

YALE ENVIRONMENTAL NEWS

winter 2003
vol. 8, no. 1

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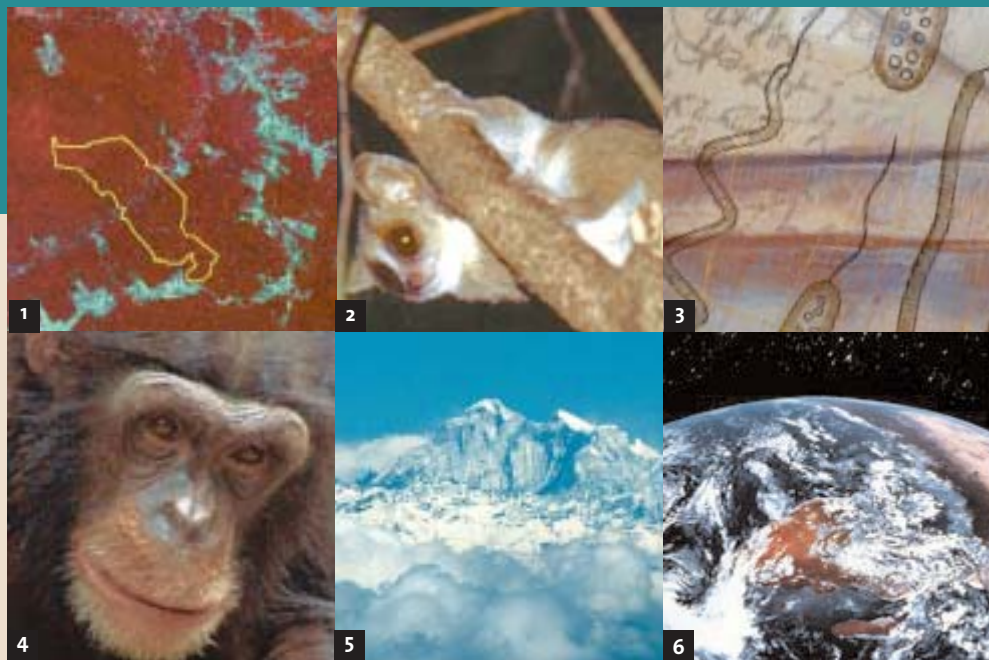
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THE RESEARCH CENTERS OF YIBS

By Karl K. Turekian, YIBS Director

The Yale Institute for Biospheric Studies (YIBS) was funded in 1991 with a gift from Edward P. Bass. One of the intentions of YIBS was to establish multi-disciplinary centers through which its environmental and ecological missions would be fulfilled.

Professor Leo W. Buss, the first Director of YIBS, issued a request for proposals for the establishment of the Centers. With the help of a review committee, the many proposals that were submitted were evaluated. As a result of this competition, the following Centers were established: the Center for Biological Transformation; the Center for Computational Ecology; the Center for Earth Observation; the ECOSAVE Center (Study of Ecology & Systematics of Animals on the Verge of Extinction); and the Center for the Study of Global Change.

The Center for the Study of Global Change was actually established two years prior to the establishment of YIBS and logically fell into the mission of the Institute.

The Centers were meant to be innovative and supportive of the educational and research mission of the University. They were to be supported by funds in addition to those available through the Institute. For example, the Center for the Study of Global Change was

initially supported by funds from other resources to initiate the seminar series and visiting scholars programs. The Center for Earth Observation received funding for its initial computer needs and ECOSAVE has received funds from a variety of sources. Corporate gifts have assisted in the establishment of the DNA laboratory in ECOSAVE as well as funding initial support for the Center for Biological Transformation.

There are continuing efforts to seek financial support of some of the Centers through corporate giving as well as other sources.

As part of the establishment of the activities of the Centers it was clear that the Centers would be evaluated periodically and new Centers would enter the competition. As the result of this competition, the Centers under the YIBS umbrella are now the six shown above. Descriptions of each of the active Centers follow.

In addition to the YIBS Centers, there are three affiliates of YIBS. They are the Genocide Studies Program (<http://www.yale.edu/gsp>); the Center for Solar & Space Research; and the Center for Biodiversity & Conservation Science of the School of Forestry and Environmental Studies. Each of these Centers or Programs has had relationships with YIBS through financial support or shared interests.

YALE INSTITUTE FOR BIOSPHERIC STUDIES (YIBS) RESEARCH CENTERS

YIBS CENTER FOR EARTH OBSERVATION (YCEO)

METAMORPHOSIS AT YIBS

Ronald Smith, Director

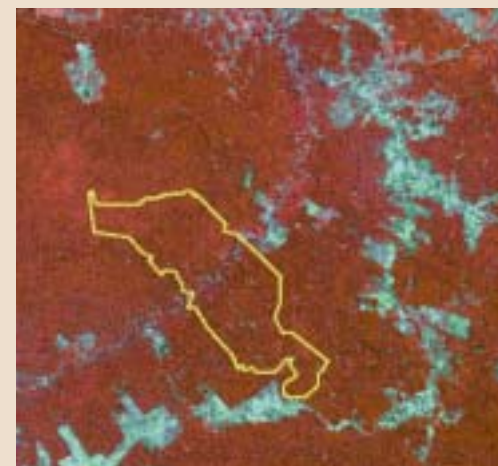
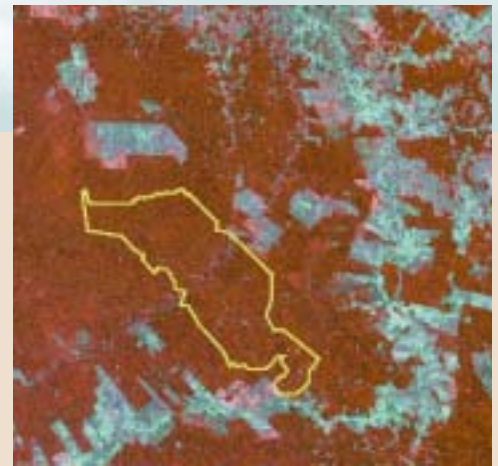
The pace of activity at the YIBS Center for Earth Observation (YCEO) is quickening again after a period of refurbishment and renewal. Beginning in the winter of 2001, Yale's satellite remote sensing center has been

undergoing a set of changes designed to provide improved facilities for the Yale environmental science community. Simultaneously with its move to the Class of '54 Environmental Science Center (ESC) on Sachem Street, the Center has installed a new computer system and expanded its disk archive for data storage. The new Center is located just off the rotunda in the ESC, a convenient location for students and staff from several Yale departments and schools. The new computer system is a substantial expansion of previous capability, with nearly a tripling of CPU speed of the workstations and servers. Updated versions of the most powerful image analysis software programs have been installed on the new system. The disk capacity has been increased to 800 gigabytes, allowing Center users to undertake larger projects with higher resolution image data sets. The computer upgrades at the Center were supported by several organizations, espe-

cially the Yale Institute for Biospheric Studies, the Environmental Studies Program and the Center for the Study of Globalization.

A key annual activity at YCEO is the support of the course "Observing the Earth From Space". This spring-term course is an intensive introduction to the techniques and applications of satellite remote sensing. The enrollment includes both undergraduates and graduate students from a variety of academic departments. The central theme of the course is the detection of change in the earth's land surface, atmosphere and oceans. With the planned expansion of the Center's facilities, the course will be able to accommodate nearly 50 students.

Research at the YCEO covers many aspects of environmental sciences in many regions around the world. The following are a few of the student and faculty projects that are underway at the Center.



ANALYSIS OF LAND-USE CHANGE IN THE EXTRACTIVE RESERVES OF SOUTHWESTERN AMAZONIA, BRAZIL: ARE SMALL-HOLDER RUBBER TAPPERS SIGNIFICANTLY CONTRIBUTING TO DEFORESTATION?

Christiane Ehringhaus, a doctoral candidate at the School of Forestry & Environmental Studies (F&ES), is examining the role of extractive reserves as a conservation and development strategy in the Brazilian Amazon region. In the context of massive tropical rainforest destruction, the harvest and marketing of non-timber forest products (NTFP) has been championed as an alternative means of generating income while maintaining forest cover intact. The focus of Christiane's doctoral research is to evaluate how different conservation and development policies affect land-use choices within an ecological, social, and political context in the Southwestern Amazonian State of Acre, Brazil.

Using an interdisciplinary theoretical and methodological approach, combining political

STUDENT AND FACULTY PROJECTS THAT ARE UNDERWAY AT THE CENTER

- > Analysis of Land-Use Change in the Extractive Reserves of Southwestern Amazonia, Brazil
- > Incorporating Measures of Rainless Days and Smoke-Plume Radiation Reduction into the Risk Model of Forest Flammability in Amazonia
- > Land Use Patterns in the Sacred Valley of Peru
- > South West Asia Project (SWAP)
- > Characterization of Eco Regions in Africa (CERA)
- > Vegetation Dynamics and Changes in the Hydrological Balance

ecology, ethnobotany and land-use analysis, the research investigates different land use scenarios in which NTFP play an important role in order to determine the social, economic, political and ecological drivers and constraints that influence and shape land-use decisions and the capacity of local people to market NTFP.

This study uses Landsat Thematic Mapper satellite images to determine land conversion rates in different extractive reserves, and to compare the rates and patterns of deforestation with those outside the reserves. She is investigating the ability of satellite imagery to distinguish between agricultural and pasture areas. Christiane will pay particular attention to the differentiation of the various stages of secondary succession following agricultural activities within different forest types.

The Landsat TM images on page 2 show an extractive reserve in 1986 and 1996. In this false-color image vegetation is shown as red and cleared regions are blue. The reserve, outlined in yellow, is 46 km (29 mi) long by 11 km (7.5 mi) wide.



LAND USE PATTERNS IN THE SACRED VALLEY OF PERU

Karina Yager, a new Ph.D. student in the Department of Anthropology, is studying the historic and modern land use patterns in the highlands of Peru. Along with the land use changes, there are observable ecological changes occurring in the landscape due to human and natural influences including landslides, deglaciation, and active soil erosion. The goal of her research is to evaluate both

the ecological and human dimensions of the land use changes in the region from the Inca period through today. The archaeological data include prehispanic landscape transformations such as complex terracing systems and irrigation canals. Historical documents from the sixteenth and seventeenth century provide detailed accounts of the land use patterns upon colonial arrival. The modern analysis of land use is facilitated by the use of aerial documentation in the form of aerial photographs beginning in 1930 through modern day satellite imagery.

Karina has already spent much time studying the highlands of Peru. Now she plans to use the Center for Earth Observation to continue her work using aerial photographs and remote sensing imagery to detect the principle agricultural patterns in the Sacred Valley. “The human-environment interplay has a profound impact on how the landscape is transformed and maintained. The objective of my research is to provide a historic and holistic understanding of how this relationship is carried out in the highlands of Peru. The facilities and software at the CEO lab allow me to analyze the human and ecologically induced transformations of the landscape evident in the aerial documentation” said Karina. At the CEO lab, Karina will combine her anthropological fieldwork with data from the aerial photographs and satellite imagery to perform a spatial and temporal analysis of the principle land use changes in the region.



INCORPORATING MEASURES OF RAINLESS DAYS AND SMOKE-PLUME RADIATION REDUCTION INTO THE RISQUE MODEL OF FOREST FLAMMABILITY IN AMAZONIA

Doug Morton, a recent graduate of the F&ES Master’s Program, has been working on methods to improve our understanding of forest fires in Amazonia. His research will augment a predictive model of forest flammability in Amazonia, RisQue, by incorporating measurements of the period between rain events and the effects of smoke on radiation load and fuel drying rates, and the area of forest burned by escaped pasture fires.

A part of this analysis involves the measurement and analysis of many 1999 Landsat Enhanced Thematic Mapper satellite images for the transitional forest region of the southern Amazon basin in the state of Mato Grosso. The correlation between burned areas and various factors of development will compliment the climatic components of flammability in this region. The goal of this project component is to assess the total area of burned transition forest in 1999, delineating changes in vegetation structure and range based on ground-truthing efforts in July/August 2001.

The image above is taken from a Landsat ETM satellite image of Mato Grasso, Brazil in the dry season of 1999. The smoke plume is 29 km (18 mi) long. An uncontrolled pasture fire has spread to the adjacent forest.

YALE INSTITUTE FOR BIOSPHERIC STUDIES RESEARCH CENTERS

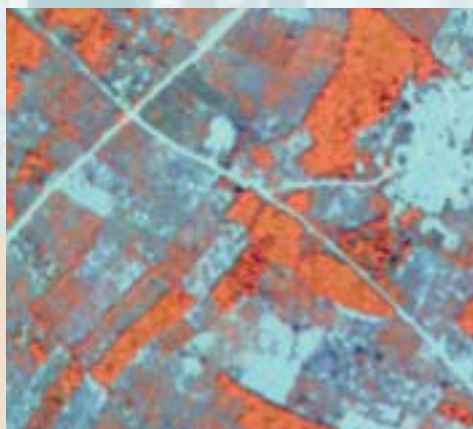


SOUTH WEST ASIA PROJECT (SWAP)

The South West Asia Project (SWAP) is a NASA funded research program dedicated to the study of landscape and climate changes in the Middle East. The leaders of the project are Frank Hole from the Department of Anthropology and Ronald Smith from Geology and Geophysics. This project is done in collaboration with the International Center for Agricultural Research in the Dry Areas (ICARDA) in Aleppo, Syria. The objective of SWAP is to quantify and monitor the processes shaping the landscapes of Southwest Asia.

There are several major components of the SWAP research efforts. Roland Geerken, an Associate Research Scientist at Yale, is working on one aspect of this research as the Range Lands project. This sub-project concentrates on correlating satellite-acquired vegetation signatures to biophysical parameters, and how these can be used to describe important range parameters such as condition and carrying capacity. The results are being used to improve the monitoring of degradation/desertification processes, to model and make projections on vegetation growth, and to make satellite-supported range management strategies more sound and efficient.

The image above shows the important rangeland perennial shrub *Noaea mucronata* and annual grasses. A portable spectrometer is used to monitor changes in plant reflectance characteristics throughout the growing cycle. This information is then compared to satellite images acquired at several times throughout the growing season. Careful temporal and spectral analysis allows regions of degraded rangeland to be identified over vast areas of steppe in this region.



CHARACTERIZATION OF ECO REGIONS IN AFRICA (CERA)

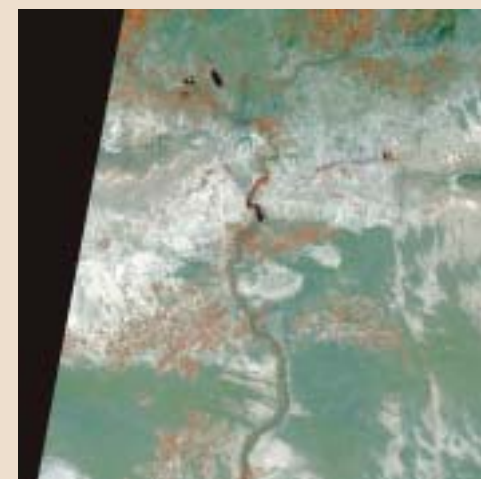
The Characterization of Eco Regions in Africa (CERA) project is a collaboration among the Yale Center for Earth Observation (CEO), the Yale School of Forestry and Environmental Studies (F&ES) and the International Institute of Tropical Agriculture (IITA), in Africa. The Yale side of the project is led by Professor Mark Ashton and Dr. Prasad Thenkabail.

The main goal of this research will be to use multispectral and hyperspectral datasets of different eras to characterize, and quantify: (A) *Chromolaena odorata* dominant fallow and the dominant agroforest systems of humid-forests, (B) *Imperata cylindrica* dominated fallow and the dominant agroforest systems of savannas, and (C) inland-valley wetlands across humid-forests and savannas. The study will establish interactions between regeneration (fallow), plantations (e.g., cocoa, coffee), slash-and-burn agriculture, humid-forests, inland-valleys, and logging.

The CERA project team will use sensor data from satellites of: (a) pre-1999 era (TM and MSS), (b) Earth Observing System (EOS) era (ETM+, ASTER, MODIS, IKONOS), and (c) New Millennium Program era (Hyperion, ALI). They hypothesize that the new generation of sensors will substantially improve estimates of carbon sequestration in tropical regrowth subsequent to deforestation, and deforestation and land use change.

Vegetation estimates might be considerably improved using new technology to differentiate logged from unlogged primary rainforests, and different successional phases of forest after disturbance (both anthropogenic and natural origin). This would considerably refine and improve estimates of the nature of forest degradation and biodiversity loss in the region.

In the false color image above, oil palm plantations appear deep red. The green patch at the road intersection is an orange grove. This image is from the high-resolution IKONOS sensor and is able to discern individual trees from space.



VEGETATION DYNAMICS AND CHANGES IN THE HYDROLOGICAL BALANCE

Ben Zaitchik is researching vegetation dynamics and recent changes in the hydrologic balance in South West Asia. This work contributes to the SWAP project at the CEO and will be the focus of Ben's PhD in the Department of Geology and Geophysics.

Ben will be concentrating on the Khabur River watershed. The Khabur River has its source in southern Turkey. It joins the Euphrates River in eastern Syria near the border of Iraq. As in most arid regions of the world, scarce water resources have profound social, economic, and political impacts.

The two images above show the lower reaches of the Khabur River during the dry season in 1990 and 2000. The red areas are heavy vegetation that is the product of irrigation. In 1990 there is intense irrigated agriculture along the length of the Khabur. By 2000 most of the water has been diverted to large irrigated agricultural projects in Turkey or been retained by dams in northern Syria. The focus of agriculture has moved out of the river floodplain onto the higher poorer soils in the region.

ECOSAVE CENTER (EC)

Elisabeth Vrba, Director

Our six faculty represent a diverse spectrum in terms of the organisms studied, analytical methods, and global field locations. Yet we all share the central focus of ECOSAVE, which is to add new knowledge on global

biodiversity and on the processes that produced it. Included within this focus is understanding the historical pattern of phylogenetic relationships among living and extinct organisms, and the distribution in time and over geography of the elements of that pattern (from molecules and morphology to speciation and extinction) in the context of earth's physical dynamics. Such compound patterns are a powerful substrate for innovation on evolutionary processes and conservation strategy. The interaction in EC of specialists on living organisms with paleontologists is a special strength because understanding the present or predicting the future requires understanding the past.

Our goals for the future fit in well with the renaissance over the past decade in environmental science at Yale. EC support will emphasize exploration and discovery of new living and fossil forms—the naissance or birth of new

information on hitherto unknown species in present and past ecosystems from the far-flung corners of the earth—because we envision that this is where the cutting edge will be in the future. International and especially third-world collaborations in research and exchange of scientists and students will feature prominently. 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. Thus 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

FACULTY MEMBERS

Adalgisa Caccone
Michael Donoghue
Jacques Gauthier
Jeffrey Powell
Anne Yoder

Fig. 1. A group of Galapagos tortoises of unknown geographic origin at the Charles Darwin Research Station on the island of Santa Cruz in the Galapagos archipelago (Ecuador). DNA based studies in Jeff Powell's and Gisella Caccone's laboratories have been used to trace the geographic and evolutionary origin of these individuals. Molecular studies are used in concert with ecological, behavioral, and demographic data for setting conservation priorities for this endangered group of giant reptiles, which were a crucial inspiration for arguably the most profound revolution in biology, Darwin's theory of evolution by natural selection

Fig. 1





Fig. 2



Fig. 3



Fig. 4

march at Yale and elsewhere, and EC should be a part of that globalization.

EC's past and ongoing achievements, in science, teaching, and worldwide collaborations have positioned it well to succeed in these goals. The places involved range from the southwestern U.S. through Ecuador, Brazil, Europe, Russia, China, Laos and Vietnam, to Ethiopia, Mali, Burkina Faso and Madagascar. The launching in 1998 of the Molecular Systematics and Conservation Genetics Laboratory (MSCGL), and recruitment of its director Gisella Caccone, is one of EC's seminal successes. The MSCGL has established flourishing teaching programs, and is also the exceptionally productive site of a wide range of integrative programs with foreign collaborators. Two Gaylord Donnelley Postdoctoral Fellows, Claudio Ciofi from Italy, who just finished his two year fellowship heading MSCGL projects, and Luciano Beheregaray from Brazil, who is currently at Yale working on projects in the MSCGL. The diversity of the numerous collaborative MSCGL researches, on animals ranging from mosquito malaria vectors and cave crickets to prairie chickens and Siberian tigers, is illustrated by the few examples below.

Study of the Galapagos tortoises by Gisella Caccone and Jeff Powell with collaborators is a long-term EC project. The tortoises are the largest terrestrial ectothermic herbivores still alive **Fig. 1** and represent a unique radiation that was an inspiration to Charles Darwin. Through support from EC, National Science Foundation, and National Geographic Society, the team has amassed a collection of about 2400 blood samples from the remaining natural populations as well as captive animals.

Analyses of these samples has resulted in the most complete and solid phylogenetic analysis of the eleven extant species, identification of the effects of recent movement of tortoises (likely by whalers and buccaneers in the last 300 years), and confirmation of a heretofore unrecognized second conservation unit on the island of Santa Cruz

Fig. 2. These studies are becoming a classic case of conservation genetics and widely recognized. For example, Gisella has been invited to the International Congress of Genetics in Australia specifically to present this work.

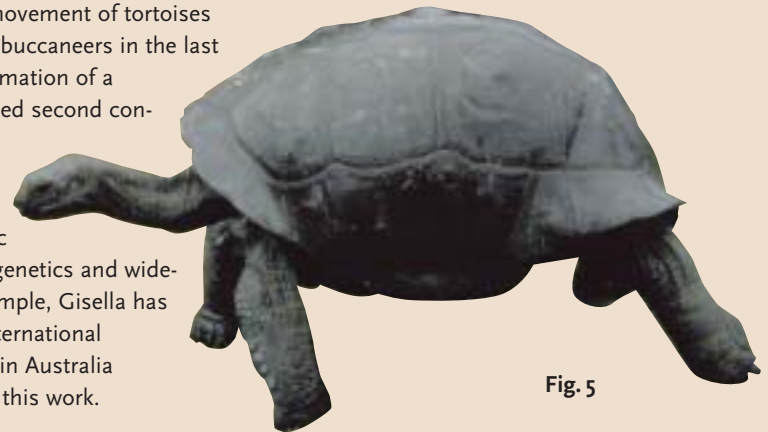


Fig. 5

Fig. 2. Map of the Galapagos Islands with a schematic phylogeographic history of the Galapagos tortoises based on 1.5 million bases of DNA sequencing on 161 tortoises from all the 21 extant populations. The older islands of San Cristóbal and Española are the likely first islands colonized from mainland progenitors. The arrows represent colonization events within Galapagos with the numbers indicating very approximate temporal order. We hypothesize the solid arrows were natural colonization events and the dashed arrows possibly human-induced translocations. In the 17th to 19th centuries, whalers and buccaneers collected tortoises as a source of fresh meat and as many as 200,000 may have been removed. Tortoises were occasionally stashed on various islands for safe keeping and even tossed overboard in large numbers in near shore areas to lighten cargo during flight or battle.

Fig. 3. Luciano Beheregaray collecting fishes in the flooded forest of the in the Brazilian Amazon. His project will provide insights into the processes that generate biological diversification in the Amazon, a region with the most diverse fish fauna and perhaps one of the least studied. This project is part of a partnership between Yale and PIABA a community based interdisciplinary project sponsored by the Universidade do Amazonas. Project PIABA ("buy a fish save a tree") aims to understand the ecological and sociocultural systems of the middle Rio Negro basin for purposes of conserving the ornamental fishery at commercially feasible and ecological sustainable levels.

Fig. 4. Claudio Ciofi with the Indonesian members of his team collecting a blood sample for genetic analysis from a recently trapped Komodo dragon on the island of Flores. This project is part of a multidisciplinary effort to protect this species. This project includes a strong educational component achieved through inclusion of members of the local communities in a variety of conservation oriented field projects.

Fig. 5. The Aldabra tortoise is the only surviving giant tortoise in the Indian Ocean. It survives in a single natural population on the Aldabra atoll. DNA based studies shed light in its origin and level of genetic diversity

Fig. 6. Xantusiid lizard resting on a rock. The "Night lizards" prefer living in dark confined spaces, such as in rock crevices, caves, beneath bark and logs. Understanding their phylogeny has been a puzzling phylogenetic problems for a long time. Molecular data and a collaboration by Gisella Caccone and Jacques Gauthier have shed some light on this issue.

Fig. 7. The DNA -based phylogeny for Night lizards, generated by Gisella and Jacques, overturned a number of previous hypotheses. For instance, the two island species, *Cricosaura typica* on Cuba and *Xantusia riversiana* on California's Channel Islands, were proposed to have passively rafted to their present locations when their respective islands separated from mainland North America. The present analysis resulted in maximum-likelihood estimates of divergence times (minimum and maximum times are given in millions of years along branches, gray bars represent errors). When the divergence times of the two island forms were compared with independent estimates of the age of their respective islands, in each case the age of the island is much older than that of the species. That indicates that these species dispersed to the islands from the mainland, rather than that they always lived there, as widely assumed previously.



Fig. 6

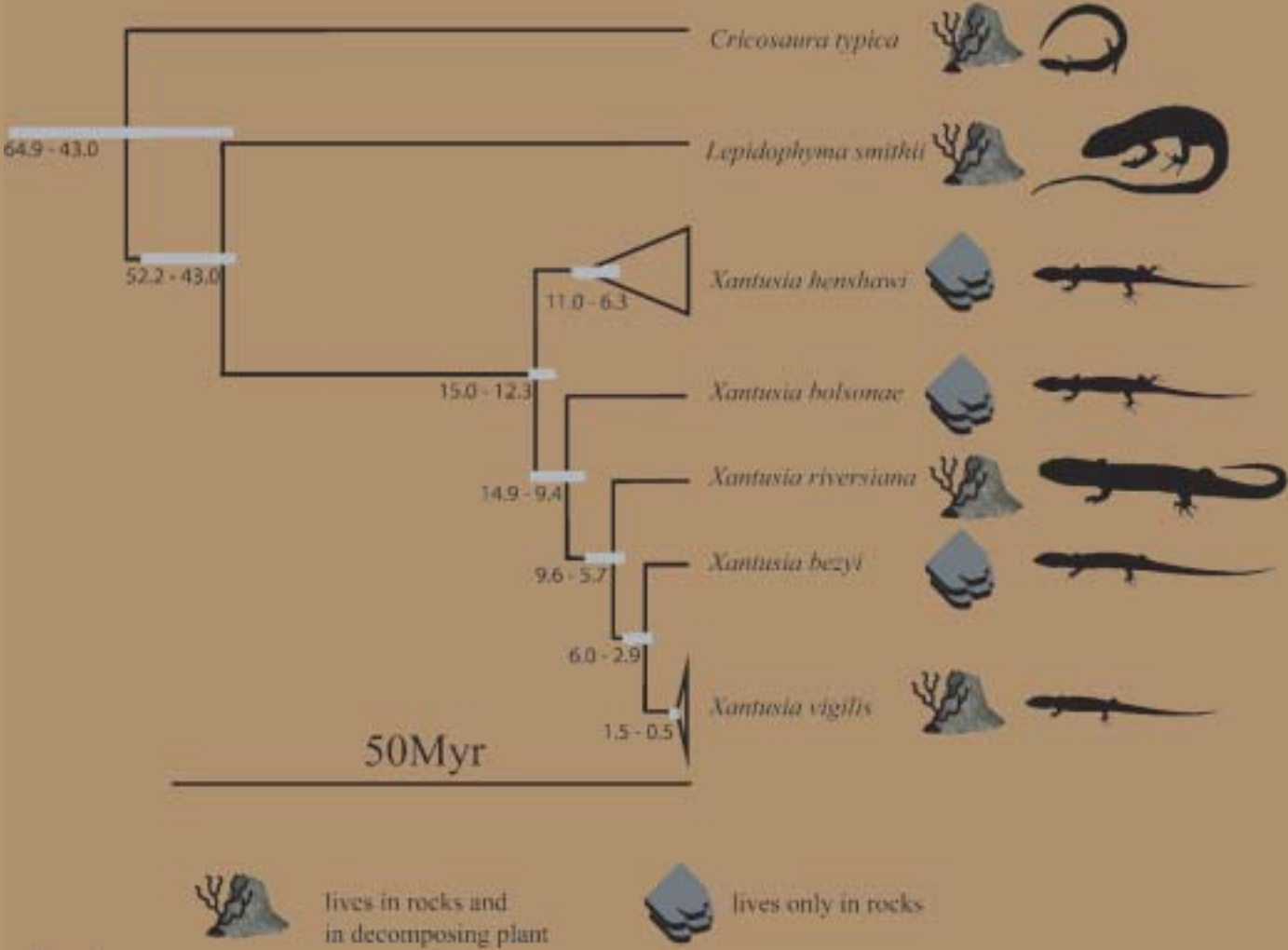


Fig. 7

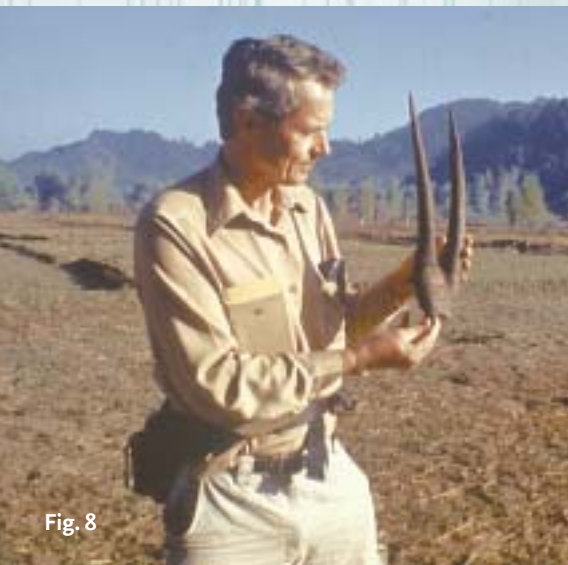


Fig. 8



Fig. 9

George Schaller

Fig. 8. George Schaller, Director for Science, Wildlife Conservation International, in Vietnam with a partial skull and horns of the saola, a new genus and species *Pseudoryx nghetinhensis* from the remote high altitude forests of the Annamite Mountains in Vietnam, that was first described in 1993. (Source: George Schaller)

Fig. 9. The giant muntjac *Megamuntiacus vuquangensis* in Laos is a recently discovered new form of large mammal. Its morphology was analyzed by George Schaller and Elisabeth Vrba.

A project on fishes in Amazonia is headed by Luciano Beheregaray **Fig. 3** in collaboration with Gisella and others. They are studying evolutionary patterns in fishes from the floodplains of the Rio Negro, the largest dark water river in the world located in the middle of the Amazonian forest. The project aims to compare population genealogies, based on DNA sequences, of four co-distributed fish species to evaluate the influence of historical events in shaping evolutionary diversification in Amazonia. An expedition early this year explored over 1,200 miles of rivers and streams, collected around 1,300 fishes and taught principles of conservation biology for fishermen and Amazonian students.

The Komodo Dragon research, headed by Claudio Ciofi **Fig. 4**, exemplifies how conservation of endangered species benefits from multidisciplinary collaboration. Claudio is currently collecting a comprehensive data set on the genetics, reproductive biology, demography, distribution, and sustainable use of natural habitats, of the Komodo dragon *Varanus komodoensis*, an endangered giant monitor lizard in Indonesia. These data will be integrated in setting management priorities for extant populations. Ciofi is also supervising a collaboration with U.S. institutions (Zoological Society of San Diego, The Nature Conservancy) and Indonesian ones (Department of Forestry, and Udayana University, Bali) which has established a research laboratory for molecular biology and endocrinology at Udayana University, and supported the training in wildlife management techniques of Indonesian graduate students and staff of Komodo National Park.

Where did the Aldabra tortoises come from, and are the native Seychelles tortoises really extinct? Gisella Caccone and coworkers were able to solve these questions thanks to collaboration with Nature Protection Trust of Seychelles and a generous gift to ECOSAVE from Mr. Coleman Burke. Aldabra, an isolated atoll in the Indian Ocean, is the only location where wild populations of these giant tortoises survive **Fig. 5**. Giant tortoises once inhabited islands throughout the western Indian Ocean.

Madagascar, Africa and India have all been suggested as possible sources of colonization for these islands. Using mitochondrial DNA sequences the team showed that the Aldabra tortoises came from Madagascar, probably by floating on ocean currents flowing northward from the east coast of Madagascar. In a second study Gisella's group addressed the question whether native Seychelles tortoises are extinct, as was long thought likely, or whether their lineage may survive in captivity as suggested by a recent morphological study. The latter claim has been controversial since the morphological characters of the carapace used to identify these species can be sensitive to captive conditions. The potential survival of a giant tortoise species previously thought extinct is an exciting prospect for conservation. Unfortunately the present genetic studies indicated that the morphotypes suspected to represent the Seychelles species do not show levels of variation and genetic structuring consistent with this hypothesis.

A systematic analysis of Xantusiid "Night lizards" by Gisella Caccone and Jacques Gauthier has just been completed. These sedentary and secretive lizards **Fig. 6** live in confined spaces such as rock crevices in isolated populations ranging from the American Southwest southwards into Central America, with one island endemic on Cuba, *Cricosaura typica*, and another on the Channel Islands off Southern California, *Xantusia riversiana*. They include species with dramatic differences in body size and peculiar habitat preferences. An integrative approach based on molecular, morphological, biogeographic, and paleontological data resulted in a pattern **Fig. 7** that resolves several persistent controversies in lizard evolution: Night lizards are not close to the gekkoes which they resemble but are scincomorph lizards related to the cosmopolitan skinks and African cordyliforms. Similarities in morphological and ecological specializations in rock-dwelling *Xantusia* are not the result of common ancestry, but instead are convergences related to similar environmental pressures. For instance, the "island giant," *X. riversiana*, is embedded within the dwarf *Xantusia* on the



Fig. 10



Fig. 11

mainland, rather than being sister to them or close to *Lepidophyma smithii*, the other giant in the analysis. The Cuban outlier, *Cricosaura*, previously thought to be closest to *Lepidophyma*, is actually the most basal branch, or sister to all other xantusiids. Another exciting conclusion concerns how the two island species came to be on their respective islands (see caption of Fig. 7) and the putative influence of the end Cretaceous asteroid impact on the Cuban *Cricosaura*.

Research on the causal linkages between paleoclimate and evolution in Elisabeth Vrba's laboratory resulted in an ECOSAVE-sponsored international conference and volume (edited by Vrba and others), which continues to be widely cited. This research continues with analyses of the macroevolutionary patterns of all the larger African mammals of the past 25 million years (my). Collaboration with George Schaller, Wildlife Conservation International, included the conference and volume *Deer, Antelopes, Giraffes, and Relatives: Past, Present and Future*, and analyses with colleagues of gene sequences, morphology, behavior, ecology, and phylogeny of Bovidae, with emphasis on rare and endangered high-altitude species from Tibet, Vietnam and Laos **Figs. 8, 9**. Collaboration with other American and Ethiopian members of the Middle Awash Research Program **Fig. 10** continues. Excavation of eastern Ethiopian six to one-half million years old strata has yielded hundreds of mammalian fossils, and many new species and genera including early hominids, that have resulted in a series of papers in *Nature*

and *Science*. The record shows patterns of large-scale episodes of speciation, extinction and migratory exchange with Eurasia in relation to major environmental changes. For example, while the Awash area is very arid today **Fig. 11**, at some past times when our early relatives lived there, lush well-vegetated inland deltas and river margins were present that resembled the modern Okavango Delta in Botswana **Fig. 12** in terms of the presence and relative abundances of mammalian genera.

The research of Michael Donoghue, one of our two new members, is focused on understanding biological diversity, especially from the perspective of evolutionary history. Much of his work has focused on the phylogeny and of plants, and especially on the flowering plants, but he is also interested in fungi. Within the context of ECOSAVE he and his students are actively extending their research on the biogeography of the Northern Hemisphere **Fig. 13**, especially on the evolution of the alpine flora of the eastern Himalayas in China **Figs. 14, 15**. Here the ultimate goal is to discover why so many new species have been generated within this "biodiversity hotspot" **Fig. 16**—by far the most diverse temperate-zone flora on Earth—and how and when the alpine flora of this region has served as a source for the colonization of other high-elevation areas around the Northern Hemisphere, and even the Andes of South America. Additional field studies are being planned to explore the Hengduan Mountain region of Yunnan and the Qinghai-Tibetan Plateau, focused especially on a diverse group of high-

Fig. 10. Members of the Middle Awash Research Program (MARP) studying newly excavated fossils from eastern Ethiopia in the laboratory for paleontology and paleoanthropology of the National Museum of Ethiopia, Addis Ababa. From right to left: Tim White, co-leader with Berhane Asfaw of MARP, Bruce Latimer from the Cleveland Museum of Natural History, and Ethiopian colleagues Berhane Asfaw, Yohannes Haile Selassie, a Ph.D. student, and Elisabeth Vrba.

Fig. 11. The Middle Awash area, eastern Ethiopia, is arid today. Elisabeth Vrba is inspecting the fragmentary remains of a fossil hippopotamus that lived here about 3.4 million years ago when this area was well-watered and wooded, perhaps comparable to the Okavango Delta shown in Fig. 12.

Fig. 12. The Okavango Delta, Botswana, was formed by faulting due to southward extension of the African Rift. This delta within the Kalahari desert has a mosaic of habitats from deep water channels and floodplains to grassland, woodland and dense high canopy tree stands. Its possible resemblances, in terms of plant genera and the presence and relative abundances of diverse mammalian genera, to some of the ancient eastern African Rift-associated ecosystems in which our early hominid relatives lived (see Fig. 11) is currently being investigated by Elisabeth Vrba. There is concern that this ecosystem will progressively deteriorate due to human development. We may lose not only one of the few remaining regions in southern Africa capable of sustaining populations of large mammals and reptiles but also the closest thing we have to a "museum" of some of the ancestral hominid habitats.



Fig. 12



Fig. 13



Fig. 18



Fig. 14

Fig. 13. Research in Michael Donoghue's laboratory is attempting to unravel the biogeographical history of plants around the Northern Hemisphere. One goal is to use knowledge of phylogenetic relationships to determine which plant groups moved between Asia and Eastern North America more recently through the Bering land bridge (the "Pacific track") as opposed to earlier across the north Atlantic (the "Atlantic track").

Fig. 14. Chinese colleagues of Michael Donoghue on a recent botanical expedition near the border of Tibet and Qinghai province, China, showing alpine habitats between 3,000-6,000 meters.

Fig. 15. A bizarre Himalayan member of the daisy lineage, which like the more familiar edelweiss of the European Alps, shows striking adaptations to life at high elevations.

Fig. 16. The Yangtze river cutting one of the world's deepest gorges through the Hengduan mountain region in Northwest Yunnan, China. Extreme topographic variation has been a major factor in generating this biodiversity "hotspot."

Fig. 17. Photograph of a mouse lemur, *Microcebus griseorufus*, taken near Ampoza, Madagascar.

Fig. 18. Anne Yoder in the southwest of Madagascar with a team of Field Museum paleontologists.

Fig. 19. Anne Yoder in her Yale laboratory with colleagues and students from Madagascar (July, 2002).



Fig. 15



Fig. 16

elevation plants known as the Dipsacales. Collections from these and related field trips will be deposited in Chinese institutions and in the Peabody Museum, and materials for genetic and biogeographic studies will be databased and made widely accessible to the scientific community.

Anne Yoder, our second new member, is currently involved with multiple projects relating to the evolutionary history, phylogeography, species diversity, and conservation of Madagascar's vertebrates. Among the many vertebrate groups being investigated are lemurs **Fig. 17**, carnivores, rodents, tenrecs, chameleons, and plated lizards. For several of these groups, Anne also has samples of extinct taxa for which she is attempting to extract and sequence ancient DNA. Her collaborations with numerous Malagasy scholars **Figs. 18, 19** are vital to her research program in that they allow her unprecedented access to rare biological specimens. At the same time, she is concentrating on training her collaborators in modern methods of phylogenetic and conservation genetic methods. The eventual goal is to initiate a self-sustaining conservation genetics program in Madagascar, to be run and operated by Malagasy scientists.



Fig. 19



Fig. 17

YALE INSTITUTE FOR BIOSPHERIC STUDIES RESEARCH CENTERS

THE MOLECULAR SYSTEMATICS AND CONSERVATION GENETICS-ECOSAVE LABORATORY: FUNCTION AND ACCOMPLISHMENTS

What is it? The MSCG-Ecosave Laboratory was established in the fall of 1998. The mission of this structure is to have undergraduate, graduate students, post-doctoral fellows, and faculty take advantage of the great advances in molecular genetics of the past 20 years to address environmental, biodiversity, epidemiological, and conservation related questions. The laboratory is open to the entire academic community. We teach students how to use genetic data for a variety of organismal and conservation related projects. 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.

How does it operate? The MSCG Lab is equipped with state of the art instrumentation to carry out genetic analyses on nucleic acids. Students are trained in using these technologies and in interpreting data in two different types of settings: formal courses and research rotations of various lengths. The laboratory director (Gisella Caccone) teaches three courses: an intensive laboratory course (EEB315L), and two seminars, which explore principles of conservation genetics (EEB320) merits and limits of molecular methodologies in evolutionary biology (EEB375). The one-to-one training is carried out through 3 to 12 months research projects. These projects can be senior research projects (undergraduates) or part of doctoral work (graduate students), or short one-semester projects (rotations). The MSCG laboratory provides financial support for both types of projects. Graduate students are encouraged to seek alternative funding sources after having produced preliminary data to bolster grant proposals.

Past Accomplishments In the past three years of activity we have trained more than 50 students, with numbers steadily growing through the years. Undergraduates are mostly Molecular, Cellular & Developmental Biology (MCDB), and Ecology & Evolutionary Biology (EEB) majors. Graduate students are master and doctoral students from departments and schools across campus (Ecology and Evolutionary Biology, Geology and Geophysics, Anthropology, the School of Forestry and Environmental Studies, and the School of Epidemiology and Public Health). Students and post-doctoral fellows using the MSCG facility have authored numerous scientific publications in highly qualified scientific journals. They have presented their data in national and international symposia, and have been successful in securing some funding by national and international agencies to continue the research projects started in the MSCG laboratory. Agencies that have funded their studies are: National Science Foundation (NSF), World Health Organization (WHO), Environmental Protection Agency (EPA), Sea Grants, the Nature Conservancy, US Fish and Wildlife Service, Department of Environmental Protection (DEP), Office of Long Island Sound Program, Marsh Ecology Research Program/NJ Sea Grant.

Future Goals In January 2002 the MSCG laboratory moved to its permanent location in the Class of '54 Environment Science Center (ESC). We are planning to continue the research training and expand the number of students to whom this opportunity is offered. Another important mission of the MSCG lab is the establishment in concert with the Peabody Museum of a cryo-laboratory to preserve and document the Earth biodiversity through long term storage of tissues, cell lines, and nucleic acids of animal and plants in specialized liquid nitrogen tanks. Space has been allocated in ESC to house this frozen research collection. We are in the process of seeking extra funding for equipment and personnel.

STUDENT RESEARCH PROJECTS

Undergraduate and graduate students have been involved in a variety of research projects exploring the world's biodiversity using molecular techniques integrated in a multidisciplinary approach that encompasses morphological, ecological, biogeographic, and paleontological components. The following is a list of some of the more than 25 projects that have been going on in the laboratory in the past years. It is only meant to provide a sense of the diversity of research topics which the students have been exposed to. Other projects, part of ongoing collaborations with other research groups at Yale, are listed in the Ecosave Center research report.

Speciation in main vector of malaria in Africa

Anopheles gambiae, the most important vector of the malaria parasite in sub-Saharan Africa **Fig. 1**, is an extremely genetic heterogeneous species. Using a variety of DNA markers we have been trying to understand how many isolated or semi-isolated genetic units of *A. gambiae* exist and whether these are evolving into separate species (Gentile et al. 2001; Gentile et al., 2002). This knowledge will improve our understanding of malaria epidemiology and will help in implementing appropriate vector control strategies (della Torre et al., 2002).

Phylogeography of the greater prairie chicken, including the extinct heath hen

Over-hunting and human alterations to the landscape have negatively impacted Greater prairie chickens (*Tympanuchus cupido*) populations. One of its subspecies, the "heath hen", became extinct in 1932. Another one, the Attwater's prairie chicken, limited to a small

population on the Gulf Coast of Texas, is critically endangered and may soon join the heath hen if current population trends do not change. We have been using DNA markers to understand the levels of genetic divergence in this species, including the extinct heath hen. This genetic analysis has potential conservation implications. The Nature Conservancy has shown considerable interest regarding the re-establishment of a population of prairie chickens on Martha's Vineyard to replace the heath hen, and one role of this project is to identify the closest extant relative of the extinct heath hen for this potential introduction. This project will also elucidate the genetic distinctiveness of the Attwater's prairie chicken population and other Midwestern greater prairie chicken populations, thereby providing valuable information for determining whether supplementing declining populations is a desirable conservation strategy.

Conservation genetics of the Siberian tiger

The Siberian tiger (*Panthera tigris altaica*) is a critically endangered subspecies whose range is now limited to a small region in the Asian Far East with only 200 to 400 animals remaining in the wild in fragmented isolates **Fig. 2**. We are using non-invasive sampling techniques to extract DNA from individuals throughout its entire range to evaluate levels of genetic diversity and amount of genetic differentiation between the different populations in the region. In collaboration with the Wildlife Conservation Society (New York), we have already obtained over 140 samples representing the entire Russian population. We are now seeking funds to continue the sampling and conduct the genetic analyses. Genetic information will be geo-referenced and combined with the existing Geographic Information System

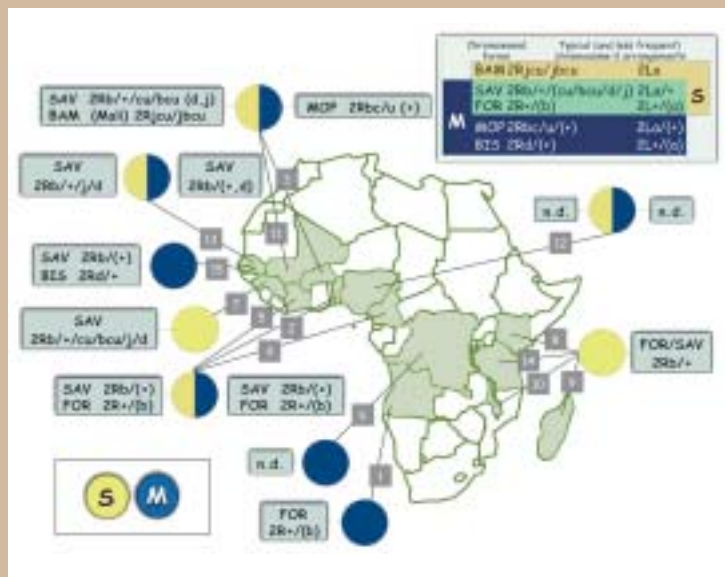


Fig. 1

Fig. 1. Map of Africa showing the distribution of chromosomal and molecular forms in populations of the mosquito *Anopheles gambiae* s.s., the most important vector of malaria in sub-Saharan Africa. Genetic analyses revealed complex patterns of genetic variation within this species. Knowledge of the levels and patterns of distribution of genetic diversity are essential for developing effective control strategies of this nefarious insect vector, responsible for spreading a disease that causes each year 1 to 2 million deaths, mostly among children and pregnant women (Gentile et al, 2002. *Genetics*, 161: 1561-1578; dellaTorre et al., 2002. *Science*, 2002).

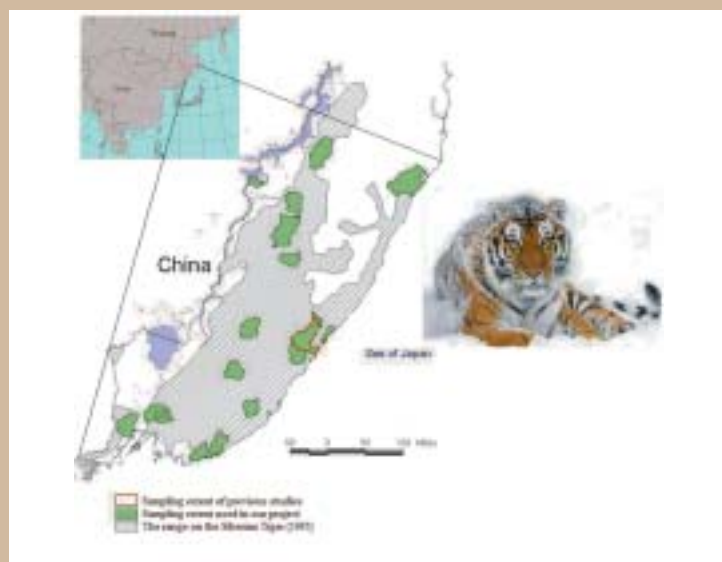


Fig. 2

Fig. 2 Range of the Siberian tiger and localization of the samples used in a DNA study. Integration of population genetic analysis, geographic information system analysis and individual based modeling will provide information on the effects of habitat fragmentation on the most endangered tiger subspecies on Earth. This project is part of a collaboration with WSC (World Conservation Society).



Fig. 3

Fig. 3. Wood frogs mating in one of the ponds in Yale-Myers Forest. Genetic fingerprinting will allow to uniquely identify parents and offspring and to assess the reproductive success of the parents and survival of their offspring.

for the Siberian tiger. The integration of ecological, genetic, and geographical information will ultimately lead to the implementation of better conservation strategies for this subspecies.

Genetic differentiation of big-leaf Mahogany in Central America

Big-leaf Mahogany (*Swietenia macrophylla*) is highly endangered throughout much of its native range, which extends from Mexico to southern Brazil. Mahogany is threatened both by the overall rate of tropical deforestation and by intensive selective logging in otherwise undisturbed forest due to the species' high economic value. Loss or fragmentation of populations often results in lowered genetic diversity, reducing a species' ability to adapt and survive in changing conditions. Detailed genetic characterization is therefore crucial in order to effectively conserve endangered species. We therefore used highly variable molecular markers in order to assess genetic

diversity in populations of mahogany in six countries across its Mesoamerican range and discovered a significant degree of genetic differentiation and strong correlation between the geographic and genetic distances between populations.

Blood is Thicker than Water: The Importance of Kin Structure and Variation on the Population Dynamics of Wood Frogs

Individual variation in fitness and patterns of relatedness can affect the growth rate of a population through such things as inclusive fitness, inbreeding depression and disease. By making it possible to identify individual organisms and infer relatedness, molecular techniques make such studies feasible in the wild. Anders Halverson, a F&ES Ph.D student, is combining ecological, behavior and molecular techniques to evaluate the importance of kin level structure and variation on the population ecology of wood frogs (*Rana sylvatica*) in their natural habitat in northeast Connecticut **Fig. 3**.

CENTER FOR MICROBIAL DIVERSITY (CMD)

Margaret Riley, Director

The Yale Institute for Biospheric Studies recently announced the creation of a new Center for Microbial Diversity. The mission of this center is to apply our understanding of microbial ecology, evolution and diversity to

address human health and ecological concerns. To this end the Center for Microbial Diversity is coordinating the efforts of the wealth of existing Yale microbial-minded faculty to address such concerns in a synthetic and cross-disciplinary way. The first concern the Center will tackle poses a truly life-threatening challenge. Can we apply microbial evolutionary and ecological information to address one of the primary and increasing threats to human health; the emergence of multiply-resistant pathogenic bacteria?

Within the next 15 years, the death toll due to bacterial infection will skyrocket and no new 'magic bullet' is on the horizon. Every new antimicrobial we find, design or develop will encourage the emergence of already existing resistant microbes. The spread of this resistance to human pathogens is then simply a matter of time and intensity of human-mediated selection (by over-use and misuse of antibiotics). To address this concern will require more than simply developing a larger arsenal of antibiotics. It will take more than reinforcing to the medical community (and the public) the importance of following rationale guidelines for proper antibiotic use. Long-term solutions demand the coordinated efforts of epidemiologists, population geneticists, microbial physiologists and ecologists as well as engineers, physicians and clinicians. Proposed solutions must gain acceptance from the pharmaceutical and agricultural companies and politicians. Physicians and other health workers must be convinced to employ these novel solutions

and society at large must be willing to accommodate and accept the changes in current health practices required. There are no existing programs at National Institutes of Health (NIH) or the National Science Foundation (NSF), no national centers or even university departments that have attempted to coordinate such a multidisciplinary effort to tackle this challenging and critical concern.

The Center for Microbial Diversity will take a first step towards addressing this challenge by bringing together Yale researchers as well as representatives from Connecticut-based pharmaceutical companies and physicians and clinicians from the Yale-New Haven Hospital to define the existing problem, to view the problem from a variety of perspectives and to generate research strategies aimed at novel, long-term solutions.

What we require are truly novel approaches to solving this critical national and worldwide need. One such solution involves the development and use of narrow spectrum, rather than the traditional broad spectrum, antibiotics. Such a switch would ensure a longer shelf life per drug, reduce the intensity of selection for any particular resistance mechanism and allow the patient to retain his or her healthy microbial communities and therefore reduce the rate of nosocomial infections. This solution makes perfect sense from an ecological and evolutionary perspective. However, implementing such a solution creates an extraordinary challenge. First, narrow spectrum drugs must be discovered or developed (which Yale



YALE INSTITUTE FOR BIOSPHERIC STUDIES RESEARCH CENTERS



Seated from left to right: Dr. Paul Turner, Dr. Margaret Riley, Dr. Debra Bessen, Caroline Obert, Carla Goldstone

Second Row from left to right: Jeffrey Huckaby, Dr. Milind Chavan, Siobain Duffy, Dr. Susanna Remold, Lisa Nigro, Alicia Bennett, Cynthia Winkworth

Third Row from left to right: Ben Kirkup, Dr. Remy Froissart, Dr. Kara O'Keefe, Dr. John Wertz, Hamid Rafi, Chijioke Okeke, David Kysela

researchers are actively pursuing). Second, appropriate diagnostics are required for rapid and specific pathogen diagnosis in the hospital (a procedure currently avoided with the use of broad spectrum antibiotics). Third, application of evolutionary and ecological theory is required to design the most effective strategy of administration to avoid or delay the emergence of resistance. Fourth, the pharmaceutical companies must be convinced that production of such drugs is in their long-term financial interests. I will stop short of including the steps involved in the regulation and enforcement of such an approach.

In this example, the role of the CMD is to focus its resources on enabling and coordinating these disparate stages of development. It will provide resources to aid in discovery and/or development of narrow spectrum antimicrobials and will initiate partnerships with pharmaceutical companies to explore the potential of such drugs in the market and the requirements for mass production. The Center will enable discussions between University and pharmaceutical researchers and clinicians to determine methods for rapid diagnosis to identify specific pathogens in real time in a hospital setting. This series of steps represents just the tip of the iceberg in achieving the desired long-term solutions, but clearly

represents the cross-disciplinary nature and new pathways of communication required.

The CMD has an integrated educational mission. First, there is the traditional approach of developing courses to train our undergraduates, medical students and physicians about the seriousness of this health concern and the absolute requirement for a change in our current practices to achieve a long-term solution. One such graduate course already exists: *Ecology and Evolution of Infectious Disease*. However, it is critical that we target a broader audience. The Center is currently developing a course for non-science majors that will address more generally the role of microorganisms in our modern world, from human health and bioterrorism to the health of the biosphere. A second, novel educational approach involves the development of a series of workshops to serve in the education of researchers and clinicians in pharmaceutical companies, hospitals and governmental agencies, such as the Center for Disease Control (CDC) or the National Institute of Health (NIH), as well as the general public. These workshops will not only educate the participants about the problem and our proposed solution, but will also continuously supply the Center with new perspectives from the field about alternative solutions to consider.

The newly created Center for Microbial Diversity has set for itself an extraordinary challenge. There are no existing solutions to the antibiotic resistance emergency. No magic bullets are in the pipeline. With the breadth of microbial-minded researchers at Yale and with the development of strong ties between Yale faculty and Connecticut-based pharmaceutical companies, health workers and legislatures we are poised to meet this critical challenge.

CENTER FOR FIELD ECOLOGY (CFE)

The YIBS Center for Field Ecology (CFE) was founded in 2002 to support field based research and teaching in the environmental sciences. Comprised of faculty from departments and schools across the University, its goal is to help make Yale a world leader in ecology by supporting faculty development, student research, and infrastructure projects to enhance field-based research and teaching. To do so it awards grants to graduate students for pilot projects leading towards a PhD and to undergraduates for summer internships on field ecology projects with Yale faculty. It has inventoried field studies being done at Yale

and field sites available to Yale faculty and students; the results are now available on the Center's web site (<http://www.yale.edu/cfe>). Its future goals include endowed faculty chairs, substantially upgraded field sites, additional graduate and undergraduate support, and undergraduate curricular offerings that enable Yale students to engage seriously with field ecology.

PhD Pilot Grants

These grants allow beginning graduate students to develop their own ideas independently. They are highly sought after and very competitive. Demand greatly exceeds supply. In 2002 the following awards were made:

THE MAINTENANCE OF LYME DISEASE IN NATURE

Brandon Brei

School of Epidemiology and Public Health

Mr. Brei is investigating the natural reservoirs of Lyme Disease in Connecticut by combining landscape ecology with molecular analysis of pathogens collected from the blood of small mammals.

THE COLONY STRUCTURE OF SIPHONOPHORES



Casey Dunn

Siphonophore

Dept. of Ecology & Evolutionary Biology

Mr. Dunn is tracing the evolutionary origins of functional specialization using colonial pelagic

hydrozoans as a model system. These animals are particularly appropriate because of the dramatic division of labor among parts of the colonies.

HOW PLANTS TOLERATE DROUGHT



Erika Edwards

Pereskia aculeata, one of the cactus species

Department of Ecology and Evolutionary Biology

Ms. Edwards is studying the evolutionary origins and physiological basis of drought tolerance in plants by conducting a comparative physiological and morphological investigation of the group most closely related to the ancestors of the cacti.

THE FACULTY ADVISORY COUNCIL OF THE CFE

Director

Stephen C. Stearns
Edward P. Bass Professor of Ecology and Evolutionary Biology
Chair, Department of Ecology and Evolutionary Biology

Department of Anthropology

Richard Bribiescas
 Andrew Hill
 Alison Richard
 David Watts

Department of Ecology and Evolutionary Biology

Michael Donoghue
 David Post
 Melinda Smith
 Steve Stearns
 Anne Yoder

Environmental Studies Program

Jeffrey Park

School of Epidemiology and Public Health

Durland Fish
 Leonard Mustermann

School of Forestry and Environmental Studies

Mark Ashton
 Gaboury Benoit
 Lisa Curran
 Michael Dove
 Peter Raymond
 Oswald Schmitz
 Thomas Siccama
 David Skelly

Department of Geology and Geophysics

Ruth Blake
 Derek Briggs
 Leo Hickey

Department of Molecular, Cellular and Developmental Biology

Mary Helen Goldsmith

Peabody Museum of Natural History

Richard Burger
 Michael Donoghue
 Leonard Mustermann

YALE INSTITUTE FOR BIOSPHERIC STUDIES RESEARCH CENTERS

HOW FUNGI DEGRADE WOOD IN THE TROPICS



Jane Halverson

White Rot Fungi

Departments of Geology and Geophysics and Chemical Engineering

Ms. Halverson is probing the diversity of white rot fungi that break down lignin in the dead wood of tropical forests. Lignin composes 5-30% of the dry mass of woody plants, and its degradation plays an important part in the global carbon cycle.

THE IMPACT OF HISTORY AND SELECTION ON SEXUAL REPRODUCTION IN ADELGIDS



Nathan Havill

Woolly Adelgids

Department of Ecology and Evolutionary Biology

Mr. Havill is studying the life cycle of one of the most important pests of forest trees in North America to ask what determines the switch from sexual to asexual reproduction and thus the evolutionary potential of the insect.

REHABILITATING DRY TROPICAL FORESTS



Heather Peckman

Dry, tropical forest

School of Forestry and Environmental Studies

Ms. Peckman is working with small landholders in Central America to develop economically viable agricultural systems that protect natural areas and rehabilitate degraded ones. Her particular focus is on the sustainable simultaneous exploitation of forests and cattle.

THE IMPACT OF KINSHIP ON POPULATION ECOLOGY



M. Anders Halverson

Wood Frog

School of Forestry and Environmental Studies

Mr. Halverson is using genetic fingerprinting to evaluate the importance of kinship to the population ecology of wood frogs in the wild. Wood frogs are an ideal model system in which to pose this question because of their short generation time and discrete breeding habitat – small woodland ponds.

HORMONES AND PARASITES IN WILD MALE CHIMPANZEES



Michael Muehlenbein

Chimpanzee

Department of Anthropology

Michael Muehlenbein is analyzing the determinants of parasite infection in our closest relatives, chimpanzees, at a field site in Uganda, with particular emphasis on the interaction between male sex hormones and susceptibility to infection.

ADAPTATION TO CAVE ENVIRONMENTS



Saverio Vicario

Cave Beetle

Department of Ecology and Evolutionary Biology

Mr. Vicario is using a promising model, cave beetles and their relatives that live outside caves, to study how repeatable evolutionary change can be. He is working in Italy, Croatia, France, and Spain.

COSTS AND BENEFITS OF GREGARIOUSNESS IN FEMALE CHIMPANZEES

Monica Wakefield

Department of Anthropology

Monica is studying the chimpanzees of Kibale National Park, Uganda, to determine why females spend more time off by themselves with their infants than do males. She suspects that the pattern results from the avoidance by females of feeding competition with males.

UNDERGRADUATE SUMMER INTERNSHIPS

David Call, supervised by Dr. Luciano Beheregaray, Gaylord Donnelly Environmental Post Doctoral Fellow working in the YIBS ECOSAVE Conservation Genetics Laboratory

Erik Crew, supervised by Professor Oswald Schmitz, School of Forestry & Environmental Studies

Michael Morita, supervised by Professor David Skelly, School of Forestry & Environmental Studies

Matthew Shirley, supervised by Professor Ruth Blake, Department of Geology & Geophysics
YIBS Center for Field Ecology Web Site: <http://www.yale.edu/cfe/>

EARTH SYSTEM CENTER FOR STABLE ISOTOPIC STUDIES

Danny Rye, Director

The YIBS Earth System Center for Stable 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 char-

acteristics 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 the new Center and

instrumentation, we are positioned to greatly impact future research and scientific discourse. A few examples of the use of light stable isotopes in studying the environment in the past are presented as examples of future potential projects. We have studied the dynamics of cloud formation and the effects that clouds have on global warming, and found that how and where clouds form can impact global warming both positively and negatively. Collaborations with the Department of Anthropology involved the study of agriculture in the Middle East, when and where irrigation became important, and the history of drought conditions in the region. We have collaborated with Fred Richards, Professor and Research Scientist in Molecular Biosphysics and Biochemistry, to investigate 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,



YIBS Earth System Center for Isotopic Studies Director Danny Rye (center) demonstrates the Center's new equipment to Professor Leo Hickey (left).

YALE INSTITUTE FOR BIOSPHERIC STUDIES RESEARCH CENTERS

SOME CURRENT PROJECTS

Ruth Blake

- 1) Enzyme reaction mechanisms and microbial metabolic pathways
- 2) Detecting life and metabolic activity in the sub-seafloor biosphere and in extraterrestrial systems
- 3) Oxygen isotope ratios of phosphate in fish teeth as a sediment stratochronometric and sea surface paleotemperature indicator tool: Application to marine red clays

Mark Pagani

- 1) The evolution of atmospheric carbon dioxide: Causes and effects of long-and short-term climate change
- 2) The Cenozoic character of terrestrial photosynthesis

Peter Raymond

- 1) Isotope geochemistry of riverine and estuarine organic carbon
- 2) Organic Carbon cycling in marshes, rivers, estuaries and oceans
- 3) Inorganic carbon cycling and air-sea exchange

Danny Rye

- 1) The fate of CO₂ in metamorphic rocks: Are they a source or a sink of CO₂?
- 2) The nature of water and condensate transport in the atmosphere

while isotopes derived from septa of the chambered nautilus constrain their early life history. Ruth Blake is active in developing oxygen isotopes of phosphates as environmental indicators and her studies may allow us to recognize ancient life on Mars.

The YIBS Earth System Center for Stable Isotopic Studies is housed in a 2,000 square foot facility in the ESC and presently there is one Finnigan MAT 251 mass spectrometer and a number of gas and chemistry lines to support the instrument. In the near future we will install two to three state of the art mass spectrometers, inlet systems and gas extraction systems that will allow us to measure the stable isotope ratios of O, H, C, S and N to a very high precision on extremely small samples of essentially every compound that occurs in the environment, including the isotopic ratios of specific organic compounds.

The first of the new instruments to be installed is a Finnigan 253 containing the latest inlet and peripheral devices. The second is a Finnigan Delta Xtended with additional inlet and peripheral configurations. The third instrument is a Finnigan Delta with an elemental analyzer and Gas Bench. Funding for the third new instrument has not yet been realized. However, because the demand for elemental analyses is very high the instrument should more than pay for itself in analysis fees. The Finnigan 251 is the workhorse for rock analysis and longer-term plans call for the replacement of the Finnigan 251. However funding for this instrument is not yet secured.

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



Newly installed Finnigan MAT 253 IRM GC/MS Mass Spectrometer

spectrum of environmental science disciplines. Our 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, microbiology, and forestry. The Center will also have 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 both from within and from outside Yale who wish to use the facility. He also has his own projects within the Center. Dr. Olack has brought a high standard of professionalism and scientific knowledge to the Center.

CENTER FOR THE STUDY OF GLOBAL CHANGE

Karl K. Turekian, Director

In 1989, Sabatino Sofia of the Astronomy Department and Karl Turekian of the Department of Geology & Geophysics asked Robert Watson, then of NASA, for help in starting discussions on global change research at Yale.

He responded by encouraging various investigators supported by his office to come to Yale for a series of seminars on global change. Among these visitors were F. Sherwood Rowland, Ralph Cicerone and Michael McElroy. This set of seminars was the beginning of the Center for the Study of Global Change.

The Center was formed before the existence of the Yale Institute for Biospheric Studies (YIBS) and became a part of YIBS as it was established. Its goal has been to maintain a presence in the area of global change studies. Global change in the Center has been defined broadly to include aspects of the changes that have led to the Earth that we now inhabit. The reason for this broad view is that we can only understand changes that are taking place now both natural and anthropogenic that we can put in a larger context.

We have had three Visiting Scholars in the Center using funds not obtained from YIBS. They were Thure Cerling of the University of Utah, Ellen Thomas then of Cambridge University and S. Krishnaswami of the Physical Research Institute in Ahmedabad, India. This initial program has set the pattern for the newly endowed Visiting Scholar program in YIBS.

To assist in this enterprise an informal group of advisors to the Center has been put into place. At present this group includes Ruth Blake, Steve Sherwood, Robert Berner, Ronald Smith, Leo Hickey, Mark Pagani, John Wettlaufer and Danny Rye from the Department of Geology & Geophysics (G&G). These people have regularly been involved with the seminar entitled "Topics in Global Change" in attendance and

in making suggestions for speakers. Other Yale participants have been Frank Hole of Anthropology, Sabatino Sofia of Astronomy, Harvey Weiss of Near East Studies, Robert Mendlesohn of the School of Forestry & Environmental Studies (F&ES) and Robert Evenson of Economics.

As an example of the activities of the Center for the past 13 years the seminar schedule for the 2002 calendar year is shown on the next page.



YALE INSTITUTE FOR BIOSPHERIC STUDIES RESEARCH CENTERS

YIBS CENTER FOR THE STUDY OF GLOBAL CHANGE SEMINAR SERIES

Spring 2002

Robert Evenson, Department of Economics, Yale University: *The green revolution and climate change*

January 14, 2002

Sabatino Sofia, Department of Astronomy, Yale University: *Solar variability and climate change*

January 28, 2002

David Beerling, Sheffield University: *Evolutionary responses of plants to atmospheric CO₂ variations*

February 4, 2002

Gerard Bond, Lamont-Doherty Earth Observatory of Columbia University: *Linking changes in solar irradiance to multi-centennial and millennial oscillations in the North Atlantic's surface and deep-water hydrography over the last 12,000 years*

February 11, 2002

Michael Schlesinger, University of Illinois: *Modeling the effect of solar variability on climate*

February 18, 2002

Klaus Lackner, Department of Earth and Environmental Engineering and the Lamont-Doherty Earth Observatory of Columbia University: *Mineral carbonate disposal for carbon dioxide produced in fossil fuel consumption*

February 25, 2002

Mukul Sharma, Dartmouth College: *Variations in solar magnetic activity during the last 200,000 years: Is there a sun-climate connection?*

March 4, 2002

Robert Mendelsohn, School of Forestry and Environmental Studies, Yale University: *From natural science to impacts: What will happen if the earth warms?*

March 25, 2002

Lonnie Thompson, Ohio State University: *Tropical ice core records: Evidence for asynchronous glaciation on Milankovitch time scales*

April 1, 2002

Peter Brewer, Monterey Bay Aquarium Research Institute: *Progress in direct experiments on the ocean disposal of fossil fuel CO₂*

April 8, 2002

Thomas Lovejoy, The World Bank: *The quest for sustainable development*

April 15, 2002

Robert Lee Hotz, The Los Angeles Times: *Antarctica: a canary bird for climate change?*

April 22, 2002

Fall 2002

Frank Hole, Department of Anthropology, Yale University: *Climate and cultural factors in the origins of agriculture*

September 9, 2002

Rowan Sage, Department of Botany, University of Toronto: *Was low atmospheric CO₂ during the Pleistocene a limiting factor for the origin of agriculture?*

September 16, 2002

Malcolm Hughes, Tree-ring Laboratory, University of Arizona: *Interannual to millennial climate fluctuations recorded in old Western trees*

September 23, 2002

Gary Brudvig, Department of Chemistry, Yale University: *Oxygen and plant growth*

September 30, 2002

Robert A. Berner, Department of Geology and Geophysics: *Plants, insects and late Paleozoic hyperoxia*

October 7, 2002

David Evans, Department of Geology and Geophysics, Yale University: *The snowball Earth*

October 14, 2002

Wallace S. Broecker of the Lamont-Doherty Earth Observatory of Columbia University will deliver the Arthur Day Lectures of the National Academy of Sciences on the following days. The overall theme is *What should we do about fossil fuel CO₂?* All lectures will be at 4 pm in 123 Kline Geology Laboratory

Lecture 1: *The likely consequences of business-as-usual*

October 16, 2002

Lecture 2: *Evidence that the Earth's climate over-responds to small nudges*

October 17, 2002

Lecture 3: *Creating a backstop*

October 18, 2002

Norbert Untersteiner, University of Washington and University of Alaska: *Sea ice in climate models: Why is it such a difficult problem?*

October 21, 2002

James G. Anderson of the Department of Chemistry and Chemical Biology and the Department of Earth and Planetary Sciences, Harvard University will deliver the Silliman Lectures this year on the overall theme *Chemistry and the Earth: Bridging electronic structure and climate*. The lectures will be in Davies Auditorium at 4 pm on the following days:

Lecture 1: *Climate Forecasts that are Tested and Trusted: A Societal Objective*

November 4, 2002

Lecture 2: *The Nature of the Chemical Bond in Transition: Prediction of Barrier Heights*

November 5, 2002

Lecture 3: *Coupling of Chemistry and Climate: Eocene, Present and Future*

November 6, 2002

Robert Aller, Marine Sciences Research Center, SUNY Stony Brook: *Coupling between sedimentary dynamics, biogeochemical processes, and carbon incineration in the Amazon-Guianasmobile mud belt*

November 11, 2002

James R. Mahoney, Assistant Secretary of Commerce and NOAA Deputy Administrator: *The U.S. Climate Change Science Program*

November 18, 2002

Mark Pagani, Department of Geology and Geophysics, Yale University: *Determining past atmospheric CO₂ concentrations using alkenones*

December 2, 2002



Karl Turekian, Director of the Yale Institute for Biopsheric Studies, in keeping with the vision of promoting interdisciplinary interactions among faculty and students in the Class of 1954 Environmental Science Center (ESC), has organized a weekly seminar series highlighting interactions that are now taking place among the occupants of ESC. Seminars have been scheduled for each Friday during the fall and winter/spring semesters, and topics relate to current research being conducted by the various participants.

THE YALE INSTITUTE FOR BIOSPHERIC STUDIES HOSTS FRIDAY SEMINARS IN CLASS OF '54 ENVIRONMENTAL SCIENCE CENTER CLASSROOM

Fall 2002 Schedule

Karl Turekian *Cosmogenic nuclides, atmospheric chemistry and climate* September 20

Ronald Smith *Landscape changes in the Middle East; Response to human and climate forcing, monitored from space* September 27

Gisella Caccone *Tales from two oceans: evolutionary genetics of Giant Calapagos and Aldabra tortoises* October 4

David Post *Fish, food, webs, and forests: vignettes from the Post Lab* October 11

Richard Burger *Climate change, catastrophism and Andean archaeology* October 18

Andrew Hill *Climate and Human Evolution: Information from the Tugen Hills, Kenya* October 25

Steven Mylon *Trace metal complexation in freshwaters as a predictor of bioavailability* November 1

Alison Richard *Southwest Madagascar: survival, subsistence, and conservation in an unpredictable environment* November 8

Xuhui Lee *Rapid response of carbon emission from a forest soil to precipitation* November 22

Richard Bribiescas *Reproductive ecology of the human male* December 6

Winter/Spring 2003 Schedule

Ruth Blake *Biogeochemistry and geomicrobiology of PO₄: Oxygen isotope studies* January 17, 2003

Anne Yoder *Molecules, Mammals, and Madagascar: Using Tree Thinking to Reconstruct the Evolution of an Island* January 24, 2003

Leo Hickey *A model for angiosperm evolution* January 31, 2003

Mark Pagani *Controls on the long-term evolution of global climates: a biomarker perspective* February 7, 2003

James Saiers *The Role of Hydrologic Processes in the Fate of Pollutants within Freshwater Environments.* February 14, 2003

Jacques Gauthier *What's in a Name? Quaternary Faunal Dynamics and the Herp Stability Hypothesis* February 21, 2003

Danny Rye *Use of Stable Isotopic Studies in the Environment: On Both Long and Short Time Scales* February 28, 2003

Peter Raymond *The Role of Rivers in Regional and Global Carbon Budgets* March 7, 2003

Elisabeth Vrba *New insights into processes of speciation based on the African mammalian fossil record of the past 10 million years.* March 28, 2003

Luciano Beheregaray *Phylogeography and the origin of species: examples from the Amazon rainforest, Galapagos Islands and the Pampas grassland* April 4, 2003; 12 Noon–1:30 PM

Susanna Remold *Environmental heterogeneity and the evolution of genetic architecture in viruses* April 11, 2003

Jeremy Redman *Observations on microbial transport in porous media and implications for groundwater quality.* April 18, 2003

Jenney Hall *The use of Foraminiferal Lithium as a Paleooceanographic Tracer* April 25, 2003

PEABODY MUSEUM OF NATURAL HISTORY



Illustration by Portia Sloan for IVPP



DINOSAUR FIND IN CHINA NAMED FOR PEABODY MUSEUM CURATOR JACQUES GAUTHIER

A newly-found dinosaur fossil from China has been named in honor of Jacques Gauthier, the curator of vertebrate paleontology at the Yale Peabody Museum of Natural History and a professor in the Departments of Geology & Geophysics & Ecology/Evolutionary Biology at Yale University. A paper describing the dinosaur and the significance of its discovery appeared in the September 19, 2002, issue of *Nature*.

Incisivosaurus gauthieri belongs to the group of theropod dinosaurs called oviraptors. Collected from sediments deposited more than 128 million years ago in the lowest part of the Lower Cretaceous Yixian Formation of China, it is one of the oldest and most primitive oviraptors found to date.

Oviraptors had highly specialized skulls, and *I. gauthieri* was no exception. Described by one commentator as resembling a “chicken with buck teeth” and a “cross between the Roadrunner and Bugs Bunny,” it was a specialized plant-eater with a pair of prominent front teeth similar to those of rodents and small, plant-chopping cheek teeth with large wear facets. Prior to this discovery, such dental fea-

tures were unknown among theropods, making *Incisivosaurus* the first theropod displaying distinct dental adaptations for an herbivorous diet.

Placing oviraptors in theropod dinosaur genealogy has been difficult because they possess a confusing combination of characteristics. They were clearly among the feathered theropods. However, in some ways they were very primitive non-flying forms, in other ways very derived. Indeed, in a few features, oviraptors were more like modern flying dinosaurs than were early flying dinosaurs. For example, oviraptors were toothless and had well developed beaks, while early flying dinosaurs such *Archaeopteryx* were toothed and beakless like more typical dinosaurs, such as *Velociraptor*.

Incisivosaurus has clarified matters because it lacks the anomalously bird-like features of later oviraptors. For example, it had teeth instead of a beak. By exhibiting certain features closer to more typical theropods, *Incisivosaurus* greatly reduces the morphological gap between later oviraptors and earlier theropods. And it demonstrates what scientists have long suspected, that some “bird-like” features evolved separately in oviraptors. The new discovery pleads a case of convergent evolution while suggesting that non-flying theropods were much more diverse ecologically than previously thought; theropods are normally thought of as vegetarians.

The generic name “*Incisivosaurus*” refers to the presence of incisor-like “buck” teeth on the premaxillary bones. The specific name “*gauthieri*” was selected, according to the

paper’s authors, a team from the Chinese Academy of Sciences, because of Professor Gauthier’s contributions to theropod systematics. Gauthier’s research focuses on phylogenetic relationships and their fundamental importance in formulating and testing hypotheses about the diverse processes influencing evolutionary change and phylogenetic divergence.





MAJOR EXHIBITION ON MACHU PICCHU OPENS JANUARY 26 AT YALE PEABODY MUSEUM; NATIONAL TOUR FOLLOWS

Machu Picchu: Unveiling the Mystery of the Incas is the marvelous and much-anticipated exhibition on that wonder of the modern world, Machu Picchu. The largest exhibition on the Incas ever assembled in the United States, it is also one of the largest undertakings in the Peabody Museum's history. Opening on January 26, it is in part a reflection of the research and findings of archaeologists Richard L. Burger and Lucy C. Salazar, co-curators of the exhibition, into the origins and uses of the famous archaeological site, which was rediscovered in 1911 by Yale professor and archaeologist Hiram Bingham III.

With its historical and scientific context and its interactive components, this impressive exhibition has something for everyone. First and foremost, it draws on Burger and Salazar's research to tell, finally, the real story of the Incas. Contrary to Bingham's speculation that Machu Picchu was occupied for centuries, Burger and Salazar show that it was active for less than a hundred years. They also demonstrate that Machu Picchu was not an isolated spiritual center, nor a refuge for the defeated Incas, but a summer retreat for the Inca elite from Cuzco, the empire's capital. Burger calls it "the Inca equivalent to Camp David."

This "country palace" situated magnificently in the Peruvian Andes was populated seasonally by the ruling Inca and several hundred craftsmen and other servants necessary to carry on the affairs of estate and government. Salazar comments, "In our exhibition





we show that Machu Picchu was a royal estate built by Inca Pachacuti, the first imperial ruler of the Empire, in 1450. A special caste of metallurgists and craftsmen lived in Machu Picchu and served the Inca elite.” These workers were well-fed and well-treated. Regarding the retreat’s location, Burger says, “Pachacuti may well have picked out the site simply because it was so beautiful. The Inca were connoisseurs of highland panoramas, and they had an aesthetic about stonework and mountain views.”

The exhibition also sets straight the composition of the population at Machu Picchu, which was, Burger says, “much more varied than people had appreciated. Today, when people look at the ruins in Peru, it’s easy to forget the sort of complexity that existed in Inca times.” Machu Picchu was the melting pot of the Inca empire, “more like New York than an isolated rural village in Peru, in terms of its cultural population. The people living in Machu Picchu were brought there from all over the empire. They were from different ethnic groups and spoke different languages. They had all been brought together in part to serve these Inca rulers.”

The exhibition is extremely visitor friendly. Drawing on the latest technology, it provides an interactive learning experience that explores the scientific methodology behind the archaeological process. Dioramas, topographic models, thematic video displays and computer interactives inform visitors about

the legacy of the Inca, and an interactive laboratory shows how archaeologists in the 21st century interpret the 15th century.

Visitors will “travel” into the past, first to Machu Picchu with Hiram Bingham and the 1911 Yale Peruvian Scientific Expedition, and then further back to the 15th century AD when Machu Picchu functioned as an Inca royal estate. Visitors will view a panorama of the high altitude cloud forest of Peru, walk along a replica of an ancient Inca road, take a self-guided interactive tour of the Inca palace complex, and inspect an Inca burial chamber. On entering the house of the Inca king, they will find a life-size mannequin of the king, whose gold jewelry and alpaca tunic have been reproduced specifically for the exhibition by craftsmen in Peru.

Central to the exhibition are some of the finest surviving examples of Inca art, many of them recovered from Machu Picchu, including over 400 gold, silver, ceramic, bone and textile artifacts, along with photographs and other memorabilia. These materials are used as springboard for a discussion of archaeological science and the way in which knowledge of relevant aspects of ecology, astronomy, metallurgy, human biology and other scientific subjects have proved to be critical in understanding the purpose of Machu Picchu and why it was abandoned.

As director of the Peabody Museum from 1995 through the end of 2002, Burger was responsible for raising the considerable funds necessary to stage the exhibition. Major support comes from federal, state, and private

foundations, including the National Science Foundation, National Endowment for the Humanities, Connecticut Humanities Council, and The William Bingham Foundation, as well as numerous individual donors. A gala previewing the exhibition and honoring its donors will take place the evening of Saturday, January 25, 2003.

The exhibition closes on May 4, 2003, when it begins a two-year tour of five major venues before returning to the Peabody for permanent installation. Those venues include the Natural History Museum of Los Angeles County (June 14 to Sept. 7, 2003), Carnegie Museum of Natural History (Oct. 18, 2003, to Jan. 4, 2004), Denver Museum of Nature and Science (February to early May, 2004), and Chicago’s Field Museum (fall, 2004). One other venue is yet to be named.

The Peabody Museum, located at 170 Whitney Avenue, is open Monday to Friday from 10 to 5, and Sunday from noon to 5. For more information about the exhibition and special viewing hours, call 203.432.9891 or e-mail peabody.special.events@yale.edu.

*Opposite page, left to right: Ritual offering vessel or *paccha*; Inca bottle; Shawl pins*

BIODIVERSITY EXPERT MICHAEL DONOGHUE TAKES OVER DIRECTORSHIP OF PEABODY MUSEUM

Michael J. Donoghue, an expert on biodiversity and the G. Evelyn Hutchinson Professor of Ecology and Evolutionary Biology, became the eighteenth director of the Peabody Museum on January 1. Professor Donoghue also has faculty appointments in the Department of Geology and Geophysics and the School of Forestry & Environmental Studies.

“Michael Donoghue’s knowledge and understanding of the importance of collections, his passion for reaching the public through exhibitions, and his intellectual distinction will make him a superb director of the Peabody Museum,” said President Richard C. Levin in announcing the new director. “He will also ensure that the museum plays an important role in the study and conservation of biodiversity.”

Yale Provost Alison F. Richard, a former director of the Peabody, said Donoghue’s appointment comes at a time of growing importance for great natural history collections, and when Yale has expanded its commitment to evolutionary biology and the environmental sciences. Said Donoghue, “I am honored and delighted to lead the Peabody Museum, and I am thoroughly committed to maintaining and building these great collections as a record of life on Earth.”

Donoghue has been closely involved with the Peabody since coming to Yale in 2000 from Harvard, where he was professor in the Department of Organismic and Evolutionary Biology and Director of the Harvard University Herbaria. He is the Peabody’s curator of botany, a role he will continue to fill as director. As Principal Investigator for a National Institutes of Health grant supporting a partnership between the Peabody Museum and the New Haven Public Schools—one exploring the relationship between biodiversity and human health—he is already raising the museum’s profile in the study and preservation of biodiversity. The *Peabody Fellows Program*, upon which this partnership expands, is currently a leading component of system-wide

reform in science education in the New Haven Public Schools.

As Principal Investigator on a three-year, \$500,000 Stavros S. Niarchos Foundation grant supporting a collaborative initiative between the Peabody and both the Natural History Museum of Crete and the University of Crete, Donoghue is at the forefront in this international exchange of ideas and best practices. The focus is biodiversity field research, the exchange of collections, applied programs for the management and protection of various ecosystems, and the design of an experimental classroom, a multi-functional educational space for hands-on inquiry to serve the museum’s public education and teacher training programs.

The author of over 130 published papers, Donoghue played an important role in building Yale’s Department of Ecology and Evolutionary Biology, created in 1998. His research all revolves in one way or another around understanding evolutionary relationships. His empirical work focuses primarily on plant diversity and evolution. Curiously, as Donoghue takes the helm of an institution renowned for its dinosaurs, he made head-



lines in September as a member of the Rockefeller University team that recreated a 240-million-year-old dinosaur eye protein. What is particularly exciting about this is that it allows us to bring to life proteins from extinct animals, and to see how they might have functioned.

Donoghue succeeds Richard L. Burger, who served as the Museum’s director for eight years. Burger will return to full-time research and teaching as a professor of anthropology and as curator of anthropology at the Peabody.



PEABODY WELCOMES NEW ASSISTANT DIRECTOR

Jane Pickering has joined the Peabody Museum as Assistant Director for Public Programs. Jane has worked in university science museums for more than 13 years, most recently as director of the MIT Museum in Cambridge, Massachusetts. Before that she was assistant curator for zoological collections at the Oxford University Museum of Natural History where she was curator of several exhibitions and started the museum’s education service. She was also a senior curator at the Royal College of Surgeons of England. Jane has a Master of Arts degree in natural sciences from the University of Cambridge and a Master of Science degree in museum studies from the University of Leicester, and is a native of England and now a permanent U.S. resident. Jane lives in Guilford, CT with her husband Chris and baby daughter Madeline.

UNWRAPPING THE PEABODY MEMBERSHIP PACKAGE

Peabody Museum membership is your doorway to the thrill of discovery, the awe of exploration, the grand sweep of life on our little planet Earth.

At the Peabody you have seen Apatosaurus, the ancient sea turtle Archelon, and life-like dioramas of our great American landscapes, learned to draw birds, slept with dinosaurs, and visited ancient Egypt. What you've seen at the Peabody just hints at the vistas available to you.

When you become a Peabody Museum member, you are automatically enrolled in the Association of Science-Technology Centers (ASTC) Passport Program, entitling you to free admission to the museums that belong to ASTC. Because this list is constantly growing (over 270 museums now!) you get an updated list each time you renew. You may now also bookmark the link to the ASTC list on the Peabody Membership web page. The ASTC logo in the upper right-hand corner of your membership card is your key to all these museums.

If you haven't had the chance to use your Passport, take note of some ideas and resources to inspire you and help you take advantage of an experience that is free and educational. The next time you're planning a vacation or looking for something new to do on a weekend, get information on the museums in the area where you are going by looking at the side bar at left for favorites from the list. Your ASTC reciprocal museums list provides web addresses and phone numbers to all 270+ museums.

And, keep in mind that not all the museums are the same! Whether you want more of what you like most at the PM, or you're looking for something you can't find here, the ASTC has it: planetariums, IMAX theaters, children's museums, wildlife and nature centers, hands-on museums, technology centers, industry museums, astronomical observato-

ries, discovery centers, archaeology, anthropology, you name it! Often museums contain a wealth of information on local ecosystems, geography, history, culture or industry. It can be a great way of getting a really in-depth view of any area you are visiting.

To help you explore, we have recently added a link to Tryscience.org www.try-science.org, a cool website co-sponsored by ASTC, IBM and others. It has a field trip planner, museum finder, live webcams of science centers around the world, experiments to try, and other fun interactive adventures.

For more information on the PM and membership, please call (203) 432-5426, or visit our website at www.peabody.yale.edu.

Peabody Museum Information

- > **Open 10 am to 5 pm Monday through Saturday; noon to 5 pm on Sunday**
- > **Admission is \$5 (adults); \$3 (children 3-15) and senior citizens 65+; free to Museum members, volunteers, and Yale University I.D. holders.**
- > **Highlight tours are held every Saturday and Sunday at 1 pm.**
- > **Parking for visitors is available for a fee (weekdays) at the south end of Yale Lot 22. Parking in designated Yale lots is free on weekends.**
- > **The Museum is wheelchair accessible. A ramp and a handicapped parking space are adjacent to the Museum on Schem Street.**
- > **InfoTape at (203) 432-5050**
- > **<http://www.peabody.yale.edu>**

MUSEUMS IN CONNECTICUT

Science Center of Connecticut, West Hartford, also includes the Roaring Brook Nature Center in Canton

Science Center of Eastern Connecticut, New London

REGIONAL FAVORITES

The Children's Museum, Boston, MA

Museum of Science, Boston, MA

EcoTarium, Worcester, MA

Woods Hole Oceanographic Institution on Cape Cod

Liberty Science Center, Jersey City, NJ

Mount Washington Observatory & Weather Center, NH (Mount Washington's weather is more extreme than Antarctica!)

Thames Science Center, Newport, RI

Brooklyn Children's Museum, Brooklyn, NY

The Franklin Institute, Philadelphia, PA

NATIONAL FAVORITES

The Exploratorium, San Francisco, CA

Pink Palace Family of Museums, Memphis, TN

Chicago boasts five member museums, including the famous Field Museum of Natural History. One member told us she saved \$90 in one day in Chicago for herself and her two children!

Space Center, Houston, TX

Vacationing in Florida? Choose from 20 member institutions!

GO GLOBAL

There are three ASTC museums in Australia, three in Caribbean and South American countries and you can visit member institutions in Israel, New Zealand, Singapore and the Philippines!!



**THE MAYA MURALS
OF BONAMPAK:
WINDOWS ON AN
ANCIENT WORLD**
A NEW EXHIBITION AT THE
PEABODY MUSEUM, OCTOBER 3
THROUGH SPRING 2003.

Located within the deep tropical rainforest of Chiapas, Mexico, the ancient Maya site of Bonampak is home to the most complete and important mural series of the ancient Americas. Over a period of 500 years or so the ancient Maya built many plazas, temples and palatial dwellings in the area, and although Bonampak is a relatively small complex compared to others, it houses some of the most stunning artistry the Maya ever produced. When the paintings were completed in AD 800, the region was suffering from deforestation, exhausted farmland, and overpopulation. Some cities were burned to the ground and others were simply abandoned. By AD 900, the forest had begun to reclaim the area and it wasn't until 1946 that the murals came to modern attention. Lacandon Maya who lived

in the region showed photographer Giles Healey (Yale '24) what they had not previously shown to any outsider: a small temple whose three rooms were covered with paintings. These paintings reveal the ancient Maya at the end of their splendor, and their exquisite detail make Bonampak an unparalleled resource for understanding ancient society.

In 1995, Mary Miller, Professor of History of Art at Yale, became concerned about the continued deterioration of the murals in the rainforest environment and thus established the Bonampak Documentation Project. The principal goal of the project was to document the paintings using infrared film, which revealed details invisible to the naked eye. During 1996 the project team recorded every scrap of paint within the three narrow cham-



bers with funding supplied by the National Geographic Committee on Exploration and Research and the Getty Foundation. After assembling the data, archaeological artist Heather Hurst (pictured right) joined the team and began a hand-painted reconstruction that would incorporate all the data sets into a single large-format work. The reconstructions, at 50% actual size and nearly 30 feet long, were completed in about two years with the assistance of painter Leonard Ashby.

The Peabody Museum's exhibition includes one of these painted reconstructions, and reproductions of the reconstructions of the other two rooms. Incorporating objects from the Museum's own collections, this exhibition is a window onto a world whose "collapse" would soon lead to abandoned cities and the end of elite society in the region.

© Bonampak Documentation Project



Heather Hurst at work on Room 3, outlining the figures by painting the background first. The ancient Maya probably mapped out the walls in a similar fashion.

PEABODY MUSEUM OF NATURAL HISTORY

THE LEPIDOPTERISTS' SOCIETY ELECTS LARRY GALL PRESIDENT

Peabody Museum of Natural History's (PM) Systems Manager and Curatorial Affiliate Larry Gall was recently elected president of The Lepidopterists' Society at its annual meeting in Savannah, Georgia. The Society is an international organization of several thousand professional scientists and amateur enthusiasts who share a dedication to the study of butterflies and moths, the Order Lepidoptera.



The Lepidopterists' Society has a long-standing connection with the PM, having been co-founded in 1947 by Curator Emeritus of Entomology Charles Remington. Both the PM and Yale's Osborn Zoological Laboratory served as the base of operations for the fledgling group during its first decade, and over the years members of the Society have contributed thousands of specimens, along with their curatorial expertise, to the collections in the Entomology Division. In July 1997, 200 lepidopterists ventured "home" to the PM and the Osborn Laboratory to celebrate the 50th anniversary of the Society, a four-day gala that featured several symposia and 60 contributed talks on different aspects of lepidopterology.

In addition to chairing the 50th anniversary meeting, Larry previously served the Society as its vice president, as a member of its Executive Council, and as editor of its scientific periodical, the *Journal of The Lepidopterists' Society*. For more information about the Society, visit its website at www.lepsoc.org, and visit the PM's entomology collections at www.peabody.yale.edu/collections/ent/

2002 BIODIVERSITY INSTITUTE EMPHASIZES COOPERATIVE LEARNING

On August 5, 2002, eleven New Haven middle school teachers completed the 40-hour Peabody Fellows Biodiversity and Human Health Institute. Funded by the National Institutes of Health, this year's Biodiversity Institute focused on a science education method known as events-based or problem-based learning. Project Director Laura Fawcett explains that this inquiry-driven and student-centered approach differs dramatically from traditional textbook methods in that it emphasizes teamwork, cooperative learning and laboratory investigation.

Starting with a scenario based on either a fictional or an actual event, teachers can create a task that engages students. For example, in light of recent news coverage of the invasive snakehead fish thriving in a Maryland lake, students might be "hired" by the local Department of Environmental Protection to create a video for younger students that explains the dangers of invasive species. To accomplish this students would be encouraged to pursue independent research using primary sources that could include newspaper and magazine articles, television reports, interviews, the internet and other media.

As District Science Staff Developer and Master Peabody Fellow Sarah Rosner explains: "It makes science more relevant so they (students) can relate to it. They're bombarded with so many things, it has to be relevant in order for them to grasp onto and buy into it." Several Peabody Fellows described the resulting teacher role as "guide on the side, not sage on the stage." Teachers would coach, question and challenge students as they actively test their own methods and experience firsthand the discovery and excitement of new scientific knowledge. Because the teachers are students during the Institute, Science Educator Terri Stern incorporated events-

RESEARCHER ON EL SALVADOR TEAM

A previously unreported occurrence of an insect disease vector—an agent that can pass a pathogen from one organism to another—has been collected in El Salvador in an area where a peculiar form of an insect-borne disease has been found.

Associate Curator of Entomology Leonard E. Munstermann was part of a four-person epidemiological team that visited El Salvador in June at the behest of the El Salvadorean Ministry of Health, and in association with the U.S. Department of Defense's Army Health Center for Health Promotion and Preventative Medicine. Accompanied by a fully armed, five-

person police guard, the team collected rodent and insect specimens from three communities in San Vicente Province. Aberrant forms of American visceral leishmaniasis, or AVL, have been reported from two of these communities, El Tortuguera and San Ildefonso. Even though it was the rainy season, the dry season AVL sand fly, *Lutzomyia longipalpis*, was collected in all three communities. No records of this insect disease vector occurring in El Salvador have been previously published. Professor Munstermann is on the faculty of the Department of Epidemiology and Public Health (EPH) at the Yale School of Medicine.



M. Doollittle

based learning into the week's curriculum. A videotape of an NBC news program on the Great Famine Project's Road to Remember Walk commemorating the Irish potato famine, caused by blight, a plant disease, was the "hook" to explore plants and their diseases.

With the exception of a provocative slide presentation by PM Curator of Botany Michael Donoghue on recent discoveries in biodiversity, this year's lectures were replaced by more active learning strategies. In "Big Mac Biodiversity," Vertebrate Zoology Museum Assistant Greg Watkins-Colwell led teachers through an analysis of the more than 50 plant species that constitute this fast food icon. Teachers used sterile plating techniques to learn about the role of spices such as cinnamon, garlic and curry in preventing food spoilage. Also, Connecticut beekeeper Candy Zarr discussed human reliance on bees for pollination, and teachers simulated bee vision by examining flowers through different colored acetates.

Even the biodiversity hike at the PM's coastal field station experimented with more active learning strategies. Teachers were divided into four teams led by pairs of Museum scientists who offered observations on the various habitats and microhabitats. During a working lunch at the end of the hike, teams pondered their new insights into biodiversity as they debated what could be removed from a habitat to cause the least damage.

On the Institute's final day, teachers completed a performance assessment task, an alternative to traditional testing. Each team demonstrated their new knowledge by creating and presenting a 10-minute skit that would teach middle school students about the complex relationship between plants and humans.

After a week spent immersed in an events-based learning module on plants, everyone agreed with this comment by David Brackett, chair of the World Conservation Union Species Survival Commission: "If you like to breathe and you like to eat, you should care more about plants."

Top: Fellow Stephaine Darden surveys biodiversity with Curator of Botany Michael Donoghue.



T. Kydes



Bottom: Eighth grader Andrew Kydes of Norwalk won the Peabody's first Biodiversity and Human Health Award at the Connecticut Science Fair for his project "Why Some Like it Hot: The Antimicrobial Effects of Spices."

BIODIVERSITY AND HUMAN HEALTH PROGRAM WELCOMES GRADUATE INTERNS

Yale graduate students Jennifer Collins '03, in the Department of Epidemiology & Public Health (EPH) at the Yale School of Medicine, and Larisa Grawe '03, in the School of Forestry & Environmental Studies (F&ES), have been hired by the Peabody Museum's Biodiversity and Human Health Program as interns for its summer institute. Both are master's degree candidates who, using the perspectives of their respective disciplines, will help Peabody Fellows teachers make the vital connections between biodiversity and human health. The two will also teach science processing skills in middle school classrooms in the fall.

As a Master of Public Health candidate in the Division of Epidemiology of Microbial Diseases, Jennifer, whose specialty is virology, was drawn to the Peabody Fellows Program by the "need to increase the level of interest in science in today's youth. It is important to

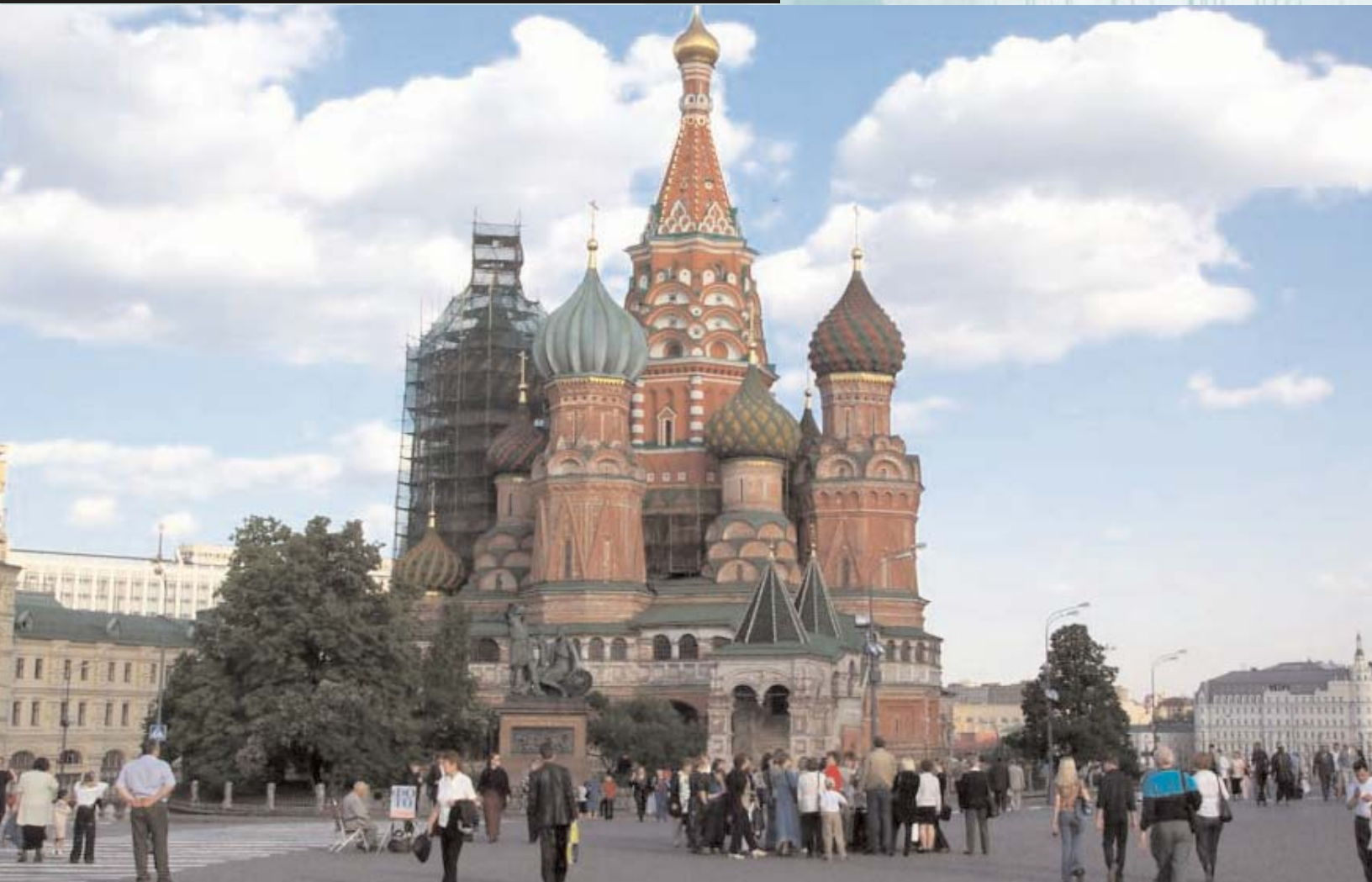
instill a sense of respect, both in children and parents, for the environment and the life that exists within it, in all of its diversity. Also, the media often presents science negatively, especially in regard to human health, so it is refreshing to be part of a program that emphasizes science and biodiversity in a positive light."

Larisa's interests include environmental education, conservation biology, paleontology, and museum education and exhibit development. Her honors research project focused on environmental education in urban elementary schools, and she spoke recently at a forestry conference about the need for a long-term public commitment to education beginning at the elementary school level. She hopes to "develop educational programs as mechanisms for social change. Education is an economical and powerful tool that can enable positive change." Larisa's master's project focuses on the analysis of museum exhibits, critiquing the incorporation of various aspects of evolution and conservation biology.



Top: Students and families explore Museum specimens at the first BioAction Lab Open House, Conte West Hills Magnet School, May 14, 2002.

Bottom: Master's degree candidates Larisa Grawe and Jennifer Collins join the Peabody team.



St. Basil's Cathedral located adjacent to Red Square in Moscow.

FORGING U.S.-RUSSIAN TIES TO COMBAT EMERGING VIRUSES AND BIOTERRORISM

By Paul E. Turner

Assistant Professor, Department of Ecology and Evolutionary Biology; Co-Director, YIBS Center for Microbial Diversity

Ever since the tragic events of September 11, 2001, there has been a growing concern that pathogenic viruses may be used as weapons for bioterrorism. These fears have prompted the U.S. and other countries to more closely monitor the existing laboratory stocks of viruses such as smallpox. However, a greater challenge is to identify members of the scientific community that are capable of engineering viruses as bio-weapons, and to determine whether these virologists might be convinced (monetarily or philosophically) to aid terrorist interests.

During the Cold War the Soviet Union trained and employed researchers in the design of virus pathogens for bio-weapons. Most of these scientists now work for government and university laboratories in Russia, studying the basic biology of viral pathogens for strictly peaceful purposes. But the faltering Russian economy threatens the persistence of these research programs. Hence, the U.S. government perceives a danger that former bio-weapons virologists in Russia (or other countries) may aid the terrorist actions of rogue

governments out of sheer need to provide for themselves and their families.

To address this concern, in June 2002 the U.S.A.'s National Science Foundation (NSF) and Department of Health and Human Services (DHHS) co-sponsored a joint U.S.-Russian workshop on the Ecology of Infectious Diseases. This conference was co-organized by the Russian Academy of Sciences and took place in Novosibirsk, Siberia, home of the high-security laboratory VECTOR where decades



Top: Conference attendees tour the high security hospital adjacent to vector laboratory. In the center of the picture is 'gator', a device used to house dangerous pathogens while researchers access the viruses from a safe distance using gloves built into the sides of the machine.

Bottom: A scientist at VECTOR demonstrating a biocontainment suit, for use while working on communicable pathogens.

Opposite page, top: A view of the buildings along Red Square in Moscow.

Opposite page, bottom: View from the high bank of the Inya River, near its mouth at Novosibirsk.

of Soviet research on bio-weapons occurred last century.

The primary goal of this historic workshop was to expose U.S. and Russian scientists to one another's research, in the hopes that our collaborative efforts can halt the spread of some of the world's most deadly viruses. In turn, an increased knowledge of virus pathogenesis should provide an increased ability to deter any unfortunate attempts to use these viruses as agents of bio-terrorism. The second goal of the conference was for these collaborations to re-invigorate the scientific programs headed by Russian virologists, allowing the former bio-weapons specialists to continue peaceful research in their home country. Representatives from NSF and DHS were also present to discuss strategies for funding incipient collaborations through money from U.S. granting agencies.

Taking part in the three-day workshop were over 40 of Russia's leading virologists, representing research that ranged from the emergence of previously unknown hemorrhagic fever viruses in Asia, to the role of Lake Baikal seals as a reservoir for viruses and other infectious agents. The U.S. delegation was composed of twenty scientists and administrative officials, from research laboratories of the government (such as the National Institutes of Health, and Centers for Disease Control), and of academia (such as Cornell University, and the University of Texas, Medical Branch). American experts included ecologists studying mosquito and tick vectors, theoretical ecologists, and molecular geneticists examining emerging viruses. My ongoing research concerns the use of viruses as model systems for testing ecological and evolutionary theory, and I was fortunate to be chosen as the only representative of this field and the only scientist from Yale University to take part in the workshop.

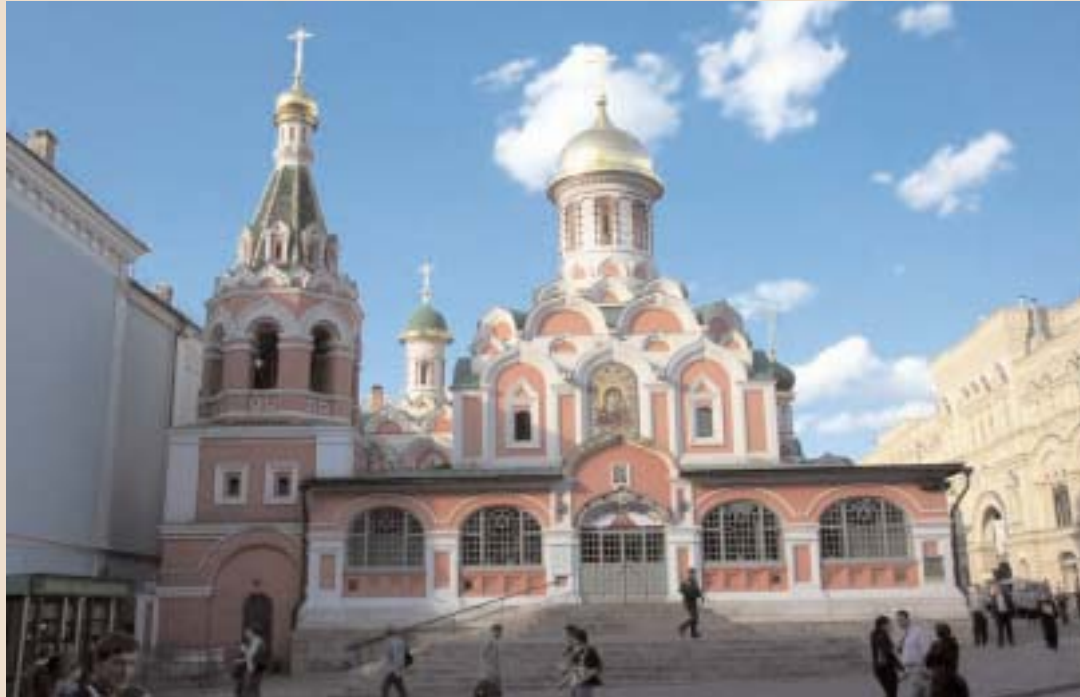
During the workshop, members of the U.S. and Russian delegations presented formal talks on their research. In addition, we took part in less formal breakout sessions concerning a variety of topics, including virus epidemiology, community ecology, the emergence of West Nile Virus, and the ongoing threat of tick-borne viral encephalitis in Russia. Here we identified the current state of knowledge on the topic, the most interesting areas for further research, and how U.S.-Russian collaborations can foster that research. These discussions proved valuable for developing collaborative approaches to better understand the basic biology, and epidemiological spread of virus pathogens in different regions of the world. More casual discussions occurred in the evenings, as the two delegations socialized over meals of traditional Russian food and Georgian wine. Although interpreters were often needed, these conversations allowed scientists of strikingly different cultural backgrounds to find common ground in combating the spread of emerging viral pathogens.

Our exposure to Russian culture was not limited to the meeting's activities. During our stay in Moscow, we visited famous icons such as Red Square, the mummy of Anatoly Lenin, and a ballet performance at the Bolshoi Theater (where we learned that dishonest ticket scalpers were not a purely U.S. phenomenon). Equally valuable were our tours of Novosibirsk's museums and a visit to VECTOR, where smallpox stocks are housed and active research occurs on highly contagious pathogens such as Ebola virus, and HIV. It was reassuring to see that VECTOR featured several mechanisms to repel thieving intruders (e.g., armed guards and barbed wire fencing), but it was also obvious that equipment upgrades were badly needed in many of VECTOR's laboratories. However, the women and men working at VECTOR are extremely competent researchers, and their vast knowledge of pathogenic viruses is a valuable (albeit under funded) resource for fighting the spread of virus diseases.

One of the emerging virus diseases studied at VECTOR is Crimean-Congo Hemorrhagic Fever (CCHF), caused by a tick-borne virus that circulates in several regions of the Old World (Africa, Asia, and Europe). As with many viruses transmitted by insects, a productive year for the insect vector inevitably means a rise in human fatalities caused by the disease. This is increasingly true for CCHF in human populations of rural Asia, such as in Kazakhstan, Uzbekistan and Tajikistan. But several mysteries surround the ecology of CCHF and other tick-borne viruses. Which species of ticks are most important in circulating these viruses? For viruses such as CCHF that are endemic to many continents, is there evidence that only a subset of these viruses are most prone to cause epidemics (similar to the supposed ability of influenza viruses from Asia to be most influential in spurring worldwide pandemics)?

The joint U.S.-Russian workshop allowed me to meet Dr. Vladimir Petrov of VECTOR, who shares my interest in addressing these and other questions regarding the biology of CCHF and similar viruses. Our plan to collaborate on studies examining the epidemiology, ecology and evolution of viruses should greatly advance our understanding of the basic biology of these pathogens. This is the first step in generating an increased ability to halt the epidemiological spread of virus pathogens, and to thwart the actions of would-be terrorists seeking to use these viruses as bio-weapons.

Photographs courtesy of Paul Turner.





left to right: Daniel Esty, Professor of Environment Law and Policy; David Evans, Assistant Professor in Department of Geology and Geophysics; Professor Menachem Elimelech

YALE PROFESSOR RECEIVES AMERICAN BAR ASSOCIATION AWARD

Daniel Esty, Professor of Environmental Law and Policy at Yale University, with appointments in both the School of Forestry & Environmental Studies (F&ES) and the Law School, received the American Bar Association (ABA) 2002 Award for Distinguished Achievement in Environmental Law and Policy at the ABA's annual meeting. The prestigious award is given annually to an individual and an organization for accomplishments in the field that lead to significant progress in environmental law and policy.

Esty received the award for his contributions to environmental law and policy during his career in academia and his prior work at the U.S. Environmental Protection Agency. The ABA Selection Committee made special note of Professor Esty's efforts to develop the Environmental Sustainability Index (ESI) and "its implications for the development of an analytical basis for environmental and resource decision-making." The ESI project, conducted jointly by Yale, Columbia University and the World Economic Forum, measures a country's capacity for sustained environmental success and provides a comprehensive snapshot of a country's likely environmental quality of life in the future. The 2002 ESI report and data are available for download (www.yale.edu/envirocenter).

The other recipient of this year's award is Vermont Law School's Environmental Law Center.

Esty's research interests cover a wide range of environmental law and policy issues. His recent work focuses on new approaches to environmental regulation, including the use of economic incentives and other market mechanisms; environmental performance measurement and the benefit of data-driven environmental decision-making; environmental protection in the Information Age; environmental effects on competitiveness; trade and environment linkages; global environmental governance; corporate environmental management; and environment and security.

In addition to his teaching role, Esty is the director of the Yale Center for Environmental Law and Policy and the recently launched World Fellows Program. In June 2002 he completed a four-year term as associate dean of academic affairs for F&ES. In 2000, *The Earth Times* named Esty one of the world's "100 Most Influential Non-Governmental Officials," and in 1998 he was identified as one of the world's "100 Most Influential Environmental Leaders" by the same publication. In 1999, he was named one of 100 worldwide "Global Leaders of Tomorrow" by the World Economic Forum.

PACKARD FELLOWSHIP AWARDED TO DAVID EVANS OF GEOLOGY & GEOPHYSICS

Dr. David Evans, Assistant Professor in the Department of Geology and Geophysics, has been awarded a Packard Fellowship by the David and Lucille Packard Foundation for his research on reconstructing the pre-Cambrian world. The Foundation has a long-standing interest in strengthening both university-based research and graduate education, and the fellowship program was formulated to encourage the nation's most promising young university professors to pursue their science and engineering research with few funding restrictions and limited paperwork requirements. Each year the Foundation invites the presidents of 50 universities to nominate two young professors from their respective institutions. Nominations are carefully reviewed by the Fellowship Advisory Panel of distinguished scientists, and up to 20 Fellows are recommended to receive individual grants of \$625,000 over a five-year period. The Foundation hopes that this program will improve scientific research by persuading exceptional scientists and engineers to remain within academia to conduct basic research and to teach the next generation of science leaders.

Dr. Evans's research is directed toward the long-term physical and chemical evolution of planet Earth, and its effects on the evolving biosphere. He and his students are measuring magnetic directions preserved in ancient rocks to determine the motions of continents and supercontinents (where all or most of the continents were joined together) during the last 3000 million years. These motions provide insights into the internal dynamics of the Earth as its mantle churns in order to lose

heat to space. His work has also identified processes relating ancient ice ages to the comings and goings of these supercontinents, including episodes when our planet may have frozen over completely for as long as 10 million years at a time. These “Snowball Earth” ice ages seem to have occurred at pivotal points in biological evolution, such as indicated by the sudden first appearance of diverse animal fossils about 550 million years ago. Dr. Evans is also interested in how earliest life could have evolved without the benefit of a geomagnetic shield from cosmic radiation, as it is commonly assumed that the early Earth’s internal magnetic field was much weaker than it is now. He and his students are currently conducting their fieldwork in northern Canada, Newfoundland, Australia, and South Africa.



**RUTH E. BLAKE IS THE 2002
F.W. CLARKE MEDALIST OF THE
GEOCHEMICAL SOCIETY**

Dr. Ruth E. Blake, Assistant Professor of Geology & Geophysics and Environmental Engineering, was awarded the 2002 F.W. Clarke Medal of the Geochemical Society at a ceremony held at the Goldschmidt Conference in Davos, Switzerland in August 2002. The Clarke Medal is intended to recognize a young scientist who has made an important breakthrough in the early stages of his or her career. Dr. Blake conducted microbial growth experiments that showed that microbial metabolism/turnover of phosphate is dominated by equilibrium, not kinetic, isotope effects and results in oxygen isotope equilibrium between dissolved phosphate and ambient fluids. She also conducted rate and equilibrium studies of phosphate-water oxygen isotope exchange using cell-free isolated enzymes to provide a laboratory calibration of the phosphate-water temperature equation. Taken together, these results place important new constraints on pathways and mechanisms of phosphorus cycling in natural environments.

Dr. Blake has had an unusual academic path in that her training in geological research began very early on when she was a senior at Renaissance High School in Detroit Michigan. Her career has spanned a range of areas,

including reservoir engineering geology, groundwater research, experimental aqueous geochemistry and stable isotope biogeochemistry. Dr. Blake’s current research focus centers on microbial geochemistry and geomicrobiology and includes studies of the microbial P-redox cycle and geochemical fingerprints of microbial life in: deep-sea hydrothermal vents, Earth’s deep biosphere and extra-terrestrial systems (Mars).

Earlier in 2002, Dr. Blake participated in a research expedition to study deep biosphere microbiology on board the drillship R/V Joides Resolution on Leg 201 of the Ocean Drilling Program (ODP). The sub-seafloor biosphere may be a final frontier for new discovery of life on Earth. ODP Leg 201 made history as the first Leg devoted exclusively to the determination of the extent, distribution, and intensity of microbial activity/metabolism in the deep biosphere. A highly integrated approach was employed producing the highest resolution microbiological and biogeochemical data sets in ODP history and included: direct microbiological assays (e.g., cell counts, DNA/molecular methods) to identify specific organisms present; measurements of sediment physical properties; and analyses of pore fluid and sediment chemistry. As one of 30 shipboard scientists selected to participate on the Leg, Dr. Blake played an integral role as a shipboard geochemist by analyzing concentrations of nutrients (phosphate, ammonium, nitrate) in pore waters. Geochemical profiles showing the distribution and concentrations of key nutrients, electron acceptors/donors in deep-sea sediments were critical to the identification of biologically-active zones and specific metabolic styles; and essential to guiding real-time microbiological sampling and drilling strategies. Dr. Blake made new advances in the analysis of phosphate and nitrate, and developed a new technique for the detection of low rates of metabolic activity using novel stable isotope tracers. Yale investigators have benefited from the collections made on previous expeditions and made available to the scientific community. Dr. Blake is the first Yale faculty member to participate shipboard in the Ocean Drilling Program.

**PROFESSOR ELIMELECH HONORED
FOR LANDMARK ENVIRONMENTAL
ENGINEERING PAPER**

Every year, the Association of Environmental Engineering and Science Professors (AEESP) chooses “To recognize author(s) of a landmark environmental engineering paper that has withstood the test of time and significantly influenced the practice of environmental engineering.”

In 2002, AEESP conferred this honor on Professor Menachem Elimelech (Yale) and Professor Charles R. O’Melia (Johns Hopkins) for their paper “Kinetics of Deposition of Colloidal Particles in Porous Media,” *Environmental Science & Technology*, Vol. 24, pages 1528-1536 (1990).

Professor Elimelech and Professor O’Melia accepted their awards at the 75th Annual Meeting of the Water Environment Federation on September 30th in Chicago.

MALAGASY SCHOLARS AND STUDENTS COME TO YODER LABORATORY IN ESC

Anne Yoder joined the Yale faculty as an Associate Professor in the Department of Ecology & Evolutionary Biology (EEB) in July 2001, bringing her expertise in the field of mammalian phylogeny and evolution and in the biotic history of Madagascar. Her research interests include phylogenetic methods and theory, conservation genetics, ancient DNA analysis, the evolution of mammals, and the biodiversity of Madagascar, especially its lemurs. Through Professor Yoder's research in Madagascar, she has formed ongoing collaborations with Malagasy scholars and students and this summer was pleased to host two faculty and two Ph.D. students from the University of Antananarivo in Madagascar. Her visitors have spent a 6-week residence in her laboratory in the Class of 1954 Environmental Science Center (ESC) to collaborate on a research program in education and training on biodiversity.

Dr. Daniel Rakotondravony is the Chair of the Department of Animal Biology at the University of Antananarivo. His expertise is in

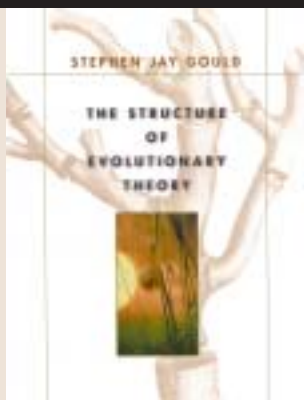
the rodents and insectivores of Madagascar and his work involves mammal-conservation management. Dr. Rakotondravony came to Yale this summer to continue his writing on animal conservation management. He is presently working on analyzing data gathered by a multidisciplinary Madagascar forest management team that culled information from a questionnaire they distributed to people living in a forest in Madagascar. This information will help to determine which areas of the forest are used more, and which areas are more important than others. The data results will be used to formulate special regulations on the use of the forest land, to develop a forest management plan and to create a map to show which parts of the forest should be used and which parts need to be protected. Dr. Rakotondravony and Dr. Yoder will work together on educational and research projects associated with a multidisciplinary approach to Madagascar's environmental problems over the coming years, and both are equally delighted with the collaboration.

Dr. Jeanne Razanabolana, a faculty member at the University of Antananarivo in Madagascar, is working on research on the parasitology of the six species of freshwater crayfish in Madagascar looking for the types of parasites that exist on these species. While at Yale, she was able to compare her findings with parasites found in crayfish in the United States. She also was able to utilize the Yale Library system to find papers relating to the methodology of this type of research and to aid her in establishing contact with others working on crayfish, with a goal to ultimately develop a plan for her own research. Professor Razanabolana expressed her appreciation for the opportunity given to her through her collaboration with Professor Yoder to visit Yale during July of 2002 that enabled her to enrich her research on crayfish and parasites.

Ph.D. candidate Marie Jeanne Raheirilalao came to Yale to work on her thesis in the biogeography of forest dwelling bird species on the highlands of Madagascar. While at Yale she was given the opportunity to access research papers and analyze data gathered from the various resources at Yale that she did not have access to in Madagascar. Marie Jeanne hopes to complete her thesis by the end of 2002 and work in the field of conservation biology in Madagascar. She has been collaborating with Professor Yoder for two years and is grateful for the opportunity to work with Professor Yoder in her new laboratory in the ESC and utilize the many resources available that helped her toward her goal of completing her thesis.

Ph.D. candidate Voahangy Soarimalala came to Yale to work on her thesis relating to the biogeography of small mammal species in the highlands of Madagascar. She began her Ph.D. studies in 1998 and is in the process of analyzing data and writing her thesis paper. Voahangy was extremely pleased to be able to work with Professor Yoder in her laboratory in the new ESC, which gave her the opportunity to use special software and look in journals that are not available to her in Madagascar. Her plans are to finish her thesis by the end of 2002 and work in the field of conservation biology in Madagascar.

DEDICATION



STEPHEN JAY GOULD DEDICATES HIS BOOK TO ELISABETH VRBA

Stephen Jay Gould was a renowned scientist who was a researcher in and expositor of evolutionary theory. Just before his death several months ago, his book, **The Structure of Evolutionary Theory**, was published by Harvard University Press.

In that detailed summary of his lifetime interest in evolutionary theory, he wrote a dedication to two colleagues with whom he had collaborated and interacted. One of these is Elisabeth Vrba, Professor of Geology & Geophysics and former Director of the Yale Institute for Biospheric Studies. Below is the dedication:

*For Niles Eldredge and Elisabeth Vrba
May we always be the Three Musketeers
Prevailing with panache
From our manic and scrappy inception at Dijon
To our nonsatanic and happy reception at Doomsday
ALL FOR ONE AND ONE FOR ALL*

ECOLOGIST CHALLENGES RELIABILITY OF A RESEARCH METHODOLOGY

By Frank Szivos

In a paper just published in the journal *Ecology*, Associate Professor David Skelly of the School of Forestry & Environmental Studies has posed a fundamental but probing question: How well do environmental scientists use their experiments to develop a realistic picture of nature?

This straightforward question has serious implications. Experiments are used throughout the environmental sciences to help develop federal drinking water standards, determine the effects of global climate change and predict the fate of endangered species.

The problem is that experiments force scientists to make difficult decisions. They can experiment in the laboratory where the environment may be closely controlled but the conditions may be unnatural, or they can work in natural environments where the working conditions make many kinds of experiments difficult or hard to interpret.

About 20 years ago ecologists proposed a kind of “Goldilocks solution.” If the laboratory is too unrealistic and the natural world is too messy, they reasoned, perhaps a compromise approach would work. So the mesocosm was born. Mesocosm, which means middle-sized world, is distinguished from laboratory environments (microcosms) and the Earth (macrocosm).

Since the concept was introduced, it has taken off, and mesocosms are now “hot science.” Thousands of experiments have been done in mesocosms. They are published in top journals and their results are seen as critical for understanding the most important environmental issues.

The problem is that no one has checked to see whether the promise has been fulfilled. “Mesocosms might not be all they are cracked up to be,” Skelly says.

Skelly turned to the lowly tadpole to make the call. The approach was simple and direct. He completed exactly the same experiment both in mesocosms—plastic, 250-gallon “cattle-watering” tanks—and within enclosures placed in natural ponds at Yale-Myers Forest. His findings show that two different amphibian species that compete intensely in mesocosms show no signs of competition in natural pond enclosures.

Further testing shows that mesocosms may provide misleading answers. “I used results from both the mesocosms and the pond enclosures to make predictions about wild amphibian populations (wood frogs),” Skelly said. “The mesocosms were simply not able to provide accurate predictions. Results from the enclosures, on the other hand, can be used to make excellent predictions about wild populations.”

While Skelly readily acknowledges that his experiment will not be the last word on the subject, he believes an important door has been opened. “I hope that this work will encourage scientists to cast a critical eye over their experimental designs and ask themselves whether their results will be as realistic as they wish them to be,” Skelly said.

If Skelly’s results are validated by others, where will that leave ecologists? His intent was not to muddy the waters: “I believe that a focus on this issue is going to lead to better experiments in laboratories, in mesocosms and in natural environments.” This is important because mesocosms are critical to the future of experimental science. As Skelly points out, “The public will not be anxious to have scientists dumping cadmium into wetlands to evaluate its effects on the environment. We need other settings for this work, and mesocosms in some form are our best hope right now.”

Nonetheless, Skelly believes his work is likely to cause controversy. “Many environmental scientists have invested heavily in the

Michael J. Doolittle



SKELLY

mesocosm concept. Understandably, they will want to be sure that there is a problem before they modify their approach,” he said. Skelly is adamant that a focus on the problem will lead to better experiments. “We have a lot of hard work to do to figure out what it will take to achieve results that reflect what’s going on in the natural world.”

Skelly’s paper is titled, “Experimental Venue and Estimation of Interaction Strength”, and it appeared as a Report in the August issue of *Ecology*.

RESEARCH AND PROGRAM HIGHLIGHTS

THE RISE OF LAND PLANTS AND THEIR EFFECT ON ATMOSPHERIC CO₂ AND O₂

Professor Robert Berner of the Geology and Geophysics Department, his students, and his collaborators have been working over the past decade on the evolution of the chemical composition of the atmosphere. A highlight of this work is the construction of a theoretical model of the carbon cycle for the past 550 million years (Phanerozoic time) that includes, among other things, mountain uplift, continental drift, global climate, solar evolution and the evolution of land plants. These factors all affect chemical weathering of silicate rocks on the continents, resulting in CO₂ removal from the atmosphere. Modeling results indicate that during the Devonian period (480-450 million years ago) the level of atmospheric CO₂ underwent a slow but very large lowering. This was due mainly to the acceleration of silicate weathering by the occupation of the continents by large, deeply rooted, vascular land plants. The plants also provided a new source of non-biodegradable organic matter, in the form of lignin, which led to the enhanced preservation and burial of dead organic matter in sediments. This resulted in vast coal deposits and contributed to further lowering of CO₂. This lowering of CO₂, because of the atmospheric greenhouse effect, led to global cooling during the subsequent Carboniferous and Permian periods and the initiation of the most extensive and long-lived continental glaciation of the past 550 million years.

Various methods have been devised to check the calculations of the theoretical modeling. Studies of the effects of trees on modern silicate weathering in Iceland and in Hawaii have been conducted by former students working with Dr. Berner. Recently, former graduate student Dana Royer, working under the direction of Professors Berner and Leo Hickey at Yale and Dr. David Beerling of the University of Sheffield, developed a method for deducing levels of atmospheric CO₂ over the past 60 million years that is based on the properties of fossil Ginkgo

leaves. A summary of the various methods of estimating ancient CO₂ levels has been published recently by Royer, Beerling, and Berner.

Besides lowering CO₂, the enhanced organic burial during the late Carboniferous and Permian periods (350-250 million years ago) is believed to have led to high levels of atmospheric oxygen during that time. This has been deduced by additional theoretical calculations based on changes over time in the abundance and isotopic composition of carbon and sulfur in sedimentary rocks. The modeling has been checked by measurements of the carbon isotopic composition of plant fossils at Yale combined with laboratory plant growth experiments at elevated oxygen levels conducted at Sheffield University by Dr. Beerling. Fossils of giant insects occur over this same period. To verify the idea that this gigantism may have been due to high O₂, experiments with *Drosophila* fruit flies are being conducted by Dr. Robert Dudley of The University of Texas at Austin. Initial results suggest that over several generations insects can become larger at elevated O₂. High atmospheric O₂ should also have led to a global increase in the frequency of fires. Investigating this is Richard Wildman of the Geology and Geophysics Department, who is conducting burning experiments of natural fuels at elevated O₂. Recent results using different fuels have refuted earlier work that purportedly showed that, at elevated O₂, terrestrial vegetation would be totally consumed by wildfire. Our planned experiments on flame spread will answer further questions regarding oxygen-enhanced wildfires.



Gale Zuckler / www.gzuckler.com

MURPHY-DUNNING

HIXON CENTER NAMES MURPHY-DUNNING DIRECTOR

Colleen Murphy-Dunning, director of the Urban Resources Initiative (URI) for the past seven years, has been named director of the Hixon Center for Urban Ecology at the Yale School of Forestry & Environmental Studies. The Hixon Center comprises URI, the Program on Coastal and Watershed Systems and the Yale-UNDP Collaborative Program on the Urban Environment. Murphy-Dunning will continue as director of URI.

The Hixon Center provides an interdisciplinary forum for scholars and practitioners to work collaboratively on integrated research, teaching and outreach to improve understanding and management of urban environmental resources within the United States and around the globe. The Center sponsors an annual lecture series, The Restoration Agenda, to bring researchers together to discuss critical issues in the field of urban ecology. In addition, the Hixon Fellowship Program sponsors student research on topics of interest to the center.

URI is dedicated to community participation in urban ecosystem management. As director, Murphy-Dunning led the development of the Community Greenspace Program, a citywide initiative to revitalize New Haven's neighborhoods by restoring vacant lots, planting street trees, beautifying front yards and building community. "Over the last eight years, the Community Greenspace Program has worked with thousands of New Haven neighbors to replant neglected areas and restore the physical and social fabric of our city," she said.



EDGAR CULLMAN JR.



EDGAR CULLMAN SR.

“One of the things that distinguishes Yale in the best sense is that undergraduates get access to the best professors Yale can offer...”

CULLMAN FAMILY GIFT SUPPORTS UNDERGRADUATE ENVIRONMENTAL STUDIES

by John Courtmanche

Their love of the outdoors and their respect for the teaching at Yale College and the School of Forestry & Environmental Studies have inspired Edgar Cullman Sr., YC '40, and Edgar Cullman Jr., YC '68, to contribute \$2 million to F&ES to support its involvement in Yale's new undergraduate environmental studies major.

“One of the things that distinguishes Yale in the best sense is that undergraduates get access to the best professors Yale can offer,” Edgar Jr. noted. “They're not reserved for graduate students.”

He added that another reason for the gift is that his daughter Georgina received her bachelor's degree in biology this year from Yale and would have liked to have majored instead in environmental studies. Georgina was already entering her senior year last fall when Yale announced its new undergraduate environmental studies major, staffed by faculty from both Yale College and F&ES. Fortunately for future Yale undergrads, they can now declare a major in which more than a third of the classes will be taught by faculty from F&ES.

The Cullmans' gift to support this initiative is the latest instance of philanthropic leadership from this family of Yale alumni. Lewis B. Cullman, YC '41, Edgar Sr.'s brother, established in 1997 the Cullman Joint Doctoral Program Fund, which links F&ES with the New

York Botanical Garden. In addition, Joseph F. Cullman 3rd, YC '35, Edgar Sr.'s other brother, established at F&ES last year the Joseph F. Cullman 3rd '35 Professorship, which focuses on teaching and research in the areas of wildlife, ecology and biodiversity.

The Cullmans believe that if more environmental studies majors enter the business world, society and the world will fare better. “I'm proud Yale wants to offer this major because I think all of us need to understand how we live together, and be concerned with protecting the environment and protecting industry that needs products grown from the earth,” says Edgar Sr. “Whether we're talking the timber business or crops for feeding our country, we need to find out how that can be properly conducted while being environmentally friendly. It's important for undergraduates to understand that the industrial sector is interested in doing that.”

Edgar Sr. and Edgar Jr. are senior executives at General Cigar Co., a leading U.S. tobacco grower, manufacturer and marketer of premium cigars.

Edgar Jr. said he respects F&ES and Dean Speth's work in fostering collaboration between environmental groups and businesses and away from confrontation. He said, “Most responsible businessmen come to the

conclusion that it's better business to be interested in the environment than not. One of the enduring features of American business, of Yankee ingenuity, is our developing processes that work well for business and well for the environment.” He and his father hope that the gift will help create educated men and women who understand that “everything we do on this earth has an impact on the environment.”

Edgar Sr. added, “If some Yale environmental studies undergraduates want to go into industry, it can be helpful that they've had a chance to understand the problems, that they can favor the environment while also protecting a manufactured product.”

The Cullmans have urged Yale to take a balanced approach to environmental studies and to work to ensure that undergraduate courses focus on “the interdisciplinary relationship of the environment with business, technology, law, politics, governance and other related areas.” In offering thanks for the gift, Dean Speth assured the Cullmans that “interdisciplinary, integrative teaching, including bringing the economy and the environment together, is a defining characteristic of our school, and is—and will remain—at the core of our undergraduate teaching.”



DOROTHY MCCLUSKEY

ALUMNA GIVES \$1 MILLION TO ENDOW MCCLUSKEY VISITING FELLOWSHIP

By David DeFusco

Dorothy McCluskey is a pioneer of sorts, although the amiable, modest mother of three grown children probably would dismiss that characterization. She was one of the first female forestry students at the Yale School of Forestry & Environmental Studies in the early 1970s and the first Democrat elected to state office in North Branford in the 20th century. In 1996 she established the Dorothy S. McCluskey Visiting Fellowship for Conservation, which she endowed in perpetuity this past summer with a \$1 million charitable gift annuity.

“Dorothy has done a wonderful thing for the future of education at our school,” said Dean Speth. “The students have benefited enormously from the McCluskey Fellows of the past, and now we are certain that these benefits will continue in the future. Hers is a wonderful, thoughtful gift.”

The McCluskey Visiting Fellowship supports senior managers and scientists from the nonprofit environmental community in pursuing academic study or independent research for up to one year. Robert Stanton, the immediate past director of the National Park Service, is the current McCluskey Visiting Fellow for Conservation, and is joined by environmental luminaries who are past occupants of the position: Wangari Maathai, founder of the Green Belt Movement in Kenya; Rachendra Pachauri of the Tata Energy Research Institute in New Delhi, India; Martin Rosen, co-founder and former president of the Trust for Public Lands; Randal O’Toole of the Thoreau Institute in Oregon; and Dennis McGrath of the Nature Conservancy.

“It’s important for students studying forestry to have the opportunity to learn and understand the environmental work being done by nongovernmental organizations and

the private sector,” Mrs. McCluskey said. “It’s of great mutual benefit and results in the broader professional education of students. It is a rewarding experience for me in every way.”

Mrs. McCluskey obtained an M.F.S. degree concentrating on environmental planning and water resource management in 1973 after three years as a part-time student and full-time mother raising three children. “We ate a lot of pizza then,” she said. She described her experience at F&ES as “warm and welcoming,” but also felt she was speaking at times on behalf of all women when she participated in class because she was sometimes the only woman. Yale College had only just become co-educational in 1969.

Although soft-spoken, she did not have any problem speaking up. In the late 1960s she helped to create the town of North Branford’s conservation commission, and in the 1970s, as a member of the town’s planning and zoning board, produced a conservation plan for North Branford in reaction to the development of wetlands that had resulted in the flooding of homeowners’ basements.

She served from 1973 to 1974 as project manager of the Connecticut Inland Wetlands Project, which was a Ford Foundation pilot project, during which time she co-authored the report, “Evaluation of Inland Wetland and Watercourse Functions.” In addition, she was director of government relations for the Nature Conservancy Connecticut chapter from 1985 to 1990 and a member of the New Shoreham (R.I.) Planning Board from 1986 to 2001.

After obtaining her F&ES degree and with a solid amount of public service already under her belt, she ran for a seat in the state legislature and won. She was a state representative from 1975 to 1982, representing the towns of Branford and Wallingford, CT, and chaired the Environment Subcommittee on Sale of Water Company Land. She had campaigned on a platform that called for a moratorium on the proposed sale of watershed land owned by the New Haven Water Company so that a study could be undertaken to determine the impact of the sale on drinking water quality.

Subsequently, instead of the land being sold, the private water utility was converted into a public regional water authority.

She attributes her victory at the polls to her high profile as a result of her community activism and the political climate of the post-Watergate era, when it was an advantage not to be an incumbent. As the first Democrat elected in North Branford since 1884, she served four consecutive terms. In the process, she developed a respect for politicians and the political process. “I came to recognize that the legislative process is a very effective—though inefficient—way to make laws in a democracy, and that it requires all different kinds of people to resolve conflicting viewpoints.”

Her experiences in public life culminated in a book that she co-authored with Claire Bennitt, an aide to then-Representative McCluskey, titled *Who Wants to Buy a Water Company? From Private to Public Control in New Haven*. The book, according to the authors, was originally conceived as a legislative history of the Regional Water Authority, but evolved into a model for how a regional water utility can balance open space conservation and fiscal responsibility for consumers in an environmentally sound manner.

Mrs. McCluskey grew up in Middletown, CT, and was exposed to nature while summering in rural Harpersville, NY, near Binghamton. She also enjoyed horseback riding and hiking in Arizona, Montana and Wyoming. After high school she attended Wheaton College, where she obtained a bachelor’s degree in philosophy and physics, and then went on to study in Norway as a Fulbright scholar. She researched the life of Fridtjof Nansen, a legendary Norwegian scientist, humanitarian and arctic explorer who in 1922 was awarded the Nobel Peace Prize for his international work in repatriation of prisoners of war.

Mrs. McCluskey lives year-round on Block Island, where she is a member of the Block Island Planning Board, with her husband, Don, who obtained a bachelor’s degree in mechanical engineering in 1942 and a master’s degree in electrical engineering in 1959, both from Yale. Until his retirement, he was treasurer/director of the Wallingford-based Unhotz-Dickie Corporation, which designs and manufactures vibration test equipment. The McCluskeys have three children: Peter, a member of the Yale College Class of 1978; Martha, a member of the Yale Law School Class of 1988; and Christine Jensen, who holds an M.S. degree from the University of Colorado.

The McCluskeys have been long-time, generous supporters of Yale, particularly F&ES for the role it plays in global environmental education. “We all share a very small planet,” Mrs. McCluskey said, “so we all also share the responsibility for using it wisely before passing it on to future generations.”

NEW YORK MAYOR PRESENTS URBAN PARK SERVICE AWARD TO URI

New York Mayor Michael Bloomberg presented the Urban Park Service Award to William Burch and Colleen Murphy-Dunning on behalf of the Urban Resources Initiative (URI) at a ceremony at the Hunts Point Recreation Center in the Bronx in May 2002.

The Yale School of Forestry & Environmental Studies (F&ES) was recognized for its partnership with New York City in examining environmental education that the Urban Park Service provides to city residents. Through the course taught by Burch and Murphy-Dunning, “Rehabilitation Ecology and Community Revitalization: Monitoring and Evaluation Techniques, Theory and Methods,” master’s students devised new methods of quantitatively measuring the success of the Urban Park Rangers programs to assess whether these curricula are beneficial to participating students and the surrounding communities.

“Their analysis will assist the Urban Park Rangers in restructuring their programs to provide superior education,” said Murphy-Dunning, director of the Hixon Center for Urban Ecology.” It also provided the students an opportunity to examine the complex relationships between cities and their parks, and the manner in which government, private and non-profit institutions can work together to build public interest in parks.”

In partnership with the Community Foundation for Greater New Haven and the City of New Haven, URI works with New Haven residents, including gardening groups, block watches, churches and other community-based organizations that take part in projects to reclaim abandoned lots and restore green spaces. URI, which is one of three research centers that make up the Hixon Center, was founded in 1988 by Burch, the Frederick C. Hixon Professor of Natural Resource Management, as a clinical teaching program for urban social forestry. The Urban Park Rangers are part of the Urban Park Service, which enforces rules and regulations in New York City’s parks, and educates the public about preserving and protecting the city’s parks and ecology.

GAYLORD DONNELLY ENVIRONMENTAL FELLOWS

Current Fellows

DR. LUCIANO BEHEREGARAY

As he continues in the second year of his Gaylord Donnelley Post-Doctoral Environmental Fellowship, Dr. Luciano Beheregaray remarked that the financial support he's receiving from the Donnelley Fellowship has provided him the opportunity to establish a project on the evolution and conservation of Amazonian fishes. This project has the potential to generate ground breaking scientific information and set an example in making available resources for assimilation and future studies in evolutionary biology, community ecology and conservation management in the Amazon. Additionally, Dr. Beheregaray is collaborating with Drs. Gisella Caccone and Jeffrey Powell in a project on the evolution and conservation of Galápagos giant tortoises. This partnership has been extremely successful, and in less than one year they have accumulated a large data set that has already yielded several important publications and promises to lead to more. However, he notes that technical competence and a good publication rate makes up only a part of a true research scientist and he says that his association with a teaching lab at in the YIBS ECOSAVE Conservation Genetics Laboratory has allowed him the possibility of training undergraduate and graduate students. Dr. Beheregaray says that the Donnelley Fellowship has offered him the chance of assimilating most of the elements needed for outstanding research, including experience with resource acquisition, interpersonal skills for collaboration, technical and managerial excellence and a high rate of scientific productivity.

DR. JEREMY REDMAN

As he begins his second year as a Gaylord Donnelley Environmental Post-Doctoral Fellow in the Department of Environmental Engineering, Dr. Jeremy Redman says he truly appreciates the opportunities the Fellowship has afforded to him. In his doctoral research at the University of California, Irvine, he focused on the narrow topic of virus filtration. Working with Professor Menachem Elimelech

at Yale has expanded his research skills and background to encompass a whole range of water quality issues, including the much broader topics of microbial and colloidal transport in porous media as well as membrane technologies for water treatment. Professor Elimelech is one of the leading researchers in his field and under his guidance and encouragement Dr. Redman has given numerous professional presentations and is preparing a number of manuscripts for publication in peer-reviewed journals.

As part of his research, he is involved with a multi-university research project focused on the molecular-level analysis of macromolecule/surface interactions in bacterial adhesion funded by the National Science Foundation's (NSF) Collaborative Research Activities in Environmental Molecular Science program. He notes that working on this project has exposed him to a number of disciplines, ranging from soil science to the atomic scale modeling of polymers as well as being able to collaborate with respected scientists at numerous universities, including Pennsylvania State and the University of Arizona. Taken as a whole, the experiences from the past year have not only strengthened his abilities as a researcher, but he says it also has enhanced his desire to continue in academia.

DR. JENNEY HALL

In August 2002, Dr. Jenney M. Hall joined Yale as a Gaylord Donnelley Environmental Post Doctoral Fellow to work with Professor Karl K. Turekian in the Department of Geology & Geophysics (G&G). Dr. Hall recently received her Ph.D. from Louisiana State University and her M.S. from the University of Kansas in 1998, and as a paleoceanographer, she uses geochemistry to reconstruct the physical and chemical changes in ancient oceans associated with climatic transitions.

Her dissertation research focused on the use of foraminiferal barium and lithium as paleoceanographic proxies. Foraminifera are single celled protists that can have shells made of crystalline calcite imprinted by both

the chemical and environmental conditions of the waters in which they lived. Hall applied the barium content of benthic foraminifera as a paleo-nutrient proxy to reconstruct changes in watermass circulation. She developed the use of barium in planktonic foraminifera as a new proxy of deglacial meltwater discharge using core material from the Arctic Ocean. Hall also investigated the use of lithium and lithium isotopes in foraminifera as tracers of paleocean chemistry. This work is significant because global processes such as seafloor spreading and continental weathering control hydrothermal and river fluxes, which are the two major sources of lithium to the ocean.

While at Yale, Dr. Hall will continue to use foraminiferal geochemistry to better understand global change processes and their effect on geochemical cycles. Additional research interests include laboratory culturing of calcareous species to establish the relationship between incorporation behavior and growth conditions using a multi-proxy approach, the characterization of submarine lava alteration in the Precambrian ocean, the use of foraminiferal geochemistry to trace anthropogenic pollution, and investigation of the trace element geochemistry of lacustrine ostracodes.

SUSANNA REMOLD

Susanna Remold began her YIBS Gaylord Donnelley Environmental Post-Doctoral Fellowship with Assistant Professor Paul Turner in the Department of Ecology & Evolutionary Biology (EEB) on October 1, 2002 and is studying the effects of environmental variation on the genetic architecture of adaptation using viruses evolved under controlled ecological conditions in the laboratory. Dr. Remold received her Ph.D. in Ecology and Systematics from Cornell University where she studied with Alison Power. She conducted research in the laboratory of Richard Lenski as a National Institutes of Health National Research Service Award Postdoctoral Fellow. Her work has focused on the ecological genetics and genomics of adaptation to variable environments.

What kinds of mutations confer the ability to use a new habitat? Are the genetics governing use of a given habitat the same for specialists and generalists? How does the historical exposure to environmental heterogeneity affect the available genetic solutions to the problem of habitat use? Dr. Remold is addressing these questions by studying the impact of environmental heterogeneity on genetic adaptation in vesicular stomatitis virus (vsv), an important rabies-like virus of livestock. She will experimentally evolve vsv under a range of spatially and temporally varying environments. By examining the phenotypic and genetic characteristics of these evolved populations, she will test predictions of ecological and population genetic theory regarding expected patterns of biodiversity and its underlying genetic architecture. By examining the differing effects of environmental variation on the underlying genetic architecture of adaptation in this simple system, we can test key assumptions of several hypotheses regarding the origin and maintenance of biodiversity. The use of an RNA virus makes this study informative to the expansion of viral host range, an issue of current importance in agriculture and in human and veterinary medicine.

DR. KLAUS MEINERS

Dr. Klaus Meiners, who received his PhD from the Institute for Polar Ecology, Kiel, Germany in October 2002, arrives at Yale in January 2003 to begin his two-year Gaylord Donnelley Environmental Post-Doctoral Environmental Fellowship. He will work with Professor John Wettlaufer in the Department of Geology & Geophysics (G&G) on *The Ecology of Frozen Oceans: Controls on Primary Production in Sympagic Communities*. The present day climate of the Earth is strongly influenced by the extent of the global ice cover. Much is made of the fact that more than two-thirds of the surface of Earth is covered by water, but on any given day, one of the Polar Oceans is freezing. Although the waxing and waning of oceanic ice is implicated in ice-albedo feedback driven cli-

mate change, a relatively untouched aspect of the process concerns the coupling between high latitude physical processes and polar ocean ecology. Not only is the issue at the heart of the food web in Earth's Oceans, but it also serves as a test bed for Astrobiology and Life in Extreme Environments. Dr. Meiners' research will focus on questions that address the habitability of frozen environments.

Past Fellows

FIRST GAYLORD DONNELLEY ENVIRONMENTAL POST-DOCTORAL FELLOW

Dr. Joseph Kiesecker, Assistant Professor of Biology at Pennsylvania State University Eberly College of Science has the distinction of being chosen as the first Gaylord Donnelley Environmental Post-Doctoral Fellow in 1997. Dr. Kiesecker received his Ph.D. in zoology from Oregon State University in May of 1997 and arrived at the Yale School of Forestry & Environmental Studies (F&ES) on July 1st of that year to begin a two-year collaboration with Associate Professor of Forestry and Environmental Studies and Ecology and Evolutionary Biology, David Skelly. While at Yale, Dr. Kiesecker investigated the influence of fungal pathogens on the distribution of larval amphibians and dynamics of their communities. He collaborated with several scientists, graduate students, post-doctoral fellows and professors while pursuing his interest in disease ecology. This led him to examine the effects of pathogenic infection on behavioral interactions. He also examined the role that disease plays in regulating host populations and collaborated with researchers at Oregon State University and the University of Maine, allowing him to continue to pursue his interest in amphibian conservation and behavioral

ecology. After leaving Yale for the University of Pennsylvania in June of 1999, Dr. Kiesecker continued to work with Professor Skelly on projects examining the role of food resources and the ecology of larval amphibian communities and how large scale changes in forest canopy cover can alter these associations. His work at Yale as a Gaylord Donnelley Post-Doctoral Fellow resulted in many publications and Dr. Kiesecker is grateful for the opportunities the Fellowship has afforded him in enhancing his career in research and academics. His current research encompasses population, community and disease ecology of freshwater systems.

DR. DOUGLAS GOLLIN

After completing his two-year Gaylord Donnelley Environmental Post-Doctoral Fellowship, Dr. Douglas Gollin has returned full-time to Williams College while maintaining his affiliation with the Economic Growth Center at Yale. At Williams, Dr. Gollin is closely involved with the Center for Environmental Studies and continues to work on issues relating to agriculture and economic development. Some of the work that he did as a Donnelley Post-Doctoral Fellow, in collaboration with Yale Professor Robert Evenson, has been published as a book entitled *Crop Variety Improvement and Its Effect on Productivity: The Impact of International Research* (Wallingford, UK: CAB International). He has also published several journal articles. In December 2001, he received tenure at Williams College. In hindsight, he remarks that his time at Yale as a Donnelley Fellow enabled him to carry out some research that was valuable in his own professional development and in the policy realm as well. He has maintained many of his research partnerships and personal relationships with people from Yale, and looks forward to carrying those into the future and expresses his appreciation to YIBS and to the Donnelley family for making this possible.

GAYLORD DONNELLY

ENVIRONMENTAL FELLOWS

Past Fellows

(Continued)

DR. CLAUDIO CIOFI

Dr. Claudio Ciofi completed his 2-year Gaylord Donnelley Environmental Fellowship in June 2002. During his two years as a Donnelley Fellow at Yale, he developed a number of research projects on the genetics and ecology of island reptiles, and established long-term collaboration with both US and foreign Institutions aimed at the management and conservation of endangered species.

Dr. Ciofi contributed to a project initiated by Jeffrey Powell from the Department of Ecology & Evolutionary Biology (EEB) and Adalgisa Caccone from the YIBS ECOSAVE Conservation Genetics Laboratory on the population genetics and phylogeography of giant Galápagos tortoises by providing data on the level of genetic divergence and patterns of gene flow among extant populations. This information was obtained through the analysis of DNA extracted from blood samples collected from wild animals during a number of expeditions to the Galápagos archipelago, Ecuador. DNA analysis was performed by using a set of novel genetic markers from the nuclear genome developed specifically for giant tortoises. This work produced a number of manuscripts that are either in press or in preparation and provide data which can be incorporated into wildlife management plans devised by the environmental authorities of Galápagos National Park.

Dr. Ciofi also developed a research program initiated during his Ph.D. on population management of the Komodo monitor, the world's largest species of lizard with the most limited range of all big predators. Analysis of population genetics, home range, demography and distribution were integrated to notions on habitat status to build up a data set for management planning. He prepared a draft for a five-year collaboration with the Indonesian Department of Forestry to review the current management plan of Komodo National Park, Southeast Indonesia, and implement updated methods for wildlife monitoring and conservation. A number of grants obtained from US

Institutions and the long-term involvement of the Zoological Society of San Diego and Udayana University (Bali, Indonesia) ensured initial funding for capacity building, capital equipment purchase and hiring of personnel. A multidisciplinary initiative, the Komodo dragon project now includes a laboratory for molecular genetics and endocrinology being set up at Udayana University, a training program for staff members of Komodo National Park, and research capability to implement management activities. Part of this work is documented on published manuscripts and in a recent book on the biology and conservation of the species he co-edited and partially wrote for the Smithsonian Institution Press.

A third project he initiated at Yale concerns a population genetic study of giant tortoises of the Aldabra atoll, Seycelles. This research mainly focuses on the level of genetic differentiation and gene flow of tortoises sampled on different parts of the atoll. It is part of a preliminary set of data being gathered to increase our knowledge of the biology of the second largest of the two remaining species of giant tortoises (Galápagos and Aldabra).

During these activities, Dr. Ciofi collaborated with members of different departments at Yale such as the School of Southeast Asia Studies, the YIBS Center for Earth Observation, and the Geographical Information System at Sterling Library. He also had the opportunity to train and work with both undergraduate and graduate students on different tasks pertaining to the above-mentioned research projects.

Dr. Ciofi appreciates the opportunities afforded to him by receiving the Gaylord Donnelley Environmental Post-Doctoral Fellowship and thanks the Donnelley family for establishing this fellowship and for their interest in supporting him at Yale through the fellowship.

DR. CAMPBELL WEBB

Dr. Campbell Webb completed his 2-year Gaylord Donnelley Environmental Fellowship in August 2002. His research explores the origin and maintenance of tree species diversity in tropical forests. He analyzes forest communities both from 'classic' community ecology perspectives and using new approaches that incorporate phylogenetic information. He is hopeful that these new directions might offer major new insights to ecologists. Dr. Webb also continued his biodiversity conservation and taxonomic botany activities, in publications and in the field (in Sabah, Malaysia). He notes that Yale was an excellent base for both theoretical and applied aspects of his research, as he was able to take advantage of the resources in the Department of Ecology & Evolutionary Biology (EEB), in the School of Forestry and Environmental Studies (F&ES), and in the wider community of Southeast Asian researchers at Yale.

Dr. Webb marvels at his good fortune in managing to pursue a career that takes him to some of the most diverse and wild places on the planet, where he finds joy in learning about the plants while trying to understand their community interactions. However, nowhere can one escape from the realities of human impact on natural communities, and in the time he has been working in Indonesian Borneo, he notes that the forested area has been reduced by over 20%, and the richest, lowland forest has been reduced almost to nothing. In fact, his long-term vegetation plots in a National Park are in danger of being illegally logged within the next few years. However, while frustrated at the seeming intractability of the situation, he does not blame the local people for trying to turn their natural resources into means to increase their standard of living.

It is in the context of these complexities of conservation that Dr. Webb notes that receiving the Donnelley Environmental Fellowship was a perfect funding opportunity, matching his professional needs and desires with the

opportunities offered by the Fellowship and by Yale. He is deeply grateful to the Donnelley family and to the Yale Institute for Biospheric Studies (YIBS) for offering funding that permits, and indeed encourages independent, creative research in ecology and environmental issues. The freedom the fellowship affords is vital for developing new fields and approaches, as exemplified by his work with Michael Donoghue and David Ackerly, which is moving towards a 'new' community ecology that forges stronger links with evolutionary biology. The Donnelley Fellowship has also provided the freedom for Dr. Webb to continue his conservation work in Borneo, his taxonomic work on a field guide to the trees and shrubs of Borneo, and numerous other projects. He will take what he has learned during these two years with him into what he hopes to be a life-long struggle to understand and preserve the tropical rain forest.

DR. OFER OVADIA

Dr. Ofer Ovadia completed his Gaylord Donnelley Environmental Post-Doctoral Fellowship working with Professor Oswald Schmitz at the Yale School of Forestry & Environmental Studies (F&ES) in September 2001. During his two years as a Donnelley Fellow, Dr. Ovadia completed several research projects in pursuit of his interest in the link between behavioral and community ecology.

He submitted a theoretical Gecko (a spatially explicit individual based model developed at the YIBS Center for Computational Ecology by Booth and Schmitz, 1997) paper in which the consequences of trait variation on trophic interactions in food web were tested. This manuscript shows that initial body size variation among individual herbivore can strongly affect their population demography and change the strength of the plant-herbivore interactions. Dr. Ovadia believes that these findings may have important implications for both population and community ecology that traditionally assumed that such variation among individuals can be safely abstracted.

Another notable accomplishment realized during his Donnelley Fellowship is the results of the empirical study that show a strong link between the initial body size of grasshopper herbivores and their survival and development. This study provides a rare example for a food web experiment carried out under natural field condition in which the link between individual behavior and community level interactions were clearly evident. Additionally, it led to two manuscripts summarizing the two-year empirical study.

Dr. Ovadia is currently a postdoctoral associate in F&ES working with Professor Schmitz to understand the link between life history traits and community structure and function. He credits having received the Donnelley Environmental Fellowship with helping to support his work on the effect of state dependent decision making of individual herbivores on the strength of food web interactions which resulted in part of this study being published in the Proceedings of the National Academy of Sciences, USA. Dr. Ovadia continues to investigate the link between evolutionary and population biology and appreciates the many opportunities afforded to him by receiving the Donnelley Environmental Post-Doctoral Fellowship.

YALE INSTITUTE FOR BIOSPHERIC STUDIES POST DOCTORAL FELLOWSHIP LINDA PUTH

Linda Puth arrived in August 2002 and began her Yale Institute for Biospheric Studies (YIBS) Post Doctoral Fellowship with David Skelly at the School of Forestry & Environmental Studies (F&ES) studying the effect of landscape structure on the process of invasion. Dr. Puth received both her Ph.D. in Botany and her M.S. in Conservation Biology and Sustainable Development from the University of Wisconsin-Madison, where she studied with T.F.H. Allen. She is a broadly trained aquatic ecologist with interests in invasion ecology and the relationship between complexity and stability.

Ecologists have traditionally assumed that successful invasion by exotic species is limited more by within-habitat processes (e.g., competition) than by an organism's dispersal to a new habitat. This assumption has resulted in a paucity of research exploring the effects of landscape context on the process of invasion. Successful invasions result from the interaction between: 1) the distance between patches; 2) the ability of an organism to move through the matrix between patches; and 3) establishment of a self-sustaining population once an organism has arrived at a new patch. Most research, however, has either treated invasion as a single, unified process, which misses the influence of different aspects of landscape structure, or has concentrated on only one of these factors at a time, which has produced very good mechanistic understanding of the components of invasion without a clear understanding of how they interact to produce the overall process. Working with a variety of aquatic and semi-aquatic organisms and using a combination of experimental field systems and modeling, Linda will explore the interaction among the components of invasion to gain a better general understanding of which components and which interactions between components are most important in the invasion process. This approach should increase our understanding of the most important constraints on invasion in different contexts and increase our ability to predict the probability of successful invasion for different combinations of species and land use types.



GROVE



DUDA



SWANSON



CONKLING



RAY

From left to right:
J. Morgan Grove, Mark
Duda, Ann Swanson, Philip
Conkling, Hurlon Ray

F&ES ALUMNI RECEIVE AWARDS

J. Morgan Grove '90, Ph.D. '96, a researcher with the USDA Forest Service's Northeastern Research Station in Burlington, Vt., received the 2001 Presidential Early Career Award for Scientists and Engineers (PECASE) at a White House ceremony on July 12. The PECASE was established in 1996 to honor the nation's most promising young researchers, who receive up to five years of funding from their agencies to continue their work critical to government missions.

Grove is being honored for his work in urban ecological research. He has contributed significantly to the success of the Baltimore Ecosystem Study (BES), which is part of the National Science Foundation's Long-Term Ecological Research Network and is one of only two urban sites in the United States. The project examines both the built and natural ecosystems of Baltimore as part of an overall ecological system and seeks to understand how these ecosystems work and how they change over time.

Mark Damian Duda '85, CEO and owner of Responsive Management, received the 2002 Ducks Unlimited National Conservation Achievement Award for his research on the human dimensions of the conservation of natural resources and the environment. He writes, "We essentially have taken (professors) Steve Kellert's and Bill Burch's teachings...and developed a private business based on the idea...that good natural resource and environmental stewardship is based not only on a thorough understanding of the ecological and biological side of things, but also on the people side of things. We have been involved in the human dimension of grizzly bear, gray wolf and Mexican wolf reintroductions, conflicts over roads in the national forests, ballot initia-

tives and referenda on various natural resource issues and dozens of other environmental issues." Duda's firm has grown to almost 50 employees since he founded it in 1990. They specialize in social science research methods such as opinion and attitude surveys and focus groups.

Ann Pesiri Swanson '83 was named the 2001 Conservationist of the Year by the Chesapeake Bay Foundation, the nation's largest regional environmental organization. The award was established in 1980 to recognize superlative service and commitment to the restoration and protection of the Chesapeake Bay. Since 1988 Ann has served as executive director of the Chesapeake Bay Commission. She has galvanized strong citizen support for restoring and protecting the bay and worked with state and federal governments to coordinate management of bay issues. She also chaired the drafting committee for and was principal author of the 2000 Chesapeake Bay Agreement. She served as the American delegate at the 1998 Conference on Enclosed Coastal Seas in Stockholm. She is now involved in the interstate negotiations regarding conservation of the Chesapeake Bay blue crab.

Philip Conkling '76, president and founder of the Island Institute in Rockland, Maine, has been awarded the New England Aquarium's David B. Stone Medal for distinguished service to the environment and community. The award, named in honor of the Aquarium's principal founder, is given biannually and recognizes two outstanding leaders in marine conservation and science throughout the world. Past winners have included the late Jacques Cousteau, Walter Cronkite and filmmaker Sir David Attenborough.

Founded by Conkling in 1983, the Island Institute provides marine science programs, community development and publications that focus on the Gulf of Maine and the communities on the islands of Maine. The institute's fundamental goal is to be a bridge between the users of the Gulf of Maine and the scientific community. Under his leadership, the Island Institute has developed satellite imagery software, called GAIA (Geographic Access Image and Analysis), for education, conservation and natural resource management organizations. It has been used in over 150 Maine classrooms. The Institute recently developed a series of Web-based geographic information tools for fisheries outreach. He has published several books, including *Cape Cod to the Bay of Fundy* and *Environmental Atlas of the Gulf of Maine*, which was recognized by the American Publishers Association with a "Best Book Award" in the Professional and Scholarly Books category.

Hurlon Ray '49 and his late wife, TyJuana, were honored on June 20 by Saline County, Ark., and the Arkansas State Highway Department. The occasion was the dedication of a granite marker inscribed with the couple's names and citing their many years of community service to the people of Saline County. The monument is designed to be a permanent fixture at the scenic overlook named after them on Arkansas 5, or Old Hot Springs Road. The Arkansas Highway and Transportation Department constructed the overlook, which is one of the most picturesque rural scenes in all of Arkansas, on land donated by the International Paper Company. According to Hurlon, TyJuana, who died two and a half years ago, did most of the work for developing the scenic overlook.

SIX RECEIVE SWITZER FELLOWSHIPS

Six current and former students of the Yale School of Forestry & Environmental Studies (F&ES) have received \$13,000 fellowships from the Switzer Environmental Fellowship Program for their dedication to environmental problem solving and leadership. This Program was created by the Robert and Patricia Switzer Foundation and assists talented scholars in California and New England.

Master Candidates:

Rebecca Ashley works in parishes around Bwindi Impenetrable National Park in Uganda to determine how farmers use the trees on their farms to sustain their livelihood, identifying priority indigenous species for reintroduction onto the landscape and identifying factors that influence farmers' integration of trees onto their farms within the landscape.

Sarah Vogel is examining how different pathways of economic development affect human health, focussing on the health effects from exposure to commonly used synthetic chemicals, particularly agricultural pesticides.

Doctoral Students:

Nicole Ardoin is exploring whether the eco-region approach to conservation is an appropriate paradigm for environmental education, or whether the scale is too large to be meaningful and empowering for individuals living within an eco-regional area.

Pamela McElwee is examining how property rights, forest use and access, migration and resettlement, and international biodiversity conservation intersect in upland forests in Vietnam.

Alumni:

Jeanne Anderson's research considers the capability of an airborne remote sensor, generally known as lidar or laser altimetry, to accurately depict and reveal differences in forest structure across the landscape, and will relate those differences to land-use legacies, ecological function and biological diversity.

Joanna Grand, a doctoral student at UMass is identifying and prioritizing the remaining pitch pine-scrub oak habitat patches in central and southern Plymouth County, MA for biodiversity conservation.

For information on the Switzer Fellowships, contact Peter Otis, Director of F&ES Career Development Office at 203-432-8920.



GREENING THE AMERICAS: NAFTA'S LESSONS FOR HEMISPHERIC TRADE

Economic integration in the Western Hemisphere as envisioned in a proposed Free Trade Area of the Americas (FTAA) agreement must proceed in an environmentally sustainable manner to fully realize the benefits of freer trade and open markets argues *Greening the Americas: NAFTA's Lessons for Hemispheric Trade*.

Just released by MIT Press, *Greening the Americas* reviews the North American Free Trade Agreement's treatment of environmental issues and explores the treaty's environmental and economic impacts. The authors draw lessons from the U.S.-Canada-Mexico NAFTA experience that can be applied to the ongoing FTAA negotiations among 34 countries across North and South America. In analyzing the NAFTA model, the book highlights environmental elements that should be included in future agreements and those that should be dropped.

NAFTA, which was ratified in 1994, addressed environmental concerns through provisions in the trade agreement and in an unprecedented side agreement on the environment. It also set up the North American Commission for Environmental

Cooperation (NACEC), a tri-national body headquartered in Montreal, which addresses trade and environment issues on an ongoing basis.

Daniel Esty, Professor of Environmental Law and Policy at Yale University in both the School of Forestry & Environmental Studies and the Law School, co-edits the book with Carolyn Deere of the Rockefeller Foundation.

The book analyzes the NAFTA experience from a range of perspectives and concludes that:

- Any FTAA trade and environment agenda should be developed by the Latin American countries, not dictated by the United States.
- Broad public participation in trade policy making generates a more robust decision-making process and ultimately produces a better agreement.
- Environmental impact reviews of trade agreements represent an important tool for identifying trade-environment links that can be addressed in the course of negotiations.

To order a copy of the book, go to <http://mitpress.mit.edu/catalog/item/default.asp?sid=2A8CE072-C7FD-4A20-819D-327CB5AB60A4&tttype=2&tid=9011>.

PUBLICATIONS



Global Environmental Governance

Options & Opportunities

Daniel C. Esty and Maria H. Ivanova, editors
Yale Center for Environmental Law and Policy

YALE SCHOOL OF FORESTRY & ENVIRONMENTAL STUDIES

GLOBAL ENVIRONMENTAL GOVERNANCE: OPTIONS & OPPORTUNITIES

Managing the world's shared natural resources and addressing global scale environmental threats, such as climate change,

requires fresh thinking and redesigned mechanisms to promote international cooperation argues a new book on global environmental governance which was released at the World Summit on Sustainable Development in Johannesburg, South Africa, last August.

Global Environmental Governance: Options & Opportunities focuses on the challenges of environmental protection in an increasingly ecologically interdependent world. Drawing on a range of experts from across the world, the volume examines various critical concerns and processes. It reflects an interdisciplinary perspective, which takes up issues of international law, economics, ecological sciences and environmental policy.

Global Environmental Governance is edited by Daniel Esty, Professor of Environmental Law and Policy at Yale University in both the School of Forestry & Environmental Studies (F&ES) and the Law School, and Maria Ivanova, director of the Global Environmental Governance Project at F&ES.

Elizabeth Dowdeswell, former executive director of the United Nations Environment Program, said that the "book presents a thoughtful analysis that could inform political decisions to design a system agile enough to address evolving needs and relevant enough to be viewed as legitimate." Wangari Maathai of Kenya's Green Belt Movement said, "This volume traces the key issues of global environmental governance in a way that promotes understanding and encourages engagement."

Global Environmental Governance is published by the Yale School of Forestry & Environmental Studies. To order a copy of the book, go to www.yale.edu/environment/publications.

Yale Environmental News
Yale University
P.O. Box 208105
New Haven, Connecticut 06520-8105

Address Service Requested

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New Haven, CT
Permit No. 526

Yale Environmental News offers information on environmental research, teaching, and outreach at Yale University. It is produced by the Yale Peabody Museum of Natural History (PM), the Yale School of Forestry & Environmental Studies (F&ES), and the Yale Institute for Biospheric Studies (YIBS).

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Graphic Design: Yale RIS, Maura Gianakos

Submission Deadlines for Future Issues
Spring 2003: March 1, 2003



printed on recycled paper