphere, and has identified a number of lineages in which Japanese species are more closely related to North America species than they are to Chinese species. To further test the generality of this pattern, we need additional plant collections of critical taxa from Japan. A two-week field trip with a graduate student and a colleague (again, David Boufford from Harvard) would allow us to obtain the plant samples that could be used in preliminary studies, with an eye toward obtaining major funding through the NSF. Again, the idea would be to include DNA sequences from these plants in broader phylogenetic studies, which would capitalize on our already extensive collections from the eastern Himalayas.

We have a great deal of experience with such trips, so I am confident that we would be successful in obtaining the plants we are after. I am also quite confident that these trips would yield the preliminary data necessary for obtaining funding through other sources, especially the NSF's Biotic Surveys and Inventory program. I would be happy to provide detailed budgets, if you would find these useful at this stage.

I should also add that this trip would provide excellent field experiences for a Yale graduate student, and might very well result in a Ph.D. project. In fact, one of my students at Harvard just finished up a project that began with such a field trip. I should also mention that these trips would also be great from the

YIBS ECOSAVE CENTER continued

standpoint of building up the collections in the newly rejuvenated Yale Herbarium, where we now have an excellent collections manager who is excited about incorporating new collections from Asia. Of course, these trips would also yield tissue samples and DNAs that would contribute to the development of the cryo-preservation facility.

4

From Jacques Gauthier and his graduate student Jason Downs: 2004 EXPEDITION TO DEVONIAN STRATA OF SCAUMENAC BAY, QUEBEC, CANADA.

The invasion of land by both vertebrates and plants triggered a novel radiation that shaped the first modern terrestrial ecosystems. The increasingly complex terrestrial environment opened new ecological space underlying that spectacular organismal diversification. Jason Downs's research program includes study of the interaction between organismal diversity and ecological complexity in the terrestrial ecosystems of the Devonian Period (417-354my). Because this interaction continues to shape modern ecosystems, an understanding of its effect on fossil ecosystems is important to modern ecological conservation efforts. The proposed field project in Quebec for the 2004 field season extends work previously conducted in Devonian and Carboniferous (354-290my) strata of Nova Scotia; Pennsylvania, U.S.A.; and on Ellesmere Island, Nunavut. The proposed field work is part of an ongoing effort to gain a temporally and geographically comprehensive understanding of the earliest terrestrial plants and vertebrates and the ecosystems from which they are derived.

From Jacques Gauthier and his graduate student Krister Smith: LIZARD BIODIVERSITY AND CLIMATE CHANGE IN THE FOSSIL RECORD.

That life is bewilderingly diverse in the tropics is one of the earliest recognized ecological patterns, and the diversity of hypotheses proposed to explain this pattern is nearly as perplexing. A primary difficulty in deciding which hypotheses best fit the data is that many different variables, including temperature, covary with latitude, and many hypotheses therefore inevitably make the same predictions. The fossil record provides us with an opportunity to approach the problem in a unique way. I am focusing on a group of animals--squamate reptiles, or lizards--during a 1-million-year interval in the early Eocene in order to test the importance of a particular variable--temperature--to species diversity. The latitude of the localities I am studying was essentially invariant during this period; temperature, on the other hand, varied enormously, showing a range of at least 12 °C. Before I can adequately analyze diversity, however, I need to describe the species present (many of them are new to science) and establish as accurately as possible whom they are related to. To this end, I require funds to visit several institutions in which large skeletal collections of extant lizards are available for comparison, namely, the Florida Museum of Natural History (FLMNH), the American Museum of Natural History (AMNH), the University of Texas at Austin (UT), and the Museum of Comparative Zoology at Harvard University (MCZ). Descriptions must be published before results of diversity analyses. This work should help to clarify what factors are important in the regulation of species diversity over long time-scales. This work should also play a more pragmatic role, for in order to make rational decisions, citizens and policy-makers need to have predictions about how life is likely to respond to continuing global warming. The fossil record provides the best source of information on how life actually *has* responded to environmental perturbations.

From Jacques Gauthier and his graduate student, Brian Andres: CONSERVATION OF LARGE FLYING VERTEBRATES: INFORMATION FROM AN UNLIKELY SOURCE.

In the history of life on earth, only four groups of organisms have achieved powered flight: the insects, the bats, the birds, and the pterosaurs. However, the pterosaurs are the only one of these groups to go extinct. This is unusual considering the advantages of powered flight and that pterosaurs are the most successful of the flying vertebrates. Avian dinosaurs, the closest living relatives of pterosaurs, survived this

YIBS ECOSAVE CENTER continued

extinction event. One hypothesis as to why the pterosaurs went extinct suggests that in order to avoid competition with birds, pterosaur species grew to such large sizes that they were more prone to extinction. If there is a correlation between the size a flying vertebrate species and its probability of going extinct, then this pattern should be taken into account for the protection of flying vertebrates; for example, preferential conservation efforts on larger species of birds and bats. Indeed, many of the largest species of birds, such as the California condor and the Whooping crane, are endangered. To test this correlation, I propose to travel to and examine the flying vertebrates of the Solnhofen Formation of Germany, the first formation in which pterosaurs and birds both occur, and compare them to the late Mesozoic flying vertebrates of the United States to see whether there is a size increase in pterosaurs and whether only large flying vertebrates went extinct at the end of the Mesozoic. The Solnhofen is also the only formation that has a complete growth series of pterosaurs and this information can be used to estimate the body sizes of the usually fragmentary pterosaur specimens around the world.

5 **From Elisabeth Vrba: FOSSIL STUDIES IN ETHIOPIA.**

I request funding towards a trip approximately four weeks long during next summer 2004 for study of fossil Bovidae (antelopes, buffaloes, and allies). I plan to be mainly in Addis Ababa, Ethiopia, as a member of the American and Ethiopian Middle Awash Research Program (MARP), and also more briefly in museums in Nairobi, Johannesburg, Cape Town, and London. Excavation over the past two years of eastern Ethiopian 6.0-0.5 million year (my) old strata in the Middle Awash area has added hundreds more fossil Bovidae, which I have not yet studied. One task is to analyse the new material (during the trips to the Nairobi, London, and South African museums I will compare the Ethiopian fossils with related collections from other countries and continents); and a second objective is to investigate what the paleontological patterns mean in terms of evolutionary causes. An additional interest arises from the fact that the Middle Awash fossil strata are now the richest source of early hominid fossils, including several hominid species (*Ardipithecus ramidus*, *Australopithecus africanus*, *Australopithecus afarensis*, *Australopithecus garhi*, *Paranthropus aethiopicus*, *Paranthropus boisei*, and three species of *Homo*). Studies of Bovidae have been found useful in elucidation of the chronological, paleoecological, and paleoclimatic context of early hominid evolution. Of particular interest in my studies this year will be new bovid fossils from layers that are about 5.7-5.2 my old which contain the earliest remains of *Ardipithecus ramidus* (together with the recent hominid find from Chad, ~6 my old, among the earliest known fossil Hominidae), and from strata 2.6-2.5 my old (associated with the new species *Australopithecus garhi* and the earliest stone tools). Both intervals were marked on the one hand by large global climatic changes and on the other by the appearances of large numbers of new mammalian species in the fossil record on several continents.

From Elisabeth Vrba and her graduate student (together with geochemist Robert Berner) John Vanden Brooks:

EFFECTS OF VARYING pO_2 ON VERTEBRATE EVOLUTION: Atmospheric changes can have large effects on vertebrate evolution. The concentration of oxygen has long been thought to have not evolved much through the Phanerozoic, but recent modeling efforts have proposed an oxygen spike during the Carboniferous and Permian, upwards of 31%. I am proposing to study the effects of varying pO_2 (between 21%, modern day levels, and 31%, Late Permian levels) on two extant vertebrate groups, *Alligator mississippiensis* (150 eggs) and *Eleutherodactylus coqui* (100 juveniles). Growth rates, isotopic ratios, and bone histology will all be measured and examined. This data can then be compared to the fossil record to elucidate how changing pO_2 affected vertebrate evolution. To carry out these studies, it is necessary to construct specialized tanks to control the pO_2 and to travel to acquire the specimens. Funds needed for:

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Specialized tanks for varying pO_2 (20 in total including all modifications) ~ \$ 2,000
O₂ and N₂/CO₂ gas tanks, tubing and mixing valves
Atmospheric oxygen monitor
7000 pinhead crickets
Vitamin powder
Underwater heaters for temperature regulation in alligator tanks
Travel for acquisition of *Alligator mississippiensis* eggs from Louisiana
Travel for acquisition of *Eleutherodactylus coqui*
Materials for histological studies including clearing and staining and the production of thin sections
Isotopic Studies

Amount requested from ECOSAVE would be for tank construction and acquisition of *Alligator mississippiensis* eggs

From Elisabeth Vrba and her graduate students Alana Kawakami and Matthew Benoit:

CARNIVORE SKULL GROWTH PROJECTS: Each of these two graduate students will study aspects of growth and evolution in a substantial number of clades of CARNIVORA. Alana's special focus is on the basicranium, particularly the ear region while Matt's is on jaws and dentition. But in each case the special anatomy of interest has to be evaluated in the larger context of skull characters and body weights. This will involve extensive and repeated trips to the American Museum, New York, and the Smithsonian Institution, Washington. They will also need to purchase statistical software programs and photographic consumables. We request funding towards the expenses of each project.

From Elisabeth Vrba COMPUTER PURCHASES FOR MAMMAL ANALYSES:

Some of the software needed to complete phylogenetic analyses, of groups of fossil Bovidae from the Middle Awash, Ethiopia, and from elsewhere where these groups are found (see note above), can only be employed on a MacIntosh computer which I do not have at present. I would like to purchase the software, a MacIntosh computer and an appropriate printer. A second research project concerns the causal linkages between paleoenvironmental changes and evolution. I am approaching this problem by analysis of the macroevolutionary patterns of all the larger African mammals of the past 25 my. This is a large data base (currently ~ 4000 records from ~680 species, from ~ 242 fossil sites or site units). I have already devised mathematical algorithms for testing various taphonomic and evolutionary hypotheses on this data set. It is successfully established on an IBM computer and linked to various software programs that run on IBM computers. However, this computer is comparatively old and cranks away at the large calculations woefully slowly. I need to replace it with a new and faster IBM computer.

From Anne Yoder:

VISITING MALAGASY SCHOLAR: 1) As last year, I will be bringing Dr. Achille Raselimanana (featured in the Yale Environmental Newsletter) to my lab for a period of four months. Last summer, ECOSAVE helped to finance housing for Dr. Raselimanana, and I would like to request continued support for his housing expenses.

SYMPOSIUM: This summer, I am hosting an international symposium on methods for employing molecular data to estimate divergence events among organisms. My co-organizer, Dr. Ziheng Yang, and I are bringing speakers from New Zealand, Japan, France, England, and a variety of U.S. locations. We will receive some monies from the Society for Systematic Biology to cover speaker expenses, but anticipate the need for more funds to cover expenses for all of our speakers.

YIBS ECOSAVE CONSERVATION GENETICS LABORATORY

TOTAL SUPPORT - \$44,000 PROGRAM SUPPORT; \$76,100 FOR DIRECTOR'S SALARY & BENEFITS

Laboratory Director, Dr. Gisella Caccone

The ECOSAVE Conservation Genetics Laboratory was established in the fall of 1998. The mission of this laboratory is to train undergraduate, graduate students, postdoctoral fellows, and faculty in using molecular biology tools to study organisms. More specifically, it trains students to take advantage of the great advances in molecular genetics of the past 20 years to address environmental, biodiversity, epidemiological, and conservation questions. The laboratory is open to the whole academic community. Students are taught how to use genetic data to reconstruct the phylogeny of a group (i.e. their history). They also learn to use genes to clarify patterns and levels of differentiation between different geographic populations of the same species (i.e. their levels of genetic variability, degrees of genetic isolation), and how to use genetic data to analyze the demographic structure of populations (i.e. inbreeding / outbreeding problems, mating structures, etc.). The genetic data are integrated with ecological, morphological, behavioral, and environmental data to obtain a multidisciplinary picture of the relationships of the organisms to their environment. No other such facility exists on campus.

YIBS CENTER FOR FIELD ECOLOGY
TOTAL YIBS SUPPORT - \$20,000

The YIBS Center for Field Ecology awarded \$2,000 to each of ten PhD students to support the development of their graduate research projects: two in Anthropology, four in EEB, one in EPH, one in F&ES, and two in G&G.

They were selected from a pool of 14 applicants. Applications were read and ranked independently by Andrew Hill (Anthropology), Dave Skelly (F&ES), and Stephen Stearns (EEB).

This continues to be a good use of limited resources. The YIBS CFE is one of the few sources providing support to graduate students early in their careers; recipients report constructive use of the funds and enthusiastic gratitude (see appended statements, lightly edited only for concision).

The following is a series of brief reports on the research projects by the grant recipients:

Maria De Angelo, Department of Ecology & Evolutionary Biology (EEB)

I received \$2000.00 from YIBS CFE to conduct summer field research in the lowlands of Ecuador in conjunction with my PhD dissertation project on the phylogeography and ecology of terrestrial spiny rats, genus *Proechimys*, in northern South America. I spent one month in the lowlands of Ecuador at two field stations in the Ecuadorian Amazon: Sani Lodge, on the north side of the Rio Napo, and Tiputini Biodiversity Station, on the south side of the Rio Napo. I chose to trap spiny rats at these stations for a number of reasons; first, to gather specimens to test a Neotropical speciation model, the riverine barrier hypothesis. This hypothesis can be used to test whether rivers act as boundaries to species distributions. My second reason for trapping at these locations was to test my hypothesis that season effects the distribution of spiny rats. While trapping at these locations in the dry season (February-March 2004), trapping success was low, yielding one rat at the south side location and two rats on the north side location in one week of trapping at each station. I hypothesized that rainfall and water levels contributed to local densities of spiny rats and that I needed to sample these locations in the rainy season. The CFE grant allowed me to revisit these areas during the rainy season. I was successful in trapping spiny rats at both locations, but the northern Napo location yielded more rats. I suspect that spiny rat distribution is more strongly affected by water levels at the northern location because of the number of swamps that ring my trapping sites. Spiny rats may be isolated on terra firme during the rainy season, leading to high densities and greater trapping success. In the dry season, the waters recede; swamps dry and the rats can range farther into the forest. The southern site is not subject to seasonal flooding and this may not be a factor in spiny rat distribution. To help test my hypothesis, this summer I trained a volunteer to trap spiny rats for me at the northern site once a month for the next six months. Coupled with rainfall, habitat, and vegetation data, this information will provide knowledge of the ecological requirements of these species. Thus, the CFE grant gave me the opportunity to trap spiny rats during the rainy season in Ecuador, allowed me to hire a field assistant, and allowed me to train a volunteer who will provide long-term trapping data of spiny rats in the lowlands in Ecuador. These data will contribute to answering ecological questions that are an essential component of my dissertation research. Thank you for providing the opportunity to continue my research over the summer.

Sholly Gunter, Anthropology

My field research was conducted at the Ngogo Research Station in Kibale National Park, Uganda during the months of May – August. The purpose of my summer research was to familiarize myself with the field site and the 145 chimpanzees of the Ngogo community. My first year summer pilot research was

YIBS CENTER FOR FIELD ECOLOGY continued

made possible in large part by the YIBS Center for Field Ecology grant. I purchased my plane ticket (\$1500) with the YIBS money, which was obviously instrumental in my ability to do my research. The grant provided me funds with which to pay monthly research fees (\$300 total) to the Ugandan Wildlife Authority and the Ngogo Field Station. I also paid the \$200 fee required by the Uganda National Council for Science and Technology to conduct research within the country.

During the 10 weeks I was at Ngogo, I was able to learn the names of nearly all 145 chimpanzees and recognize them by sight. This is an essential skill for the continuation of my research, as the correct identification of individuals is necessary to collect accurate data. I familiarized myself with the Ngogo trail system and compiled a GPS map of fruit trees at which the chimpanzees fed often. The knowledge of the location of preferred feeding sites is helpful for locating chimpanzees on a daily basis. I also had the opportunity to observe chimpanzee behavior in the wild and evaluate the feasibility of several different research methods that I was considering.

I would like to thank YIBS for investing in my project and my graduate education. I am excited and optimistic about the future of my research, and very much appreciate the institute's generosity.

Rachel Novick, Department of Ecology & Evolutionary Biology (EEB)

I used my YIBS grant to support field research for my thesis project. This project has two parts: the first part is a study of host-parasite cospeciation and evolution of complex life cycles in the cedar apple rust fungi, a group of 60 species (*Gymnosporangium* spp.). The second part investigates population structure and phylogeography in one species in the group (*G. juniperi-virginianae*).

Extensive travel in North America and some travel in East Asia are required to cover the ranges of all the species. The population study will cover the natural range of *G. juniperi-virginianae*, which is restricted to the eastern U.S. Recent specimens of most species are not available in herbaria, making field collection essential, but even if they were, the process of finding the species myself adds a natural history dimension to my graduate education that I value highly.

I spent Summer 2004 collecting species in this group that live in the eastern U.S. as well as population samples of *G. juniperi-virginianae*. Thanks to my YIBS funding I was able to do collecting in Florida, Georgia, North Carolina, Pennsylvania, New York, New Jersey, Ontario, and much of New England. So far I have specimens of 30 species and population samples of *G. juniperi-virginianae* from 8 states. I also used funds from my YIBS grant to attend the annual Mycological Society of America conference.

C. Brandon Ogbunugafor, Department of Epidemiology & Public Health (EPH)

I was fortunate to receive the YIBS fellowship, which funded my research in the primary afrotropical vector for malaria, *Anopheles gambiae* s.s. I asked how different regional populations of *Anopheles gambiae* s.s. use different chemical cues to modulate their choice of oviposition site. The work took place in Central and Western Kenya in July and August of 2004.

The fellowship funding covered most of my travel and research costs, including a portion of my round-trip ticket to Kenya, and my research supplies. In terms of research supplies, the funding enabled me to build an insectary and 50 - 30 X 30 X 30 cm mesh cages where I was able to conduct bioassays. As the nature of my work involved comparing behavior of mosquitoes from different regions, I needed to travel frequently, collecting mosquito larvae daily and rearing them in the insectary I constructed in Western Kenya. A portion of the funding went toward funding this transportation. The actual rearing of mosquitoes requires cages and a sugar-based food source; YIBS money also covered the collection and maintenance of several distinct regional strains of *Anopheles gambiae* s.s.

YIBS CENTER FOR FIELD ECOLOGY continued

I accumulated so much data that analysis has occupied many of my days since returning. This data will be part of a manuscript that I will soon submit for publication and that may form the backbone of my dissertation research in malaria vector ecology. This funding was particularly important given the nature of my graduate program—I am enrolled in the combined MD/PhD program, and so much of my time during the academic year was spent completing my course requirements in the medical school. This past summer was critical because the academic year simply does not provide enough time for one to be productive scientifically and certainly not enough time to carry out fieldwork of any kind. YIBS allowed me to use the summer between my first and second academic years productively, and I now enter my second year of coursework with a solid foundation for what could be my dissertation project.

I thank YIBS for the fellowship and hope that you can continue to support field dissertation projects for graduate students.

Kevin Potts, Anthropology

I studied the feeding ecology of two communities of chimpanzees in Kibale National Park, Uganda between May and August of 2004. The distribution of chimpanzees in Kibale is markedly aggregated in the center of the park, with lower densities found in the northern and southern sectors. I am interested in determining the potential relationships between variations in feeding ecology (including feeding and foraging behaviors) of distinct communities inhabiting the park and these notable patterns of distribution and abundance. I studied the feeding behaviors of chimpanzees at two sites within Kibale: Ngogo (N= 150 chimpanzees) and Kanywara (N= 50 chimpanzees). I conducted behavioral observation using a scan sampling methodology on foraging parties of chimpanzees at each site. At specified intervals, I recorded the number of individuals feeding in a given resource patch and the resource item being eaten by each individual (including the plant species and part). I recorded each instance of entering and leaving a resource patch by each individual observed in order to determine the “patch residency time” for each feeding individual. I also recorded the distance traveled by each individual in a foraging party between feeding patches as a measure of “travel cost”. I found that chimpanzees from the large, high-density community (Ngogo) traveled a shorter distance between successive instances of feeding, and that individuals tended to feed in more distinct patches per day and for shorter lengths of time on average than did the chimpanzees from the small, low-density community (Kanyawara). The results of this pilot research have provided me with a solid foundation with which to formulate further hypotheses for my dissertation research. I am indebted to the YIBS CFE for providing the bulk of funding for this pilot project. The support I received from YIBS allowed me travel abroad to conduct my fieldwork and to pay research fees to the Uganda Wildlife Authority.

Samantha G. Rothman, School of Forestry & Environmental Studies (FE&S)

My work focuses on understanding the biological mechanisms surrounding population demography and landscape level diversity of New England species utilized as medicinal plants, such as American ginseng (*Panax quinquefolius*) and black cohosh (*Cimicifuga racemosa*). My YIBS award was the sole support of my research during the summer of 2004. I used the money primarily to establish an experimental plant population and to create a habitat model for black cohosh. The time I spent working on the model increased my skills with GIS and taught me the field skills I will need to collect and work with this type of field data.

Three large plots of American ginseng were also established at the Yale Myers Forest. The seed was obtained from a commercial grower in New York, and the plots were monitored over the summer for germination and growth. In addition to plants started from seed, bare root plants were grown. These plants will be an invaluable source of material for future experiments, as native plants are rare.

YIBS CENTER FOR FIELD ECOLOGY continued

Erika Schielke, Department of Ecology & Evolutionary Biology (EEB)

During July and August, I carried out a combination of field and laboratory studies in Burkina Faso, West Africa to develop a molecular assay that will allow for the study of predation on mosquito larvae. The goal is to develop a PCR-based assay to detect mosquito DNA in predator guts. Thorough understanding of mosquito population structure is critical to the control of malaria, which is transmitted by mosquitoes. However, we still lack information on the structure and size of the populations, and on factors, such as predation, that influence these parameters. PCR allows us to distinguish between the morphologically identical members of the *Anopheles gambiae* complex, which is responsible for the majority of malaria transmission in Africa. This gives us the sensitivity to test whether certain species of predators prey preferentially on one or more species. I sampled mosquito habitats and determined, through lab trials, which species were mosquito predators. I focused on three different predator species for the development of the assay. Predators were collected in the field and fed larvae of known identity in the lab. The predators were preserved either immediately after feeding or after varying lengths of time. At Yale, I will optimize the PCR assay for detection of mosquito DNA from predator DNA extracts. Then, using the preserved samples, I will determine for how long it is possible to detect mosquito DNA in predator guts. Development of this assay is a first step toward field studies of predation on mosquito larvae. YIBS funding assisted with plane fare, housing in Burkina Faso, and field and laboratory supplies. The field research in Burkina Faso was an invaluable introduction to study sites in West Africa, and to techniques of larval collection that I will use in my Ph.D. research. The experience also helped me to develop the direction of my dissertation project, since a PCR-based assay for predation on mosquito makes possible the study of numerous questions related to mosquito predation and population structure.

John Vanden Brooks, Department of Geology & Geophysics (G&G)

The Yale Institute for Biospheric Studies Center for Field Ecology grant provided means for several opportunities to expand my thesis research and graduate experience. Firstly, Center for Field Ecology resources allowed for field work on the Isle of Wight, United Kingdom. More specifically, funds provided equipment, airfare, rental car, lodging, and miscellaneous costs associated with travel in the United Kingdom. The primary purpose of the Isle of Wight fieldwork was to establish stable carbon isotopic records of Paleogene-age higher-plant organic matter (e.g. coal, charcoal) collected from marginal marine sediments of the Bracklesham and Solent Groups. A total of 436 samples of Eocene and Oligocene charcoal, coal, and organic-rich sediments were collected and once analyzed these samples will provide a highly resolved stable carbon isotopic records of carbon dioxide throughout the middle and late Paleogene Period.

Additionally, funds allowed for airfare to attend the Stable Isotope Ecology short course offered at the University of Utah. The course provided discussions on the application of stable isotopes at natural abundance levels for environmental and ecological studies in a multi-instructor lecture and laboratory format. This course provided in-depth considerations of stable isotopes and their ecologic applications from leading scientist in the field and hands-on laboratory experience in a state-of-the-art mass spectrometry facility, including offline cryogenic vacuum preparation techniques and training and full access on two delta S mass spectrometers, a 252 mass spectrometer, a Delta Plus mass spectrometer.

Annika Walters, Department of Ecology & Evolutionary Biology (EEB)

I spent my summer exploring stream hydrology, community structure, and ecosystem functions. Flow is viewed as the most important structuring component of streams to which many stream patterns and processes can be attributed, yet climate change and the human modification of aquatic ecosystems are significantly altering the natural hydrological flow regime of streams. The goal of my studies is to link

YIBS CENTER FOR FIELD ECOLOGY continued

the hydrological regime of a stream with ecological interactions and ecosystem processes through examining the effect of altered hydrology on stream communities, species interactions, nutrient cycling, productivity, and decomposition. The aim is to gain a greater understanding of the role of disturbance in complex natural ecosystems through studying how modifications of the hydrological regime can both directly and indirectly affect physical and biological factors in streams. This summer I focused on finding sites where I could experimentally alter stream flow, and examining my ability to measure stream flow and the response variables I am interested in, including community structure (aquatic insect sampling), nutrient cycling (water samples for total nitrogen and total phosphorus), and leaf decomposition.

The YIBS grant was used to buy personal equipment necessary for my fieldwork including waders, a couple of coolers for transporting samples, a toolbox, and tools including a hacksaw. It also helped pay for my Connecticut boating class and certification. The largest expenditure was a water level logger that I installed in one of my study streams. Together with a flow meter the water level logger allows me to gauge the stream giving an accurate measure of hydrology. Since I am interested in looking at alterations in hydrology, determining if I could accurately measure the hydrological regime was crucial in determining whether my experimentations could be successful. The YIBS grant also helped cover transportation costs (gas) to and from my sites. Having the YIBS grant made a big difference because it allowed me to explore my own ideas, not just those that my professor already had funding for, and to test whether my proposed research would be feasible giving me a better chance of getting future grants. In addition to this, it was also invaluable for purchasing basic equipment and covering transportation costs.

YIBS CENTER FOR THE STUDY OF GLOBAL CHANGE
TOTAL YIBS SUPPORT: \$8,300

The Center for the Study of Global Change has been the instrument for the discussion of environmental changes on Earth over time scales of decades, millennia and millions of years. The primary way it carries on its mission is through seminars. The primary form is through the Monday seminars entitled Topics in Global Change. Attached are the schedules for the calendar year 2004.

In addition funding has been obtained from ExxonMobil to hold a series of Forums on Climate Change.

Members of the Center, including the Director, have embarked on a study of carbon sequestration. This was in part an outgrowth of the involvement of the Director in the Intergovernmental Panel on Climate Change (IPCC) study on mitigation strategies involving carbon sequestration. This effort has been made possible by a generous gift from Nelson Talbott. Plans include attendance at a Chapman Conference on Carbon Sequestration of the American Geophysical Union in January, 2005 and the organization of a meeting at Yale subsequent to that. The principal participants are Edward Bolton, Danny Rye and Jay Ague as well as the Director.

The Center will continue its mission to keep the discussion of global change in all its aspects and time scales a viable area for discussion and action. The invitation of scholars from around the world to inform and debate one of the critical issues of our time through seminars, joint project and forums will be the main activities of the Center. The level of funding requested is roughly the same as in the past mainly to support the weekly seminars. We will continue to seek support from outside sources for special activities of the sort described above.

YIBS Center for the Study of Global Change Fall 2003 Speakers List

David Rind, Goddard Institute for Space Studies of NASA: *Solar effects on climate and the Maunder Minimum: Minimum certainty.*

James R. Holton, University of Washington: *The global transport circulation of the middle atmosphere and its possible role in constituent trends.*

William F. Ruddiman, University of Virginia: *The anthropogenic greenhouse era began thousands of years ago.*

Dorothy Koch, Goddard Institute for Space Studies of NASA and Department of Geology and Geophysics, Yale University: *Do Clouds Cleanse or Clutter the Atmosphere with Sulfate?*

Thomas M. Cronin, U.S. Geological Survey: *The Holocene climate record of the eastern U.S.*

Stephen Leatherman, Florida International University: *Sea level rise and coastal impacts.*

V. Ramanathan, Scripps Institution of Oceanography: *Aerosols and greenhouse gases: Emerging issues in regional and global climate change.*

YIBS CENTER FOR THE STUDY OF GLOBAL CHANGE continued

David Hodell, University of Florida: *Human-climate-environment Interactions in the Maya Lowlands (Yucatan Peninsula) inferred from lake sediment cores.*

John Wettlaufer, Department of Geology and Geophysics, Yale University: *Life on the edge: Interfaces, melting, and the survival of life in ice.*

Gus Speth, School of Forestry and Environmental Studies, Yale University: *Governing the global environment: Anatomy of a policy failure -- and where do we go from here.*

YIBS Center for the Study of Global Change Spring 2004 Speakers List

Carl Wunsch, Massachusetts Institute of Technology: *The Milankovitch hypothesis and other explanations of climate variability on different time scales.*

Stephen Meyers, Yale University: *Signal vs. noise: Recognition and quantification of orbital cyclicity in the stratigraphic record.*

Larry Wilen, Ohio University: *The fabric and texture of the Greenland Ice Sheet: Implications for paleoclimate.*

Jay Ague, Ed Bolton, Karl Turekian, Yale University: *Carbon sequestration.*

Ellen Thomas, Wesleyan University and Yale University: *Early Cenozoic extreme climates: Insights from ODP Leg 208, Walvis Ridge.*

Larry Peterson, Rosenstiel School of Marine and Atmospheric Sciences, University of Miami: *Abrupt climate change: Tropical clues from the anoxic Cariaco Basin.*

Stephen Schwartz, Brookhaven National Laboratory: *Aerosols and climate change: Certainties and Uncertainties.*

Philip Mote, University of Washington: *Is global warming already affecting the West's snow resources?*

Edward Cook, Lamont-Doherty Earth Observatory: *Extra-tropical Northern Hemisphere land temperature variability over the past 1000 years.*

Peter Raymond, Yale University: *The role of riverine transport of dissolved inorganic carbon in the global carbon cycle.*

Susan Trumbore, University of California, Irvine: *The residence time of carbon in tropical, temperate and boreal forests: Limits on sequestration.*

Paul Ginoux, NOAA Geophysical Fluid Dynamics Laboratory, Princeton: *Dust effects on the Earth's system: A study combining global model and satellite data.*

YIBS CENTER FOR MICROBIAL DIVERSITY
TOTAL SUPPORT - \$8,100

The CMD is an active YIBS center focusing on both education and research. The current education mission is to promote teaching of undergraduate and graduate students on the biodiversity of microbes (prokaryotes, viruses) in natural environments, and novel approaches to treating microbial diseases. A future aim is to extend the educational focus to younger students, especially pre-college students in the New Haven community.

The current research mission is to better understand and characterize the overwhelming biodiversity of microbes observed in nature. A particular focus is the ability of microbes to adapt in novel environments, especially in habitats that are so extreme that they appear unsuitable for higher organisms. Multidisciplinary approaches are needed to better understand the influence of microbial communities on ecosystem processes. The Center promotes collaboration between Yale researchers from different departments, who can lend expertise in geomicrobiology and microbial ecology and evolution.

Education accomplishments: In spring 2004, Dr. Paul Turner (Department of Ecology & Evolutionary Biology) offered for the first time a graduate/undergraduate course (EEB228b/728b) entitled Ecology and Evolution of Infectious Disease. The course emphasized the vast diversity of microbes found in the wild, and the ecological and evolutionary reasons why some of these organisms cause diseases in hosts. The enrollment of roughly 70 students was twice that which was expected, and drew students both within and outside of the Biology major. The plan is to offer the course every other year. Judging by the excitement of the undergraduates taking the course, EEB228b will serve as a valuable resource for attracting students to do research projects involved with CMD.

On May 6-7 2004 a workshop entitled “Bacteriophage Ecology and Evolution” will be held, hopefully the first of many CMD workshops at Yale University. In attendance will be Principal Investigators from various nearby universities, including Brown University, Dartmouth University, Harvard University, MIT and SUNY Albany. Various lab groups at Yale will also attend, notably those actively involved in the CMD. The focus will be on the natural ecology and evolution of bacterial viruses (bacteriophages). Some of the greatest advances in biology have come from studying interactions between bacteria and phages in the laboratory, such as proof of the spontaneous nature of mutations and elucidation of the triplet code in DNA. However, very little is known of the natural ecology and evolution of phages, despite their incredible abundance in the biosphere; e.g., phages outnumber their cyanobacteria hosts by at least 10-fold in the ocean and for this reason may regulate their hosts’ ability to drive global photosynthesis. The workshop attendees are actively pursuing questions relating to ecology and evolution of wild phage populations in various environments (terrestrial, aquatic, extreme habitats), as well as questions regarding theoretical population biology of phages. The 2–day workshop will allow the exchange of ideas on important questions to address in the near future, and the intent is to also foster collaboration between researchers featuring different skills (mathematical theory, experimental design, field collecting, genetic characterization, genomics). Equally important, the workshop falls within the education mission of YCMD because graduate and undergraduate students from the various groups will give oral presentations on their research findings. On the first night of the workshop the entire group will socialize and dine together at a restaurant in downtown New Haven, and then continue the presentations for an additional half day the next morning. The hosts for the event will be Dr. Turner and his lab group, who are actively researching the ecology and evolution of phages in both laboratory and wild settings.

A similar workshop is being planned for the fall or spring of the 2004-05 academic year. However, the focus will shift to a research area more closely related to the expertise of another key member of YCMD,

YIBS CENTER FOR MICROBIAL DIVERSITY continued

Dr. Ruth Blake (Department of Geology and Geophysics). That workshop will focus on geomicrobiology and will be hosted by Dr. Blake. There is already excitement at other local universities regarding this planned workshop, and professional and student attendees from Amherst College, Wesleyan University, and U-Mass Amherst are expected.

Research accomplishments: The CMD research program is well underway. The primary focus is collaboration between the Blake and Turner labs on a project exploring interactions between host cells (bacteria and Archaea) and viruses in extreme thermal environments, especially the island of St Lucia in the Caribbean. St Lucia features a large caldera, which contains a number of permanent hot spring pools. Studies involve molecular and phenotypic characterization of wild isolates, in order to elucidate community structure and to identify previously unknown thermophilic microbes. The molecular data can also be used to describe population structure; i.e., clonality versus high levels of genetic exchange (recombination). The expectation is that the hosts are highly clonal (as seen for thermophiles such as *Sulfolobus* in other extreme environments such as Yellowstone) but that the viruses are not necessarily clonal due to their potential for high levels of horizontal transfer between host cells. In addition to advancing our knowledge of microbial diversity in extreme environments, the hope is that the extremophiles will harbor viruses and other defense systems that may provide novel molecules for use in human therapy.

Microbial Diversity of St. Lucia Sulfur Springs

Research Goals for 2004-05:

- Determine microbial and viral diversity of hot springs using molecular DNA-based methods and traditional enrichment culture approaches.
- Focus on specific microbial groups: Fe-oxidizers/reducers; S-oxidizers—through studies of S isotope systematics; thermophiles, acidophiles.
- Examine seasonal variations and geochemical controls on virus-host relationships and microbial metabolic pathways.
- Provide student research opportunities.
- Provide educational materials for the island of St. Lucia through the Sulfur Springs Park visitor's center (a major tourist attraction).

In addition to YIBS-CMD researchers Turner and Blake, the St. Lucia Research Consortium (established in 2001 by Blake and postdoc J.P. Greenwood) includes P.I.'s from Amherst College (A. Martini), Wesleyan University (Greenwood, Gilmore, Varekamp), U-Mass Amherst (J. Holden) and George Mason University and the American Type Culture Collection (D. Emerson) with the following expertise/interests:

Amherst College: aqueous geochemistry; has established major element chemistry of the Sulfur Springs region; will provide additional geochemical analyses

Wesleyan University: trace element geochemistry; volcanology—will focus on determination of hot springs subsurface flow/plumbing network as revealed through geochemical and remote-sensing techniques

U-Mass Amherst: Culturing of thermophiles, molecular methods for diversity analysis, microbial metabolic diversity.

YIBS CENTER FOR MICROBIAL DIVERSITY continued

GMU/ATCC: Novel culturing techniques for Fe-oxidizing bacteria; molecular methods for microbial diversity analysis.

Consortium members will actively participate in the CMD by giving lectures on CMD-related and other geomicrobiological research. In addition, future participation by consortium members in CMD-sponsored workshops will be designed to educate students in the use of techniques for studying microbial diversity.

YIBS has generously funded sampling trips to St Lucia that spearheaded this project for the CMD. Additional funds are requested to support a postdoctoral researcher that would be shared by the Turner and Blake labs, and who would provide a unique bridge between YIBS, G&G, and EEB. This would allow us to continue focusing our energies on this and other exciting research programs in CMD.

Related Research:

CMD member R.E. Blake will be conducting research on microbial activity in deep-sea hot springs—hydrothermal vents—at 9°N along the E. Pacific Rise aboard the R/V Atlantis (Voyage 11, Leg 9 -- Mar.15-Apr. 1, 2004) which will include 11 dives using the deep-sea submersible Alvin to collect vent fluids, microbial mat samples and biofilms with emphasis on Fe-oxidizing bacteria.

Nadya Morales, a graduate student in the Turner lab, will begin her thesis work on the ecology, evolution and community structure of Archaea halophile-virus relationships in salterns (salt vats) in Puerto Rico. Humans regularly ingest halophilic Archaea by eating salty foods. But very little is known of the natural biology of these microbes, and of their interactions with genomic parasites such as phages.

Additional Plans:

To designate existing Blake research group facilities and lab space devoted to microbial culturing and DNA analysis as CMD space to be made available to CMD researchers at Yale (219 KGL; 3rd environmental chamber and epifluorescence microscope w/digital imaging system).

Budget:

The CMD 2003-04 budget was \$8000. These monies were spent on the spring semester workshop, and a research-related sampling trip to St. Lucia, which involved Dr. Blake and various students involved with the Blake and Turner labs.

YALE ENVIRONMENTAL NEWS (YEN)

TOTAL FINANCIAL SUPPORT:

PM - \$1,000

F&ES - \$13,000

YIBS - \$11,053

The Yale Environmental News (YEN) was created in the spring of 1995 as an initiative of the Yale Environmental Partnership, consisting of the School of Forestry & Environmental Studies (F&ES), the Yale Peabody Museum of Natural History (YPM) and the Yale Institute for Biospheric Studies (YIBS), to serve as a development tool – a tip sheet on what is happening at Yale in environmental research, teaching, and outreach.

In its original format, YEN was a four-page newsletter that had a distribution of about 1,400. Since its redesign in the spring of 2000 to a full color magazine of up to 26 pages, its mailing list has increased to 2,500, which includes individuals, corporations and foundations associated with the three entities that form the Yale Environmental Partnership, faculty associated with environmental studies, Yale Office of Development, and the Yale Office of Public Affairs. YIBS is responsible for gathering articles for YEN, and for the editing and production of the magazine.

YIBS/ESC FRIDAY NOON SEMINAR SERIES

TOTAL SUPPORT – \$18,170

FALL - 2003

Stephen Stearns, Edward P. Bass Professor & Chair of Ecology & Evolutionary Biology;
Professor, School of Forestry & Environmental Studies
Topic: *The Bet-Hedging Hypothesis for the Evolution of Sex*

David Skelly, Associate Professor, School of Forestry & Environmental Studies and Department
of Ecology & Evolutionary Biology
Topic: *Dynamic Amphibians in Changing Landscapes*

Larry Gall, Head of Computer Systems and Curatorial Affiliate, Division of Entomology –
Peabody Museum of Natural History
Topic: *Local Lepidopterology: Tales from the Connecticut Butterfly Atlas Project*

Reed Beaman, Biodiversity Informatics
Topic: *Finding Places for Specimens: Georeferencing Natural History Collections*

Kristof Zyskowski, Ornithology Collection Manager, Peabody Museum of Natural History
Topic: *Growth of the Yale Nest and Egg Collections and Use of Nest Architecture in
Reconstructing Avian Phylogenies*

Heather Wilson, Post Doctoral Associate, Department of Geology & Geophysics
Topic: *Fossils, Muscles and Molecules: Approaches to Resolving Millipede Phylogeny*

Frank Hole, C.J. MacCurdy Professor of Anthropology; Curator and Head of the Division of
Anthropology, Peabody Museum of Natural History
Topic: *Challenges to Sustainability: A Case Study in Long-Term Adaptation*

Adolf Seilacher, Professor of Geology & Geophysics
Topic: *Crinoid Holdfasts: Key to Colonized Soft Bottoms*

Klaus Meiners, Gaylord Donnelley Environmental Post-Doctoral Fellow, Department of Geology
& Geophysics
Topic: *Sea Ice Ecology: Life, Slime & Physics*

Linda Puth, YIBS Post-Doctoral Fellow, School of Forestry & Environmental Studies
Topic: *Putting the Parts Together: A Holistic View of Invasion*

Paul Turner, Assistant Professor of Ecology & Evolutionary Biology; Principal, YIBS Center for
Microbial Diversity
Topic: *Experimental Evolution and Viruses*

Karl K. Turekian, Sterling Professor of Geology & Geophysics; Director, Yale Institute for
Biospheric Studies (YIBS); Director, YIBS Center for the Study of Global Change
Topic: *The Sources of Osmium and Mercury Supply to the Farm River Salt Marsh, Branford,
Connecticut*

YIBS/ESC FRIDAY NOON SEMINAR SERIES continued

Spring – 2004

Menachem Elimelech, Llewellyn West Jones, Jr. Professor of Environmental Engineering and School of Forestry & Environmental Studies; Director, Environmental Engineering Program
Topic: *Microbial Transport and Adhesion in the Subsurface Environment*

Jeffrey Park, Chair, Environmental Studies Program; Professor, Geology & Geophysics
Topic: *Plate Tectonics and the Star Trek Paradox*

Jay Ague, Professor of Geology & Geophysics
Topic: *Carbon Dioxide in Earth's Crust and Atmosphere: Past, Present, and Future*

Benedict Kiernan, A. Whitney Griswold Professor of History; Director, Genocide Studies Program, Yale Center for International and Area Studies (YCIAS)
Topic: *Mapping Genocide: Ethnopolitical Warfare and the Environment*

Richard Prum, Professor, Ecology & Evolutionary Biology; PM Curator of Ornithology,
Topic: *New Frontiers in Feather Shape, Color Patterning, and Structural Coloration*

Theodora Pinou, Niarchos Project Coordinator, Peabody Museum of Natural History
Topic: *Epibionts Associated with Nesting Sea Turtles in Jalisco, Mexico*

Leonard Munstermann, Research Scientist, Epidemiology & Public Health
Topic: *Phlebotomine Sand Fly Disease Vectors: Issues of Taxonomy & Evolution*

Eric Lazo-Wasem, Invertebrate Zoology; PM Sr. Collections Manager
Topic: *Front Lines of Biodiversity: Caribbean Crustaceans and the Atlantic Seamount Fauna*

Amy Russell, Gaylord Donnelley Environmental Postdoctoral Fellow in Ecology & Evolutionary Biology
Topic: *The Lords of the Wings: Population Genetic Structure and Gene Flow in a Widely Dispersing Bat Species*

Stephen Meyer, Gaylord Donnelley Environmental Postdoctoral Fellow in Geology & Geophysics
Topic: *Cenomanian/Turonian Orbital Chronologies and Burial Flux Estimates: Calibrating the Biogeochemical Reconstruction of Oceanic Anoxic Event II*

Benjamin Twining, Gaylord Donnelley Environmental Postdoctoral Fellow, School of Forestry & Environmental Studies
Topic: *Metal Cycling Through Plankton Communities: A Single-Cell Approach*

William Mitch, Assistant Professor, Chemical & Environmental Engineering
Topic: *Emerging Disinfection By-Products from Chloramination of Wastewater-Derived Organic Nitrogen*

Oswald Schmitz, Professor and Director of Doctoral Studies, School of Forestry & Environmental Studies; Department of Ecology & Evolutionary Biology
Topic: *Looking at Biodiversity and Ecosystem Functioning Vertically Rather Than Horizontally*

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