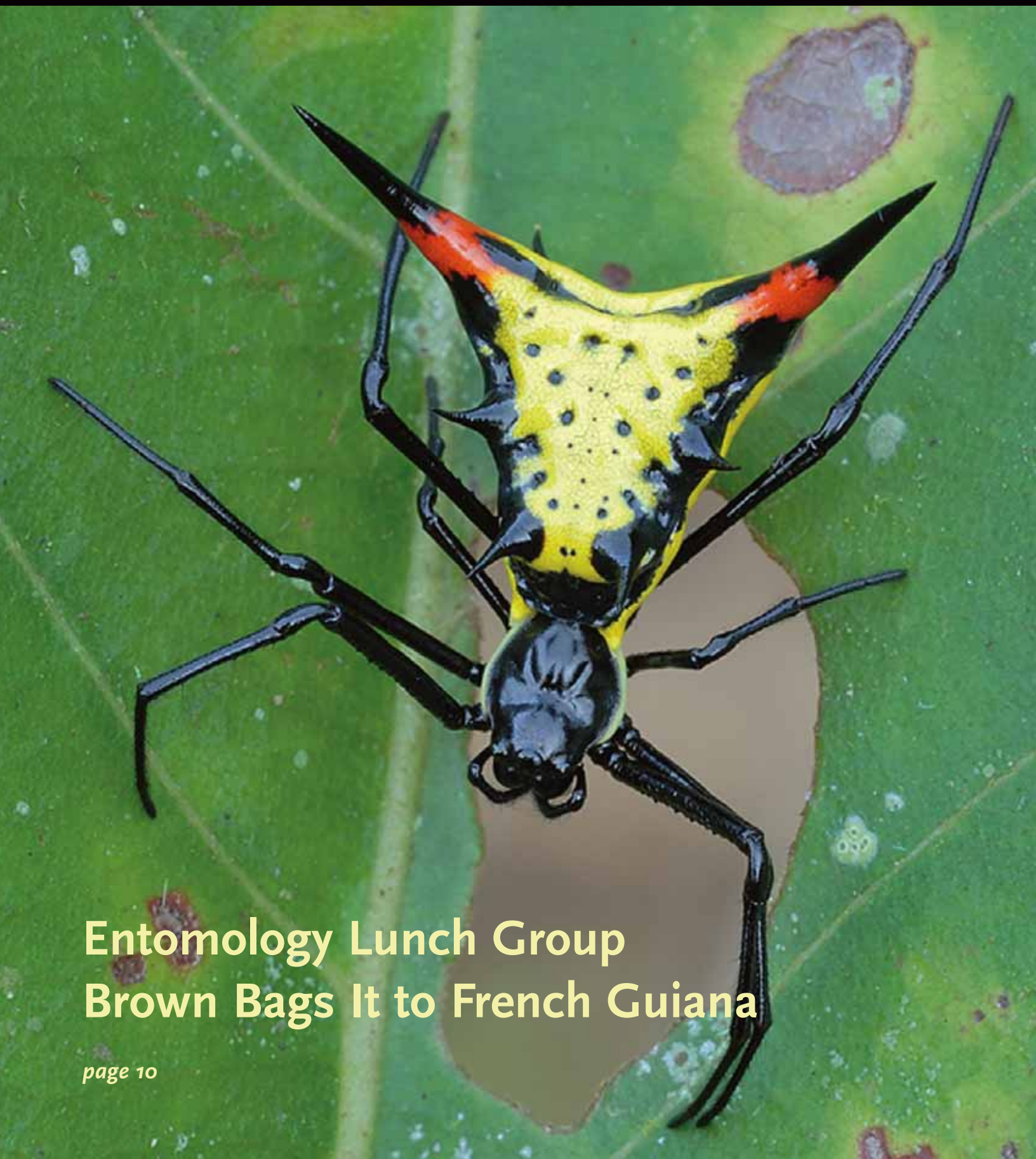
YALE ENVIRONMENTAL NEWS

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

spring 2012 · vol. 17, no. 2



Entomology Lunch Group Brown Bags It to French Guiana

page 10

FROM THE DIRECTOR

CONFERENCES, SEMINARS, SYMPOSIA

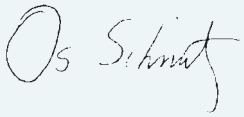
Changing Times: Changing Approaches

It is that time of year again, to produce the second issue of the *Yale Environmental News* (YEN). For the last 17 years, YEN has provided reliable, in-depth insight about all activities related to the environment at Yale, and our readership has come to anticipate receiving this magazine in the mail semi-annually.

Yet, the production of the magazine demands paper, and paper production has a considerable environmental footprint due to natural resource extraction, energy demand and pollution. In keeping with Yale University's efforts to become more environmentally conscious and sustainable, we have decided to migrate YEN to on-line web-based production.

Apart from reducing the environmental footprint, a web-based format allows us to provide a more dynamic way to present information, including more frequent and hence timely presentation of breaking findings, the ability to link stories to other background contextual information at Yale and elsewhere, and offer live discussions and interviews through video. It will also foster the use of new social media as part of the outreach, including the opportunity for the readership to participate in an on-line discussions and commentary about Yale's environmental activities.

We are excited about the host of new creative opportunities that this shift in publication medium will present. Even though it is a change, I want to assure the readership that they can still count on the YEN to maintain its tradition of producing high quality, visually compelling stories and information about the environment. We will send a postcard to inform you that the fall 2012 issue is online. If you wish to receive this information for future issues, please send your email address to roserita.riccitelli@yale.edu and we will add you to an ongoing email distribution list.



YIBS/ESC AND YCEI FRIDAY NOON SEMINARS

The Yale Institute for Biospheric Studies continues its tradition of presenting environmental interdisciplinary seminars during the fall and spring semesters. Speakers and their topics during the spring 2012 semester were:

Walter Jetz, Professor, Yale Department of Ecology & Evolutionary Biology: *Inferring Species Extinction Risk from Spatial, Environmental and Phylogenetic Information* ■ **Dame Alison Richard**, Professor Emeritus of Anthropology and Franklin Muzzy Crosby Professor of the Human Environment, Yale Department of Anthropology, former Provost of Yale University and former Vice-Chancellor, University of Cambridge: *Science in the Service of Conservation: A Case Study from Southwest Madagascar* ■ **Arne Mooers,** Professor of Biodiversity, Simon Fraser University and Edward P. Bass Distinguished Visiting Environmental Scholar in the Yale Department of Ecology & Evolutionary Biology: *(How) Might Phylogenetics Inform Conservation Biology?* ■ **Maria McNamara,** Postdoctoral Fellow, Yale Department of Geology & Geophysics: *Ancient Insects in Technicolor: The Preservation and Evolution of Insect Structural Colors* ■ **David Skelly**, Professor, Yale School of Forestry & Environmental Studies: Special YIBS Director's Vision Seminar*: How to Advance the Field of Science—Experimental Macroecology* ■ **Michael Bender**, Professor of Geosciences, Princeton University, and Yale Department of Geology & Geophysics Flint Lecturer: *The Influence of Light on Phytoplankton Productivity in the Southern Ocean, with Comments about Glacial/Interglacial CO_2 Cycles* ■ **Scott Wing**, Research Scientist and Curator, Department of Paleobiology, Smithsonian Institution and Edward P. Bass Distinguished Visiting Environmental Scholar, Yale Department of Geology & Geophysics: *Global Warming 56 Million Years Ago—Is Earth History Important to the Human Future?* ■ **Michael Donoghue**, G. Evelyn Hutchinson Professor of Ecology & Evolutionary Biology, Yale Department of Ecology & Evolutionary Biology: Special YIBS Director's Vision Seminar on How to Advance the Field of Science*: Nothing in Evolution Makes Sense Except in Light of Biology* ■ **Nicholas Longrich**, YIBS Postdoctoral Associate, Yale Department of Geology & Geophysics: *Beyond the Extinction of the Dinosaurs: Evidence For Mass Extinction Among Birds and Lizards 65 Million Years Ago* ■ **Dan Rosauer**, Gaylord Donnelley Environmental Postdoctoral Associate, Yale Department of Ecology & Evolutionary Biology: *The Global Mammal Radiation—Phylogeny, Endemism and Conservation*.

For a list of seminars and speakers for fall 2012, please visit *www.yale.edu/yibs/events_yibsesc.html*

YIBS PROGRAM FOR THE STUDY OF GLOBAL CHANGE SPRING 2012 SEMINARS

The Yale Institute for Biospheric Studies Program on the Study of Global Change presented its Global Change Seminar Series during the spring 2012 semester. The focus of the spring talks was Climate and Precipitation: Past, Present and Future Perspectives, and the speakers and their topics were:

DONNELLEY AND YIBS POSTDOCTORAL NEWS

Stephen J. Burns, Professor, University of Massachusetts, Amherst, Department of Geosciences: *Speleothem Records of the South American Summer Monsoon over the Past Two Glacial Cycles—Tropical and Extratropical Connections* ■ **Peter deMenocal**, Professor, Columbia University Lamont-Doherty Earth Observatory and Department of Earth and Environmental Sciences: *Green Sahara: Holocene Climate and Life in North Africa* ■ **David Noone**, Professor, University of Colorado and the Cooperative Institute for Research in Environmental Sciences: *Using Isotope Geochemistry to Track the Water Cycles of the Past, Present and Future* ■ **William Boos**, Assistant Professor, Yale Department of Geology & Geophysics: *Are Most Predictions of Twenty first Century Monsoon Rainfall Wrong?* ■ **Ron Smith**, Professor, Yale Department of Geology & Geophysics: *Orographic precipitation and Stable Isotope Gradients Across the Sierra Nevada and Other Mountain Ranges* ■ **Michael Bender**, Professor of Geosciences, Princeton University and Yale Department of Geology & Geophysics Flint Lecturer presented Flint Lectures: *Pleistocene Climate Events Recorded in Ice Cores; Chemical Fluxes Associated with Sea Floor Hydrothermal Processes and their Relevance to Calcite/Aragonite Seas,* and *The Influence of Light on Phytoplankton Productivity in the Southern Ocean, with Comments about Glacial/ Interglacial CO_2 Cycles* ■ **Jessica Tierney**, Postdoctoral Research Fellow, Columbia University Lamont-Doherty Earth Observatory: *Indo-Pacific Paleoclimate: Lessons from East Africa* ■ **Peter Raymond**, Professor of Ecosystem Ecology, Yale School of Forestry & Environmental Studies: *Climate Versus Land-use Controls on Inorganic Carbon Export from the Mississippi* ■ **Gabriel Bowen**, Associate Professor at Purdue University College of Science: *Water Redistribution in a Warming World: Insight from Isoscapes in the Early Paleogene and Late 20th Century* ■ **Paul O'Gorman**, Victor P. Starr Assistant Professor of Atmospheric Science, Massachusetts Institute of Technology: *Response of Mean and Extreme Precipitation to Climate Change: Theory, Simulations, and Observation*.


MESSINGER


MIDDLETON


NUGENT


OGBURN

Four Gaylord Donnelley Environmental Postdoctoral Associates Appointed

YIBS Director Oswald Schmitz is pleased to announce the appointment of four new Gaylord Donnelley Postdoctoral Associates who will serve for two years beginning in the summer/fall of 2012.

Dr. Susanna Messinger, who received her PhD from the Department of Ecology & Evolutionary Biology at the University of Michigan, will join the Yale Department of Ecology & Evolutionary Biology on July 1, 2012 as a Gaylord Donnelley Environmental Postdoctoral Associate. Her dissertation topic was "Space: The Final Frontier of Predator Evolution?" While at Yale, Dr. Messinger will work with Assistant Professor David Vasseur on research to understand the evolutionary influence of spatial structure on predator-prey population dynamics and ultimately on the structure and stability of complex communities.

Arthur Middleton, who will earn his PhD from the Program in Ecology at the University of Wyoming this summer, will join the Yale School of Forestry & Environmental Studies (F&ES) on September 1, 2012 as a Gaylord Donnelley Environmental Postdoctoral Associate. Mr. Middleton, who will work with Professor David Skelly, is conducting research on the responses of large herbivores to the risk of predation. While at F&ES, he will continue his research on wolves and elk in the Greater Yellowstone Ecosystem and initiate new work on puma-camelid-condor interactions in northwestern Argentina, and mule deer responses to energy development in Wyoming.

Dr. Bridget Nugent received her PhD in neuroscience from the University of Maryland School of Medicine and will join the Yale Department of Ecology & Evolutionary Biology on August 1, 2012 as a Gaylord Donnelley Postdoctoral Associate under the mentorship of Assistant Professor Suzanne Alonzo. Dr. Nugent's previous work on the biological basis of sex differences in the brain uncovered the importance of epigenetic processes in the establishment and maintenance of masculinized and feminized neural phenotypes. Her work with Dr. Alonzo will focus on understanding phenotypic variation in a wild population of teleost fish, the ocellated wrasse. Male ocellated wrasses display marked differences in physical phenotype and reproductive strategy, and may alter their phenotype based on social or environmental cues. By investigating the hormonal, genetic, and epigenetic differences in the brains of these animals, Dr. Nugent aims to understand the proximate mechanisms that give rise to variation within a wild population and thereby provide a substrate for selection and diversification. In addition, uncovering the origins of biodiversity in this species will broaden our collective understanding of phenotypic variation and the use of alternative reproductive tactics in other organisms through comparative studies.

Matthew Ogburn, who will be earning his PhD from Brown University in ecology & evolutionary biology this summer, will join the Yale Department of Ecology & Evolutionary Biology on September 1, 2012 as a Gaylord Donnelley Environmental Postdoctoral Associate. His dissertation topic is "Drivers and Consequences of the Evolution of Succulence in the Plant Clade Portulacineae." While at Yale, Mr. Ogburn will work with Sterling Professor Michael Donoghue on research on community assembly, niche evolution and the future of alpine plant communities.

"We need to make sure that we recruit the best students, give them a really good experience while they're here that gives them the skills they need, and then we need to make sure that we send them on their way with the best possible chance of securing a leadership position that will enable them to maximize their influence."

In Conversation: Sir Peter Crane

By Eric Gershon, Sr., Communications Office, Yale Office of Public Affairs and Communications

Evolutionary biologist Sir Peter Crane has been dean of the Yale School of Forestry & Environmental Studies (F&ES) since 2009. A former director of Chicago's Field Museum and chief executive of England's Royal Botanic Gardens, Kew, he recently spoke with Yale News about F&ES's internationalism, the role of business in environmental management, and what it was like to be knighted at Buckingham Palace, among other topics. The following is an edited version of that conversation.

What do you most like telling people about F&ES?

The thing that really sparkles about this school is the student body. I'm reviewing applications for our incoming class right now. When you look at those applications, you realize these are incredibly talented people. They've often been out in the world doing something directly related to the environment. Some have been in the Peace Corps, some have been in the State Department, some on Wall Street, some working with the Nature Conservancy in this country or with the World Wildlife Fund around the world. They bring a lot to the table. What I tell students is that they're going to have a fantastic experience here. They're going to learn a lot from the faculty, but they're also going to learn a lot from each other.

The environment has no boundaries. How does F&ES reflect that?

My predecessor [former dean J. Gustave Speth] really consolidated the view that forestry and environmental studies at Yale has to be an international school, and that is also consistent with Yale's strong international emphasis. I'm an internationalist myself. I'm from the United Kingdom. I've worked in the States, and I've been fortunate to travel all over the world. So I understand the importance of an international perspective. There are two major impediments that often get in the way of dealing effectively with environmental issues. One is an inability to project into the future, to think beyond an election term and imagine about what the world is going to be like in 10 years' time or 50 years, or 100 years. The other is a lack of breadth, an inability to see the whole picture. Having an international perspective

helps provide that breadth. About a quarter to a third of our students in any given year are international, and they come from everywhere, though I'd like to see more students from Africa and from other parts of the world that so far are underrepresented.

What are some of the changes you've been making at F&ES?

We've made many changes, but in particular we have taken a good look at the curriculum. We've tried to make it more efficient and more flexible. Our students have the privilege of enormous freedom, and with that privilege comes the responsibility of figuring out how they might navigate through the 130-odd courses that we offer in any given year. We've also begun to establish more interdisciplinary courses. We're very interested in reaching the broader Yale community. There's also huge interest in environmental issues among the undergraduate student body, and we need to respond to that. For the general undergraduate population, it would be great if they all took even just one really good environmental course. Then, when they go on to be President, they'll at least have that in their background.

Where would you say F&ES is heading?

I don't think there's any doubt that we are one of the preeminent, if not the preeminent, environment schools in the country. There are four things we need to focus on, and they're pretty simple. We need to make sure that we recruit the best students, give them a really good experience while they're here that gives them the skills they need, and then we need to make sure that we send them on their way with the best possible chance of securing a leadership position that will enable them to maximize their influence. In order to accomplish these things and to maintain our reputation, the fourth priority is to be sure the research done in this school is of the very highest quality, because from that research, I think, comes our reputation. And from that reputation will come the resources to support the growth of the school.

Could you elaborate further?

From the standpoint of our research reputation there are really three things we need to do: One is what I call secure the base - we've got a long history in ecology and forestry. I don't think that our commitment to these areas will ever waver. Our focus will always stay on terrestrial systems. We want to make sure we stay strong in this area and that we stay true to our 100-year history. At the same time, we need to look at a couple of other areas that will round out the current portfolio of expertise within the school.

For one—particularly with Dean Ted Snyder's arrival at the Yale School of Management—and given the fact that we have a 30-year history of a joint degree with SOM—we need to do more on the business and environment front. Obviously there are many actors in the environmental arena, but a key group of actors is business. And businesses look at the environment in many ways beyond the natural resources they consume. They have to deal with it in terms of their license to operate, and they also see business opportunities in responding to environmental concerns. So business and the environment is an important area for us in the future.

And then, with respect to stewardship of the land, there has been much recent talk about the urbanizing global population, a population that's moving from rural areas into the cities. We can't hope to establish from the ground up a massive new cities program, but we do need to make sure that we have more expertise in that area, and related areas like industrial sustainability, than we currently do. Energy is another huge issue of great importance. We want to be sure that we're providing our students with the kind of background and training in energy and the environment that they will need in their future careers.

What are some of the interesting interdisciplinary questions people are asking at F&ES these days?

I think that just about every environmental issue has a strong interdisciplinary component and all our faculty grapple with the interdisciplinary implications of their work at some level. That usually means looking beyond the numbers and dealing with the way people think and feel about complicated issues. For example, we had a seminar recently from a researcher looking at the complexities around the siting of energy facilities. Where do you decide to put a wind turbine? A liquid natural gas facility? A new nuclear plant? These kinds of questions relate not just to the ideal of planning solutions, but to sociology and how people interact with these facilities in and around the places where they live. And these kinds of social issues come to the fore prominently in urban systems, which are an especially important for us in the future.

Are there aspects of the environment that you believe are understudied, and if so, what might be done about it?

There are several challenges, and they're interrelated, of course. A big struggle for our discipline is how you train our students to think in an interdisciplinary way. And this is particularly an issue in a university, which typically values depth over breadth. A second key area, as I mentioned before, is the need to think long-term. Short term always trumps the long term. And we've just seen this recently, for example—"We must get rid of the EPA because they're job killers." So I think that's a very important area. Another area is global governance and how we will deal in a sensible, collective way with fragmented and weak systems of international governance.

Are there some interdisciplinary collaborations that F&ES is part of that you consider especially promising?

We play a pretty active role in the Yale Climate & Energy Institute. And I think one of the things that's been really effective about YCEI has been the way it has brought together faculty not just from F&ES, but also from chemistry, from geology and geophysics, from law, and so on. Making those connections across institutional boundaries within Yale is really, really important. As another example, we have a promising new initiative focused on the Himalayas, addressing the interconnections among environment, livelihoods and cultures. At its core this has a strong collaboration between F&ES and anthropology, but also includes folks in several other departments, for example religious studies, who have active interests in the Himalayas for one reason or another.

Let's turn to your work for a moment. You're an expert on plant life. Tell us more about your research.

One of the things about my career has been that I've worked on a range of different plant groups and been interested in lots of different plants. I'm finishing a little book on Ginkgo, a plant we all know that's becoming an increasingly common sight in urban landscapes. It's among the most common street trees in Manhattan, for example. But it is also a plant which almost went extinct, not because of human causes, but because of environmental changes at the end of the last glaciation. In a sense the Ginkgo is an antidote to the more common extinction narrative—it is a tree that has been rescued by people. So I treat its story as a biography that ends on a hopeful note.

In 2004 you were knighted for your services to horticulture and conservation. What was that like?

Recognition at that level is obviously a huge honor and a wonderful experience. The day itself involves a formal ceremony at Buckingham Palace, which is shared with many wonderful people who have contributed to society in many different ways, from working as a midwife in deprived areas of London to serving the British government overseas to playing soccer, or whatever. Everyone who gets one of the awards—whether it is a knighthood or some other honor—attends the ceremony and has a few private moments with either the queen or, in my case, Prince Charles. In the case of knighthood they still do the kneeling and the sword—which, with everyone looking on, and a slight touch of nerves, is a lot more complicated than it looks.

Professor Ronald Smith Wins Teaching Prize

Ronald B. Smith, the Damon Wells Professor of Geology & Geophysics and professor of mechanical engineering was recently awarded The Harwood F. Byrnes/Richard B. Sewall Teaching Prize. This award was celebrated at a reception hosted by Yale College Dean Mary E. Miller and was designated by the Yale College Committee on Teaching, Learning and Advising, chaired by Karen Wynn, professor of psychology, based on student nominations.

In an interview conducted by Susan Gonzalez, associate editor of Yale Daily Bulletin, *Susan reported that Professor Smith teaches his students that Nature is more than just beauty. He has learned firsthand that events such as hurricanes and thunderstorms are more than just mysterious occurrences. Smith has flown in an airplane through all kinds and speeds of wind, studying the details of such atmospheric conditions. He tells his students that as mysterious as nature can be, it is within their power to understand it scientifically, and to do so is an exciting adventure.*

The following is an edited version of the conversation Professor Smith had with Susan about his teaching at Yale.

What do you most enjoy about teaching at Yale?
I enjoy teaching at Yale primarily because of the type of students we get here. Yale students are very ambitious. They do their work; they are interested; they respond to the ideas that you put before them. That's the thing that perhaps has allowed me to change as a teacher: getting all that feedback from the students.

If they weren't doing the work or they weren't interested or they weren't ambitious, then teaching would be kind of a one-way enterprise, where I'd be talking to them and that would be the end of the story. But Yale students talk back, and so over the years I've learned a bit from them about what makes sense, what they're interested in, and what's important. Their feedback has been essential for that and it all comes from their attitude of wanting to learn.

What have your students taught you?
I think my students have taught me how to form a logical argument. I've also learned that students learn in different ways. Some students have one channel where they learn, but other students have a different channel. Over the years I've learned how to put things in a way that different students can understand. So this goes beyond just teaching: It's how people understand new material or new things. Students, in the way they learn or fail to learn, have taught me how to present ideas in a way that is understandable to people. That's something you just learn from teaching; there's no book that can do that. You have to teach and get feedback from students.

Do you have a teacher who particularly inspired you?
I've had good teachers over the years. I think, though, that [my own interest in science] goes back to high school. I had a teacher whose name I've forgotten, but I'll never forget him because he was a good physics teacher. One day he asked me if I would help set up some in-class demonstrations, getting things cooking on the tabletop, some physics experiments, and I was totally into that. At the end of that semester I was in love with physics simply because he gave me that chance to show what I could do.

But more than that, he set up things that everybody could identify with. So today, I try to do that in my teaching. I like nothing better than to set up some crazy desktop experiment. In my introductory course I set up a cloud in a chamber. I love that, and students love that.

When I first came to Yale in this department, Brian Skinner was teaching his introductory course and doing that in a very successful way. So I didn't take courses from him but I used to peek in on his lectures and see what he did, and that was an inspiration, too. So a lot of people have contributed to my teaching.

If there is one thing you want your students to learn, what would it be?
I want my students to have the feeling that understanding nature is within their grasp. I

think for many people, nature is out there and they enjoy it and value it, but they don't think they could ever understand it. I want my students to know that they can understand nature.

I tell my students that there are three ways they can learn to understand nature. When they are out of doors—instead of just putting in their iPod when they are walking down the street—look around. Look at the clouds, the atmosphere. See which way the wind is blowing; see what the water is doing if you are by the shore. Develop that habit of observation. When you are flying, get a window seat. Look out the window. So observe, observe, observe.

The second thing is to quantify. Don't just take what you observe as some beautiful phenomena but try to imagine: Is it important? Is it less important? How much water is evaporating? How strong is the wind blowing? What fraction of the sky is covered by clouds? Try to make it a bit of a quantified experience.

And the third one is to try to ask "why." Why does that phenomena happen? Why is that cloud there? Why is the wind today blowing from the west, but yesterday it was blowing from the south? So if they could learn to observe, to quantify and to ask why, then I'd be successful as a teacher.

Do you have a memorable classroom moment you'd like to share?

Years and years ago I had an experience that sticks with me. It has to do, again, with the different way students learn. I had a student attend my class who had no sight, and like most of us, I imagined that visual learning is the main way we learn things. But this young woman ended up being the number-one student in my class that year and had no sight. And so that taught me something. There are many ways we learn, and the way you and I learn may not be the way someone else learns.

I still remember being sort of shocked at that and made the mistake perhaps of wondering whether the student could do that work, but of course she had been through this before. She knew she could do the work, and after a few weeks I knew she could do the work, too. But it took me a little time to realize someone could learn in a different way.

I had students work on weather maps, and she did that with Braille. In class, she had no trouble whatsoever. I could show a movie, and she would understand what was going on better than other kids!

Yale Professor Receives Monaco Award

By David DeFusco, Director of Media Relations and Outreach; Editor, Environment:Yale

Michelle Bell at the Yale School of Forestry & Environmental Studies (F&ES) and Department of Chemical and Environmental Engineering, and an expert on the environment and human health, has received the inaugural Prince Albert II de Monaco/Institut Pasteur Award for outstanding contributions to her field.

Dr. Bell, professor of environmental health at F&ES, was honored by the Institut Pasteur and the Prince Albert II of Monaco Foundation at a scientific symposium on environmental changes and their impact on human health on March 23, 2012 in Monaco.

Prince Albert II of Monaco and the Institut Pasteur, a nonprofit research center in Paris dedicated to the prevention and treatment of disease, established the award to honor scientists for their study of how environmental conditions affect public health.

"We are very delighted by this recognition of Michelle and her research, which reflects well on the strength and diversity of work at F&ES," said Dean Peter Crane. "It also extremely gratifying that the Monaco Award recognizes not only the excellence of Michelle's research, but its great practical importance for public health and environmental policy."

Dr. Bell joined Yale in 2004 and became a professor in 2011. Her research investigates how air pollution and extreme weather contribute to mortality and affect health outcomes such as pregnancy, and how climate change could affect human health. Her work integrates epidemiology, atmospheric sciences, environmental engineering and biostatistics, and is global, with studies in the United States, Europe, Asia and South America.

Dr. Bell has conducted several landmark studies of environmental health. In 2004 she led the largest study to date of the health effects of tropospheric ozone, establishing a clear link between ozone and premature mortality in 95 large U.S. communities covering about 40% of the U.S. population over a 14-year period. The study was published in the Journal of the American Medical Association.

In one of the earliest and largest studies on climate change and air pollution, she estimated changes in ozone levels and the subsequent health response under climate change for 50 U.S. cities by linking air quality, meteorological and climate change models.

Dr. Bell has published 70 peer-reviewed publications and has received other prestigious awards, including the National Institutes of Health's Outstanding New Environmental Scientist Award in 2006 and the Health Effects Institute's Rosenblith Award in 2004.

The US Environmental Protection Agency, the World Health Organization and regional environmental agencies have used her results in establishing health-based policies for air pollution, including particulate matter, ozone and carbon monoxide.

"I strive for research that is relevant to the medical community and policymakers, and that helps address real-world environmental problems," she said.

YALE PEABODY MUSEUM OF NATURAL HISTORY

EVENTS

BIG FOOD: HEALTH, CULTURE AND THE EVOLUTION OF EATING

On view through December 2, 2012

This wide-ranging exhibition on the food challenges of the 21st century also looks at our changing eating habits and alarming levels of obesity. Using an engaging multimedia and family-friendly approach, visitors will explore topics as diverse as the neuroscience of appetite, human origins as hunter-gatherers, media influences on food preferences, and the serious health consequences associated with obesity.

This exhibition is presented by the Yale Peabody Museum in collaboration with CARE (Community Alliance for Research and Engagement) and the Rudd Center for Food Policy and Obesity. The presenting sponsor is Anthem Blue Cross and Blue Shield Foundation.

PEABODY SUMMER YOUTH PROGRAMS

July and August 2012

Summer youth camps can provide countless enriching and memorable experiences for children. Week-long camps at the Yale Peabody Museum and at Yale's West Campus for students entering 1st to 9th grade provide fun and learning about natural history and cultural history—topics such as biodiversity, astronomy, natural science drawing, ancient survival skills, ancient cultures and archaeology—in a relaxed setting, through engaging hands-on experiences and YPM's world-class collections and exhibits.

FIESTA LATINA!

October 13, 2012

Join us for our annual celebration of Latin American cultures! Enjoy performances of traditional and contemporary Latin American music and dance, along with games, crafts and storytelling for the whole family.

PALEO-KNOWLEDGE BOWL

November 11, 2012

In this annual competition, teams of students in grades 4, 5 and 6 from around Connecticut and beyond answer some very difficult questions about paleontology, especially dinosaurs. Each year this unique contest receives rave reviews from teachers, parents and students. This is a n excellent opportunity for students with an interest in science to team up with their schoolmates and be rewarded for what they know! Visit our website for details.

Information and updates at (203) 432-5050 and *http://peabody.yale.edu*

Relics: Travels in Nature's Time Machine

September 20–21, 2012

What would you rather save from extinction: three different species of parrots, or a hummingbird, an owl, and a parrot? With increasing frequency, such heartbreaking choices are becoming the reality in nature conservation. Given limited resources, conservation biologists face the need to select the targets of their conservation campaigns very carefully. Rather than trying to protect every single species on Earth, they now try to save representatives of as many distinct and diverse evolutionary lines as possible, and the easiest way to find such diversity is to look at the survivors of the oldest lineages of life.

This theme will be explored in two talks at Yale by entomologist and conservation biologist Dr. Piotr Naskrecki. On September 20, 2012, the Yale Peabody Museum of Natural History will host an evening presentation by Dr. Naskrecki as part of its John H. Ostrom Program Series. The second talk, on September 21, is a YIBS/ESC Friday Noon Seminar, sponsored by the Yale Institute for Biospheric Studies. The presentations, based on Dr. Naskrecki's latest book *Relics: Travels in Nature's Time Machine* (University of Chicago Press, 2011), will discuss some of the oldest surviving groups of animals and plants, examining ancient organisms as they carry through and continue to exist in ecosystems of the globe today. Dr. Naskrecki argues for their increased conservation, while taking readers on a journey around the world to places that are windows to our old, beautiful planet's past.

Author and photographer Piotr Naskrecki is a research associate with the Museum of Comparative Zoology at Harvard University and an entomologist and conservation biologist. He served as past Director of Invertebrate Diversity Initiative with Conservation International and is one of the founding members of the International League of

Piotr Naskrecki (2)

Conservation Photographers. He received his PhD in entomology from the University of Connecticut, and his publications, both technical and popular, strive to promote appreciation and conservation of invertebrate animals. Dr. Piotr's field research, which deals mostly with the behavior and biology of singing insects, has taken him to six continents and often to areas rarely, if ever, visited by other biologists.

For times, locations and updated information on these talks, please visit *http://peabody.yale.edu/events/* and *www.yale.edu/yibs/events_yibsesc.html* closer to the event date.

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Ammonites, Indian Wars and the Exploration of the American West

By Neil H. Landman (PhD Yale '82), Curator, Division of Paleontology (Invertebrates), American Museum of Natural History, and Copeland MacClintock, Division of Invertebrate Paleontology, Peabody Museum of Natural History

Contained within the collections of the Yale Peabody Museum of Natural History (YPM) is a fossil invertebrate that, although scientifically unimpressive, owes its uniqueness to its connection to one of the most historically charged episodes in American history, the Battle of the Little Bighorn, commonly known as "Custer's Last Stand."

The fossil is an ammonite, a kind of mollusc that flourished in the Cretaceous seas that once covered parts of South Dakota and Montana. The specimen, 12 inches (30 centimeters) in diameter and weighing more than 13 pounds (nearly 6 kilograms), is partly broken. When complete, it would have been twice as large. Its intricate patterns, known as sutures, represent the marginal plications of the septal partitions that subdivide the ammonite shell into chambers. The specimen belongs to the species *Placenticeras meeki*, named in honor of the American paleontologist Fielding B. Meek. According to the YPM accession record (no. 881) and the original specimen label, the fossil was "collected and donated by General John Gibbon" (a similar specimen is shown here for comparison).

General John Gibbon was one of the principals of the Battle of the Little Bighorn. A letter to Professor O.C. Marsh at Yale College accompanies the fossil:

A fossil from the Yellowstone River with the compliments of Genl. Gibbon for Prof. Marsh. It may not be much of a curiosity, but Genl. Gibbon wishes Prof. M. was here to decide that question for himself & make his own selections from tons upon tons of such thing[s] which are found here.

J.G.
Camp Mouth of Big Horn
July 16th 1876
(From Yale Library Manuscripts & Archives)

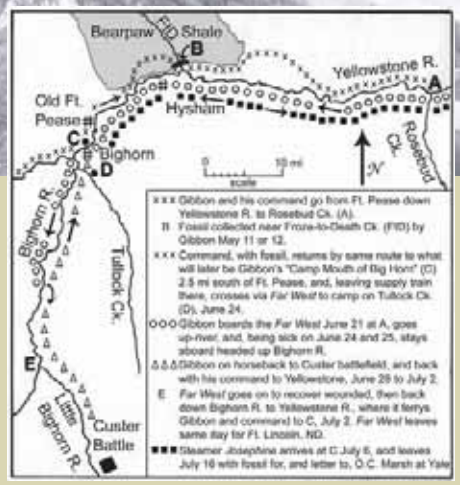
What is the story behind this ammonite? In the countless tellings and retellings of the Battle of the Little Bighorn, no one has ever mentioned an ammonite. How does it fit into the events leading up to the historic battle? Where and when did Gibbon acquire it?

In 1876, John Gibbon was in charge of the US Infantry at Fort Shaw in the Montana Territory near present-day Great Falls. He commanded the Montana Column, consisting of about 450 men, one of the two commands involved in the Battle of the Little Bighorn. According to the battle plan drawn up on June 21, 1876, General George Custer, in charge of General Alfred Terry's command, and Major Marcus Reno would approach the Little Bighorn from the south. General Gibbon, accompanied by General Terry himself, would approach from the north, with all groups converging on June 26 or 27 (*Adventures on the Western Frontier*, Major General John Gibbon, Alan Gaff and Maureen Gaff, eds. Bloomington, Indiana University Press, 1994). On the eve of June 24, Gibbon was sick aboard the steamer *Far West* anchored near the mouth of the Bighorn River. His men were camped nearby on Tullock Creek near the present-day town of Bighorn, three days' march from the battlefield. In the meantime, Custer, believing that the Cheyenne and Sioux had discovered his presence, launched his ill-fated surprise attack shortly after noon on June 25. When Gibbon arrived at the bloody scene on June 27, Custer's soldiers were already decimated, but Gibbon helped save the lives of many of Major Reno's troops. Gibbon and his men buried the dead and carried the wounded down to the *Far West*, which had made its way up the Bighorn River to the mouth of the Little Bighorn. They then retraced their route back to the awaiting supply train located at what Gibbon would later call "Camp Mouth of Big Horn" in his July 16 letter to Marsh.

In the context of this chronology, where and when did Gibbon acquire the ammonite? Figuring out the "where" necessitates some paleontological sleuthing using the geological map of Montana. A rock formation known as the Bearpaw Shale is exposed on both sides of the Yellowstone River at four different places within 100 miles (about 160 kilometers) of the Bighorn River along Gibbon's march route. This formation consists of marine strata that were deposited in a shallow seaway that covered Montana and other parts of the northern Great Plains about 70 million years ago. Paleontological investigations by many

A Weathered specimen of *Placenticeras meeki* (YPM IP037069), collected and donated by General John Gibbon. A. Detail of suture. B. Detail of nacre. Photo: Steve Thurston

B Another specimen of *Placenticeras meeki* (YPM IP032456), for comparison. This one is from the Pierre Shale at Sage Creek, South Dakota. Photo: Jessica Utrup



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geologists, including our own research, show that this formation contains an abundance of fossils, the most conspicuous of which are ammonites like Placenticeras meeki. Thus, in a general sense, the most likely source of Gibbon's ammonite is the Bearpaw Shale. But is it possible to be any more specific than that?

Without the guidance of any original journals by Gibbon, which are not known to exist, it is difficult to answer this question. However, the next best source is the journal of Edward McClernand, Gibbon's engineer officer, whose journal was compiled from his notes and published posthumously in 1969 (*With the Indian and the Buffalo in Montana, 1870–1878, with "Journal of Marches under Colonel John Gibbon, April 1 to September 29, 1876,"* E.J. McClernand, The Arthur H. Clark Co., Glendale, CA.). He made the following entry for May 12, 1876, while on the march down the Yellowstone:

Starting at 7:20 a.m., a few minuted march brings us to "Froze-to-Death Creek,".... There is but little water in it, and that is poor; it has a narrow bottom, in which there is some timber. On each side are "bad lands," containing many fossils, mostly mussels.

(*Adventures on the Western Frontier*, pp. 136–137.)

This entry suggests that Gibbon collected the ammonite on the north side of the Yellowstone River near the mouth of Froze-to-Death Creek on May 11 or 12 near the present-day town of Hysham. Not knowing where his command would be taking him in the future, Gibbon would not have missed the opportunity to collect this specimen from among the "tons upon tons of such things" that he saw there. Thus, the specimen would have been acquired more than a month before the Battle of the Little Bighorn but only shipped home several weeks afterward. On the morning of July 16, Gibbon put the ammonite, packed with the accompanying letter, onboard the steamer *Josephine*, which was anchored at "Camp Mouth of Big Horn," and sent it downriver bound for New Haven.

Gibbon wrote a follow-up letter to Marsh one year later inquiring about the disposition of the ammonite:

Ft. Shaw, M.T.
May 3? 1877

My dear Professor:

Last summer whilst on the Yellowstone I shipped you two small boxes of fossils, sending them down the river with directions to forward them from Bismarck. Never having heard of them since I fear they may have miscarried and should like to know whether or not they even reached you. That region is a prolific one for your explorations, and now that we have just established there & the Indian War appears to be about over you no doubt will feel tempted to extend your important investigations to that comparatively unknown region.

Yours very truly,
John Gibbon

(From Yale Library Manuscripts & Archives)

It is remarkable, given what Gibbon went through, that he still remembered the fossil one year later. And although Marsh himself did not personally follow up on Gibbon's advice, the closing years of the 19th century witnessed a procession of western expeditions sponsored by academic and research institutions such as Yale University, the American Museum of Natural History and the Philadelphia Academy of Sciences, as well as by the U.S. government. These expeditions expanded and refined the knowledge of the geology and paleontology of the American West and built on earlier dispatches from fur traders, explorers and military men such as John Gibbon.

Thanks to Jessica Utrup YPM for help with historical research and preparation of figures, and Steve Thurston (American Museum of Natural History) for helping prepare photographs.

C Geologic map of part of south-central Montana showing the Bearpaw Shale, General Gibbon's routes, and the fossil locality. Photo: Jessica Utrup/Cope MacClintock

Entomology Lunch

By Victor O. DeMasi, Curatorial Affiliate, Division of Entomology, Peabody Museum of Natural History

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Group Brown Bags It to French Guiana

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Every Thursday at noon members of the Yale Peabody Museum of Natural History (YPM) Division of Entomology, its visitors, and the arthropod-inclined from nearby institutions gather for a brown bag lunch and to share news and specimens of in terest. The weekly luncheon was the brainchild of the late Curator of Entomology Charles Remington, for more than four decades a professor at Yale. Enthusiasm for insects continues at this weekly gathering to this day in testament to the influence of this dedicated entomologist on his associates.

Two years ago YPM Museum Technician Maishe Dickman, a frequent lunch participant, suggested and then organized an outing for the group to Kaw-Roura Nature Reserve in French Guiana. A week-long trip in October 2010 and another in September 2011 included medical entomologist Dr. Leonard Munstermann, Division of Entomology Curator and Senior Research Scientist in Epidemiology at the Yale School of Public Health, curatorial affiliates Dr. Bill Krinsky (Diptera and Coleoptera) and Victor DeMasi (Lepidoptera), and insect enthusiast Maishe Dickman. Also participating were Mike Thomas, a biologist at the Connecticut Agricultural Experiment Station, photographer Roanna Metowski, Suzanne Krinsky (whose interest is in Sphinx moths), honor roll high school student Maya Jayne Munstermann, nature author Giff Beaton, and Orianna DeMasi, Computer Systems Engineer, Lawrence Berkeley Laboratory.

French Guiana, or "Guyane" as the French call it, on the northeast coast of South America, is most remembered for its notorious penal colony, Devil's Island. These days it is home to France's space program and remains mostly wilderness with a largely inaccessible interior. The area has been spared recent extensive Amazonian deforestation and still supports much of its original flora and fauna.

The reserve, near the coast, sits astride a narrow ridge. It is traversed by an excellent all-weather road. Many trails radiate at right angles to the road and fall off precipitously in short walks from it. The ridge's forest is second growth with a dense impenetrable understory. The vegetation of the steep side slopes is more mature, with larger trees, which are not more than 120 feet tall. Unlike the ridgetop tangle, these older stands of forest allow easy walking underneath the canopy. A busy nearby lumber

A Incredible katydid wasp mimic *Aganacus pseudosphex*. Photo: Michael Thomas

B The tiger moth *Gorgonidia buckleyi whitfordi*. Photo: Michael Thomas

C Close-up of the head of a sphinx moth caterpillar. Photo: Michael Thomas

Cover Photo: The Orb Weaver Spider (Family Araneidae). Photo: Michael Thomas

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mill harvests the timber, but the area is still a very diverse habitat. Bedrock is easily exposed anywhere one scrapes a few leaves aside, making it doubtful that this ridge ever supported really big trees like those that shade the deep forest of the Ecuadorian Amazon or East Africa's Kakamega Forest.

During the hot dry season at the Kaw Reserve, midday to late afternoon is best passed in the shade. Our two dry season outings (16 days total) were interrupted by only one afternoon of heavy downpour, a welcomed relief from the heat. A good equatorial soaking is a singular moment to witness. This place is drenched in the rainy season—11 inches fell in 24 hours in January 2012, during a week of continuous showers that offered only six hours of sun. That is 25% of Connecticut's annual rainfall. The rain is good for insect diversity, but inhibits entomologists.

Many tropical butterflies can only be recorded by attracting them with baiting techniques or capturing them in baited traps. Tropical zones have entire guilds of species that never nectar at flowers, but are instead attracted to the abundant fruits and other fermenting substances absent in temperate zones. The casual observer seldom sees these species. Forest canopy species are plentiful, but are poorly known and often seen only when they descend briefly into light gaps on the forest floor created by tree falls and trails. Baited traps hoisted upward toward the forest canopy and secured at different levels yield a more diverse sample both of butterflies from the higher forest strata and their congeners too fast to net. In some respects, the high canopy is analogous to the deep ocean—seemingly near, but yet still guarding inaccessible secrets.

In addition to Lepidoptera species, other groups of insects, such as flies and beetles, were sampled with traps baited with concoctions of fermenting fruit, fish and meat. Dr. Munsterman trapped biting flies, which can be vectors of disease, and found significant differences in the fauna separated only by dozens of vertical feet.

One group of tropical butterflies that is particularly poorly studied is the family Riodinidae. Unlike most butterfly species whose caterpillars feed on plants, the known riodinids have a different larval feeding strategy that includes an association with ants, where the riodinid larvae confuse the ants with chemical signals that allow them to live unmolested within the ant colonies. They receive food and protection even though they are trespassers. Contemporary entomological work in tropical forests focusing largely on canopy fauna is describing many new insect species, including riodinids.

Dawn-to-dusk outings secured approximately 20 species of riodinids, most as only single individuals and some still undetermined to species. These efforts were associated with punishing attacks by horseflies with centimeter-long proboscises. Both butterfly and horsefly specimens are now in the YPM entomology collections.

Danger lurked close by. Orianna DeMasi happened unexpectedly on a fer-de-lance pit viper while working the trap lines. Pit vipers of the genus *Bothrops* are the most poisonous of snakes in the Neotropics. The reptile is aggressive and well camouflaged, striking without warning, and attacks typically result in death or amputation unless the antidote is given immediately—not likely, when a walk from the deep forest and a one-hour car ride are necessary to reach help. Local agricultural workers will often machete off a bitten digit to avoid almost certain spread of the toxin. Shaken up by the encounter, and with the situation "unfanged," Orianna returned safely to California with 10 fingers and 10 toes.

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Our evening gatherings included show-and-tell with informed identifications and life histories across the entomological spectrum. It was just another Thursday lunch among passionate science enthusiasts.

For a look at what museum entomologists brought back from Guyane, see locality and other label data from the YPM butterfly collection—processed by YPM Division of Entomology Informatics Manager Larry Gall and his cadre of student helpers—by logging on to *http://peabody.yale.edu/collections/search-collections?ent* and entering pertinent information (in some cases digital photographs of the specimens are available). To learn more about the YPM Division of Entomology, visit *http://peabody.yale.edu/collections/entomology*.

D *Agrias narcissus* turned up once in bait traps on each trip. Months of searching for this rare, incredibly beautiful aurelian in other neotropical stations has never rewarded any of these field investigators. Photo: Roanna Metowski

E A typical forest regime. Photo: Roanna Metowski

F The colorful Guianan Cock-of-the-Rock (*Rupicola rupicola*) nests in the Kaw-Roura reserve. Photo: Roanna Metowski

G Victor DeMasi spends a blistering afternoon on non-entomological activities. Photo: Roanna Metowski

H Maishe Dickman at the Peabody with a sampling of French Guiana specimens. Our first trip delivered an abundance of *Morpho* species seldom seen in one season—seven in all. Photo: Victor DeMasi

I Maishe Dickman with a specimen of the extremely rare *Morpho eugenia*, which flies only in the earliest light of dawn. This one was dragged down in a forest clearing after several days' sleepy efforts and many wild swings with a net on an extension pole. Photo: Victor DeMasi

J Victor DeMasi examines the insect diversity at a light trap. Photo: Roanna Metowski

K Orianna DeMasi baits one of the author's traps before hoisting it into the forest canopy. Photo: Victor DeMasi

L Roanna Metowski shoots Mike Thomas shooting Bill Krinsky. Photo: Roanna Metowski

M Bill Krinsky prepares his specimens at a great jungle lab. Photo: Victor DeMasi

N Orianna DeMasi displays a monster Owl Butterfly (*Caligo eurilochus*) taken in a bait trap. Photo: Victor DeMasi

O Roanna Metowski entertains two large beetles (*Megasoma acteon*) at the light trap. Photo: Victor DeMasi

P One of the impressive blacklighting nights. Photo: Roanna Metowski

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Study Confirms Horned Dinosaurs Are Separate Species

By Nicholas R. Longrich, Postdoctoral Fellow, Yale Department of Geology & Geophysics

In the late 1800s, Othniel Charles Marsh, the first head of Yale's Peabody Museum of Natural History (YPM), sent his men out west to look for old bones and found them in the arid grassy hills of eastern Wyoming, bones of animals that had lived and died 65 million years ago, on the edge of an ancient and now-vanished sea. Marsh found an amazing variety of creatures—mammals, fish, birds, lizards, snakes—but the most fantastic of all were the dinosaurs, and the strangest of these were the horned dinosaurs. No one had ever seen anything like them before. They were giant plant-eating reptiles as big as elephants and their enormous skulls had huge beaks and jagged rows of teeth to slice through tough plants.

One bore a horn on its nose and two more over the eyes. A thick, solid shield of bone, bearing hornlets along the edges, stuck out from the back of the skull. This one Marsh named "three horned face"—*Triceratops*. Not long after, he discovered a second kind of skull that had a shorter nose horn and a frill that was larger and thinner, with a huge pair of holes in it. This one he named the "bull lizard"—*Torosaurus*. A statue of *Torosaurus* now stands outside the YPM.

Paleontologists have argued for years about how many species of dinosaur there really are, but no one had seriously questioned the separation of *Torosaurus* from *Triceratops*. Then in 2010, paleontologists John Scannella and Jack Horner proposed that perhaps Marsh and everyone else had gotten it wrong for the last century. *Triceratops* and *Torosaurus* were really the same species, they argued, with *Torosaurus* simply the mature form of *Triceratops*. This sort of error is more common than one might expect. The tyrannosaur "*Nanotyrannus*" had previously been shown to represent a juvenile of *Tyrannosaurus rex*. However, paleontologists were skeptical.

Given Yale's historical connection to the naming of *Torosaurus* and *Triceratops*—and that the YPM has some of the best skulls in the world sitting on display and in its basements—we decided to try to resolve the issue. The key was to see whether there were any juvenile *Torosaurus* among them. If there were specimens of immature animals, then it follows that *Torosaurus* cannot really be the adult of *Triceratops*. With the assistance of graduate student Daniel Field, I tried to solve the problem.

One of the unusual features of horned dinosaurs is that their skulls suture tightly together as they mature. In a young animal, all the bones are separate, but in older animals the bones are tightly fused together by bone. Critically, we were able to show that this happens in a distinct sequence in *Triceratops*: first the skull roof fuses, then the hornlets on the frill and cheek fuse on, and last of all the snout fuses up. Along the way, the texture on the outside of the bone changes from porous (a result of many tiny blood vessels passing through and nourishing the growing bone) to a highly rugose, gnarled texture that is typical of old adults. Using this sequence made it possible to figure out whether horned dinosaur skulls were fully mature or not.

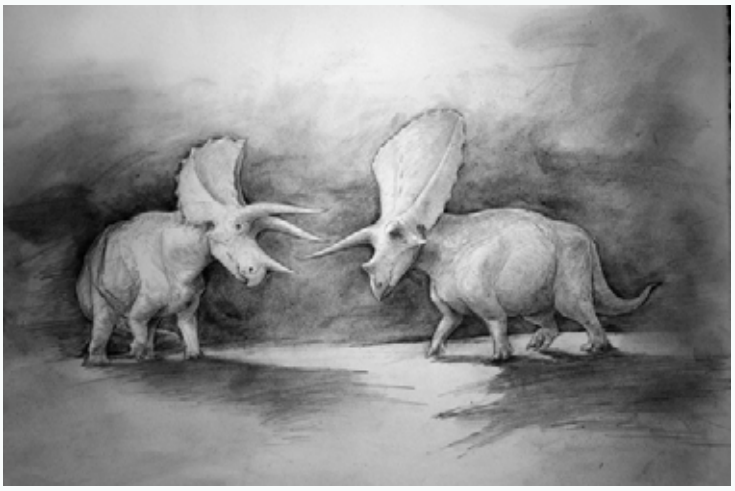
Armed with this information, we then took a new look at one of the YPM's old *Torosaurus* skulls. It was a large animal, yet several of the sutures were clearly open.

Unfortunately this skull had been prettified by the addition of paint and plaster years ago, which meant that it was now impossible to tell what was bone and what was reconstruction. However, YPM Curator of Vertebrate Paleontology Jacques Gauthier, Yale Department of Geology & Geophysics, gave us the go ahead and YPM Preparator Marilyn Fox carefully cleaned off the plaster and paint, and underneath was the skull of an immature animal. The hornlet on the cheek was free from the skull, the hornlets on the back of the skull had fallen off, and the bone that supported the beak was separate from the snout. In addition, the frill had the porous texture of young, fast-growing bone. This *Torosaurus* skull was immature, which meant that *Torosaurus* could not be the adult form of *Triceratops*. Marsh got it right back in 1892—*Torosaurus* really was something different!

These kinds of debates go on all the time because it is not always easy to tell species apart. Adults of different species can look similar when all you have to go on is the skeleton, and adults and juveniles of a single species can look different from each other. Animals in a single population can vary greatly to the point that they might even seem like separate species. The approach we used can help us understand variation in horned dinosaurs, but there is no getting around the fact that taxonomy is a messy business, an art as much as a science. Populations vary, and accumulated variation over time turns them into species. That means it is not always possible to divide animals neatly into separate species.

But ultimately these debates do matter, because we cannot really say anything about the diversity of life over time, rates of evolution, or rates of extinction, until we have first tried to count and name the species. So paleontologists will keep digging up new fossils and keep arguing about their names.

Support for the 2011–2012 research in this study came from the Yale Institute for Biospheric Studies.



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A Top, the skull of *Torosaurus latus* (YPM VP.001831) and, below, the skull of *Triceratops prorsus* (YPM VP.001822) in the Yale Peabody Museum vertebrate paleontology collections. Photo: N Longrich.

B *Triceratops* (left) and *Torosaurus* (right). Drawing: N Longrich.

Looking for exceptionally preserved invertebrate fossils in the lower Fezouata Formation, near Zagora, Morocco. Photo: Rachel A. Racicot

SIR JAMES LOUGHEED AWARD OF DISTINCTION AWARDED

Daniel J. Field (Yale PhD '15), a doctoral candidate in the Yale Department of Geology & Geophysics, has received the Sir James Lougheed Award of Distinction, PhD Level, from the Government of Alberta, Canada. Field, who received a bachelor of science undergraduate degree from the University of British Columbia, Vancouver, is studying vertebrate paleontology and evolution under the guidance of Professor of Geology & Geophysics Jacques Gauthier. His research interests are in the evolution of modern birds using fossil and molecular data, along with a deep interest in many aspects of vertebrate macroevolution and diversity. The award, which comes with a prize of Can$20,000, supports Field's research, funding fieldwork, museum collections visits and molecular analyses. Field was also the recipient of the Sir James Lougheed Award of Distinction, Master's Level, in 2011, which provided a prize of Can$15,000 for research support.

The Family Life of Fossils: Fossil Elephant Trackways in the Desert of Abu Dhabi

By Andrew Hill, Clayton Stephenson Professor of Anthropology, and Curator and Head, Division of Anthropology, Peabody Museum of Natural History

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How do you find out about the family life of extinct mammals? How many animals are there in a group? How do you know how many are males, females, adults, young ones? Mostly you do not, because such information is very difficult to get. But it would be useful to know, for all kinds of reasons.

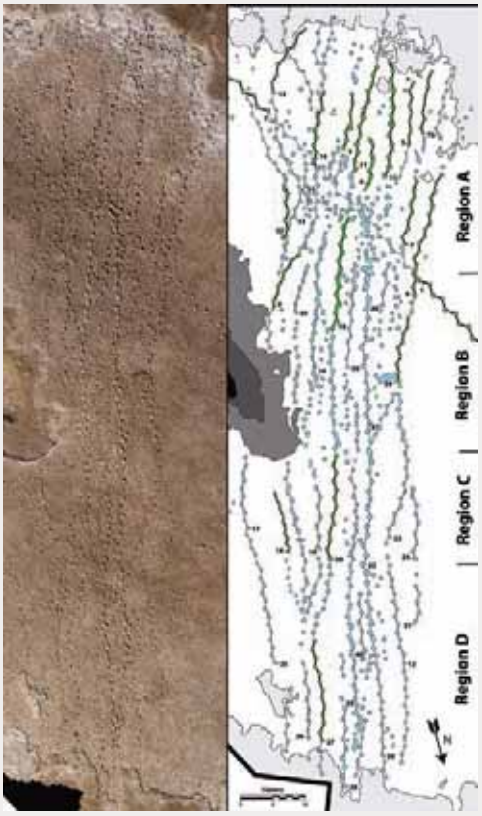
Faysal Bibi (G&G PhD '09), currently at the Museum for Naturkunde, Berlin, and I direct a joint Yale Peabody Museum of Natural History (YPM)–Abu Dhabi Tourism and Culture Authority (ADTCA) expedition in the United Arab Emirates that investigates late Miocene fossils and paleoenvironments (see "A Return to the Desert" in *Yale Environmental News* 12(2):12–13). When we renewed our work there in 2006, Mark Beech of the ADTCA, our resident UAE colleague and collaborator, showed us a huge area of fossilized elephant footprints in the Abu Dhabi desert. These tracks had been known for some time among the bedou who live there and were thought of as dinosaur footprints, until a local Emirati, Mubarak Al Mansouri, showed them to Mark. In fact, the tracks were most probably made by the extinct four-tusked elephant *Stegotetrabelodon syrticus*, one of the earliest true elephants, known also from skeletal fossils in the region. Preparator Marilyn Fox in the YPM Division of Vertebrate Paleontology prepared replicas of individual prints from these trackways, now housed in YPM, but the whole site is so large it was difficult to know what to make of it all.

Then Faysal was invited to a conference about GigaPan, an imaging technique that stitches together hundreds of individual overlapping photographs to produce one very high resolution gigapixel panoramic image. There he met Nathan Craig of Pennsylvania State University, an archaeologist who photographs archaeological sites in the Andes using cameras suspended beneath kites. Clearly, we had to get Nathan out to Abu Dhabi.

We all met there in January 2011 and dragged Nathan and his kites and cameras into the desert. As soon as he produced his first preliminary stitched images, it was instantly obvious what was going on. We could easily see that there were two separate sets of trackways. One, 260 meters long (about 853 feet), were the footprints of a single elephant. This trackway intersected diagonally with a set of parallel prints made by at least 13 individuals. Using microstratigraphical and sedimentological techniques, Mathieu Schuster of the Université de Strasbourg helped work out that the parallel set of tracks had all been produced at the same time and represented a herd.

Stride length is a very good indicator of body weight in elephants, and Faysal and our colleague Brian Kraatz of Western University of Health Sciences worked this out very accurately using the GigaPan photomosaic (see the GigaPan orthophotomosaic at *http://gigapan.org/gigapans/78542*). From this we were able to determine the probable sex of the individuals. The solitary track was the largest, almost certainly made by a mature male. The smaller herd prints were consistent with a group of females and generations of offspring. This arrangement matches the distinctive sexually segregated social structure of both African (*Loxodonta*) and Asian (*Elephas*) modern elephants, which form stable social units led by matriarchs, consisting of related females and their offspring. Male elephants are raised in the family unit until adolescence, after which they disperse to lead primarily solitary lives, re-uniting with female-led groups only intermittently, such as for reproduction. These astonishing trackways give us rare information about group size, and suggest that the modern kind of social structure and behavior was present right at the origin of the family Elephantidae, some seven million years ago.

Read more about these trackways in the 2012 article "Early evidence for complex social structure in Proboscidea from a late Miocene trackway site in the United Arab Emirates," by Faysal Bibi, Brian Kraatz, Nathan Craig, Mark Beech, Mathieu Schuster and Andrew Hill, published in *Biology Letters* (doi: 10.1098/rsbl.2011.1185), and at the Mleisa1 Tracksite Press Page "In the footsteps of prehistoric elephants" (*http://mleisa1.wordpress.com/*).



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A Close up of a single isolated track of footprints. Photo: © Faysal Bibi

B A reconstruction of the *Stegotetrabelodon syrticus* herd as they leave their footprints behind on a muddy Abu Dhabi plain seven million years ago. Painting by paleontological artist Mauricio Antón. Photo: © Mauricio Antón.

C The orthophotomosaic of the elephant trackways (left), with the interpretation of individual tracks (right). The mosaic was produced by Nathan Craig, using a Canon S90 camera suspended beneath a Rokkaku kite. Photo: © Nathan Craig

D An oblique view of Nathan Craig's photographic mosaic, populated by computer-rendered reconstructions of the elephants. Photo: Renderings © Mauricio Antón.

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A Gallery of Nature's Remedies

Works of art depicting organisms as diverse as horseshow crabs and leeches to red onions and passion flowers were featured in *Nature's Remedies: Plants and Animals*, the spring semester exhibition of natural history themed art hosted at Yale's Class of 1954 Environmental Science Center (ESC). On view from January 6 to June 20, 2012, this exhibition of 38 works by members of the Guild of Natural Science Illustrators Greater New York Chapter (*www.gnsi.org/groups/gny*) examines a range of species with connections to therapeutic treatments derived from the natural world.

Side-by-side with these works are explanations researched by the artists about the associated remedies from both folklore and the latest naturopathic products. The pieces are executed in a wide variety of techniques and media, including watercolor on vellum, graphite, gouache, silverpoint, colored pencil, acrylic on mylar, and even hand-colored aquatint etchings. The artists' reception was held at the ESC on March 30, 2012.

Accompanying the exhibition is a display in the ESC rotunda, *Nature's Remedies: Herbal Remedies and the Development of Botany and Medicine*, that presents a brief overview of the history of the use of plants in the treatment of illnesses, both historical and modern. This display is on view through the summer of 2012 and features material from the Yale Herbarium at the Peabody Museum of Natural History's Division of Botany (*http://peabody.yale.edu/collections/botany*).

A Chinese Rhubarb *Rheum rhabarbarum*
Watercolor, 12 x 16 inches, by Stella Grove
Chinese Rhubarb *Rhubarb* (*rheum rhabarbarum*) is named for its leaves, which resemble the human palm, and is generally propagated from cuttings and grown as an ornamental. It is among the many plants listed in the *Shennong pen Ts'ao ching (Great Herbal)*, a survey of medicinal plants said to have first appeared in China about 2,000 years ago. The bright yellow powder derived from the roots became an important part of European medicine. In the mid-18th century, *R.rhabarbarum* was being cultivated as an edible garden rhubarb and the rhizomes were used in folk medicine as a mild laxative. ©Stella Grove

B Frontispiece depicting Woodland Pinkroot *Spigelia marilandica* L. and the title page of the second volume of the Fenn Collection in the Yale University Herbarium, four volumes with almost 700 herbarium specimens collected in 1822 by Horatio Fenn as part of his studies at the Medical Institution of Yale College. The Fenn Collection is the earliest known herbarium material collected in Connecticut and is among the oldest collected in New England. Early herbaria were often in book form and belonged to individuals. Modern herbaria are kept as separate sheets and usually belong to institutions. Photo: Yale Herbarium

C Horseshoe Crab L. *polyphemus*
Watercolor and gouache, 22 x 24 inches, by Dorie Petronchko
The Horseshoe Crab *Limulus polyphemus* has remained unchanged for more than 250 million years. The blue blood of *L. polyphemus* is harvested from about 250,000 horseshoe crabs each year for a highly sought-after anti-toxin (Limulus Amebocyte Lysate, or LAL) used in the study of disease and to ensure that intravenous drugs, vaccines and medical devices are free of bacterial contamination. The chitin in the crab's exoskeleton is antimicrobial and is used for sutures, dressings for burns and surface wounds, contact lenses, powdered make-up and cleaning up toxic compounds like PCBs. *L. polyphemus* compound eyes allow scientists to study human diseases like retinitis pigmentosa. These uses by the medical industry and by eel and conch fisherman who use female crabs for bait are raising concerns about excessive harvesting of the species, because many migrating shorebirds depend on the crabs as a food source. Alternatives to LAL and to the female pheromone that attracts eel and conch are being researched. ©Dorie Petronchko

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Tim White Named Eastern Fellow

Tim White, Director of Collections and Operations, Peabody Museum of Natural History (YPM), has been named a 2012 Eastern Fellow by Eastern Connecticut State University (ECSU). The ECSU Fellows program recognizes alumni who have distinguished themselves in their careers and Fellows are invited to return to campus to meet in the classroom and informally with students, faculty and administrators and share their specialized academic and work experience. The ECSU Class of 2012 Alumni Fellows were introduced at a campus ceremony on March 14, 2012. "Today's Fellows are role models, the kind of graduates we want our students to be," said ECSU President Elsa Núñez during the induction luncheon. "For them to come back to our campus to speak with our students about their career success is a wonderful gift to the university."

White began his career at Yale as the first collections manager of YPM's Division of Invertebrate Paleontology, one of the top three collections of invertebrate fossils in the world. In his current position, he oversees YPM's Archives and 12 curatorial divisions, combined collections of more than 13 million specimens and objects. As project manager for the Environmental Science Center Collections Project, he was closely involved in the planning of the Class of 1954 Environmental Science Center (ESC), and continues to have an active role in ESC programs and operations, including establishing the popular ESC natural history art exhibitions. He is a member of the Yale Digital Commons Advisory Group and the Yale Arts Area Advisory Committee.

White is a former president of the Society for the Preservation of Natural History Collections and has served on councils for the Natural Science Collections Alliance and the Paleontological Society, as well as on several professional panels and boards, including the Smithsonian Advisory Committee on Collections Stewardship; the Heritage Health Index Natural History Advisory Group, the first comprehensive survey to assess the condition and preservation needs of U.S. collections; the advisory board for collections stewardship at London's Natural History Museum; and the Paleontology Portal Steering Committee. In 2008, White gave the keynote address on sustainability and museums at the 100th Anniversary of the National Taiwan Museum in Taipei.

Also recognized by ECSU in 2008 as an Eastern Fellow was Senior Collections Manager Eric Lazo-Wasem of the YPM Division of Invertebrate Zoology.

Shown with ECSU President Elsa Núñez (second from right) are 2012 Eastern Fellows (left to right) YPM Director of Collections and Operations Tim White, forensic psychologist Carla Goodwin from Massachusetts, and Wendy Daly, owner of a leading pediatric clinic in Louisville, KY. Photo: Courtesy of ECSU

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Peabody Division of Botany Acquires Important Regional Collection

By Patrick Sweeney, Collections Manager, Division of Botany, Peabody Museum of Natural History

The Division of Botany at the Yale Peabody Museum of Natural History (YPM) is pleased to announce that it has acquired a major part of the herbarium of the Connecticut Agricultural Experiment Station (CAES), which has been donated to Yale University. This important regional collection, the third largest herbarium collection in Connecticut, has been housed at the CAES in New Haven since the late 1800s. Yale will acquire approximately 15,000 specimens of vascular plants, mosses, algae and lichens. Fungal specimens will remain at CAES.

Material in the CAES herbarium dates back to the late 19th century. Although collected primarily in New England, it contains a substantial number of specimens collected elsewhere in North America and in Europe. The collection includes material collected by notable botanists and Yale faculty and alumni, such as Oscar D. Allen (professor of chemistry at Yale), John A. Allen (Yale 1884), George P. Clinton (CAES botanist and Yale research associate), James Dwight Dana (professor of geology and mineralogy at Yale), Amos Eaton (co-founder of Rensselaer Polytechnic Institute), and Frank W. Hall.

The acquisition of the CAES herbarium strengthens the status of the Yale Herbarium, housed in the YPM Division of Botany, as one of the most important repositories of New England herbarium material in the world. The Yale Herbarium was the herbarium of record for the flora of southern New England from 1864 until the mid-20th century and has the most extensive holdings of Connecticut vascular plants collected in the 19th and early 20th centuries.

The CAES collection was donated in advance of a major renovation project on the CAES's Jenkins Laboratory, where it was formerly located, and was physically moved to the YPM in March 2012. It will be incorporated into the general Yale Herbarium collection during the remainder of the year.

The Division of Botany is indebted to the CAES for its donation and thanks Sandra Anagnostakis, a scientist in the CAES Department of Plant Pathology and Ecology and curator of the CAES Herbarium, for initiating and facilitating the transfer. We would also like to thank YPM Project Registrar Annette Van Aken and YPM museum assistants Lynn Jones and Nathan Utrup for their help in planning and carrying out the move.

A **YPM Division of Botany Collections Manager Patrick Sweeney with CAES herbarium specimens at their former location in the attic of the Jenkins Laboratory building at the Connecticut Agricultural Experiment Station in New Haven. Photo: Lynn Jones**

B **The YPM truck in front of the Jenkins Laboratory. The rectangular white structure on top of the building is the attic where the CAES herbarium was housed. Photo: Lynn Jones**

Mapping Human Risk for Lyme Disease: An Environmental Approach

by Maria Diuk-Wasser, Assistant Professor, Yale School of Epidemiology & Public Health

A new map delineates well-defined areas of the eastern United States where humans have the highest risk of contracting Lyme disease, a rapidly emerging tick-borne ailment with symptoms that range from a rash, headaches and fever to arthritis and Bell's palsy. As part of the most extensive Lyme-related field study ever undertaken, researchers found high infection risk confined mainly to the Northeast, Mid-Atlantic and Upper Midwest and low risk in the South. The results were published in the February issue of the *American Journal of Tropical Medicine and Hygiene*. Given frequent over- and under-diagnosis of Lyme disease, the new map could arm the public and health officials with critical information on the spatial distribution of human risk.

The geographic pattern of human risk for infection with *Borrelia burgdorferi*, the tick-borne pathogen that causes Lyme disease, was mapped for the eastern United States by researchers at the Yale School of Public Health in collaboration with Michigan State University, the University of Illinois and the University of California, Irvine, through a cooperative agreement with the Centers for Disease Control. Using a standardized methodology, roughly 100 field collectors sampled ticks in 304 individual sites from 2004 to 2007 from Maine to Florida and across the Midwest by dragging a one-meter by one-meter square of corduroy cloth. Nymphs of the black-legged tick *Ixodes scapularis* were tested for infection with *B. burgdorferi* to estimate the density of infected *I. scapularis* nymphs, a measure of human infection risk. By modeling the relationship between density of infected ticks and ground-based and remotely sensed climate and landscape predictors, a predictive surface of human risk was generated. Current areas of high and low risk for Lyme disease were delineated and areas of future expansion were predicted.

The maps that emerged from the tick survey show a clear risk of Lyme disease in large parts of the Northeast, from Maine as far south as Maryland and Virginia coastal areas. The researchers also identified a separate and distinct Lyme disease risk region in the upper Midwest, encompassing most of Wisconsin, a large area in northern Minnesota, and a sliver of northern Illinois. Most established populations of *I. scapularis* were found to be infected with *B. burgdorferi*, except four populations along expansion fronts, implying that the pathogen spreads with, or quickly follows, expansion of the tick.

The goal of the fieldwork was to provide doctors and public health officials with a better sense of where people are at risk of Lyme disease by using the presence of known Lyme-carrying ticks as the main indicator of risk. Accurate and timely diagnosis of Lyme disease is critical because delay may lead to severe disease requiring more aggressive treatment. On the other hand, overuse of antibiotics sometimes results in serious negative outcomes. Current geographical assessments of Lyme disease risk are heavily reliant on reports of human infections, which can be a poor predictor of risk due to frequent misdiagnosis. In addition, infected *I. scapularis* ticks may colonize a region long before they actually infect a human with Lyme disease, which means risk can be significant even without a confirmed case.

Although this map represents a key step in our understanding of geographic risk for Lyme disease, it's essential to continue monitoring the distribution of ticks and pathogen, because there is strong evidence that they are both expanding, mostly along the edges of their current distribution. This map provides an essential baseline for tracking the spread of the infection from areas endemic in 2004–2007.

The map that emerged from the tick survey shows a clear risk of Lyme disease in large parts of the Northeast (including eastern Pennsylvania) from Maine going as far south as Maryland and Northern Virginia in the Washington DC metropolitan area. There is also a separate and distinct Lyme disease risk region in the upper Midwest. It includes most of Wisconsin, a large area in northern Minnesota, and a sliver of northern Illinois.

Credit: Maria Diuk-Wasser, Yale School of Public Health.

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Road Runoff Spurring Spotted Salamander Evolution

Spotted salamanders exposed to contaminated roadside ponds are adapting to their toxic environments, according to a Yale paper in *Scientific Reports*. This study provides the first documented evidence that a vertebrate has adapted to the negative effects of roads, apparently by evolving rapidly.

Salamanders breeding in roadside ponds are exposed to a host of contaminants from road runoff. Chief among these is sodium chloride from road salt, which reaches average concentrations 70 times higher in roadside ponds compared to woodland ponds located several hundred feet from the road.

"While the evolutionary consequences of roads are largely unknown, we know they are strong agents of natural selection and set the stage for fast evolution," said Steven Brady, the study's author and a doctoral student at the Yale School of Forestry & Environmental Studies. "These animals are growing up in harsh environments where they face a cocktail of contaminants, and it appears that they are evolving to cope with them."

Brady found that salamanders in roadside ponds have higher mortality, grow at a slower rate and are more than likely to develop L-shaped spines and other disfigurements. In roadside ponds, only 56% of salamander eggs survive the first 10 weeks of development, whereas 87% survive in the woodland ponds. As roadside ponds become more toxic, the surviving salamanders may develop a genetic advantage over their counterparts living in woodland ponds.

The salamanders that survive year after year in the roadside ponds seem to have adapted to the harsh conditions. "The animals that come from roadside ponds actually do better—substantially better—than the ones that originate from woodland ponds when they're raised together," Brady said.

It is not altogether new that animals adapt to human activities. For example, fish have begun to mature at smaller sizes in response to commercial fishing. But whereas humans directly consume fish, salamanders are just bystanders to human activities. This suggests that the most species, which are not specifically targeted for human use, may be experiencing profound evolutionary consequences. And it seems that even species not being driven to extinction—and seldom thought about—are changing.

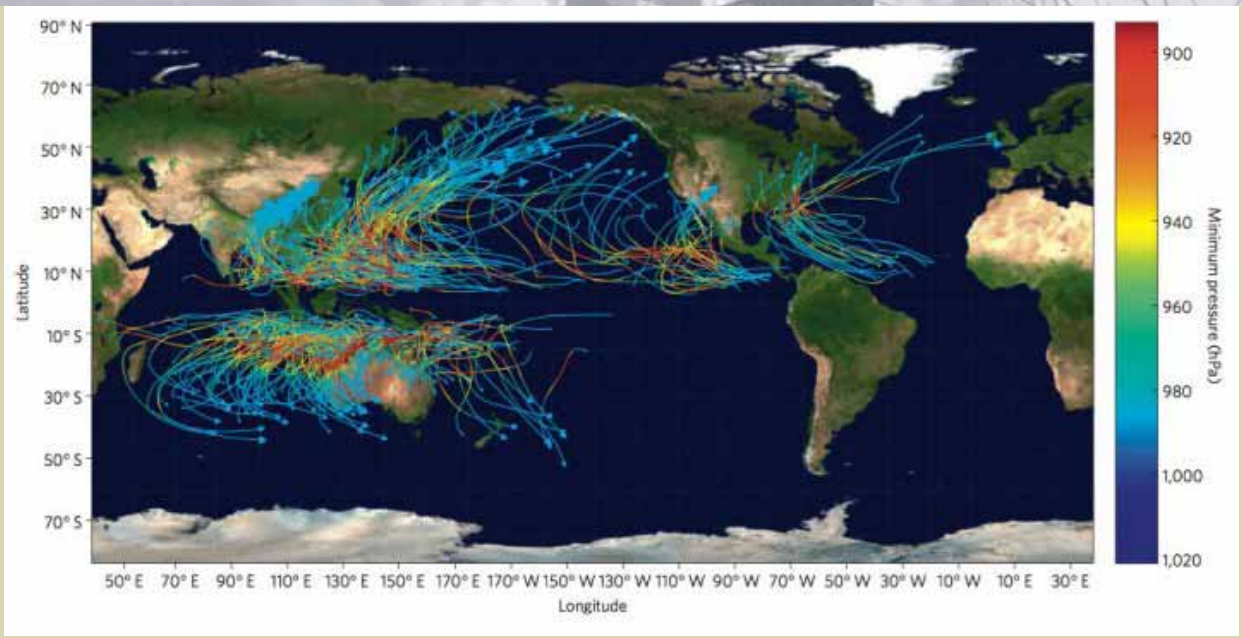
"This adaptation is certainly encouraging for conservation," said Brady. "But our modern footprint is fundamentally changing species in ways we don't understand and, critically, we don't know if these adaptive responses will keep pace with environmental change."

Brady observed the development of the salamanders in 10 ponds—five roadside and five woodland—at Yale Myers Forest and in the town of Willington, both in northeastern Connecticut. The paper "Road to Evolution? Local Adaptation to Road Adjacency in an Amphibian (*Ambystoma maculatum*)" is available at *www.nature.com/srep/2012/120126/srep00235/full/srep00235.html*

Additional graphics of this research are available at *https://picasaweb.google.com/114974158024600954678/SpottedLocalAdapt?noredirect=1.*

A A female spotted salamander gravid with eggs in route to her breeding pool. There she will lay a cluster of approximately 100 eggs. Eight to ten weeks later, those eggs will hatch as larvae. In late summer, if the pool has not already dried, larvae will metamorphose into juveniles that migrate to the adjacent upland habitat. Photo: Steven Brady

B Steven Brady inspects a salamander egg mass in a woodland pool. Photo: Mianus River Gorge Preserve



The tropical cyclone model is used in conjunction with climate models to predict how the frequency, intensity and location of tropical cyclones change in the seven ocean basins of the world. The paths of 17,000 synthetic storms are followed until they strike land. The authors used historical data to estimate the damages caused by the intensity of each cyclone and what was in harm's way. Their revealed that minimum barometric pressure predicts damages more accurately than maximum wind speed.

Tropical Cyclones to Cause Greater Damage

Tropical cyclones will cause $109 billion in damage by 2100, according to researchers at Yale and the Massachusetts Institute for Technology (MIT) in a paper published in *Nature Climate Change*.

That figure represents an increased vulnerability from population and especially economic growth, as well as the effects of climate change. Greater vulnerability to cyclones is expected to increase global tropical damage to $56 billion by 2100 from $26 billion per year, double the current losses from $26 billion per year if the present climate remains stable.

However, climate change is predicted to add another $53 billion of damages. The damage caused by climate change is equal to 0.01 percent of gross world product (GWP) in 2100.

The United States and China will be hardest hit, incurring $25 billion and $15 billion of the additional damages from climate change, respectively, amounting to 75% of the global damages caused by climate change. Small islands, especially in the Caribbean, will also be hit hard, suffering the highest losses per unit of GWP.

The research reveals that more intense storms will become more frequent with climate change. "The biggest storms cause most of the damage," said lead economist on the project, Robert Mendelsohn, Edwin Weyerhaeuser Davis Professor of Forest Policy at the Yale School of Forestry & Environmental Studies; Professor of Economics; and a professor in the Yale School of Management. "With the present climate, almost 93% of tropical cyclone damage is caused by only 10% of the storms. Warming will increase the frequency of these high-intensity storms at least in the North Pacific and North Atlantic Ocean basins, causing most of the increase in damage."

The authors based their estimates on a future global population of 9 billion and an annual increase of approximately 3% in gross world product until 2100. "More people making a lot more income will put more capital in harm's way," he said.

Tropical cyclones today cause $26 billion in global damages, which is 4 percent of gross world product. North America and East Asia account for 88 percent of these damages, because these regions have powerful storms and well-developed coastlines.

The future economic damage from tropical cyclones will be less than $1 billion a year in Europe and South America because there are few storms there, and the damage in Africa will be low because, Mendelsohn said, there is "relatively little in harm's way." Damages in Asia and Central America are expected to grow rapidly in concert with high economic growth. The Caribbean-Central America region will have the most damage per unit of GWP—37%.

"When you calculate damages as a fraction of GWP, island nations are hit disproportionately hard," he said.

The paper, "The Impact of Climate Change on Global Tropical Cyclone Damage" (available at *www.nature.com*) used a tropical cyclone integrated assessment model that was developed with Kerry Emanuel, a professor of atmospheric science at MIT. "The paper demonstrates how to integrate the atmospheric science of tropical cyclones and economics," said Emanuel.

Storm tracks and minimum pressure for a sample of synthetic storms. The tracks show that storms are more frequent in the western Pacific. The minimum pressure (hpa) or storm intensity is measured by their color. Storm intensity is higher over the warm waters near the Equator and lower over the cooler waters towards the poles.

Source: Mendelsohn, R., K. Emanuel, S. Chonabayashi, and L. Bakkensen. 2012. "The Impact of Climate Change on Global Tropical Cyclone Damage" ***Nature Climate Change*** **doi:10.1038/nclimate1357**

Glacial Carbon May Hold Record of Environmental Change

By David DeFusco, Director of Media Relations and Outreach; Yale School of Forestry & Environmental Studies

New clues as to how Earth's remote ecosystems have been influenced by the Industrial Revolution are frozen in glaciers, according to a paper in the March issue of Nature Geoscience.

"Remote regions are often perceived as being pristine and devoid of human influence," said Aron Stubbins, the study's lead author and an assistant professor at the Skidaway Institute of Oceanography. "Glaciers show us that burning fuels has an impact upon the natural functioning of ecosystems far removed from industrial activity."

Glaciers provide a great deal of carbon to downstream ecosystems, and many scientists believe the source of this carbon is from ancient forests and peatlands that were overrun by glaciers. However, the carbon comes mainly from contemporary biomass and the burning of fossil fuels that gets deposited on the surface of glaciers. Once it's deposited by snow and rain, carbon-containing dissolved organic matter (DOM) in the glacial ice moves with the glacier and is eventually delivered downstream, where it provides food for microorganisms at the base of the marine food web.

"These findings imply that the deposition of this ancient fossil-fuel organic carbon is ubiquitous, with important implications to the functioning of different ecosystems," said Peter Raymond, a co-author of the study and professor of ecosystem ecology at the Yale School of Forestry & Environmental Studies.

Glaciers and ice sheets together represent the second-largest reservoir of water on Earth, with glacier ecosystems covering 10%, yet the carbon dynamics underpinning those ecosystems remain poorly understood.

"Increased understanding of glacier biogeochemistry is a priority, as glacier environments are among the most sensitive to climate warming and the effects of industrial pollution," Raymond said.

Glacier ice loss is accelerating globally, driven in part by the deposition of carbon in the form of soot or "black carbon," which dark-

Switzerland Ranked at the Top of 2012 EPI, Latvia First in New Pilot Trend Rankings

Switzerland leads the world in managing pollution and natural resources, according to the 2012 Environmental Performance Index (EPI). Switzerland ranked highest in ecosystem vitality and environmental health, and was particularly strong in biodiversity and habitat protection and air pollution control.

The EPI, produced by researchers at Yale and Columbia University in collaboration with the World Economic Forum, ranks 132 countries based on the basis of 22 indicators in 10 major policy categories, including air and water pollution, climate change, biodiversity and forest management.

The United States placed 49th in the 2012 EPI, performing strong on water and air pollution management, but weak on controlling greenhouse gas emissions and promoting renewable electricity generation. The US ranks behind other industrialized nations, including France (6th), the United Kingdom (9th), Germany (11th) and Japan (23rd).

In addition, the United States is 77th in the new Pilot Trend EPI, which ranks countries by how much they improved issue-by-issue from 2000 to 2010. The United States's ranking suggests that little progress has been made on environmental challenges over the past 10 years.

Of the emerging economies, China and India rank 116th and 125th in the EPI, respectively, reflecting the strain that rapid economic growth imposes on the environment. Brazil ranks 30th, suggesting that a concerted focus on sustainability as a policy priority will pay dividends and that the level and pace of development is just one of many factors affecting environmental performance.

Latvia, Norway, Luxembourg and Costa Rica are in the top five of the EPI, whereas South Africa, Kazakhstan, Uzbekistan, Turkmenistan and Iraq—all grappling with deteriorating environmental circumstances as a result of economic development pressures and other challenges—placed at the bottom of the rankings.

The Pilot Trend EPI, introduced this year by the Yale-Columbia research team, shows Latvia at the top, followed by Azerbaijan, Romania, Albania and Egypt.

"The EPI and Trend EPI demonstrate that policy choices matter when it comes to environmental progress," said Angel Hsu, the 2012 EPI project director and doctoral student at the Yale School of Forestry & Environmental Studies. "Latvia has launched major energy and environmental initiatives in recent years by eliminating coal from its power generation and by reforesting. Other countries at the top of the lists have similar strengths."

While many countries had positive environmental performance trends, some deteriorated from 2000 to 2010. Estonia, Bosnia and Herzegovina, Saudi Arabia, Kuwait and Russia dropped in the rankings on pollution control and natural resource management. Russia, at the very bottom of the Trend EPI ranking, suffers from poor environmental public health, overfishing and forest loss.

For countries near the top of the EPI rankings, the Trend EPI results will not be particularly meaningful because the long time leaders have limited room for improvement. Iceland, for example, ranks 13th in the EPI but 64th in the Trend EPI, reflecting its high ranking in the EPI over the past decade. However, some top-tier performers on this year's EPI have strong

ens glacier surfaces and increases the absorption of light and heat. The burning of biomass and fossil fuels by people around the globe are the major sources of black carbon.

Stubbins and his fellow scientists have conducted much of their research at the Mendenhall Glacier near Juneau, Alaska. The researchers' findings also reveal how the ocean may have changed over past centuries. The microbes that form the very bottom of the food webs are particularly sensitive to changes in the quantity and quality of the carbon entering the marine system.

Since the study found that the organic matter in glacier outflows stems largely from human activities, it means that the supply of glacier carbon to the coastal waters of the Gulf of Alaska is a modern, post-industrial phenomenon. "When we look at the marine food webs today, we may be seeing a picture that is significantly different from what existed before the late 18th century," he said. "It is unknown how this manmade carbon has influenced the coastal food webs of Alaska and the fisheries they support."

The paper can be viewed online at *www.nature.com/ngeo/journal/vaop/ncurrent/pdf/ngeo1403.pdf*. For more details, visit *www.skio.usg.edu/people/stubbins/*. This work is supported by the National Science Foundation: *www-beta.nsf.gov/awardsearch/showAward.do?AwardNumber=1146161*.

Trend EPI rankings, indicating improved performance over the past 10 years. The United Kingdom, for example, ranks 20th on the Trend EPI, demonstrating significant progress on several environmental issues.

"As leaders gather for Rio+20 in June, they need to know who is leading and who is lagging on energy and environmental challenges," said Daniel Esty, director of the Yale Center for Environmental Law and Policy and Hillhouse Professor at Yale.

Esty, who is on leave from Yale, is commissioner of the Connecticut Department of Energy and Environmental Protection. "Like so many other areas of decision-making, environmental policy has become more data-driven and experience-based," he said. "The EPI provides a proven tool for assessing performance on an absolute basis. The new Trend EPI offers a way to track progress over time and is a mechanism for gauging the efficacy of government programs and indentifying best policy practices."

Analysis of the policy drivers underlying the 2012 rankings makes it clear that income is a major determinant of environmental success. Investments in safe drinking water and modern sanitation, in particular, translate quickly into improved environmental health results. At every level of development, however, some countries achieve results that exceed other countries with similar economic circumstances, demonstrating that good governance and careful policy choices also affect performance.

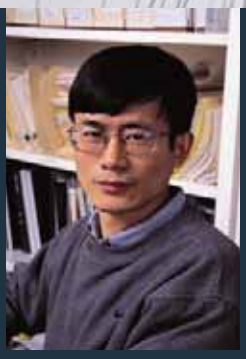
"It is wonderful to see the impact that the EPI has begun to have across the policy world," said Kim Samuel-Johnson, chair of the Yale Center for Environmental Law & Policy board of directors and co-creator of the project. "Many countries are realizing the value of using these indicators to benchmark performance over time."

The EPI and Trend EPI build on the best available global datasets from international organizations, such as the World Bank and the UN Food and Agriculture Organization, as well as research institutions such as the Battelle Memorial Institute, University of Maryland, University of Frankfurt and the "Sea Around Us" Project at the University of British Columbia. Serious data gaps limit the ability to measure results, particularly changes in performance, on some important issues.

"Our findings are only as solid as the underlying data, and we have a long way to go in some areas," said John Emerson, associate professor of statistics at Yale and principal investigator of the 2012 EPI. "Particularly distressing is the lack of accurate global and comparative data on waste management, toxic exposures, agricultural sustainability and water resources."

Marc Levy, deputy director of Columbia's Center for International Earth Science Information Network and one of the EPI project leaders, added: "Although there was an effort at the 1992 Earth Summit to launch the world on a path toward environmental sustainability, we have witnessed the opposite—stagnation on many critical issues. The meager data we have available clearly demonstrates this fact. It makes no sense to enter a period of heightened pressure on the environment with such inadequate monitoring of those pressures."

The Environmental Performance Index was made possible through financial support from FedEx and the Samuel Family Foundation. To view both rankings, visit *http://epi.yale.edu*.



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Yale Corporation Appoints Two Faculty to Named Professorships in the School of Forestry & Environmental Studies

By David DeFusco, Director of Media Relations and Outreach; Editor, Environment:Yale

Xuhui Lee and John Wargo, members of the faculty at the Yale School of Forestry & Environmental Studies (F&ES), have been appointed to named professorships by the Yale Corporation for their outstanding contributions to scholarship. "Xuhui and John have contributed immensely to the advancement of environmental scholarship, as well as to the life of the school," said Dean Peter Crane. "They are richly deserving of this honor."

Xuhui Lee has been named the Sara Shallenberger Brown Professor of Meteorology. Lee obtained training in meteorology at the Nanjing Institute of Meteorology before receiving his PhD in soil science at the University of British Columbia in 1992. He was appointed assistant professor at F&ES in 1994 and became professor in 2002.

An internationally renowned expert in the biophysics and biometeorology of natural and human-dominated ecosystems, including agricultural systems, Lee works on how radiation, water, heat and trace gasses are exchanged between the vegetation and the atmosphere, as well as how these interactions influence large-scale biogeochemical processes such as the carbon cycle.

Lee has almost 90 peer-reviewed publications and has had continuous grant support from national and international sources since 1996. He currently serves as the editor-in-chief of the journal Agricultural and Forest Meteorology.

From 2004 to 2007 he was director of doctoral studies at F&ES, and he also has chaired several faculty searches and served on a range of internal committees. In addition to teaching specialized courses in his research area, he has taught climate change science and policy.

"Xuhui has an outstanding record of research and is a committed and excellent teacher, as well as a good university citizen," said Dean Crane.

John Wargo has been named the Tweedy/Ordway Professor of Environmental Health and Politics. John Wargo holds a BA in English from the University of Pennsylvania, master's in landscape architecture from the University of Massachusetts, and PhD from Yale in 1984. He is an expert on the threats to human health posed by environmental hazards.

His book, *Our Children's Toxic Legacy*, won the American Publishers Association Prize for the best book in political science in 1998. His most recent book, *Green Intelligence* (Yale University Press. 2009), examines the history of science and law regulating pesticides, radionuclides, diesel emissions, mercury in the food chain and plastics. It received several awards, including the Independent Publisher Book Award Gold Medal (2010) in the Environment, Ecology, and Nature category. His current work includes an exploration of the growing tension between tighter, more energy-efficient buildings and the increased diversity and concentration of chemicals in indoor areas. He is also co-author of *Ecosystems: Science and Management* (Springer Verlag, 1998).

Wargo has testified before the US House and Senate, recommending legal strategies to protect children from environmental hazards, and has served on a variety of advisory boards for the US Environmental Protection Agency, U.S. Centers for Disease Control, the World Health Organization and the UN Food and Agriculture Organization.

He also has made substantial contributions to the teaching of environmental studies to doctoral, master's and undergraduate students at Yale, with a particular focus on environmental policy, politics, law and threats to human health.

As chair of the Environmental Studies Program in Yale College, he has played a key leadership role over the past decade in the design and rapid growth of the major. He has built many partnerships between faculty in F&ES and those in other Yale departments and professional schools, encouraging others to teach and mentor environmental studies majors. The size of the major has nearly tripled within the past five years. His own undergraduate course in "Environmental Politics and Law" is one of the most subscribed classes in Yale College and is featured as a Yale online course, with 24 filmed lectures freely available on the web and transcripts translated into 50 languages.

"John is a superb teacher, renowned scholar and a deeply committed university citizen," said Dean Crane. "We would not have such a successful environmental studies major without his hard work and leadership. He lavishes a huge amount of time on the program to the great benefit of our students."

New Methodology Assesses Risk of Scarce Metals

Yale researchers have developed a methodology for governments and corporations to determine the availability of critical metals, according to a paper in *Environmental Science & Technology*.

In "Methodology of Metal Criticality Determination," the researchers evaluate the importance of scarce metals using a methodology that determines their supply risk, environmental implications, and vulnerability to supply restriction.

"In the past few years, a number of organizations have attempted to evaluate metal criticality, but the methods used have varied widely and so have the results," said Thomas Graedel, Clifton R. Musser Professor of Industrial Ecology at the Yale School of Forestry & Environmental Studies. "This is the first time that this topic has been addressed in the peer-reviewed literature."

The criticality methodology, based on a US National Research Council template, is designed to help corporations and national governments evaluate the risk of not having access to critical metals and to inform strategic decision-making around resource use.

"If you're a corporation, you don't want to design and manufacture something only to find out that you don't have important materials," he said.

The criticality methodology evaluates supply risk for entities that use metals on the basis of three components: geological, technological and economic; social and regulatory; and geological. The first of these components measures the potential availability of a metal's supplies, and the latter two address the degree to which the availability of the supply might be constrained.

According to the paper, the most obvious questions related to a metal's availability in the ground are how much there is, whether it is technologically feasible to obtain, and whether it is economically practical to do so.

Regulations and social attitudes can either impede or expedite the development of mineral resources. For example, communities are aware of the potential for environmental damage from tailings ponds and may resist the development of a new mine.

Governmental policies, actions and stability can significantly affect the ability to obtain mineral resources. Graedel said that, in general, the more concentrated the mineral deposits are in one area, the higher the risk of supply restriction.

"This work was stimulated by China's attempt to horde rare earth metals, which are being almost entirely mined and processed in China," said Graedel. "We asked ourselves: How do you know what's scarce? If you know a metal is scarce, how do you know if you should worry about it? We think this methodology has substantial legitimacy."

The paper can be viewed at
http://pubs.acs.org/doi/abs/10.1021/es203534z

Journal Features Tropical Research by F&ES Students

Eight School of Forestry & Environmental Studies (F&ES) master's students engaged in research on the conservation and management of tropical resources have published their results in *Tropical Resources*, the annual journal of the Tropical Resources Institute at Yale (TRI).

"The research topics are tributes to the open minds and creativity of F&ES students," said Michael Dove, Margaret K. Musser Professor of Social Ecology. "These studies reaffirm that when it comes to conservation and development projects, local wisdom and initiatives are often most successful."

The research in Tropical Resources is divided into three main themes: institution-building, human health and adaptation to climate change. The students, whose research was funded by TRI, are Geofrey Mwanjela, Adenike Adeyeye, Juan Pablo Vallejo, Eliza Little, Ran Song, Ana Karla Perea Blázquez, Stephen Wood and Gil Depaula.

"Some of the best work carried out over the past year by F&ES students on tropical societies and environments is published in the journal," said Lisa Bassani, TRI's program manager.

Mwanjela's article concerns the Mnazi Bay Marine Park, established in 2000 on the southeastern coast of Tanzania. Like many protected areas created over the past couple of decades, this project sought to marry environmental conservation and local socioeconomic development. The park was developed around existing communities of ethnic Makonde and Makua, who had traditionally depended primarily on fishing for their livelihoods. To better conserve the marine environment, the park management sought to redirect the local communities' livelihood focus away from fishing. A decade later, the results of this initiative are mixed.

Adeyeye's research focuses on community-based sanitation initiatives to address health hazards in the Ekiti State of southwest Nigeria. The initiatives here consisted of establishing

water and sanitation committees to promote the digging of boreholes (for hand-washing) and construction of latrines. The participation of women was deemed essential to the program, but equal representation did not ensure equal participation.

Vallejo's research focuses on the water-resource systems of the Caribbean region of Colombia. Flooding and droughts have taken a toll on the region over the past two decades, and climate change and the loss of 95% of this region's native forests are causing economic, social and ecological vulnerability.

Little's research deals with urbanization and the spread of dengue fever in the municipality of Patillas in southeastern Puerto Rico. She examines the distributions and habitats of two dengue vectors in Patillas: the mosquito Aedes aegypti, and Aedes mediovittatus, a native, tree-dwelling mosquito that is seen as a potential vector. Her analysis will enable dengue interventions to be focused on the highest-risk urban environments.

Song and his collaborators' work in a Hawaiian tea plantation examined how shade levels and age affect the concentrations of chemicals, such as caffeine in tea plants. It is an analysis of the correlation between health-benefiting chemicals in tea and two much-discussed variables of the tea plant: the age of the leaf and whether or not the plant is shade-grown.

Blázquez examines existing mechanisms for adapting to climatic perturbation, especially drought, among peasant households in Mexico. She frames her study as an effort to inform planning for climate-change consequences and responses. She notes, however, that the effects of globalization on Mexico's agrarian economy make it difficult to ascertain whether these mechanisms represent adaptations to climatic, rather than economic, stress or more likely a combination of the two.

Wood did a comparative study of climatic variation on agro-biodiversity and peasant household economies, again framed as a way to assess the future effects of climate change. It is based on a study of the Fouta Djallon region of northern Guinea and southern Senegal. He found that as temperature—if not precipitation—increases, so does crop diversity, and as the latter variable increases, so does household income.

DePaula's study concerns the consequences of increasing global temperatures on residential energy use in less-developed countries. Brazil's economy is booming and its middle class is growing and so is consumption of electricity. He investigated how projected increases in temperature will affect growth in consumption and concluded that future increases in energy consumption in Brazil will vary according to income levels and local climatic conditions. Overall, though, the growth in Brazil's middle class will substantially increase the climate change effects on its energy sector.

For more information on the Tropical Resources Institute or its fellows, visit *environment.yale.edu/tri* or contact tri@yale.edu.

Wyss Scholars to Promote Land Conservation Out West

By David DeFusco, Director of Media Relations and Outreach; Yale School of Forestry & Environmental Studies

On a cross-country bicycle tour for Habitat for Humanity several summers ago, Chris Colvin peddled hard toward the 9,600-foot summit of Togwotee Pass from Riverton, Wyoming, eyeing the open grassy meadows and Whitebark pines to distract from the burn in his legs. As he crested, the snow-capped spires of the Grand Teton Mountains burst forth from the asphalt horizon, their mighty peaks piercing the opalescent blue as if laying claim to the heavens. Colvin's breath caught. It was at that moment, he said, that he fell in love with the Rocky Mountains.

Now a master's student at the Yale School of Forestry & Environmental Studies (F&ES), Colvin will continue his studies this summer as a Wyss Scholar, consulting for the National Park Service's Denver Service Center on the development of management plans for national parks.

Mikailah "Mik" McKee and Jonathan Loevner are the other 2012–2013 Wyss Scholars, bringing the total of F&ES recipients to 15 since the program began in 2006.

The Wyss Scholars Program aims to create a generation of leaders in western land conservation. It covers up to half of the tuition and expenses of getting a master's degree and for postgraduate work. Scholars are also awarded a stipend to cover summer research or an internship in conservation.

In addition, the Wyss Foundation is expanding its program over the next three years to attract three students from the Yale's Divinity School, School of Management, Law School or Graduate School of Arts & Sciences who are planning to apply their skills in conservation.

"The Wyss Foundation is pleased to support a seventh class of Wyss Scholars at Yale as part of our commitment to building leaders in western land conservation," said

Matt Hollamby, program officer at the Wyss Foundation. "Today, someone working in conservation has to understand everything from science and policy to real estate transactions and social media. F&ES is preparing its students for these new careers on campus and by connecting students to conservation projects that are happening now."

The Wyss Scholarship will enable Colvin to pursue his interest in public lands and their relationship to rapidly growing urban centers for two years of work in the West after he graduates next year. He would one day like to work for the US Forest Service, National Park Service or Bureau of Land Management.

"I think it's important for the future of environmental stewardship to make sure that people who live in cities feel connected to natural areas and their public lands," he said.

Colvin grew up in San Francisco. He vacationed at Mount Rainier National Park and stayed in the Paradise Inn, which his great-great-grandfather—the architect Frederick Heath—designed and his grandfather managed. After graduating from University of California Berkeley in 2005, he was a back country ranger in Yellowstone National Park, worked for the US Forest Service and it was at Stanford University where he heard about Yale from alumni.

"The strength of Yale is that you don't just learn how to do things or how to perform tasks. You learn how to think creatively and how to approach problems with a clear, open mind and strong analytical tools," he said.

Jonathan Loevner was exposed to the Rocky Mountains and Great Plains as a child vacationing with his family in Wyoming, and at Carleton College in Minnesota where he studied history and environmental science. At Carleton he developed an interest in land management while working two summers for the US Forest Service in Idaho.

Loevner said he wants to lead projects that improve forest health and create jobs in rural communities. "I became interested in the connection between communities in the Rocky Mountains and landscapes because almost everyone is making a living off the land in some way, whether it's by farming, timber or recreation."

The Wyss Scholarship will help him pursue his dream of improving public land governance out west for the Forest Service or a land management agency. "Getting the Wyss Scholarship is an honor," he said.

Loevner said the greatest challenge in a lot of places in the West is not necessarily managing natural resources, but dealing with political challenges—getting people to agree on what needs to be done. "It should be an important part of educating a land management professional, and I'm definitely getting it here at F&ES," he said.

Mik McKee's parents were dairy farmers in Chelsea, Vermont, where 1,250 people live within 40 square miles. McKee spent a great deal of his childhood outdoors where, he said, he developed an appreciation for the "intrinsic and cultural values" of a rural environment.

After graduating from Hobart and William Smith Colleges in Finger Lakes, New York, he set out to find himself in the wide open spaces of Big Sky Country—Bozeman, Montana. The construction industry was booming and the jobs were plentiful, but what he really wanted to do was work for the US Forest Service. He finally got a chance, landing a job on a fuels crew where he was usually at the vanguard of wildfire suppression efforts. When he left Bozeman, he became a member of the Chena Interagency Hotshot Crew, an elite wildfire crew in Alaska that prided itself on physical stamina and its ability to undertake dangerous assignments.

Not surprisingly, McKee will use the Wyss Scholarship to pursue his interest in fire management and in promoting conservation on working lands, like ranches and farms. "To get the Wyss Scholarship is extremely exciting," he said. "It'll push my academic boundaries further."

He said that growing up in a farming community gives him an appreciation for the challenges that small towns face in retaining young people, supporting good schools and keeping businesses. "Farming is an intensive use of the land, but it isn't at odds with the idea of preserving land," he said. "The two can coexist and that's the direction that conservation needs to head."

Left to right: Wyss Scholars Christopher Colvin, Mikailah "Mik" McKee and Jonathan Loevner.

YIBS Student Awards Announced

Yale Institute for Biospheric Studies (YIBS) Director Os Schmitz is pleased to announce the recipients of the YIBS Small Pilot Grant Awards, the MS Grant Awards, the Dissertation Enhancement Grant Awards, and the Dissertation Improvement Awards for 2012.

YIBS SMALL PILOT GRANT AWARDS FOR 2012

David Post, the director of the YIBS Small Pilot Grant Awards Program and professor in the Yale Department of Ecology & Evolutionary Biology chose the following students to receive awards:

Meredith Atwood
Yale School of Forestry & Environmental Studies
Award: $3,000
Research topic: "Food Webs in Temporary Ponds"

Karin Burghardt
Yale Department of Ecology & Evolutionary Biology
Award: $3,000
Research topic: "Impact of Plasticity in Plant Herbivore Interactions on Ecosystems Processes"

Jessamy Doman
Yale Department of Anthropology
Award: $3,000
Research topic: "Paleoecology at the Origin of Hominins: The Faunal Evidence, 5.7-7 Ma"

Anobha Gurung
Yale School of Forestry & Environmental Studies
Award: $1,750
Research topic: "Understanding Exposure to Traffic-related Air Pollution in Kathmandu, Nepal"

Kathryn Hacker
Yale School of Public Health
Award: $3,000
Research topic: "Eco-epidemiology of Leptospirosis in the Urban Slum Communities"

Nikki Springer
Yale School of Forestry & Environmental Studies
Award: $2500
Research topic: "Wild Energy: Renewable Energy Generation in Wilderness Lands"

MS GRANT AWARDS FOR 2012

Members of the MS Grant Awards committee, David Post, professor in the Yale Department of Ecology & Evolutionary Biology, and Peter Raymond, professor in the Yale School of Forestry & Environmental Studies, chose the following students to receive awards:

Cara Mae Cirignano
Yale School of Forestry & Environmental Studies
Award: $1,750
Research topic: "The Monetary Value of Air Pollution Impacts from American Beef Cattle"

Geoffrey Giller
Yale School of Forestry & Environmental Studies
Award: $2,500
Research topic: "Estrogenic Contamination of Ground and Pond Waters"

Max Lambert
Yale School of Forestry & Environmental Studies
Award: $2,500
Research topic: "Endocrine Disruption between Amphibian Species and Among Land Uses"

DISSERTATION ENHANCEMENT AWARDS FOR 2012

Richard Bribiescas, Chair of the Dissertation Enhancement Awards committee and professor and chair of the Yale Department of Anthropology, and his committee members James Saiers, Professor in the School of Forestry & Environmental Studies (F&ES), and Andrew Hill and Eric Sargis in the Department of Anthropology, chose the following doctoral students to receive awards of $10,000 each:

Rachel Racicot
Advisor: Professor Jacques Gauthier in the Department of Geology & Geophysics
Research topic: "Phylogenetics of Dolphins and their Relatives (Cetacea: Delphinoidea): Evolution and Diversification of Extant and Fossil Delphinoids as Depicted by Inner Ear"

Woosok Moon
Advisor: Professor John Wettlaufer in the Department of Geology & Geophysics
Research topic: "Arctic Sea Ice: Trends, Stability and Variability"

Kristina Guild
Advisor: Professor Roderick McIntosh in the Department of Anthropology
Research topic: "Colonization, Interaction and the Evolution of Landscape: The Arrival of Human Communities on the Southwest Coast of Madagascar"

DISSERTATION IMPROVEMENT AWARDS FOR 2012:

Akram Agha Ali
Yale School of Forestry & Environmental Studies
Award: $4,000
Research Topic: "Water Use in Pakistan's Agriculture: "Efficient Water Allocation in Pakastani Agricultural Production"

Luisa Cortesi
Department of Anthropology
Award: $5,000
Research Topic: "Living in Floods: Knowledge(s) and Technologies of Disastrous Water in North Bihar, India"

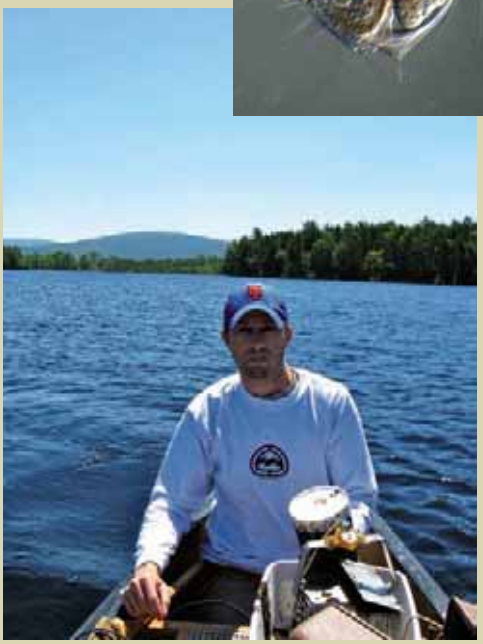
Andrew Jones
Department of Ecology & Evolutionary Biology
Award: $5,000
Research Topic: "Adaptation in alewife (Alosa pseudoharengus) via RAD sequencing"

Kimberly LaPierre
Department of Ecology & Evolutionary Biology
Award: $5,000
Research topic: "Drivers of Grassland Invertebrate Community Structure: Effects of Soil Nutrient Availability and Vertebrate Herbivores on Invertebrate Resource Limitation"

Mary Rogalski
Yale School of Forestry & Environmental Studies
Award: $5,000
Research Topic: "Ecological and Evolutionary Responses to Historic Lake Pollution"

Zaarur Shikma
Department of Geology & Geophysics
Award: $2,700
Research Topic: "U- and Th-bearing phases in aquifer host rock-source for high radium activity in the Nubian Sandstone aquifer"

YIBS Donnelley Fellow Receives Jasper J. Loftus-Hills Young Investigators Award



Matthew Walsh, Postdoctoral Fellow in the Department of Ecology & Evolutionary and former Yale Institute for Biospheric Studies (YIBS) Gaylord Donnelley Postdoctoral Environmental Fellow, has been chosen to receive a 2012 Jasper J. Loftus-Hills Young Investigators Award. This award recognizes outstanding and promising work by investigators who received their doctorates in the three years preceding the application deadline, or who are in their final year of graduate school and have recently received their doctorate.

Walsh studies questions at the interface of community ecology and evolutionary biology and has studied fisheries-induced adaptive change in Atlantic silversides and the evolutionary consequences of indirect effects in the killifish. At Yale, Walsh has studied the cascading ecological and evolutionary consequences of diversification in a fish predator in lakes, and has shown that diversification in the alewife, an important fish in coastal ecosystems along the Atlantic coast of North America, has driven evolutionary divergence in the life history and investment in sex in *Daphnia* (water fleas), the dominant grazer in most lakes. He has also shown that evolution in *Daphnia* significantly altered both consumer-resource interactions with algae and overall ecosystem function. His work at Yale demonstrates that evolution in one organism can propagate through ecological interactions to cause a cascade of evolution that drives evolution in other organisms, which in turn have additional ecological effects.

Walsh will receive the award from the American Society of Naturalists on 9 July 2012 at the first Joint Congress on Evolutionary Biology in Ottawa, Canada.

Fungal Biology at Yale: Shedding Light on Development, Evolution and Metabolism

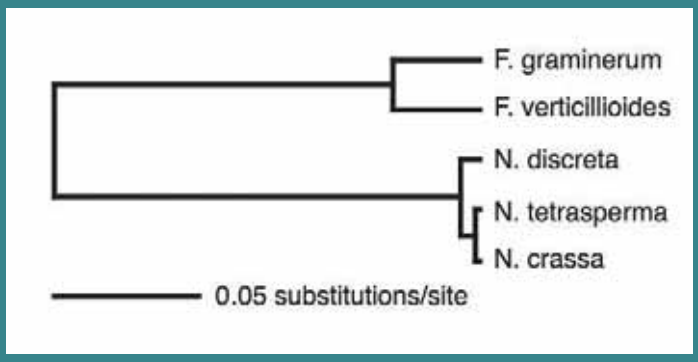
By Nina Lehr, PhD

In May 2010, I joined Professor Jeffrey Townsend's lab in the Yale Department of Ecology & Evolutionary Biology as a Gaylord Donnelley Postdoctoral Environmental Fellow, where I have been working on the evolution of gene expression underlying sexual development in fungi.

The life cycles of some filamentous fungi, including the model ascomycetous fungus *Neurospora crassa*, have been studied intensively. However, unlike the well-studied development of complex, three-dimensional structures in plant and animal development, little is known about the genetic basis of the development of the complex, three-dimensional fruiting bodies called perithecia. Generally speaking, ascomyceteous fungi are the predominant disease-causing fungi for plants and animals and therefore understanding the mechanism of the sexual development is of great importance. *N. crassa* can undergo either an asexual or sexual life cycle. The sexual life cycle requires strains of two mating types, *mat* A and *mat* a. While some genes involved in sexual development have been identified by mutagenesis screens and characterized, a unified model for the genetic control of this developmental process has yet to emerge. I am interested in understanding the mode of the sexual development: how these complex, three-dimensional fruiting bodies develop and evolve. This project will yield results that are critical to studies of the ecology and epidemiology of fungal disease, and moreover, fungi offer a straightforward model for studying the evolution of gene expression underlying morphogenesis. Fungi represent ideal organisms for investigations, because they are easily and rapidly grown and

A

A Carotenoid and melanin production in *Neurospora* spp. in *N. crassa* and *N. discrete* both mating types, mat a and mat A, produce a large amount of cartenoids which accumulate in the mycelium (A, B, D, E). In *N. tetrasperma mat A* synthesizes larger amounts of cartenoids than *mat a* (C, F). After 144 hours the perithecia are fully developed in all three species. The black color is due to the presence of melanin (G–I).



B

genetically manipulated, feature many available and complete genome sequences, and undergo a sexual cycle terminated with the formation of fruiting bodies with a few well-characterized tissues types.

To analyze fungal fruiting body development on a comprehensive scale, I have performed Illumina next generation sequencing of gene expression in three *Neurospora* species, *N. crassa*, *N. tetrasperma* and *N. discrete*, over the time course of sexual development. This sequencing was followed by a comparative gene expression analysis of selected known developmental genes, genes differentially expressed between species, as well as genes in key biochemical pathways such as the melanin and carotenoid biosynthesis. Melanin provides protective functions from environmental stresses, and the high diversity within the fungal kingdom, as well as the ability to exploit extreme environments, is thought to be due to its beneficial features. Carotenoid pigments protect fungi from reactive oxygen species arising from environmental factors such as carbon and nitrogen starvation or light. In *Neurospora crassa*, the synthesis of carotenoids is induced by the blue light-responsive genes *al-1*, *al-2*, and *al-3*. Characterizing genes responsible for fungal response to light provides a window into how fungi perceive the environment, and into the role of light in influencing cellular development and metabolism. The carotenoid biosynthesis pathway in *Neurospora crassa* has been studied intensively, for the asexual development, but so far there is no information on the linkage between the sexual life cycle and the formation of perithecia. Our data indicate that the regulation of expression of genes involved in the carotenoid biosynthetis pathway are not only important for asexual, but also for sexual reproduction.

Neurospora sp. produces fruiting bodies similar to those of the closely related plant pathogenic species *Fusarium graminaerum* and *F. verticilloides*. I have compared our transcriptomic sequencing data of the three *Neurospora* species with transcriptomic sequencing data of *Fusarium* sp. acquired by our collaboration partner Professor Frances Trail, University of Michigan, and used the iPlant Discovery Environment to estimate the ancestral evolutionary transitions that resulted in the shifts in morphology in these two genera. We are currently screening candidate genes by performing crosses using available knockout mutants. We aim to reveal evolved differences in the regulatory circuits that control development, identifying genes with novel function that could provide new targets for fungicides and other antifungals. Our present data provide insight into how fungal pathogens may adapt to their hosts based on shifts in gene expression, together with divergent and convergent evolution of gene function leading to fungal sexual development.

In May 2012, I joined Professor Scott Strobel's lab in the Department of Molecular Biophysics and Biochemistry at Yale, whose research focus is on RNA structure and function. Like Professor Townsend, Professor Strobel is interested in the metabolic underpinnings of fungal biology and his lab works with endophytes and their natural products. Since 2007, plant material has been collected in rain forest expeditions from which endophytes have been isolated, and I am particularly interested in volatile organic compounds that have been highlighted for their potential as fuel alternatives.

C

B Phylogenetic tree of the closely related *Neurospora* and *Fusarium* species. Maximum likelihood tree from a branch and bound search using ITS1+5.8S+ITS2 rDNA data.

C Fully developed perithecium 144 hours after crossing. Top: Scanning electron microscopy of fruiting body. Bar = 99 μ Bottom: Light micrograph of a squash of a mature perithecium. Asci (a) containing ascospores (as) are shown.

BASS DISTINGUISHED VISITING SCHOLARS

JARAMILLO

BLOCH

POSSINGHAM

YIBS to Host Three Edward P. Bass Distinguished Visiting Environmental Scholars During 2012–13

Yale Institute for Biospheric Studies (YIBS) Director Os Schmitz is pleased to announce the appointments of three Edward P. Bass Distinguished Visiting Environmental Scholars during the 2012–13 academic year.

Carlos Jaramillo, a paleobotanist at the Smithsonian Tropical Research Institute in Panama, will serve as a Bass Distinguished Visiting Environmental Scholar in the Yale School of Forestry & Environmental Studies (F&ES) during the fall 2012 and spring 2013 semesters. Colombian by birth, Dr. Jaramillo is quickly emerging as the undisputed leader in understanding the origin of neotropical forests. His research investigates the causes, patterns and processes of tropical biodiversity at diverse scales of time and space, and addresses questions from a paleontological perspective (mainly using fossil pollen, spores, plant megafossils and dinoflagellates), a point of view that is largely needed to understand and predict the behavior of biota in tropical ecosystems. He is also interested in Cretaceous-Cenozoic biostratigraphy of low latitudes, developing methods for high-resolution biostratigraphy and the paleobiogeography of Tethys.

Dr. Jaramillo combines an extremely lively intellect with a real passion for fieldwork and as a result, new data and new ideas about the deep-time history of tropical forests are literally pouring out of his lab.

Dr. Jarmillo is a welcome addition to F&ES, and will also interact closely with the ecology and evolutionary biology environment, the geology community, and with paleontology and paleoclimate research groups while at Yale.

Jonathan Bloch, Associate Professor of Geological Sciences, Anthropology, and Zoology, and Associate Curator of Vertebrate Paleontology at the Florida Museum of Natural History, will serve as a Bass Distinguished Visiting Environmental Scholar in the Yale Department of Anthropology during the spring 2013 semester—from mid January to mid April. Dr. Bloch's research on primate evolution is of interest to many faculty in biological anthropology and geology and geophysics. He has recently been studying turtles, snakes and crocodylimorphs in addition to mammals, and can also address mammalian phylogenetics in the Systematics Discussion Group.

Dr. Bloch has been collaborating with Professor Eric Sargis, Yale Department of Anthropology, on a Mammal Tree of Life project funded by National Science Foundation. While in residence at Yale, he will interact with faculty and students from the departments of Anthropology, Geology & Geophysics, Ecology & Evolutionary Biology and with staff at the Yale Peabody Museum of Natural History.

Hugh Possingham, professor of ecology and conservation science at the University of Queensland, Australia, and a fellow of the Australian Academy of Sciences, will serve as a Bass Distinguished Visiting Environmental Scholar in the Yale School of Forestry & Environmental Studies for one month during March/April 2013. For more than 20 years, Professor Possingham has been a leading innovator in the development of theory and quantitative tools in support of conservation goals. His earlier work focused on the development of population viability analysis and the design of conservation reserves. More recently, he has been a leader in the integration of scientific insight with conservation decision making, and has been extremely successful as a scientist, with his work being cited more than 1,400 times last year alone (h-index= 47).

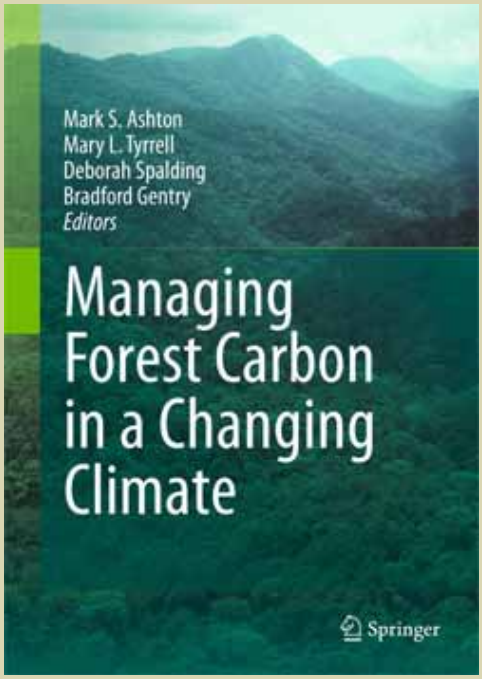
Alongside his scholarship, Professor Possingham has developed two highly successful software packages. ALEX was one of the first comprehensive population viability packages. Unlike some of its commercially available competitors, ALEX is free and it encourages—in fact requires—users to think carefully about

whether they have enough data. More recently, Professor Possingham was a leader in the development of MARXAN, a hugely successful software package designed to support conservation planning.

He has been quite active in translating his research findings into real change. In 2004, Australia was abuzz with the news that Queensland, a state previously known to be a laggard in the protection of native habitats, had banned all future land clearance on state-owned property (a huge fraction of the available land). The effort for the prohibition had been led by Professor Possingham, who is often called in by the federal government to advise on matters of conservation policy. Currently, the Australian government is using MARXAN for planning decisions about federal lands.

We anticipate that Professor Possingham's stay at Yale will prompt interactions with interested faculty and students in F&ES, as well as from the departments of Anthropology, Ecology & Evolutionary Biology, and Economics.

Book Examines Science and Policy of Forest Carbon



Forests are critical to mitigating the effects of global climate change because they are large storehouses of carbon, but there are significant uncertainties about the actual behavior of many of their sinks and sources, according to a recently published textbook, *Managing Forest Carbon in a Changing Climate* (Springer 2012).

The book, written by researchers at the Yale School of Forestry & Environmental Studies (F&ES), is a comprehensive review of the science of carbon sequestration in forests, management of forests for carbon mitigation and poverty alleviation, and the socioeconomic and policy implications of managing forests for carbon.

The book is organized in four parts: the science of carbon sequestration in forests; sciencea of measuring carbon in forests; management of forests and forest products for carbon storage; and socioeconomic, business and policy aspects of managing forests for carbon.

Today emissions from land use, land-use change and forestry are estimated at 17% of annual, global carbon dioxide emissions, which exceeds the amount of emissions from transportation. "All the regional nuances, variations and impacts related to land use in many biomes are largely unknown," said Mark Ashton, a co-author of the book and the Morris K. Jesup Professor of Silviculture and Forest Ecology at F&ES. Mary Tyrrell, executive director of the Global Institute of Sustainable Forestry at F&ES, co-author, said that the few studies on carbon in deep soils are restricted to the developed world. "Deforestation in tropical areas, where the soils are more fragile, may release a lot of carbon."

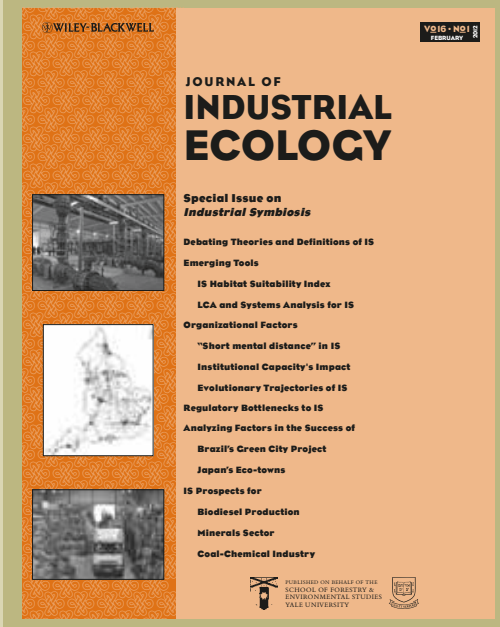
The goal of the book, the authors say, is to provide recommendations for graduate students, land managers and policymakers on vital areas that need research and guidelines for forest carbon management and policy.

"By creating a publication that outlines the research that has been done on forest carbon—pointing out what we know and don't know and the implications for policy decisions—the hope is that land managers and policymakers will have a stronger foundation for making choices," said Brad Gentry, co-

author and senior lecturer, research scholar, and co-director of the Center for Business and the Environment at F&ES, and senior lecturer at the Yale School of Management.

Managing Forest Carbon in a Changing Climate grew out of a series of seminars that were organized by faulty, students and alumni at F&ES, and is available to read online.

Yale Journal Advances Understanding of Industrial Symbiosis



Making one company's waste another company's raw material has long been one of the most intriguing notions in industrial ecology. This strategy, known as industrial symbiosis—by analogy to the manner in which some species in nature cooperate to mutual advantage—came to public attention in the early 1990s, when an industrial district in Denmark with a dense web of resource sharing and by-product exchanges was discovered. Efforts to replicate the Danish example led to a search for other examples and strategies to create such industrial networks. Twenty years later, numerous examples have been documented and countries from China and Korea to the United Kingdom have embarked on programs to establish or facilitate industrial by-product exchange. A special issue of Yale's *Journal of Industrial Ecology (http://jie.yale.edu/Vol16Symbiosis)* highlights research that moves beyond case studies to couple empirical research with theory-building.

To complement the special issue, a selection of previously published articles on industrial symbiosis has been compiled at *http://jie.yale.edu/symbiosis*.

The *Journal of Industrial Ecology (www.wileyonlinelibrary.com/journal/jie)* is a peer-reviewed, international bimonthly journal that examines the relationship between industry and the environment from the perspective of the growing field of industrial ecology. Owned by Yale, it is headquartered at the Yale School of Forestry & Environmental Studies, and published by Wiley-Blackwell.

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Yale Peabody Museum of Natural History

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

We welcome submissions from faculty, staff and students.

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