YALE ENVIRONMENTAL NEWS

The Yale Peabody Museum of Natural History, the School of Forestry & Environmental Studies, and the Yale Institute for Biospheric Studies

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Greetings from New YIBS Director Jeffrey Park

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RoseRita Riccitelli

News from the Director of YIBS

By Jeffrey Park

I was honored last autumn to be asked to serve as the Director of Yale's Institute for Biospheric Studies by President Richard Levin and Provost Andrew Hamilton.

I have had the great benefit of succeeding Derek Briggs, whose able leadership of YIBS has given me momentum and guidance for the future. To a large extent, the change in YIBS leadership has been marked by continuity in its activities: the Donnelley postdoctoral fellowship program, support for graduate students in YIBS-allied departments, the lively symposia sponsored by the Center for the Study of Global Change, the isotope measurements and genomic sequencing of the Isotope Center and ECOSAVE lab, respectively, and the ever-tasty sandwiches served at the Friday YIBS lunch seminars. The global environment outside Yale is far from static, however, and YIBS will respond to, and hopefully anticipate, its changes.

American society faces interlocking challenges in the 21st century, and it is not assured success in confronting any one of them. We wish to maintain economic activity at levels that satisfy basic needs and desires, to retain healthy natural environments outside the "built" environment, and to use natural resources in a manner that is sustainable enough to keep the game going into the 22nd century. At the turn of this century it was still possible to believe that Earth's natural environment was a sideshow to the main arenas of human endeavor: business, technology, culture, political activity and war. As I write this, a shift in perception is occurring as food and energy shortages remind us of our two-way interaction with our planet. If motivated only by personal desires and market forces, a society tends to deplete its environmental resources unthinkingly. In an Environmental Studies seminar I taught with John Wargo, we examined how overfishing in Atlantic waters, facilitated by advances in trawler technology, refrigeration and supermarket marketing, has forced millions of people to give up eating cod. That was 2004. This is 2008 and the stakes we face are larger. The twin pressures on global agriculture exerted by the developing world's hunger for meat and the developed world's thirst for biofuels has raised the prospect that millions of people might need to give up eating, period.

Acknowledging the environmental challenge is not the same as addressing it. There is no way to turn back the calendar to a time in which 9 billion human beings lived on Earth in a sustainable manner. Such a time has never existed. Instead, we must innovate, adapt and adjust. The enormous scope of the environmental challenge informs the proper role of biospheric studies at a great university like Yale. We must understand how life and our planet interact in order to develop sensible policies for managing our own ever-expanding role in the natural world. Developing new knowledge relevant to this problem is the principal goal of YIBS.

YIBS supports faculty-hiring initiatives across Yale's departments and schools to facilitate research and scholarship in many topical areas. YIBS seeds faculty positions across the University by offering salary support for five years to each new YIBS professor. Each year members of the Faculty Council and the External Advisory Board of YIBS discuss new research opportunities at their respective meetings. This deliberative process has done much to rejuvenate the study of organismal biology on campus, and has grafted new research subfields onto existing departments and schools.

YIBS faculty positions have been allocated to address a wide variety of biospheric concerns. To preserve biodiversity in locations touched by human activity, one must understand how biodiversity sustains itself outside human intervention. YIBS has seeded several faculty positions in Ecology & Evolutionary Biology, and each year awards Gaylord Donnelley environmental postdoctoral fellowships to researchers in the biodiversity of both our present world and in the geologic past. YIBS seeded a faculty position in Geology & Geophysics, maintaining Yale's leading scholarship in how climate and atmospheric greenhouse gases are related together in earth history. So-called "green" technology softens the impact of economic growth on the natural world. YIBS has seeded faculty positions in sustainable engineering, water resource management and green architecture. Ecological disruption will influence the spread of disease pathogens; YIBS seeded a relevant faculty position in the School of Epidemiology and Public Health. The impersonal dynamics of the natural world are not the only factor to consider; societal impact is also malleable. YIBS has seeded faculty searches in environmental anthropology, with a focus on the societal impact of globalization, and in demography, because population pressure catalyzes environmental impact.

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In addition to the hiring initiatives of the past decade, the Faculty Council last year authorized YIBS to seed a faculty position in geomicrobiology, the symbiosis of microbial life within the Earth system. Initiated as a partnership between the departments of Geology & Geophysics and Ecology & Evolutionary Biology, this corner of biospheric studies soon attracted support from other Yale departments. In addition to the Molecular, Cellular & Developmental Biology department and Yale's School of Medicine, stakeholders include the Chemistry and Astronomy departments, motivated by the potential use of microbes for innovative chemical synthesis and by the search for extraterrestrial life. An interdepartmental hiring initiative in the broad field of microbiology has been presented to the Dean of Yale College and the Provost. Establishing a multi-departmental faculty cluster in the newly acquired laboratories of Yale's West Campus is one possible outcome of this effort.

Biospheric studies at Yale serves broadly based intellectual and societal goals, but an even broader set of goals was articulated this year by Yale faculty across a dozen departments and schools. As of this writing, a proposal to create the Yale Climate Institute (YCI) is being prepared for the Provost. The creation of YCI is motivated by the recognition by Yale's climate scientists, biologists, economists and policy scholars that the impending impact of human-induced climate change is perhaps the greatest challenge of all time to human ingenuity. Strategies to mitigate or adapt to climate change could be needed too soon to accept the usual intellectual separation of science and policy research within the University. YCI proposes a bold reorganization of Yale's natural and social scientists around the four themes of (1) environmental dynamics and climate history, (2) climate change mitigation, (3) climate change adaptation, and (4) energy resources. In early March a workshop was held to assess the range of climate-related research currently performed at Yale. The range is surprisingly large, from climate effects on disease-vector ecology to novel photovoltaic polymer technology to policy ideas that meld free-market concepts with environmental protection. The workshop showed that Yale has a sufficient mix of faculty research to initiate a credible multi-disciplinary effort in climate studies. Some critical research areas, such as biofuels and marine biology, are lightly covered at Yale at present, and a substantial public outreach effort has been proposed for the center. The final form of the proposed institute is subject to many uncertainties. At this stage of planning, however, one thing is clear: YIBS will play an important role if the Yale Climate Institute becomes a reality.

The Winter/Spring 2008 semester has been an exciting one for YIBS, full of opportunity. I thank RoseRita Riccitelli for smoothing the leadership transition for me, and whose new title of Assistant Director properly reflects her role in keeping the Institute humming with activity.

RoseRita is ably supported by Daniele Dugre-Martin, Senior Administrative Assistant. Thomas Lovejoy, the chair of the External Advisory Committee, has been a consistent source of intellectual and moral support. Together we look forward to an interesting future for YIBS.

COVER: Squinting Brown Bush Butterly, *Bicyclus anynana*. Photo by Kathleen Prudic. See page 25 for article.

CONFERENCES, SEMINARS, SYMPOSIA

YIBS/ESC FRIDAY NOON SEMINARS

The Yale Institute for Biopsheric Studies (YIBS) continues its sponsorship of the weekly YIBS/ESC Friday Luncheon Seminars. The seminars are held in the Class of 1954 Environmental Science Center (ESC) during the fall and spring semesters. The Spring 2008 featured the following list of speakers and topics:

Julie Newman, Director, Yale Office of Sustainability, *Institutionalizing Sustainability: Moving from Theory to Practice at Yale* ■ **Michael Donoghue**, Director, Yale Peabody Museum of Natural History, G. Evelyn Hutchinson Professor of Ecology & Evolutionary Biology, *Developing intersections between phylogeny and ecology* ■ **David Post**, Assistant Professor, Ecology & Evolutionary Biology, *The tail of two fish: ecological implication of phenotypic variation in alewives* ■ **William Schlesinger**, Director, Institute of Ecosystem Studies, Millbrook, New York, *Balancing the global nitrogen cycle* ■ **James Saiers**, Professor of Hydrology, School of Forestry & Environmental Studies, *History and hydrology of the florida everglades* ■ **Austin Hendy**, Gaylord Donnelley Postdoctoral Environmental Associate, Department of Geology & Geophysics, *Marine biodiversity during the Cenozoic: assessing the response of clams and snails to global paleoenvironmental and biogeographic change* ■ **Jay Ague**, Professor, Department of Geology & Geophysics, *Exergy, energy, and sustainability* ■ **Julie Zimmerman**, Assistant Professor in Chemical Engineering and at the School of Forestry & Environmental Studies, *Designing tomorrow* ■ **David Tank**, Postdoctoral Associate, Yale Peabody Museum of Natural History, Lecturer, Department of Ecology & Evolutionary Biology, *Inferring processes from patterns–three scales and tales using plant phylogenies* ■ **Alison Galvani**, Assistant Professor, Epidemiology & Public Health, *The epidemiological game theory of influenza vaccine* ■ **William Piel**, Associate Director, Yale Peabody Museum of Natural History, *Tools for phyloinformatics* ■ **Larry Gall**, Head of Computer Systems Office, Curatorial Affiliate Yale Peabody Museum of Natural History, *Leveraging access to the Yale Peabody Museum of Natural History: informatics approaches in the collections.*

For an updated schedule, please visit the YIBS Web site *www.yale.edu/yibs/ESC_Seminar.html*

FORUM ON SOLAR VARIABILITY AND CLIMATE CHANGE

Under the sponsorship of the Yale Institute for Biospheric Studies (YIBS) Center for the Study of Global Change, a Forum on Solar Variability and Climate Change was held at Yale University on March 28 and 29, 2008. The meeting was convened by professors Karl Turekian, from the Department of Geology & Geophysics, and Sabatino Sofia, from the Department of Astronomy. Scientists from the United States, Canada, France, Switzerland and the United Kingdom made 10 presentations covering observation and theory. Professor Paul Charbonneau from the University of Montreal presented "A Novel Semi-empirical Model for the Total Solar Irradiance." Professor Sofia from Yale presented a theoretical work describing the "TSI Variability Produced by Structural Changes of the Solar Interior." Dr. Claus Frohlich from PMOD/Switzerland made a presentation entitled "Solar Irradiance Variability During the Last Three Solar Cycles: Observations and Mechanisms." Dr. Stuart Jordan, emeritus Senior Scientist from the NASA/Goddard Space Flight Center, made an after-dinner presentation entitled "The Role of the Sun in Global Warming." Professor Sarbani Basu from Yale spoke on "Helioseismic Evidence of Changes Inside the Sun." Professor Juerg Beer, Eawag/Switzerland, spoke on "Long-term Solar Variability and Evidence for Solar Forcing from Paleoclimatic Records." Dr. Gerard Thuillier from CNRS/France described the PICARD space mission. Michael Schlesinger, University of Illinois, addressed "Has the Sun Changed Climate?" Professor Gabi Hagerl from the University of Edinburgh, Scotland spoke on "Estimating the Solar Contribution to Surface Temperature Changes over the last Few Centuries: Was it the Sun, Greenhouse Gases, or Volcanoes?" Finally, Dr. Drew Shindell from NASA/GISS concluded the meeting with a presentation entitled "Effects of Solar Variability on Regional Climate: Models and Observations."

The presentations, all uniformly informative and stimulating, can be found on the web at *www.yale.edu/yibs/Solar%20Variability%20Program/*.

In summary, although at the present time global warming is likely dominated by the increase of the concentration of greenhouse gases, that was not the case for the past, and solar irradiance variations have played significant roles in past climate changes. However, despite the dominance of current greenhouse gases, it is essential to understand the role of all natural climate drivers (mainly solar changes and volcanic eruptions) to properly calibrate climate models and obtain robust estimates of climate sensitivity to greenhouse warming.

Ocean and Climate Forum

Climate change caused by increasing concentrations of greenhouse gases in the atmosphere has become a matter of grave concern for our society. To understand the mechanisms and effects of this climate change we need to look at different key components of the climate system—one of these critical components is the world ocean. Measurements and observations indicate that the ocean is already changing. Significant variations in ocean temperatures are observed at depths reaching 1000 meters. There are reports on the slow-down of the Gulf Stream over the last several decades. The upwelling of cold water off the coast of California failed in 2005 for the first time during the period of regular observations, with detrimental effects on fisheries. Changes in the properties of El Niño and climate shift of the late 1970s are other examples (during the last three decades, we have experienced the most intense El Niño episodes in more than a century).

The Yale Institute for Biospheric Studies (YIBS) Center for the Study of Global Change presented an Ocean and Climate forum on April 11 and 12, 2008. Convened by professors Karl Turekian, Alexy Fedorov and Steve Sherwood of Yale University, the forum featured nine distinguished speakers from the US and UK who discussed topics relevant to these issues. Steve Griffies (Geophysical Fluid Dynamics Laboratory, Princeton, NJ) and David Marshall (Oxford University) talked about challenges and progress made in the understanding and modeling of the ocean with a hierarchy of models of different complexities, from simple conceptual models to state-of-the-art general circulation models (GCMs). Mary-Louise Timmermans (Woods Hole Oceanographic Institution) discussed physical processes occurring in the Arctic Ocean, including those that led to an unprecedented loss of perennial sea ice in the Arctic during the summer of 2007.

Harry Bryden (University of Southampton) and Fiamma Straneo (Woods Hole Oceanographic Institution) concentrated on the Atlantic Meridional Overturning Circulation (AMOC) and deep-water formation in the northern high latitudes, responsible for transporting large amounts of heat from low latitudes to the northern Atlantic. In particular, Dr. Bryden described the great progress made so far in monitoring the strength of the AMOC with the array of instruments of the RAPID program—a joint program between American and European scientists.

Agatha de Boer (University of East Anglia) talked about the role of the Southern Ocean in climate, and in particular about the mechanisms by which ocean processes can regulate the concentration of carbon dioxide in the atmosphere. Niklas Schneider (University of Hawaii) and Annalisa Bracco (Georgia Tech) discussed the role of the Pacific and Indian oceans, respectively, in global and local climate and weather patterns. Finally, Jennifer MacKeanon (Scripps Institution of Oceanography) gave a thorough overview of mixing processes in the ocean that supply energy to the ocean meridional overturning.

The central piece of the evening program, which included dinner and a discussion of these topics among the forum participants, was a talk by Kerry Emanuel (Massachusetts Institute of Technology) focusing on the role of tropical cyclones for climate and especially for the ocean general circulation.

The forum was well attended by students, postdocs and faculty from the Department of Geology & Geophysics and other Yale departments.

MIGRATION, POLITICS AND POPULATION SEMINAR SERIES

The Interdisciplinary Bioethics Center and the Yale Institute for Biospheric Studies (YIBS) co-sponsored a seminar series, *Migration, Politics and Population,* during the winter/spring semester. There were six seminars in the series:

Stathis Kalyvas, Arnold Wolfers Professor of Political Science at Yale University, presented *War and Population Movements* on January 24.

Uli Mayer, Professor and Chair of the Department of Sociology at Yale University, presented *Life Courses In the Transformation of East Germany—the Contribution of Social Demography to the Study of System Disruption*, on February 7.

Jasmina Besirevic-Regan, Dean Trumbull College and Lecturer in Ethnicity & Migration and Sociology, presented *The Ethnic-Cleansing of Banja Luka: National Homogenization, Political Repression and the Emergence of a Bosnian Muslim Refugee Community* on February 21.

Michael White, Professor of Sociology at Brown University, presented *The New American Immigration: Success or Segmentation?* on February 28.

Khachig Tololyan, Professor, Department of English at Wesleyan University, presented *The Armenian* Diaspora on March 6.

Matthew Connelly, Associate Professor in the Department of History, Columbia University, presented *Unnatural Selection* on March 27.

For a listing of future seminars relating to population and demography, please visit the YIBS Web site at *www.yale.edu/yibs*

Evolution and Medicine: Fresh Insights from Recent Interactions

Two symposia organized at Yale, in February and April, brought together leaders from evolutionary biology and medicine to examine issues that touch both fields. The symposia may lead to innovations in the Yale College curriculum and have helped to put evolutionary medicine on the strategic planning agenda for the University, a process that should begin this fall.

The Yale Symposia on Evolution in Health and Disease were designed to address a broad range of biological questions and concerns. How much should doctors know about evolution? Would those who knew a substantial amount be more effective in saving lives and reducing suffering than those who knew little or nothing? Would providing medical students with a rigorous background in evolutionary biology improve health enough to justify the costs? Are evolutionary insights primarily important in research or are some of them also helpful in the clinic? Should Yale be building strength in this area—and, if so, then should it be through teaching, research, in the School of Medicine, or in Yale College?

The symposia made clear that evolution has been particularly effective in providing insights into infectious diseases, reproductive medicine, human genetics and cancer. Sebastian Bonhoeffer, from the ETH Zurich, discussed HIV evolution; Carl Bergstrom, from the University of Washington, Seattle, shed new light on the evolution of antibiotic resistance. How pathogens evolve in response to vaccines was the subject of Andrew Read, from Pennsylvania State University. David Goldstein, from Duke University, spoke about pharmacogenomics. Ruslan Medzhitov, from the Yale School of Medicine, addressed the evolution of the host-pathogen interaction; Jonathan Pritchard, from the University of Chicago, explained how signals of selection can be detected in the human genome. David Haig, from Harvard University, described Prader-Willi syndrome and the evolution of human childhood; Chris Kuzawa, from Northwestern University, spoke on the fetal origins of adult disease. The evolution of the Y chromosome was the focus of David Page from MIT. Carole Ober from the University of Chicago discussed the evolution of HLA genes, and Paul Turner from Yale addressed the evolutionary ecology of viruses. Ajit Varki from the University of California, San Diego, described how the genetics of hominid evolution is a Rosetta Stone for understanding human disease.

The symposia were organized by professors Stephen Stearns and Paul Turner in Yale's Department of Ecology & Evolutionary Biology and Durland Fish, Charles Lockwood and Stephen Malawista in the Yale School of Medicine. They were attended by many Yale faculty and students from both sides of campus, as well as scientists and physicians from as far away as Edinburgh and New Mexico.

The current interaction between evolution and medicine can be compared with a similarly productive cross-fertilization of ideas that occurred fifty years ago when physicists took up biology and contributed to the revolution in molecular biology. New perspectives bring new insights and approaches. Since this interaction is comparatively recent, its relevance for some parts of the medical enterprise, such as surgery, is not yet as clear. As one evolutionary biologist put it, "I absolutely want my pediatrician, oncologist, internist, and ob-gyn to understand evolution, but I don't want my orthopedic surgeon to take time away from anatomy and physiology to study it. I want her to understand my knee!"

The talks were videotaped and can be viewed at *www.yale.edu/evomedsymposia/program.html*. You are invited to have a look. You will learn why the evolutionary genetics of HIV makes vaccine development difficult at the same time that it illuminates the reasons for the evolution of sexual reproduction. You will see how simple changes in the hospital management of antibiotics can put the brakes on the evolution of drug resistance. Similar changes in cancer chemotherapy could prolong the lives of many cancer patients. You will learn why evolutionary biologists are concerned about the massive use of imperfect vaccines, vaccines that do not make the entire host population unavailable to the pathogens. They think, with good reason, that an unwanted byproduct will be the evolution of more virulent pathogen strains. Imperfect vaccines should definitely be used, for they can save millions of lives, but their consequences should be understood and prepared for. You will come to understand how evolutionary conflicts between the parents over the amount to be invested in the child have produced, as byproducts, some of the dangerous symptoms of pregnancy, including dangerously high maternal blood pressure and maternal diabetes, as well as intriguing suggestions into the causes of retardation and mental disease. These insights, and many more, await you at the Web site.

The symposia were made possible by the generous support of the Provost, the schools of Public Health and Forestry & Environmental Studies, the departments of Ecology & Evolutionary Biology, Molecular Cell & Developmental Biology, and Molecular Biochemistry & Biophysics in the Faculty of Arts and Sciences, the Yale Institute of Biospheric Studies, the Yale Peabody Museum of Natural History, and Celera.

National Geographic Explorer Television Films in Yale Reproductive Ecology Laboratory

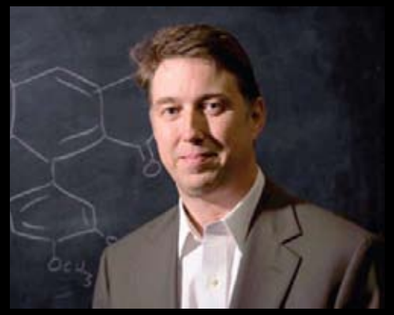
Last November a film crew from National Geographic Explorer (NGE) television descended on the Reproductive Ecology Laboratory (REL) in the Class of 1954 Environmental Science Center (ESC) for a full day of filming for its episode entitled "Testosterone Factor," which aired on February 13, 2008. The focus of this episode was on the effects of testosterone on male behavior in humans as well as other primates and organisms. The evolutionary significance of these associations was also of particular interest.

NGE interviewed Professor Richard Bribiescas and Dr. Stephanie Anestis of the Department of Anthropology regarding their research on testosterone, behavior, and human evolution. Bribiescas discussed how testosterone and other hormones affect risky behaviors in human males and how they augment reproductive effort. Anestis focused on her research on dominance and aggression in chimpanzees as well as the methods by which researchers are able to collect samples for hormone analysis in a non-invasive manner. The remainder of their full day visit was rounded out filming hormone assessment methods in the lab.

Preview clips are available on the lab website (*http://pantheon.yale.edu/~rgb25*) under the 'Media' section. Downloads of this episode should be available on iTunes in the near future. The REL is the core laboratory facility for the Center for Human and Primate Reproductive Ecology, a Yale Institute for Biospheric Studies sponsored research center headed by Professor Bribiescas.

Yale's Anastas Honored

By Janet Emanuel



Paul T. Anastas, Professor in the Practice of Green Chemistry, was honored on May 4 by the Council of Scientific Society Presidents with its Leadership in Science award for founding the field of "Green Chemistry."

Known as "the father of green chemistry," Anastas has worked to develop the field over the past 17 years. He joined the Yale faculty in 2007, where he serves as Director of the Center for Green Chemistry and Green Engineering, which advances the sciences, education and use of sustainable technologies.

The Council of Scientific Society Presidents is an organization of presidents, presidents-elect, and recent past presidents of about 60 scientific federations and societies. The combined membership numbers well over 1.4 million scientists and science educators in 150 disciplines. Each year the council confers its Citation for Leadership and Achievement to individuals in honor of their special achievements in support of scientific research.

"I am honored and pleased to present the award to Paul Anastas," said Council President Martin Apple, "for his strategic and bold vision and pioneering initiatives that created the global green chemistry enterprise, for his breakthrough research that created economic incentives to reduce industrial waste, for leading the U.S.A. to sponsor the Presidential Green Chemistry Challenge, and N.S.F to create the technology for a sustainable environment program, for founding the Green Chemistry Institute, for preventing millions of kilograms of hazardous chemicals from entering the environment, [and] for his 12 principles redirecting progress on chemical frontiers to address key 21st century challenges."

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RESEARCH AND PROGRAM HIGHLIGHTS

Anastas Honored
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Anastas focuses his research on the design of safer chemicals, bio-based polymers, and new methodologies of chemical synthesis that are more efficient and less hazardous to the environment. He has published nine books and numerous papers on the subject of science and technology for sustainability.

Before coming to Yale, Anastas was the director of the Green Chemistry Institute, headquartered at the American Chemical Society in Washington, D.C., where he established 24 green chemistry chapters in countries around the world, including China, Ethiopia, India, Japan, and South Africa. In a prior position with the White House Office of Science and Technology Policy, he spent five years as the principal supporter within the administration for governmental programs related to the environment.

Anastas holds joint appointments at Yale in the School of Forestry & Environmental Studies, the Department of Chemistry, and the Department of Environmental Engineering. He received his B.S from the University of Massachusetts and his Ph.D from Brandeis University.

Among his numerous awards are the John Jeyes Medal from the Royal Society of Chemistry and the H. John Heinz III Award for the Environment, and the U.S. Environmental Protection Agency's Joseph Seifter Award, their highest scientific recognition.

Previous recipients of the award include Nobel laureates F. Sherwood Rowland and Dudley Hirschbach, President of the National Academy of Sciences Bruce Alberts and former Dean of Yale Engineering D. Alan Bromley.

Study Offers New Paradigm on Ecosystem Ecology

by David DeFusco

Predators have considerably more influence than plants over how an ecosystem functions, according to a School of Forestry & Environmental Studies study that was published in February 2008 in *Science*.

The findings, according to author Oswald Schmitz, Oastler Professor of Population and Community Ecology, are a "revolutionary" shift in thinking on the subject. Ecosystem ecologists have long held that plants and their interaction with the soil determine the type and abundance of herbivores and carnivores in an ecosystem. Schmitz's paper, "Effects of Predator Hunting Mode on Grassland Ecosystem Function," shows that the opposite is true.

"Most ecosystem ecologists think that the supply of nutrients in plants determines who can live up in higher trophic (feeding) levels," said Schmitz. "This study shows that it's the top trophic levels determining how the plants interact with the soil."

In a three-year experiment conducted in 14 enclosed cages at Yale-Myers Forest in northeastern Connecticut, Schmitz observed that the jumping spider (*Phidippus rimator*) prowls its neighborhood, or ecosystem, and engages in random acts of violence against its plant-eating prey, the garden-variety grasshopper (*Melanoplus femurrubrum*). And much like victims of crime, grasshoppers facing an imminent threat go into a heightened state of alert, taking refuge in the ecosystem's dominant plant, goldenrod. Its mobility restricted, the grasshopper dines on its own shelter, promoting habitat diversity in the process.

Goldenrod's competitors—asters, Queen Anne's lace and a variety of clover and grasses—flourish, but the diversity comes at a price. With the demise of goldenrod, nitrogen—a key fertilizer in the soil's renewal—is depleted. In the same experiment, nursery web spiders (*Pisaurina mira*), which Schmitz called "sit-and-wait ambush spiders" because they are coy about their predatory intentions, occupy a certain "bad neighborhood," enabling grasshoppers to avoid them, roam the ecosystem and eat a wider variety of plants. In this milieu, goldenrod thrives, ultimately nourishing the soil when its nitrogen-rich tissue decays.

"What's really cool here is that different spiders have different hunting modes, and it's those modes that cause grasshoppers to behave differently, which then carries down the chains of the community structure of the plants," said Schmitz. "So it's a top-down view, and in that sense it's revolutionary, because it's a paradigm change in ecosystem ecology. Plants, ecosystem ecologists say, have an indirect effect on carnivores. My research shows that carnivores have an indirect effect on plants."

Schmitz said that the study's underlying principles can apply to larger ecosystems, such as Yellowstone National Park, and have implications for conservation policies. "If elk are facing cougars, which are ambush predators, they're going to change where they are on the landscape. Whereas when elk face wolves, they may not change their location; they'll only respond to an imminent threat, because wolves are continually wandering around on the prowl."

He added, "We know that elk can have a huge impact on plant diversity and, as a consequence, on nutrient-cycling properties. And so the way they use the landscape, which depends on what predator they face, will change the local ecosystem processes."

Funding for the study was provided by the National Science Foundation's Ecological Biology program.

Jumping Spider
Phidippas rimator

Agriculture Changing Chemistry of Mississippi River

Midwestern farming has injected the equivalent of five Connecticut Rivers annually into the Mississippi River during the past 50 years, according to a study published in January 2008 in *Nature* by researchers at Yale and Louisiana State universities.

"It's like the discovery of a new large river being piped out of the corn belt," said Pete Raymond, lead author of the study and Associate Professor of Ecosystem Ecology at the School of Forestry & Environmental Studies (F&ES.) "Agricultural practices have significantly changed the hydrology and chemistry of the Mississippi River."

The researchers tracked changes in the levels of water and bicarbonate, which form when carbon dioxide in soil water dissolves rock minerals. Bicarbonate plays an important, long-term role in absorbing atmospheric carbon dioxide, a greenhouse gas. Oceans absorb carbon dioxide but become more acidic in the process. "Ocean acidification makes it more difficult, for example, for organisms to form hard shells in coral reefs," said R. Eugene Turner, a co-author of the study and a professor at the Coastal Ecology Institute at Louisiana State University.

The researchers concluded that liming and farming practices, such as changes in tile drainage and crop type and rotation, are most likely responsible for most of the increase in water and carbon in the Mississippi River, which is North America's largest river.

Raymond said that the research team analyzed 100-year-old data on the Mississippi River that had been warehoused at two New Orleans water treatment plants, and combined it with their own data on precipitation and water export. "A notable part of this finding is that changes in farming practices play a larger role than changes in precipitation in the increase in water being discharged into the river," he said.

The researchers used their data to show the effects of this excess water on the carbon content of the river, and argue that nutrients and pollution in the water are altering the chemistry of the Gulf of Mexico.

The other co-authors of the paper, entitled "Anthropogenically Enhanced Fluxes of Water and Carbon from the Mississippi River," are Neung-Hwan Oh of F&ES, and Whitney Broussard of the Department of Oceanography and Coastal Sciences at Louisiana State University. The research was funded by the National Science Foundation.

Interactive Web Site Calculates Costs of Climate Change

A national policy to cut carbon emissions by as much as 40 percent over the next 20 years could still result in increased economic growth, according to an interactive website reviewing 25 of the leading economic models being used to predict the economic effects of reducing emissions.

Robert Repetto, Professor in the Practice of Economics and Sustainable Development at the School of Forestry & Environmental Studies (F&ES), who created the site, said, "As Congress prepares to debate new legislation to address the threat of climate change, opponents claim that the costs of adopting the leading proposals would be ruinous to the United States economy. The world's leading economists who have studied the issue say that's wrong. And you can find out for yourself."

The interactive Web site, *www.climate.yale.edu/seeforyourself*, synthesized thousands of policy analyses in order to identify the seven key assumptions accounting for most of the differences in the models' predictions. The site allows visitors to choose which assumptions they feel are most realistic and then view the predictions of the economic models on the basis of the chosen assumptions.

Among the key assumptions are that renewable energy technologies will be available at stable prices; that higher fossil fuel prices will stimulate energy-saving technological change; that reducing U.S. carbon emissions will reduce economic damages from climate change and air pollution; and that the United States will incorporate international trading of emission permits into its national policy.

Even under the most pessimistic assumptions, U.S. gross domestic product (GDP) would still grow by 2.4 percent per year, reaching $23 trillion by 2030 even if emissions are reduced by 40 percent below projected business-as-usual trends, as compared to historical growth rates of 3 percent a year over recent decades. Under the most favorable assumptions, GDP would rise slightly above 3 percent a year.

"The website shows that even under the most unfavorable assumptions regarding costs, the U.S. economy is predicted to continue growing robustly as carbon emissions are reduced," said Repetto. "Under favorable assumptions, the economy would grow more rapidly if emissions are reduced through national policy measures than if they are allowed to increase as in the past."

Descriptions of the 25 economic models used in the analysis can be found in *The Costs of Climate Protection: A Guide for the Perplexed*, published by the World Resources Institute in 1997, and *The Costs of Greenhouse Gas Mitigation With Induced Technological Change: A Meta-Analysis of Estimates in the Literature*, published by the Tyndall Centre for Climate Change Research in 2006.

YALE PEABODY MUSEUM OF NATURAL HISTORY

EVENTS

LAS ARTES DE MEXICO
On view through July 19, 2008
The Museum's latest traveling exhibition celebrates the rich and diverse artistic traditions of Mexico, examining over 3,500 years of art and culture and of tradition and change across the broad spectrum of Mexican life.

PEABODY SUMMER YOUTH PROGRAMS
July and August 2008
Another summer of 12 fun, week-long programs for students entering 3rd to 9th grade, on topics as diverse as biodiversity, astronomy, natural science illustration, ancient survival skills, ancient cultures and archaeology. See the Yale Peabody Museum website for details.

JUNGLES: PHOTOGRAPHS BY FRANS LANTING
On view from August 23, 2008 to February 22, 2009
A personal exploration of nature in the tropics by master photographer and naturalist Frans Lanting, this unique collection of images taken over 20 years in jungles from the lowlands of Congo to the cloud forests of the Andes interprets the aesthetic splendor and the remarkable natural history of tropical rainforests.

TRAVELS IN THE GREAT TREE OF LIFE
On view through February 22, 2009
This multimedia and family friendly exhibition explores how we discover the complex relationships that link all living organisms together.

Supported by the National Science Foundation.

Information and updates at (203) 432-5050 and *www.peabody.yale.edu*

Peabody Director Michael Donoghue Elected to AAAS

Yale Peabody Museum of Natural History Director Michael J. Donoghue, G. Evelyn Hutchinson Professor, Yale Department of Ecology & Evolutionary Biology, has been elected a Fellow of the American Academy of Arts and Sciences. The AAAS, one of the nation's oldest and most prestigious honorary societies and independent policy research centers, honors excellence by annually electing to membership men and women who have made vital contributions to their fields and to the world. Donoghue was named a Fellow in the Section on Biological Sciences.

Among the world's leading evolutionary biologists, Donoghue is also Professor of Geology & Geophysics and Curator of Botany at the Yale Peabody Museum. His research on understanding the tree of life (phylogeny) focuses on plant diversity and evolution, especially on the origin and early evolution of flowering plants and on the geographical distribution of plant diversity.

Donoghue also works on conceptual and theoretical issues, specifically the nature of species, phylogenetic nomenclature, and character evolution. In addition, he has published on methods for assessing the direction of evolution, the analysis of large data sets, and identifying shifts in the rate of diversification. He helped build TreeBASE, a relational database of phylogenetic knowledge, and is a leader of DIVERSITAS, an international organization devoted to biodiversity science.

Donoghue has conducted field studies in China, especially in the eastern Himalayan region of Qinghai, Sichuan and Yunnan, research that connects with another major interest of his, the historical assembly of plant communities around the Northern Hemisphere.

In 2005, Donoghue was elected to the U.S. National Academy of Sciences in recognition of his distinguished and continuing achievements in research. The NAS is a private organization of scientists and engineers that acts as an official adviser to the federal government on matters of science or technology.

Sally Pallatto

Peabody Director Michael J. Donoghue

Founded in 1780 by John Adams, John Hancock and others, the 228-year-old nonprofit AAAS has included among its members some 200 Nobel laureates and more than 60 Pulitzer Prize winners. The newly elected members will be inducted at a ceremony on October 11, 2008, at the Academy's headquarters in Cambridge, Massachusetts.

Jessie Cohen (4)

A pair of Black *and Rufous Giant Elephant Shrew brothers on display in the Yale Peabody Museum's Travels in the Great Tree of Life* exhibition, on loan from the Smithsonian's National Zoo in Washington, D.C.

Sally Pallatto

Explaining the Tree of Life:

An Interview with Peabody Director Michael Donoghue

By Rosemary Volpe, Publications Editor

Travels in the Great Tree of Life is the Yale Peabody Museum's new, family-friendly and very popular exhibition that uses multimedia, live animal and plant displays, and museum specimens to explore how we discover the complex relationships that link all living organisms. Recently, Yale Peabody Museum Director Michael Donoghue, the G. Evelyn Hutchinson Professor of Ecology and Evolutionary Biology, took some time to explain the background behind this innovative exhibition developed by the Museum.

Volpe: What is the "Tree of Life"?

Donoghue: The Tree of Life is a branching diagram that depicts how organisms are related to one another through common ancestors at different times in the past. We can "read" this diagram to see whether two species are more closely related to one another than they are to a third species; that is, to see which of the species share a more recent common ancestor. Although some phylogenetic relationships are pretty obvious, others are not. One example would be the elephant and elephant shrew, which are more closely related to one another than either is to, say, a giraffe. Did you know that humans and mushrooms are more closely related than either is to a sunflower?

Volpe: How do researchers figure out these relationships? What methods do they use?

Donoghue: Because we rarely can make direct observations on ancestry, we have to infer phylogenetic relationships in the Tree of Life by looking at the shared, evolutionarily derived structural characteristics of organisms. Today, though, we also have a second, very powerful, line of evidence, namely comparing DNA sequences directly. This works for living organisms, and often for museum specimens and even sometimes for fossils.

Volpe: How hard is it to figure out this "relatedness"?

Donoghue: It's often very difficult! The Tree of Life is immense. Not only does it include the 1.7 million known species, but also the estimated 10 million existing species yet to be discovered, and perhaps another 100 million extinct species. Remember that extinct species are also part of the Tree of Life, and with fossils we almost always have only the structural, or morphological, evidence to make our inferences.

So studying the Tree of Life generates a great deal of data, these days much of it molecular. And this necessitates the use of powerful

continued on next page

Reed Beaman

The pitcher plants of the Old World (left) and the New World (right) evolved independently, apparently as an adaptation to low-nitrogen soils.

***Rafflesia arnoldii* produces the largest known individual flowers, nearly three feet (one meter) across and weighing up to 15 pounds (7 kilograms). The flowers open only rarely and then only for about five days.**

Tree of Life
continued from previous page

computers and special algorithms and statistical techniques to analyze it all. How best to accomplish this task is the subject of a major worldwide research effort.

On top of the sheer size of the problem, sometimes relationships can fool us. Some organisms that are very similar in appearance turn out to be only distantly related, while organisms that look very different can be very closely related. For instance, convergent evolution, in which similar traits evolve in quite distantly related lineages, can lead to mistakes. The molecular work done with pitcher plants, for example, shows that despite having the same general shape and insect-eating strategies, different species of insectivorous plants evolved independently in quite unrelated lineages. The flip side is that some organisms that look very different from one another can turn out to be closely related. For example, tiny modern birds are quite closely related to huge dinosaurs. A similar surprise from plants is that *Rafflesia*, from Borneo, which produces the largest flowers in the world, turns out to be directly related to plants with miniscule flowers.

Volpe: So why is this research important?

Donoghue: Understanding relationships in the Tree of Life allows us to make predictions that are important for human well-being. This is especially true in three areas: agriculture, where this knowledge can help us breed better crops; in medicine, as with the study of the origin of diseases such as the West Nile virus; and in the conservation of biodiversity when we can help predict the movement of species in response to global changes.

A very specific example in which this research has proven helpful is in the treatment of snake bites in Australia, where knowledge of the relationship of venomous species guides the selection of the most effective antivenins. Phylogenetic methods have also been used recently in tracing the origin and spread of HIV, and in designing vaccines.

Volpe: What Tree of Life research is going on at Yale and the Peabody Museum?

Donoghue: At the moment, there are several Tree of Life research projects in progress here. My own work has been supported recently by two National Science Foundation awards, one that looks at the very early evolution of green plants and the origin of land plants, and another focused at how the 250,000 species of flowering plants—the dominant plant group on Earth—are related.

The research of Jacques Gauthier, Professor of Geology & Geophysics and Curator of Vertebrate Paleontology, is focused on how the major lineages of squamates, the lizards and snakes, are related to one another. This research is especially interesting in dealing with how fossils fit into the Tree of Life.

Many other Yale faculty and Peabody curators are focused on Tree of Life research, including Thomas Near, Assistant Professor of Ecology & Evolutionary Biology and Assistant Curator of Vertebrate Zoology, working on the phylogeny of fishes; Richard Prum, Curator of Vertebrate Zoology and the William Robertson Coe Professor of Ornithology in Ecology & Evolutionary Biology, studying bird evolution; and Eric Sargis, Associate Professor of Anthropology and Associate Curator of Vertebrate Zoology, whose focus is on primates.

Come to think of it, most of the biology professors associated with the Peabody are involved in Tree of Life research in one way or another.

Travels in the Great Tree of Life is supported by the National Science Foundation through the Angiosperm Tree of Life, CIPRES and EuphORBia awards. A highlight of the exhibition are its live animals, including a pair of elephant shrews on loan from the Smithsonian National Zoo. To see a short video of the elephant shrews and learn more about the exhibition visit the Peabody Web site at *www.peabody.yale.edu/exhibits/*.

The Peabody Awards 2008 Simpson Prize

The recipient of this year's George Gaylord Simpson Prize is Jakob Vinther, a doctoral student in the Yale Department of Geology & Geophysics, for his paper "Machaeridians Are Palaeozoic Armoured Annelids," co-authored with Peter Van Roy and Derek E. G. Briggs (*Nature* 451(10):185–188, January 10, 2008).

Originally from Denmark, Vinther has been interested in fossils and evolution since he was a child. His research focuses on the radiation of animals at the beginning of the Cambrian (540 million years ago), specifically on how mollusks and annelids diversified to the groups we know today. By incorporating both molecular biology and fossils from the Yale Peabody Museum collections in this research, he seeks to reconstruct the tempo and mode of organismal evolution that took place in a rapidly changing biosphere and to understand their functional adaptations to life in specialized ecological niches. The machaeridians are an excellent example of the adaptive radiations taking place in early animal evolution. These annelid worms (relatives of earthworms and leeches) evolved a mineralized armor, which gave them an ability to explore niches similar to mollusks. The machaeridians went extinct, however, after existing in the world seas for more than 180 million years.

Each year the Yale Peabody Museum of Natural History awards the George Gaylord Simpson Prize to a Yale University graduate student or recent doctoral candidate for a paper concerning evolution and the fossil record. The prize is named for George Gaylord Simpson (1902–1984; Yale Ph.D. '26), the most influential paleontologist of the 20th century and a major proponent of the modern evolutionary synthesis.

Michael Novacek's Special Lecture Honors Latest Peabody Verrill Medal Recipient Alison Richard

Steve Forrest/Insight Visual

ABOVE The front of the medal bears a likeness of A. E. Verrill, while the obverse depicts a starfish representative of his pioneering work in invertebrate zoology.

LEFT Alison F. Richard

From time to time the Board of Curators at the Yale Peabody Museum of Natural History awards it highest honor, the Addison Emery Verrill Medal, to distinguished scholars in recognition of their contributions to the natural sciences.

On April 23, 2008, former Yale provost and Yale Peabody Museum of Natural History director Alison F. Richard, now Vice-Chancellor of Cambridge University, was awarded the Verrill Medal at a ceremony at Yale's Luce Hall. Opening remarks from Yale Institute for Biospheric Studies (YIBS) Director Jeffrey Park were followed by the presentation of the Edward P. Bass Distinguished Lecture, on "Biodiversity Past, Present, and Future: From the Island of Madagascar to Island Earth," by Michael Novacek, Senior Vice President and Provost of Science, and Curator of Paleontology, at the American Museum of Natural History, sponsored by YIBS and the Yale Peabody Museum.

Dr. Novacek's presentation on the mass extinction event we are currently witnessing, especially devastating in fragile refugia that harbor unique species, focused on Madagascar, the research terrain of Alison Richard. He explained that this island has been the substrate of a spectacular 90-million-year evolutionary experiment not only involving Alison's lemurs, but also its unique species of tenrecs, geckos, spiny succulent trees and other wondrous organisms, and that human-induced devastation of natural habitats in Madagascar is forcing many of its species to the brink of extinction. Many of these species represent unique lineages with ancient histories, so their loss also means the loss of irreplaceable information about diversity, structure, genes and genealogy. He noted that Madagascar is but one example of the massive trauma to ecosystems and species on a global scale caused by habitat destruction, over-harvesting, pollution, invasive species and climate change. What organisms will get through this sieve of destruction and how will the resultant environments define our quality of life in the future?

For some of the answers, Dr. Novacek suggests we must look to the fossil record, which shows that the early colonizers after mass extinction events were often wide-ranging, opportunistic species, the ancient analogues of rats and weeds. He said that humans are destined to be embraced by such a pest and weed ecology as the current extinction event advances, and that the great wellsprings of global biodiversity, the tropical rainforests and coral reefs, will no longer yield the potentials for biotic enrichment that fuel evolutionary change. Explaining that although there are examples of resource management and land conversion that show the human capacity for mitigating the crisis, he said that the effort needs a major rescaling. At the same time, the critical roles of species in providing ecosystem services, natural beauty and pleasure, and in sustaining human lives is a message that requires constant attention and re-crafting to reach diverse audiences.

Afterward, Yale Corporation member Edward P. Bass and Yale President Richard C. Levin shared stories about Dr. Richard from her time at the University. Peabody Director Michael Donoghue then presented the Verrill Medal to Dr. Richard as a tribute to her many contributions in her field of primate research, particularly for her work on the lemurs of Madagascar, and for her outstanding leadership as a conservationist, educator and administrator. Dr. Richard was among the first to recognize the importance of preserving the biodiversity on which human well-being depends. As director of the Peabody during a crucial period, her guidance brought a new appreciation of the Museum to the Yale community, expanded exhibitions, education, and public outreach programs, and greatly enhanced the Museum's national and international reputation.

Previously, on October 17, 2007, in a ceremony at Yale's Sprague Hall opened by Yale University Provost Andrew Hamilton, Yale Peabody Museum Director Michael Donoghue presented the medals to Dr. Peter Raven of the Missouri Botanical Garden and Professor Edward O. Wilson of Harvard University, in recognition of their work as scholars, teachers and leaders in conservation efforts around the world. The presentation was followed by "The Future of Life on Earth," a "fireside chat" between these two extraordinary biologists, moderated by Yale Corporation member Edward P. Bass. This wide-ranging, spirited discussion covered topics such as the catastrophic decline in biological diversity, the importance of preserving our natural heritage, the human ecological footprint on Earth, and the significance of nature for our mental and spiritual well-being.

Moderator Ed Bass poses points for discussion with Dr. Wilson and Dr. Raven at the Luce Hall "fireside chat." Photo: Susan Donoghue

ABOVE, TOP TO BOTTOM: Michael Donoghue, Edward Bass, Alison Richard, and President Richard Levin; Michael Novacek; E. O. Wilson, Photo by J. Chase; Peter H. Raven, Photo by K. Foster

The Verrill Medal, established in 1959, was the idea of S. Dillon Ripley, then director of the Yale Peabody Museum and later Secretary of the Smithsonian Institution, "to honor some signal practitioner in the arts of natural history and natural science." It is named for one of the 19th century's great zoologists, Yale scientist A. E. Verrill (1839–1926), known worldwide for his studies of starfish, squids, corals and other marine animals. For a list of past recipients and to view a video of the fireside chat with Drs. Raven and Wilson, visit *www.peabody.yale.edu/explore.*

Research on Sustaining Biocultural Diversity Presented at Policy Symposium

By Michael R. Dove, F&ES Margaret K. Musser Professor of Social Ecology, Professor of Anthropology, and Curator, Division of Anthropology; Dana Graef, Ph.D. '13, Yale Department of Anthropology/F&ES; and Adrian Cerezo, Ph.D. '12, F&ES

Members of the Yale School of Forestry & Environmental Studies (F&ES) Social Ecology Doctoral Lab of Professor Michael R. Dove and Carol Carpenter, F&ES Lecturer and Associate Research Scientist in Natural Resource Social Science and Adjunct Lecturer in Anthropology, presented an invited plenary paper on the "Cultural Politics of Sustaining Biological and Cultural Diversity" at the American Museum of Natural History's April 2–4, 2008 symposium on "Sustaining Biological and Cultural Diversity in a Rapidly Changing World: Lessons for Global Policy" in New York City. Professor Dove and doctoral students Adrian Cerezo (F&ES), Dana Graef (Anthropology/F&ES), Cassie Hays (Sociology), Sarah Osterhoudt (F&ES/Anthropology), Jonathan Padwe (F&ES/Anthropology) and Jeff Stoike (F&ES) combined case studies from their fieldwork around the world with critical analysis of academic and policy literature to address this topic.

One of the latest intellectual efforts in conservation to bridge human society and the natural world involves the concept of "biocultural diversity," which attempts to correlate, compare and sustain diversity in both realms. In examining this concept, we ask: What is gained and lost with this concept of biocultural diversity? What is being sustained, for whom, where, and according to whose agenda?

There are advantages to interdisciplinary borrowings like the concept of biocultural diversity, not least that of a new, hybrid perspective; but they are also subject to oversimplification. For example, there is a tendency to assume that biological and cultural diversity can be conceived and measured in analogous ways. Whereas studies of biological diversity are typically categorized in terms of genes, species and ecosystems, however, studies of cultural diversity resist such divisions. Cultural boundaries are not the same as species boundaries, and the extinctions of culture are not the same as species extinctions.

Also, there are often unexamined issues of scale in common approaches to biological and cultural diversity. Whereas thinking about biological complexity has shifted in many cases to larger, regional scales, thinking about cultural complexity tends to remain at the local level. In many studies of biocultural diversity, language is used as a proxy for culture, but this too can be problematic. For one thing, language may be lost while culture is maintained. In addition, the assumption that areas of high biological and cultural diversity coincide no longer holds in the modern world. For example, the borough of Queens in New York City encompasses extraordinary linguistic diversity, but it is obviously not a biodiversity hotspot.

Consider also the value of biological and cultural diversity to different constituents. Sustaining indigenous cultures and endemic species tends to be given a higher value or more weight in policy decisions. But this focus on what is different and exotic, like charismatic flora and fauna, can lead to ignoring more "mundane" forms of life, such as those of the productive human landscapes that dominate the tropics and subtropics. Western ideals of conservation can lead to a limiting and misleading focus on minor parts of the rural landscape (such as "sacred forests") at the expense of landscapes with the most social, economic and perhaps also biological importance.

External, sometimes romanticized, concepts of local communities and local knowledge can make it difficult to develop partnerships with local communities. National policy attempts at sustaining cultural diversity may be met with mixed reaction by the culture being "sustained." Efforts to conserve cultural as well as biological diversity are further complicated by the fact that local leaders, academics, and practitioners usually speak not just different technical languages, but they speak to different audiences and with varying needs for complexity versus simplification. In addition to studying the culture of others, therefore, we need to study our own academic, policy and activist cultures.

Finally, for nearly a generation, environmentalism's most important metric has been diversity. With the rise in concern over global climate change, this metric seems to be changing from one of diversity to one of, perhaps, stability versus instability. The paramount question—Is a given area's diversity being diminished and what can be done to halt this?—is becoming: How is a given area's climate changing and what can be done to mitigate this? Thus, we should be asking what the implications of the politics of global climate change are for the politics of biocultural diversity. Will the former overshadow the latter? Does the politics of global climate change in some sense even oppose the politics of biocultural diversity?

© CBC-AMNH/Kevin Frey (2)

TOP Dana Graef presents a summary of the plenary paper at the American Museum of Natural History symposium in New York.

BOTTOM Adrian Cerezo discusses the concept of complexity at the April policy symposium.

NOW AVAILABLE

The *Bulletin of the Peabody Museum of Natural History, Yale University* publishes original research based on specimens, artifacts and related materials maintained in the Yale Peabody Museum's curatorial divisions. The current issue reports on research on the phylogeny of logperch darters, on a new reconstruction of a Late Devonian eurypterid, deep-sea research among the western North Atlantic seamounts, the taxonomy of Eocene primates, and how radiocarbon dating revealed the true age of a Connecticut horse.

As of January 2008, abstracts and full text of papers published in the Yale Peabody Museum's *Bulletin* are accessible online through BioOne (*www.bioone.org/*), an electronic database of high-impact bioscience research journals. BioOne is available by institutional subscription through universities, government agencies and corporate libraries worldwide.

The *Bulletin of the Peabody Museum of Natural History* is published twice a year, in April and October. Information available at *www.peabody.yale.edu/scipubs/*, or contact the Yale Peabody Museum Publications Office at (203) 432-3786 or peabody.publications@yale.edu. For manuscript submissions for potential publication in the *Bulletin* contact Executive Editor Larry Gall directly at lawrence.gall@yale.edu or (203) 432-9892.

Peabody Mammalogy Collection Receives ASM Accreditation

Last fall, the Yale Peabody Museum's Associate Curator of Mammalogy Eric Sargis invited the Systematic Collections Committee of the American Society of Mammalogists (ASM) to evaluate the mammal collection at the Yale Peabody Museum of Natural History. On October 26, 2007, two members of the committee, chair Bill Stanley, Negaunee Collection Manager of Mammals at The Field Museum, and Link Olson, Curator of Mammals at the University of Alaska Museum, visited the Peabody's Division of Vertebrate Zoology.

Hosts Sargis and Vertebrate Zoology Collections Manager Kristof Zyskowski led the ASM committee members on an inspection tour of the collection, from the point where a specimen first enters the building through to the drawer in which it is ultimately deposited. The committee evaluated all aspects of the collection, including specimen preparation, storage and curation, and later met with Sargis, Thomas Near, Assistant Curator and Acting Head of the Division of Vertebrate Zoology, and Tim White, Assistant Director for Collections and Operations.

The committee was very impressed with the Peabody's Mammalogy Collection, particularly the new facilities in the Class of 1954 Environmental Science Center, and with Zyskowski's dedication to managing the collection. Although they made some minor recommendations for improvement, especially for the osteology collection housed in the basement of Kline Geology Laboratory, the committee recommended the collection for ASM accreditation in their final report.

Accreditation is part of the Division's overall planning for the strengthening of the Peabody's Mammalogy Collection. This recognition as an accredited repository for specimens opens up greater opportunities for grant funding and increases the visibility of this small but important collection to researchers worldwide. For the same reason, Sargis worked with the Peabody's Systems Head Larry Gall and informatics specialist Reed Beaman to make the Mammalogy Collection available on MaNIS, the Mammal Networked Information System (*http://manisnet.org*) in February 2007. With final approval from the ASM president, the collection has now been officially accredited and will be reported to the members of ASM at their annual meeting in June 2008.

Susan Hochgraf

Kristof Zyskowski (2)

RIGHT Skull of the Philippine Flying Lemur (*Cynocephalus volans*). Note the highly distinctive comb-like lower incisors.

TOP Kristof Zyskowski examines antelope ground squirrels of the genus *Ammospermophilus*.

BOTTOM This collection drawer holds specimens (round skins plus skulls in boxes) of antelope ground squirrels of the genus *Ammospermophilus* from western North America.

YIBS CENTER FOR FIELD ECOLOGY

Supporting Field Based Research and Teaching in the Environmental Sciences

The YIBS Center for Field Ecology (CFE) is a Yale Institute for Biospheric Studies sponsored research center that supports field based research and teaching in ecology. Research supported by CFE bridges five academic units and has addressed topics ranging from the evolutionary history of plant communities, paleoecology and conservation, to the effects of climate change and invasive species on ecosystems. Teaching efforts have exposed a generation of undergraduate and graduate students to experiments that test the influence of climate change on New England's salt marsh ecosystems.

Founded in 2002, CFE was created to help Yale become a world leader in ecology by supporting graduate student research in ecology, facilitating the teaching of field ecology at Yale, and stimulating and coordinating efforts to improve the research facilities of Yale University's natural lands. Graduate research is supported through an annual Pilot Grant Program, and teaching is facilitated by supporting infrastructure.

Pilot Research for Graduate Students

The CFE Pilot Research Grants Program was created to help early career Ph.D. students in field ecology explore projects of their own choosing and gather the pilot data required to justify external funding. Research on "field ecology" is defined broadly to include field-based projects that draw from behavior, ecology, evolution, epidemiology, paleontology, and related fields. Since 2002, the Pilot Research Grants' program has supported the research of 70 graduate students from five academic units: Anthropology, Ecology & Evolutionary Biology (EEB), Epidemiology & Public Health (EPH), Geology & Geophysics (G&G), and Forestry & Environmental Studies (F&ES).

The diversity of research funded by Pilot Grants is amazing. The first two cohorts of 28 students funded in 2002 and 2003 have mostly graduated. Erika Edwards (EEB, Ph.D. 2005) explored the evolutionary origin of cactus life forms and used phylogenetics to study climate change. Erika is an assistant professor at Brown University. Mark Urban (F&ES, Ph.D. 2006) studied the ecology and evolution of amphibian metacommunities and is currently a postdoctoral fellow at the National Center for Ecological Synthesis and Analysis in Santa Barbara, California. Nathan Havill (EEB, Ph.D. 2006) explored the evolutionary history of interactions between adelgids, a major forest pest in eastern North America, and their host plants. Nathan is a scientist working with the USDA Forest Service. Michael Muehlenbein (Anthropology, Ph.D. 2004) studied hormone-mediated trade-offs between the immune and reproductive systems in chimpanzees and is an assistant professor at the University of Wisconsin, Milwaukee. Eric Palkovacs (EEB, Ph.D. 2007) studied feedbacks between ecology and evolution in alewives, important predators in coastal lakes in New England, and their zooplankton prey. Eric is a postdoctoral fellow at the University of Maine.

In 2007, CFE funded 12 graduate student pilot projects. Among them, Meghan Avolio (EEB) is studying how climate change and mycorrhizal associations influence and interact with genetic diversity to determine plant community structure in tallgrass prairie ecosystems. Holly Kindsvater (EEB) is studying maternal investment in live bearing fish in Mexico. Elaine Hooper (F&ES) is testing the effects of forest fragmentation on forest seedling biodiversity in the Brazilian Amazon. Daniel Piotto (F&ES) is studying the spatial dynamics of forest succession in the Atlantic forests of southern Bahia, Brazil. Jean Eric Rakotoarisoa (EEB) is studying the effects of forest fragmentation on the phylogeography of an endemic rodent species in northeastern Madagascar. Jonathan Richardson (F&ES) is testing the role of habitat connectivity and local adaptation on amphibian population persistence. Erik Sperling (G&G) is studying the paleoecology of the Cambrian explosion using high resolution stratigraphy in Siberia.

Hands-on Experience for Undergraduate Students

In 2005, CFE funded the construction of a rainfall exclusion experiment in a coastal salt marsh located at the Richards Property, Guilford (part of the Yale University natural lands). The experiment was designed by Doctors Melinda Smith (EEB) and Peter Raymond (F&ES) to test how climate change affects salt marsh ecosystems. In New England, climate change is expected to change both the absolute amount of, and the variation in precipitation. The rainfall exclusion experiment addresses how reduced precipitation—a source of fresh water inputs—might influence salt marsh productivity and plant community composition. The experiment was integrated into the Field Ecology curriculum (taught jointly by EEB and F&ES) in 2005–2007, and has been used as a platform for senior thesis projects in EEB. The experiment is maintained as a long-term platform for research and teaching in EEB and F&ES.

Yale Natural Lands

Yale University owns natural lands from salt marshes along Long Island Sound to forest land in northern Vermont. CFE administers a number of small parcels of land, including property at Linsley Pond, where Yale researchers and students have studied limnology since the 1930s; Bethany Bog, which is a glacial kettle lake with a unique flora that has lain neglected for years and is under some threat from local dumping; and a tract of about 200 acres next to the Yale Golf Course, which is mostly used by locals for recreation. Linsley Pond is used for research by professors David Post (EEB), Peter Raymond (F&ES) and Gabe Beniot (F&ES), and by Professor David Skelly (F&ES) for teaching aquatic ecology. Currently, the Yale property at Linsley Pond does not provide access to the lake. Researchers and students access the lake from a beach owned by the Linsley Lake Association. In 2007, David Post, Assistant Director of CFE, initiated an effort to improve the teaching and research facilities at Linsley Pond. Construction of a parking area, storage shed, and a dock to improve research and teaching at Linsley Pond should be completed in the summer of 2008.

For further information you may contact Professor Stephen S. Stearns, Director of CFE, Assistant Professor David M. Post, Assistant Director, or visit the CFE Web site at *www.yale.edu/cfe*

LEFT TO RIGHT

A. Annika Walters (EEB) installing an experimental stream diversion at Yale Myers Forest, CT. *Photo by David Post.*

B. Eric Palkovacs (EEB, Ph.D. 2007) on Rogers Lake, CT, holding jars with young-of-the-year alewives. *Photo by David Post.*

C. Manja Holland (FES, Ph.D. 2008) studying the impacts of emerging diseases on amphibian populations.

D. Peter Raymond at twhe rainfall exclusion experiment in a coastal salt marsh located at the Richards Property, Guilford, CT. *Photo by Erika Schielke.*

E. Eric Palkovacs (EEB, Ph.D. 2007), Christopher Dalton (EEB, B.S. 2006), and David Post sampling fish with a purse seine in Linsley Pond, CT.

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The Todai–Yale Initiative and the History of Japanese Scholars at Yale

By Shae Trewin, Collections Manager, Division of Historical Scientific Instruments

Shae Trewin (3)

TOP Dr. Takuji Okamoto of the University of Tokyo studies a thermodynamic surface model reportedly made by James Clerk Maxwell and sent to Josiah Willard Gibbs in 1896.

MIDDLE Dr. Walter Joyce gives the Todai–Yale visitors a tour of the vertebrate paleontology collection.

BOTTOM Dr. Roger Colten shows the anthropology collection to the Todai–Yale visitors.

The Todai-Yale Initiative for Japanese Studies and Related Humanities and Social Sciences was established at Yale in the fall of 2007. Built on several years of collaboration between Yale University and The University of Tokyo (Todai), the initiative is a continuation of Yale's century-old connection with Japanese scholarship.

An inaugural scholar of the Todai–Yale Initiative, Dr. Takuji Okamoto, Associate Professor in the Department of History and Philosophy of Science at Todai, came across the book *Rudiments of Natural Philosophy and Astronomy,* perhaps one of the earliest links between Yale and Japan in science. Written by Yale astronomer and natural historian Denison Olmsted, the book was published at a predecessor institution of Todai in 1866 and shelved in Todai's Komaba Library. One of Olmsted's popular works for noncollege students and teachers, it was reprinted in the United States at least four times.

Dr. Okamoto's work at Yale focuses on documenting Japanese students and scholars, particularly scientists, who studied at Yale in the late 19th and early 20th centuries. An interesting case study is the lesser known Japanese scientist Kimura Shunkichi, a graduate student at Yale in the mid-1880s. Kimura is one of a few students whose dissertations were supervised by Yale's most eminent physicist and polymath Josiah Willard Gibbs. Though largely unnoticed in the United States, Gibbs's theories on statistical mechanics and thermodynamics were intensely followed by British and European physicists such as James Clerk Maxwell and Max Planck. After graduation, Kimura returned to Japan and eventually joined the navy, where he worked on the development and improvement of wireless telecommunication devices. These devices played a significant role in Japan's victory over Russia in the Battle of Tsushima in 1905.

The dissemination of Gibbs's ideas in Japan was also established through his acquaintance with Todai's sixth president, Yamakawa Kenjiro. Awarded his degree in 1875 from the Sheffield Scientific School, Yamakawa was the first Japanese graduate at Yale. Though there is no documentation as to whether Yamakawa was taught by Gibbs, we know that Gibbs sent offprints of his papers to Yamakawa after he returned to Japan. A professor of physics at the Tokyo Imperial University and later at Kyoto, Yamakawa went on to become privy councilor to the Emperor of Japan and a member of the House of Peers with the title of *danshaku* (baron).

The Todai–Yale Initiative organized a one-day workshop on Japanese materials research at Yale. A visiting group of presenters from Todai toured the Yale Peabody Museum and its collections, including the Division of Historical Scientific Instruments. Dr. Okamoto, the appointed keeper of a small collection of historical scientific instruments at Todai, was impressed by the similarity of objects used at both institutions. A more interesting observation, however, was that because Japan had less access to European and American scientific instrument markets, older instrument technology that was considered obsolete at Yale was used successfully for a longer time. The difference between the two collections, therefore, is not necessarily about instruments, but when instruments were retired. The sharing of information and resources between the two collections will further enhance the history of science at Yale and the intellectual exchanges between scholars at Yale and in Japan.

GAYLORD DONNELLEY FELLOW AWARDED AAUW POSTDOCTORAL FELLOWSHIP

The generation of new scientific knowledge and its service to society requires talent, ability, and perspectives from a highly educated and diverse workforce. To meet this demand, it is imperative that every scientist has the opportunity to achieve and contribute in their respective fields. For over 100 years, the American Association of University Women (AAUW) has promoted this mission and advanced equity for women in academia through advocacy, education, and research. Each year the AAUW awards over $4 million in fellowships, grants, and awards to help women achieve their academic goals. Kathleen Prudic, a Gaylord Donnelley Postdoctoral Environmental Fellow, was recently awarded a highly competitive postdoctoral fellowship from AAUW for 2008–2009.

Kathleen has been working as a Gaylord Donnelley Fellow with Professor Antónia Monteiro in the Department of Ecology & Evolutionary Biology (EEB) since October 2007. Their research is an interdisciplinary project to understand the diversity and function of butterfly wing patterns. Specifically, they are investigating the multiple functional roles of butterfly wing eyespots in mating behavior and predator avoidance in the Squinting Brown Bush Butterfly, *Bicyclus anynana*. Kathleen will continue this work with the AAUW fellowship next year. Her previous research done during her doctoral dissertation investigated the sensory ecology of warning coloration and mimicry in insects. Although a graduate of the University of Arizona, the groundwork for her dissertation was done by Professor Charles L. Remington and his students at Yale University. A chapter of her dissertation related to Professor Remington's research was featured on "Quirks and Quarks," a CBC science radio show (*www.cbc.ca/quirks/archives/07-08/feb23.html*) and published in the *Proceedings of the Royal Society B* 275: 1125-1132.

2008 GAYLORD DONNELLEY PRIZE

Each year the faculty in the Program in Environmental Studies awards the Gaylord Donnelley Prize to the author of a distinguished piece of interdisciplinary scholarship in Environmental Studies. The Prize is presented to a senior at commencement. It is funded by an endowment from the Gaylord and Dorothy Donnelley Foundation and the Donnelly Family, in memory of Mr. Gaylord Donnelly, a conservationist dedicated to advances in research and education.

The co-recipients of the Gaylord Donnelley Prize for 2008 are Emily Joy Jack-Scott (B.A. '08, Silliman College) for her senior essay "A Tale of Two Shore Towns: Avalon and Wildwood, NJ" and Anna Liora Johnson (B.A. '08, Silliman College) for her senior essay "Climate Change and Agriculture: Carbon Sequestration in Agricultural Soils."

Emily Jack-Scott examined factors influencing beach maintenance and shoreline protection policies through the comparison of two shore towns in New Jersey, Avalon and Wildwood. The New Jersey shoreline accrues $50 billion in tourism every year, but that industry is contingent on the stabilization of barrier islands along the Atlantic coastline and could be threatened if current projections of sea level rise and storm intensification made by the Intergovernmental Panel on Climate Change are accurate. Through the evaluation of two case studies that represent opposite approaches to beach maintenance practices, Jack-Scott's research suggests that variation in beach maintenance policy across coastal communities are rooted in differences in beach morphology, residential versus commercial development layouts, attitudes of officials and local activists, historical context of storm damage, and lastly outlooks on how beach maintenance encourages economic opportunities. She proposes a framework that lends itself to the assessment of local beach maintenance strategies and contributes to the assessment of both biological and social implications of policy implementation. The categories of this research framework are Geomorphology, Community Involvement and Leadership, History of Development (including residential and commercial property location, and history of storm damages), as well as Local Knowledge and Perception of Threat.

Anna Johnson investigated the carbon sequestration potential of different agricultural systems at the Center for Environmental Farming Systems at North Carolina State University. Due to growing interest in avenues for carbon sequestration to reduce atmospheric CO_2 increase, the potential for soil carbon sequestration through agricultural management practices has received greater attention in recent years. In addition, soil carbon sequestration is unique in that it also provides benefits to soil and crop health. At the Center for Environmental Farming Systems at North Carolina State University, long-term farming systems trials were established in 1998. Six systems were established: two conventional systems, one till and one no-till; an organic system; a crop-pasture system; a woodlot system; and a successional system. Johnson's research explored the carbon sequestration potential of these systems by three factors: the carbon and nitrogen content of first the soil, then of its density fractions, and finally consideration of the rate of microbial respiration. Through her investigations, Johnson suggests that while these systems are able to sequester some carbon and are valuable in their relationship to agricultural health, agricultural practices and soil types are not ideal for maximum carbon sequestration.

Yale Launches Online Environmental Magazine

Yale University and its School of Forestry & Environmental Studies (F&ES) launched an online magazine this spring that aims to become one of the world's leading sites for authoritative, cutting-edge opinion, commentary and in-depth reporting on the major environmental issues of the day.

The Web publication, *Yale Environment 360*, is edited by Roger Cohn, the award-winning former editor of *Mother Jones* and *Audubon* magazines. In announcing Cohn's appointment, Yale President Richard C. Levin said, "The time is right for a global publication that will serve as a forum for provocative writing and thinking on ways to tackle urgent environmental challenges."

The new site (*http://e360.yale.edu/*) publishes articles by scientists, journalists, academics and leaders in the environmental field. It will also present a variety of multimedia content, including videos, slideshows and audio, as well as a daily digest of major environmental news and science from throughout the world.

In its inaugural issues, *Yale Environment 360* features articles from around the globe, including environmental reporting from China, Russia and the Arctic. Among the inaugural contributors are authors Bill McKibben and Elizabeth Kolbert, a staff writer at *The New Yorker*.

"Yale is our home base," said Cohn, "but we are looking out at the world and examining the major environmental issues of the day."

F&ES Dean Gus Speth noted that the magazine is coming online at a moment of unprecedented concern about environmental issues, sparked in large measure by growing evidence of the effects of global warming. That intensifying interest, coupled with the virtual nature of *Yale Environment 360*, has created an opportunity to publish a journal that will appeal to an international audience of policy makers, scientists, journalists, environmental activists and general readers.

"We believe that there is a need for a dynamic web publication, international in its reach, that provides authoritative journalism, sound science and informed opinion and analysis on the environment," said Speth. "*Yale Environment 360* will deliver first-rate reporting and commentary and will help make the science of environmental issues understandable and accessible to a worldwide audience."

The site provides an important connection between the academic community and other communities working on environmental issues, but is written for a general audience. Using F&ES as a springboard, *Yale Environment 360* establishes contacts with academics and environmental experts at universities and organizations around the world, inviting them to contribute to the site. The magazine also seeks contributions from leading thinkers in foreign affairs, international development, "green" business and the environmental movement.

Yale Environment 360 has received the strong support of Dean Speth and President Levin, who see the online publication as an integral part of Yale's effort to become an increasingly international institution and to become known as a leading green university. *Yale Environment 360* is funded by major grants from the William and Flora Hewlett Foundation and the John D. and Catherine T. MacArthur Foundation.

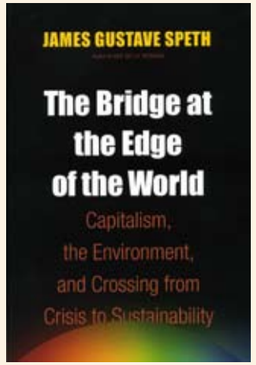
"Yale is working on many fronts to be one of the world's leading green universities," Levin said. "With *Yale Environment 360*, it will move to the forefront of reporting on and finding solutions to the most pressing environmental issues of our time."

Cohn comes to *Yale Environment 360* from a distinguished career in magazine and newspaper journalism, much of it focused on the environment. During his tenure as editor-in-chief at *Mother Jones*, from 1999 to 2005, he revitalized the magazine, focusing on in-depth investigative reporting and top-quality writing. In 2001, *Mother Jones* won the prestigious National Magazine Award for General Excellence. Under his editorship, *Mother Jones*' circulation rose to an all-time high, and the magazine frequently broke stories that received national attention, including an award-winning series on the Bush administration's environmental record.

Prior to that, Cohn was executive editor of *Audubon* from 1991 to 1998, helping lead the magazine during a period when it became nationally known for its cutting-edge environmental reporting. He had previously been a staff writer at *The Philadelphia Inquirer*, where he served as one of the nation's first environmental reporters.

A 1973 graduate of Yale College, Cohn has written widely for numerous publications, including *The New York Times Magazine*, *The Washington Post Magazine* and *Outside* magazine. He has also been a visiting professor at the Graduate School of Journalism at the University of California at Berkeley.

Book Examines Clash of Capitalism and the Environment



The environment will continue to deteriorate so long as today's capitalism continues to be the modern world's economic engine, argues Gus Speth, dean of the Yale School of Forestry & Environmental Studies (F&ES), in his new book, *The Bridge at the Edge of the World: Capitalism, the Environment, and Crossing from Crisis to Sustainability*.

Seeing an "emerging environmental tragedy of unprecedented proportions," Speth says the book's aim is to describe a non-socialist alternative to capitalism. That alternative includes moving to a post-growth society and environmentally honest prices, curbing consumerism with a new ethic of sufficiency, rolling back growing corporate control of American political life, and addressing the enormous economic insecurity of the average person.

"My point of departure is the momentous environmental challenge we face," Speth says. "But today's environmental reality is linked powerfully with other realities, including growing social inequality and neglect and the erosion of democratic governance and popular control." Speth examines how these seemingly separate areas of public concern are intertwined and calls on citizens to mobilize spiritual and political resources for transformative change on all three fronts.

Donald Kennedy, editor-in-chief of *Science*, calls Speth's book, "A powerful and ambitious attempt to characterize the changed strategies that environmental organizations need to adopt to become more effective. This book challenges many things that would seem to have political immunity of a sort—among others, corporate capitalism, the environmental movement itself and the forces of globalization."

Co-founder of the Natural Resources Defense Council and the World Resources Institute and a former White House advisor, Speth has been called "the ultimate insider" by *TIME* magazine. But now, faced with evidence of galloping degradation of the planet, Speth has concluded that "all in all, today's environmentalism has not been succeeding." He calls on environmentalists to "step outside the system and develop a deeper critique of what is going on."

Speth argues that aggregate economic growth is no longer improving the lives of most Americans and suggests that in some ways it is making individuals worse off—environmentally, socially and psychologically. "It is said that growth is good—so good that it is worth all the costs, that somehow we'll be better off," says Speth, "We are substituting economic growth and more consumption for dealing with the real issues—for doing things that would truly make us better off."

The book calls for measures that provide for universal health care and alleviate the devastating effects of mental illness; guarantee good, well-paying jobs and increase employee satisfaction, minimize layoffs and job insecurity and provide for adequate retirement incomes; introduce more family-friendly policies at work, including flextime and easy access to quality child care; and provide individuals with more leisure time for connecting with their families, communities and nature.

"My hope is that all Americans who care about the environment will come to embrace these measures—these hallmarks of a caring community and a good society—as necessary to moving us beyond money to sustainability and community," he says. "Sustaining people, sustaining nature—they are just one cause, inseparable."

Speth writes that gross domestic product (GDP), the dollar value of all goods and services produced by the economy, is a poor gauge of human well-being or welfare. The book cites studies showing that throughout the entire period following World War II, as incomes skyrocketed in the United States and other advanced economies, reported life satisfaction and happiness levels stagnated or even declined slightly.

Speth says that these studies suggest the need for a radical rethinking and reordering of society's priorities. Obsession with consumption and GDP growth now caused more harm—to the environment, social fabric and world security—than good.

It took all of history, Speth notes, to build the $7 trillion world economy of 1950; today, economic activity grows by that amount every decade. At current rates of growth, the world economy will double in size in less than two decades. "Society is facing the possibility of an enormous increase in environmental deterioration, just when we need to move strongly in the opposite direction."

The Bridge at the Edge of the World: Capitalism, the Environment, and Crossing from Crisis to Sustainability is published by Yale University Press (*yalebooks.com*).

PUBLICATION SERIES Yale School of Forestry & Environmental Studies

Diversity and the Future of the U.S. Environmental Movement explores why diversity and properly executed inclusion are critical to the future success of environmental organizations and the wider environmental movement in the United States. This book, conceived and edited by Emily Enderle '07, contains essays by a diverse group of distinguished environmentalists from many sectors, including business, nongovernmental organizations, religion, science, health, journalism and education. It is an inspiring look at how diversity can create value, resiliency and competitive advantage for environmental organizations, large and small.

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