YALE ENVIRONMENTAL NEWS

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

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Predicting Global Species Extinction Risk

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CONFERENCES, SEMINARS, SYMPOSIA

YIBS/ESC AND YCEI FRIDAY NOON SEMINARS

Yale Institute for Biospheric Studies (YIBS) and the Yale Climate & Energy Institute (YCEI) continue their collaboration in presenting Friday noon seminars. The schedule serves both audiences of YIBS and YCEI with an outstanding speaker line-up. The fall 2010 semester featured the following speakers and their topics:

YIBS/ESC Friday Noon Seminars:

David Bercovici, Professor and Chair of the Department of Geology & Geophysics, Yale University: *Volcanic eruptions: Trembling, choking and going kaboom (with a little physics thrown in for good measure)* ■ Howard Ochman, Professor of Ecology & Evolutionary Biology and Director of the Microbial Diversity Center, Yale University: *The gut microbiota of humans and other great apes* ■ Daniel Rosauer, Gaylord Donnelley Environmental Postdoctoral Associate, Ecology & Evolutionary Biology, Yale University: *Putting evolution on the map: spatial analysis of phylogenetic diversity informs conservation priorities* ■ Trude Storelvmo, Assistant Professor of Geology & Geophysics, Yale University: *Aerosols, climate and geo-engineering* ■ Federico Spada, YIBS Environmental Postdoctoral Associate, Astronomy, Yale University: *The Sun as a climate driver* ■ Mary Evelyn Tucker, Sr. Lecturer and Sr. Scholar, School of Forestry & Environmental Studies and Yale Divinity School, Yale University: *Cultural values and environmental ethics* ■ Christopher Clark, YIBS Environmental Postdoctoral Associate, Ecology & Evolutionary Biology, Yale University: *Singing with feathers: How feathers make sound in a diversity of birds.*

YCEI Friday Noon Seminars:

Mark Pagani, Professor of Geology & Geophysics, Yale University: *Estimates of climate sensitivity to CO_2 from the geologic record* ■ Carl Wunsch, Cecil and Ida Green Professor of Oceanography, Massachusetts Institute of Technology: *What controls modern sea level change* ■ John Kessler, Assistant Professor in the Department of Oceanography, Texas A&M: *Using the Deepwater Horizon disaster to investigate the biogeochemical cycling associated with rapid methane emissions* ■ Andrew Hendry, Associate Professor, McGill University: *Humans, evolution, and the future of biodiversity* ■ Ben Orlove, Professor, Columbia University: *Environmental citizenship in Latin America: climate, intermediate organizations and political subjects* ■ Dr. George Arnold, National Coordinator for Smart Grid Interoperability, National Institute of Standards and Technology, US Department of Commerce: *The Smart Grid: Power for the 21st Century.*

YIBS and YCEI will continue to combine their offerings in the spring of 2011. Please visit the YIBS Web site for the schedule of dates, speakers and their topics at *www.yale.edu/yibs/events_yibsesc.html*.

YIBS CENTER FOR THE STUDY OF GLOBAL CHANGE WEEKLY SEMINARS

The YIBS Center for the Study of Global Change director, Sterling Professor Karl K. Turekian, presented a program of Global Change Seminars in the fall of 2010 with emphasis on the paleontological record of the K/T (Pg) extinction event.

Speakers and their topics were:

Jacques Gauthier, Professor in the Department of Geology & Geophysics, Yale University: *Lizards at the K/T boundary* ■ **Julia Clarke**, University of Texas at Austin: *Reviewing the Late Cretaceous/early Paleogene evidence for lineage origin and extinction in birds* ■ **Ellen Thomas**, Senior Research Scientist and Editor of Marine Micropaleontology, Yale University: *Asteroid impact at the K/Pg boundary: Food supply to the deep sea continues* ■ **Tyler Lyson**, Graduate Student in the Department of Geology & Geophysics, Yale University: *Response of turtles at the K/T boundary* ■ **Leo Hickey**, Professor, Department of Geology & Geophysics, Yale University: *The fate of plants at the K/T boundary* ■ **Timothy Bralower**, Professor and head of the Department of Geosciences, Pennsylvania State University: *Geographic controls on nannoplankton extinction across the K/Pg boundary* ■ **Anjali Goswami**, Lecturer in Paleobiology, University College, London: *Catastrophe or opportunity?: The impact of the K/T boundary event on mammal diversity and evolution* ■ **Carl Wunsch**, Cecil and Ida Green Professor of Physical Oceanography, Massachusetts Institute of Technology: Flint Lecture Speaker–1st lecture: *Determining the ocean circulation of the past;* 2nd lecture: *The ocean and paleoclimate fluctuations;* 3rd lecture: *What controls modern sea level*

change? ■ **Andrew Scott**, Professor of Applied Palaeobotany, Royal Holloway, University of London: *Fanning the flames of time: Fire and oxygen, evolution and the Younger Dryas* ■ **Matt Friedman**, Lecturer in Palaeobiology, University of Oxford: *Patterns of marine vertebrate turnover during the end-Cretaceous event: Linking extinction and ecology* ■ **Richard Bambach**, Research Associate, Smithsonian National Museum of Natural History: *Clams and calamities: Bivalves and the K/T extinction event* ■ **Michael Polcyn**, Director of the Visualization Laboratory and Adjunct Research Associate in the Department of Geological Sciences, Southern Methodist University: *Mosasaur diversity, extinctions and the K/Pg boundary in Angola* ■ **Christopher J. Hollis**, Micropaleontologist and Section Manager, Paleontology, Institute of Geological and Nuclear Sciences, Lower Hutt, New Zealand: *A South Pacific perspective on the causes and consequences of mass extinction at the K/Pg Boundary* ■ **Neil Landman**, Curator, American Museum of Natural History: *The Cretaceous/Tertiary boundary in New Jersey: Last gasp of a dying era?*

Please visit the Center's Web site at *www.yale.edu/yibs/research/CSGC.html* for a list of upcoming seminars in the spring of 2011.

YALE PEABODY MUSEUM OF NATURAL HISTORY

EVENTS

14TH ANNUAL CELEBRATION OF MARTIN LUTHER KING, JR. DAY
January 16 & 17, 2011

The Yale Peabody Museum's renowned two-day festival in honor of Dr. Martin Luther King, Jr. and his efforts to ensure environmental and social justice among all people. The weekend's activities will include world-class performances and educational activities for visitors of all ages.

DINOSAUR DAYS
February 21–26, 2011

Join us during the February school holidays for our yearly celebration of paleontology and everything dinosaurs.

SKELETONS IN THE CLOSET: IT'S ID DAY AT THE PEABODY
April 18, 2011

Have you found something interesting that you'd like to have identified? Come to the Great Hall! Our experts will be on hand to identify your finds or give you their best guess. Or come to see what others bring. Living creatures must be safely secured in breathable containers and promptly returned to their native environment.

BACKYARD BLOODSUCKERS: BIODIVERSITY BITES BACK!
April 21, 2011

The Yale Peabody Museum's teacher professional development program presents activities that look at how we are changing environments in ways that bring people into closer contact with organisms that transmit disease from one species to another, including changes in Connecticut. Learn from experts about predictions for West Nile virus and Lyme disease at this fun and engaging program for the whole family. Sponsored by a Science Education Partnership Award (SEPA) from the National Center for Research Resources, part of the National Institutes of Health.

EARTH DAY CELEBRATION
April 22, 2011

Enjoy fun activities for the whole family and learn from local organizations about simple actions that can make for healthy, sustainable surroundings and protect the planet.

BLACK HOLES: SPACE WARPS & TIME TWISTS
On view through May 1, 2011

Black Holes: Space Warps & Time Twists explores some of the most mysterious and powerful objects in the universe. Designed like a space mission that lets visitors search for evidence of real black holes through interactive experiences, this exhibition also includes a section on the work of Yale scientists.

INVASION OF THE BLOODSUCKERS: BEDBUGS AND BEYOND
Opening May 26, 2011

How do you identify bedbugs, lice, mosquitoes and other bloodsucking arthropods? This exhibition focuses on these common human parasites, their life cycles, how they differ from other household pests, and the evolution of the complex mouthparts that enable blood feeding.

SEPA SCIENCE EDUCATION PARTNERSHIP AWARD

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

Botanical Art Exhibit Showcases Herbaceous Winter Fruits

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The Age of Reptiles, a mural by Rudolph F. Zallinger. ©1990, 2001, Peabody Museum of Natural History, Yale University, New Haven, Connecticut USA. All rights reserved.

An exhibition of large nature portraits, *Seed Pods,* by botanical artist Dick Rauh is the latest natural history art on display in the first floor exhibition space at Yale's Class of 1954 Environmental Science Center. On view from September 4 through December 7, 2010, many of the seventeen watercolor paintings and one glicée print, which stretch from 1993 to the present, resulted from Rauh's involvement as illustrator for *A Guide to Wildflowers in Winter: Herbaceous Plants of Northeastern North America* by Carol Levine (Yale University Press).

As the artist explains, "seed pods" as used in the exhibition title is a generic term, and does not refer to the more accurate botanical meaning of a legume. A better term would be dry fruit. Although we tend to associate the word fruit with the succulent products we buy in the produce department, botanically "fruit" has a much wider definition, referring to the mature ovary with its associated parts. Apples, oranges, tomatoes, and their ilk are "fleshy fruits," but there is another whole spectrum of "dry fruits," such as nuts, that also use the transformed floral ovary to enclose, protect, and finally disperse seeds. Some remain closed throughout the process, others split open to release their seeds. Some often bear unfamiliar names like achenes, follicles, capsules, and samaras, but all come under the general heading "seed pod," and most persist through the autumn and winter.

According to Rauh, "Studying the specimens under the microscope led me to discover the astounding detail and intrinsic grace of these generally overlooked remnants. Bereft of appealing taste, scent, and brilliant color, the other qualities of these fruits come into relief. When enlarged, their architectural features and profuse forms more than make up for what they lack in obvious appeal. A sincere desire to exploit the inherent beauty of these winter fruits caused me to break one of the traditional 'rules' of botanical paintings and to enlarge my subjects between five and twenty times their actual size. Once I became entranced by the beauty I found in the specimens I drew for the book, I was hooked, and have been seeking out and painting more and more of these subjects, now almost twenty years after publication. I hope that you are left with a new appreciation of these brown, dry-looking stragglers that are part of our autumn and winter landscape, and that you might be tempted to take a second look."

Dick Rauh came to botanical painting in retirement, after a career in motion picture special effects. In addition to earning a certificate in botanical illustration from The New York Botanical Garden, in 2001 he received his doctorate in plant sciences from the City University of New York. Rauh's work won the Gold Medal and "Best in Show" awards at the 2006 Royal Horticultural Society Show in London. He is a member of the Brooklyn Botanic Garden Florilegium Society, and president of the American Society of Botanical Artists and past president of the Guild of Natural Science Illustrators. His work is in the permanent collections of the Lindley Library in London, the New York State Museum, and the Hunt Institute for Botanical Documentation at Carnegie Mellon University. He is an instructor in the botanical illustration certificate program at the New York Botanical Garden, where he was named "Teacher of the Year 2010."

A ***Thlaspi arvens,*** **Watercolor, 35.225 x 27.25 inches**
© Dick Rauh

B ***Paeonia follicles,*** **Watercolor, 33.25 x, 27.25 inches**
© Dick Rauh

B

Vertebrate Evolution Across the Cretaceous–Tertiary Boundary in Eastern Montana

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A Curator of Vertebrate Paleontology Eric Sargis (left) and graduate student Stephen Chester (right) screen for Paleocene mammals and other small vertebrates at Camel Butte.

B Graduate students Allison Hsiang (front), Tyler Lyson (center) and Stephen Chester (back) prospect for vertebrate fossils at Camel Butte.

Photos courtesy of Rachel A. Racicot ©2010

A team of paleontologists led by graduate students Stephen Chester (Anthropology) and Tyler Lyson (Geology & Geophysics), and Yale Peabody Museum of Natural History (YPM) Curator of Vertebrate Paleontology Eric Sargis are investigating the transition of vertebrates across the Cretaceous–Tertiary (K/T) boundary. The K/T boundary is marked by a mass extinction event, which was likely caused by a meteorite impact near the Yucatan Peninsula 65 million years ago. Although known mainly for the disappearance of the non-avian dinosaurs, the K/T extinction is also one of the most significant events in mammalian evolutionary history. Following this extinction event, mammals underwent an adaptive radiation and began occupying diverse ecological niches in the early Paleocene. However, the timing of this adaptive radiation, the overall diversity of mammals present in the early Paleocene, and the evolutionary relationships among these fossil mammals and modern mammals is largely unknown because of the paucity of late Cretaceous and early Paleocene fossil localities.

To assess whether previously documented patterns are robust for vertebrates across the K/T boundary, YPM paleontologists spent this past summer excavating one of the earliest known Paleocene fossil localities. This fossil site, located in Fallon County in eastern Montana, was found by YPM volunteer Brian Roach in 2006. The locality was nicknamed "Camel Butte" for two distinct humps formed by the top of the hill.

The importance of Camel Butte was immediately recognized, because of the number of vertebrate fossils on the surface and for its proximity to the K/T boundary. The main fossil-bearing horizon is approximately 8 feet (2.5 meters) above the boundary, which likely indicates that Camel Butte represents a time period less than 100,000 years after the extinction event. Although Yale crews have returned to this locality every year since its discovery to surface-collect fossils of crocodiles, turtles, salamanders, and fish, such efforts often yielded only a single mammalian jaw or isolated tooth. This past summer the YPM team of paleontologists, which also included Yale Department of Geology & Geophysics graduate students Rachel Racicot and Allison Hsiang, decided to undertake an intensive screen-washing excavation at Camel Butte to recover small mammals. These mammals are mostly represented by teeth that are only millimeters in length.

The screen-washing operation was a great success and produced nearly 100 mammal fossils that have since been deposited in the YPM Division of Vertebrate Paleontology collections. Most of these fossils represent condylarths, an extinct group of archaic ungulates (hoofed mammals) that first appeared after the K/T extinction event. Other fossil finds include teeth of multituberculates, a group of extinct rodent-like mammals that were present in the Cretaceous and survived the extinction event. Many of the fossils collected this past summer likely represent new mammalian species, which are currently being described by Chester and colleagues for later publication.

The Yale team made another important discovery approximately 28 inches (70 centimeters) below the K/T boundary—a *Triceratops* brow horn. This fossil is one of the youngest dinosaur remains ever recovered. This discovery encouraged the crew to continue prospecting below the boundary, where they found several Cretaceous mammal jaws, including multituberculates. The occurrence of mammal fossils before and after the extinction event makes Camel Butte one of the most important sites to date for studying mammalian evolution across the K/T boundary. The team plans to continue paleontological expeditions in eastern Montana to develop a better view of evolutionary patterns of mammals and other vertebrates across the K/T boundary. Undergraduate students are encouraged to contact Dr. Sargis (eric.sargis@yale.edu) if interested in participating in field work next summer.

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T. rex Cannibalism?

By Suzanne Taylor Muzzin, Associate Director, Office of Public Affairs

It turns out that the undisputed king of the dinosaurs, *Tyrannosaurus rex*, didn't just prey on other dinosaurs, but also on each other. Paleontologists from the United States and Canada have found bite marks on the giants' bones that were made by other *T. rex* dinosaurs, according to a new study in the TKTK issue of the journal *PLoS ONE*.

While searching through dinosaur fossil collections for another study on mammal tooth marks on dinosaur bones, Yale researcher and Gaylord Donnelley Environmental Postdoctoral Associate Nicholas Longrich discovered a bone with especially large gouges. Given the age and location of the fossil, the marks had to be made by *T. rex*, Longrich said. "They're the kind of marks that any big carnivore could have made, but *T. rex* was the only big carnivore in western North America 65 million years ago."

It was only after discovering the bite marks were from a *T. rex* that Longrich realized the bone itself also belonged to the behemoth. After searching through a few dozen *T. rex* bones from several different museum fossil collections, he discovered a total of three foot bones (including two toes) and one arm bone that showed evidence of *T. rex* cannibalism, representing a significant percentage.

"It's surprising how frequent it appears to have been," Longrich said. "We're not exactly sure what that means."

The marks are definitely the result of feeding, although scientists aren't sure whether they are the result of scavengers or the end result of fighting, Longrich said, adding that if two *T. rex* fought to the death, the victor might have made a meal out of his adversary. "Modern big carnivores do this all the time," he said. "It's a convenient way to take out the competition and get a bit of food at the same time."

However, the marks appear to have been made some time after death, Longrich said, meaning that if one dinosaur killed another, it might have eaten most of the meat off the more accessible parts of the carcass before returning to pick at the smaller foot and arm bones.

While only one other dinosaur species is known to have been a cannibal, Longrich said the practice was likely more common than we think and that closer examination of fossil bones could turn up more evidence that other species also preyed on one another.

The finding is a big clue into the obscure eating habits of these enormous predators. While today's large carnivores often hunt together in packs, *T. rex* likely acted on their own, Longrich said. "These animals were some of the largest terrestrial carnivores of all time, and the way they approached eating was fundamentally different from modern species," he said. "There's a big mystery around what and how they ate, and this research helps to uncover one piece of the puzzle."

Other authors of the paper include John Horner (Montana State University), Gregory Erickson (Florida State University) and Philip Currie (University of Alberta).

A An illustration of a *T. rex* feeding on the carcass of another *T. rex*.

B A toe bone from a large *Tyrannosaurus rex* showing bite marks left by another *T. rex*. Photo by Suzanne Taylor Muzzin

Helping Hands (Full of Minerals!)

By Stefan Nicolescu, Collections Manager, Division of Mineralogy

The request for help that came from the hosts of the 20th General Meeting of the International Mineralogical Association less than three weeks before its start was a stark reminder of the lean times we live in, even for the scientific community. IMA 2010 was to be held August 21–27, 2010 at the Eötvös Loránd University in Budapest, Hungary, which has one of the oldest university mineral collections in Europe. Started in 1774, by the beginning of the 19th century this collection had become the largest educational systematic mineral collection in Europe.

To this day the Eötvös Loránd University mineral collection is housed in its historic, late-19th-century wooden cabinets. The global economic recession brought the cessation of funding for all acquisitions, only the latest in a long list of mishaps that have plagued this collection during its more than two centuries of existence. Therefore, early in August the IMA organizers sent out a plea to meeting participants "to help the development of the collections by donating mineral, rock and ore specimens."

Three generous collectors associated with the Yale Peabody Museum of Natural History (YPM) heard the call for help an ocean and (almost) a continent away and replied without hesitation. These three are Fred D'Ambrose and Fred E. Davis, long-time and highly qualified volunteers in the YPM Division of Mineralogy (where we warmly know them as Fred #1 and Fred #2, respectively), and Museum Technician John V. Ferro, Jr., a full-time YPM staff member. (Rumor has it that John became interested in mineral collecting after he came to YPM and noticed that many minerals on display already had "Ferro" in their names!)

Together the three sent 22 specimens to the Eötvös Loránd University mineral collection (adding 25 pounds to my checked luggage, along with the logistical challenges to be expected when flying with such goods, but that is another story!). This was the largest donation (15% of 143 specimens received) given by any group. Ten cases were set up at the IMA meeting to display donated minerals—and two were entirely taken up by the gifts from the Connecticut donors. This must have impressed the editors of the meeting's daily newsletter, because on the last day of the conference one of the Connecticut cases—holding mostly John's gifts—was featured in the meeting's published acknowledgment.

Each donor also received a certificate of appreciation on behalf of Director Tamás Weiszburg and Curator Erzsébet Tóth of the Eötvös Loránd University mineral collection. Although probably not the most scientifically significant gifts (a few IMA 2010 participants donated mineral co-type material of recently discovered new mineral species), through the number and relevance of their donated samples and the generosity of their gesture the Connecticut donors have made an undeniable mark on the Eötvös Loránd University mineral collection.

Peter Pekker, BAY-NANO Institute for Nanotechnology, Miskolc, Hungary

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Stefan Nicolescu (5)

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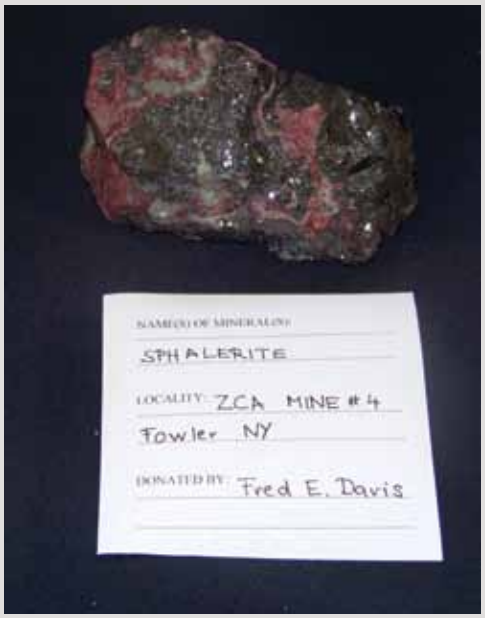

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A The Eötvös Loránd University mineral collection, housed in its late 19th century wooden cases.

B *From left to right:* Volunteers Fred Davis and Fred D'Ambrose, and John Ferro of the YPM Construction Shop.

C The two cases holding the 22 mineral specimens donated to the Eötvös Loránd University mineral collection.

D Kyanite sample donated by Fred D'Ambrose.

E Sphalerite sample donated by Fred E. Davis.

F Almandine samples donated by John V. Ferro, Jr.

Yale Undergraduate Finds Research Opportunities in Peabody Mammal Collection

Aspen Reese (Yale '12), a junior Department of Ecology & Evolutionary Biology major in Timothy Dwight College, has been working in the mammal collection of the Yale Peabody Museum of Natural History (YPM) for more than a year. There she has systematically identified North American rodents, rabbits, bats, and carnivorans to subspecies. She has also been preparing study skins and skeletons of lemur specimens originating from the Duke Primate Center. Most recently, she's applied her preparation skills to Alaskan mammals collected during recent fieldwork by YPM Curator of Mammalogy Eric Sargis and YPM Division of Vertebrate Zoology Curatorial Affiliate Link Olson, Curator of Mammals, University of Alaska Museum of the North. On completion of these new specimens, Reese will return to working on the mammals collected earlier and stored in the YPM Division of Vertebrate Zoology freezer.

Reese has also been working with Sargis on the taxonomy and ecogeography of treeshrews from Southeast Asia. A National Science Foundation grant awarded to Sargis funded her trip to Berkeley, where she was trained in georeferencing methods by the BioGeomancer Working Group at the University of California's Museum of Vertebrate Zoology. This grant also funded her trip to the US National Museum of Natural History (USNM) at the Smithsonian Institution, where she was trained in X-ray measuring techniques by USGS Curator of Mammals Neal Woodman. Reese continues her work measuring the digital proportions of the hands of nearly 150 USNM treeshrew skins X-rayed by Sargis and Woodman for a future publication on the taxonomy of the *Tupaia glisbelangeri* species complex. She also continues to georeference collecting localities for an ecogeographic study of these taxa.

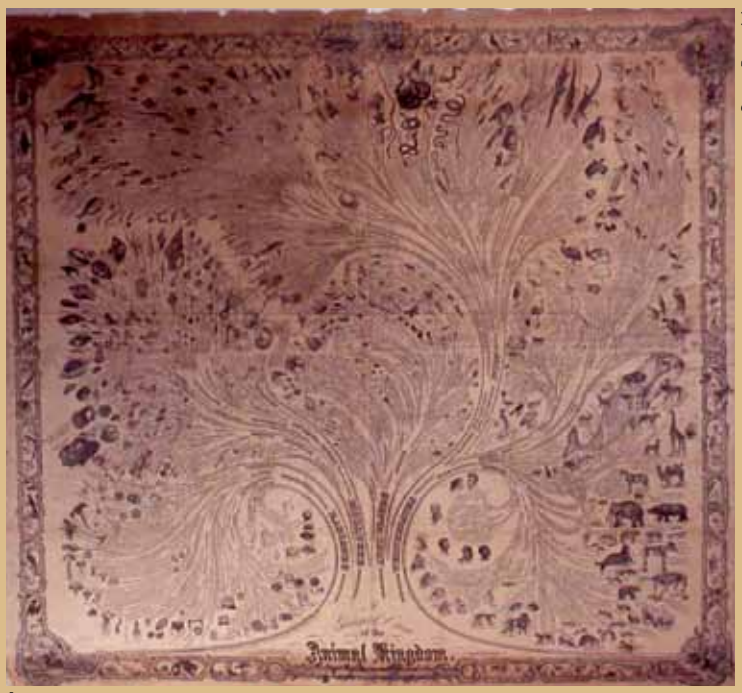
Reese plans to study the morphology and behavior of pikas for her senior thesis, which will include participating in a YPM collecting trip with Sargis and Olson in Alaska.

Yale junior Aspen Reese, an EEB major, preparing a snowshoe hare (*Lepus americanus*) collected on an expedition co-directed by YPM Curator of Mammalogy Eric Sargis.
Photo © 2010 Gregory Watkins-Colwell

A General View of the Animal Kingdom

CONSERVATION OF THE ANNA MARIA REDFIELD WALL CHART

By Susan Butts, Senior Collections Manager, Division of Invertebrate Paleontology



Susan Butts (4)

A

The Division of Invertebrate Paleontology at the Yale Peabody Museum of Natural History (YPM) recently conserved a rare and historically important wall chart, the ornately illustrated *A General View of the Animal Kingdom* by Anna Maria Redfield. This 1857 wall chart, originally designed to accompany Redfield's book *Zoölogical Science, or Nature in Living Forms* (its 743 pages, available at www.google.com/books, also richly illustrated) published in 1858 by E. B. & E. C. Kellogg, New York and Hartford, Connecticut, is an important document in the study of biology and in the pioneering work of women in science.

The chart's intricate and accurate illustrations of representatives of the animal kingdom are portrayed as a "Tree of Life" that illuminates the relationships of the major groups of organisms. The eloquent phrases on the chart express a humanistic Victorian view of nature (often intermingled with anthropomorphism, biblical overtones, and the biological superiority of humans). Aside from its artistic merits, the chart is intriguing because at the time it was uncommon to depict the relationship of organisms in a tree. This chart actually pre-dates Darwin's *The Origin of Species* by two years (although Darwin's 1837 scientific notebook also arranged organisms in a Tree of Life). Redfield's work is not acknowledged in prominent evolutionary texts such as Darwin's, nor does Redfield refer to Darwin's theories of evolution, although she does mention his research as a naturalist.

Anna Maria Redfield (1800–1888, née Treadwell) was born to a wealthy Canadian family, educated at the Mrs. Emma Willard Seminary, and afterward took post-graduate classes in Clinton, New York (presumably at the institution that was the precursor of Hamilton College, where her uncle, Reverend Dr. Davis, was president). She later lived in Syracuse, New York, and attended scientific conferences and other conventions to promote and sell her book and wall chart to the academic world. Like many wealthy Victorian women, she was an avid naturalist and amassed a large collection of shells, minerals, botanical specimens, and scientific papers. However, few women of her generation could claim the influence afforded by the publication and use of Redfield's educational wall chart and textbook. Yet, Redfield remains a relatively minor and poorly recorded figure in the history of women in science, let alone biological and evolution studies in general. She was honored with the equivalent of a masters of arts degree by Ingham University, the first institution of higher learning for women in the United States.

How the wall chart came to the Peabody is unknown, but presumably it was purchased for classroom use, probably around the time it was published. It has been housed in YPM's Division of Invertebrate Paleontology for at least 45 years.

In the conservation of the wall chart by Gary E. Albright, a paper conservator with an international reputation, the backings were removed mechanically and with water, and varnish removed by bathing the chart in alcohol; the chart was washed with water to remove discoloration and acidity. The treated paper was then affixed to a new backing of Japanese kozo paper and cotton muslin using a wheat starch adhesive. Tears were mended and losses filled by the Japanese paper backing. Areas of loss were toned to make them less obvious. In general, missing design elements were not reconstructed, except where the nature of the original was obvious. The Division completed the full conservation project with support from the Peck Stacpoole Foundation, restoring the wall chart to an acceptable condition, photographically documenting the process and results, and framing the chart with archival materials to allow others to enjoy this unique contribution to the study of evolutionary science.

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A High resolution imaging of the wall chart *A General View of the Animal Kingdom* was funded by the Yale Office of Digital Assets and Infrastructure. While many copies of the original book still exist (57 copies of the original printing, according to the WorldCat database of library books in the United States), only two other copies of the wall chart are known, both of which were sold through auction houses. Yale's chart, however, had been exposed to the elements over years of use and improper storage and its condition had slowly degraded. Water damage, discoloration of the varnish, and desiccation had compromised the paper and multiple cloth backings. It also had suffered a large tear and several smaller tears.

B Detail of the wall chart before and after conservation. A second edition of the book attributes the beautiful illustrations to Reverend E. D. Maltbie of Syracuse, New York, who had preferred to remain anonymous for the initial printing. However, by the second printing, after his death, his identity was revealed.

C Yale Peabody Museum staff members Lourdes Rojas and Jessica Bazeley examine *A General View of the Animal Kingdom* on display in the Class of 1954 Environmental Science Center. The framing was done with acid-free archival materials and topped with UV-absorbing Plexiglas™ to prevent any damage from sunlight.

The 2010 Simpson Prize Recognizes Research Papers on the Earliest Animal Life

The Yale Peabody Museum of Natural History (YPM) is pleased to present its George Gaylord Simpson Prize for 2010 to Erik A. Sperling and Jakob Vinther, both doctoral candidates in the Yale Department of Geology & Geophysics.

Sperling received the prize for his 2010 paper "Where's the glass? Biomarkers, molecular clocks, and microRNAs suggest a 200-Myr missing Precambrian fossil record of siliceous sponge spicules," co-authored with Jeffrey M. Robinson, Davide Pisani and Kevin J. Peterson (*Geobiology* 8[1]:24–36). Sperling's research encompassed both the earliest evidence for animal life in the fossil record and molecular analysis of modern demosponges to provide insights into the Precambrian origins of multicellular animals more than 700 million years ago.

Vinther was recognized for his 2009 paper, "The canal system in sclerites of lower Cambrian/ Sinosachites (Halkieriidae: Sachitida): Significance for the molluscan affinites of the sachitids" (*Paleontology* 52[4]:689–712). Vinther was also a receipient of the 2008 Simpson Prize for a paper on machaeridians, palaeozoic armoured annelid worms, published in *Nature*.

YPM's George Gaylord Simpson Prize is awarded annually to a Yale University graduate student or recent doctoral candidate for a paper concerning evolution and the fossil record. The prize is named for George Gaylord Simpson (1902–1984; Yale PhD '26), the most influential paleontologist of the 20th century and a major proponent of the modern evolutionary synthesis.

Erik Sperling grinding sponges in liquid nitrogen for RNA extraction in the Dartmouth College lab of Dr. Kevin Peterson. Photo by Jakob Vinther

Erik A. Sperling

Sperling's doctoral research focused on determining the body plan of the last common ancestor of animals and the time period in which this ancestor originated. His molecular phylogenetic work showed that sponges are paraphyletic (part of a taxonomic group that does not include all the descendents of a common ancestor); in other words, some sponges (Calcarea and Homoscleromorpha) are more closely related to the Eumetazoa, animals with some tissue and organ systems, than they are to demosponges, a class of animals whose skeletons have siliceous spicules, slender supporting spikes made of silica. This result suggests that the last common ancestor of ani-

Erik Sperling in the field in southern Namibia investigating Ediacaran Nama Group fossils. Photo by Ian Rose

Jakob Vinther and *Archaeopteryx*. Photo by Ryan Carney

mals was constructed like an adult sponge and fed using the water-canal system.

Sperling then addressed the temporal origins of animals, a question for which there is conflicting signals in the fossil record of sponges. Organic geochemical records suggest an early origin for sponges, before the first Snowball Earth glaciation, a planetary ice age about 635 million years ago. The first sponge spicules, however, do not appear until later, near the beginning of the Cambrian, approximately 540 million years ago. Sperling used the presence and absence of specific microRNA genes as an independent test of his traditional molecular phylogenetic data, with robust results that allowed the application of a molecular clock to that dataset. The dates from the molecular divergence analysis agreed with the organic geochemical record and suggested that sponges with siliceous spicules were present prior to the Snowball Earth glaciations, although ocean conditions did not allow for the preservation of their spicules.

Erik Sperling (Yale PhD '10) is originally from Bainbridge Island in Washington State. He received his BS and MS degrees in geological and environmental sciences from Stanford University. Before starting his doctoral work at Yale, Sperling worked at the South Australian Museum on the famous Ediacara fauna and was convinced to add an understanding of molecular biology to his paleontological toolbox. This eventually led to his thesis work, supervised by Derek E. G. Briggs, Frederick William Beinecke Professor of Geology & Geophysics at Yale University, and co-supervised by Kevin J. Peterson, Associate Professor of Biological Sciences at Dartmouth College, that combined paleontological and molecular insights into the origin and early evolution of animals. In Fall 2010 Sperling began a postdoctoral position at Harvard University investigating environmental changes during the Precambrian and the effect of these changes, particularly oxygen levels, on early animal evolution.

Jakob Vinther

Originally from Denmark, Jakob Vinther (Yale PhD '11) studied at University of Copenhagen before coming to Yale. His research interests are in early animal evolution, primarily the emergence and interrelationship of animals, the Metazoa, which radiated in a period between the Precambrian and Cambrian (600 to 500 million years ago) in the "Cambrian explosion," when it is seems that most animal groups evolved from a common ancestor in a short time. With a focus on the divergence of annelids and mollusks, his research uses both the study of the molecular biology of modern organisms and the fossil record to understand how these two distinct invertebrate groups diversified in a markedly changing biosphere.

Chitons (polyplacophorans) are a small group of mollusks with a conserved morphology of eight overlapping plates surrounded by a girdle with small scales. The plates contain an internal sensory canal system, called aesthetes. In this paper Vinther studied this canal system and its presence in a Cambrian stem group, the sachitids, which have a debated systematic position. The presence of aesthetes in sachitids support the idea that they are stem groups of chitons.

More recently, another important area of Vinther's work has been in understanding taphonomy, how animals are preserved in the fossil record, and especially his study of fossil melanin as part of an international research team to establish the colors of extinct organisms, such as birds.

This is the final digital copy of a page from the oldest ledger to be digitized, which lists donations in 1865 from, among others, "Prof. B. Silliman," "Prof. G. J. Brush," "Prof. J. D. Dana" and "Prof. A. E. Verrill." Photo by Jessica Slawski

Peabody Document Digitization Project Both Preserves and Uncovers History

By Jessica Slawski, Museum Assistant, Collections and Operations

The Yale Peabody Museum of Natural History (YPM) regularly adds to its estimated 12 million specimens and objects in its collections through fieldwork, donations and other means. What most people are not aware of is the amount of original documentation—source materials such as ledgers, catalogs, field notebooks, and correspondence—that is available for YPM's collections. This unique documentation provides background information about the discovery or historical context of specimens and objects. In many cases, no other copy of the original material exists. Some of this material is more than 150 years old and is slowly deteriorating, with broken spines, loose pages and miles of adhesive tape holding them together. This documentation needed to be preserved as much as the specimens themselves.

In September 2009, Yale's Office of Digital Assets and Infrastructure (ODAI) gave YPM and other Yale departments around campus the opportunity to join a university-wide collaborative effort to digitize archival materials. With the help of three APT BookScan 2400RA robotic book scanners donated to Yale by Kirtas Technologies, Inc., a pioneer in high-quality digitization, YPM began digitizing all of its original source documentation at its research collection facility at Yale's West Campus. Due to the amount of material, a phased approach was put in place: Phase 1, high priority items such as old ledgers and catalogs in poor physical condition; Phase 2, field notebooks and bound correspondence; and Phase 3, any loose items considered pertinent to the collection.

The next step was to examine the copyright status of each document to determine if it could be copied for archival storage or for use in research. To organize the copyright issues, a one page checklist was devised and used by all YPM curatorial staff to evaluate every item to be digitized. Any document that was not in the public domain, that Yale did not own the copyright to or that could not be copied under the doctrine of fair use was not slated for digitization.

Once all the materials were prepared, scanning began. Although it is called a "scanner," the Kirtas APT Bookscan actually takes high resolution photographs while a robotic arm turns the pages of a document. The speed of the machine can be adjusted to anywhere between 300 and 2,400 pages per hour. At full speed, the APT Bookscan can photograph an average 300-page ledger in eight minutes—11 times faster than a human! In manual mode, without using the robotic arm, it would take three hours to turn those same 300 pages. Occasionally manual mode was necessary to process some of the more challenging or delicate materials, such as bound items with broken spines or folded pages, scrapbooks filled with materials of various sizes, and carbon copy correspondence.

After the scans were processed through the Kirtas software, they were compiled into a single high resolution PDF (portable document format) file. Each PDF was transferred to KE EMu database, YPM's collections management system, and from there to the University's recently launched Digital Asset Management

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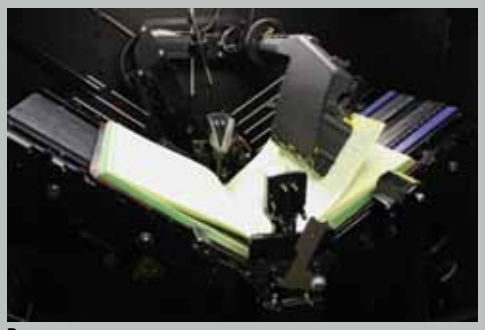

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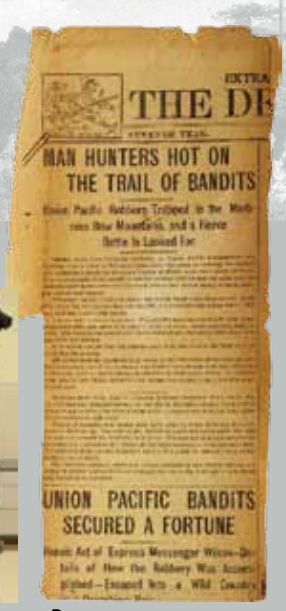

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A This 1865 ledger from the YPM Archives is an example of the typical preservation problems of the oldest YPM ledgers. Photo by Jessica Slawski.

B A ledger from the YPM Division of Anthropology being digitized page by page by the robotic scanning arm. To see the APT Bookscan in action visit http://odai.research.yale.edu/digital-assets. Photo by Jessica Slawski.

C The Kirtas APT Bookscan 2400RA scanner. Photo by Jessica Slawski.

D The 1899 newspaper article found in Richard Swann Lull's field notebook describing the search for Butch Cassidy. Photo by Mary Ann Turner.

system (DAM). The DAM is a central component of the Yale Digital Commons. Developed by ODAI, the Yale Digital Commons is a collaborative framework for developing services to support the management and use of Yale's digital assets.

The benefit of this high-throughput digitization technology is that it can process large amounts of material while not being highly labor intensive. This technique also helps to preserve the original material during digitization, unlike a flatbed scanner, which puts stress on the pages and spine of a book. Once all of YPM's original source materials—all 1,010 items—are assembled into the KE EMu database, the next task will be to electronically link specimens and objects to their corresponding original documentation. Imagine being able to click on a catalog number and not only see a picture and description of the specimen or object, but also see the field notes of the person who discovered it, the map where it was discovered and the letters written about it.

YPM has nearly completed the digitization of all of its Phase 1 materials, and is currently working on Phase 2 items which are yielding some interesting finds. For example, the 1926 summer field notebook of William Sinclair, a geology professor, had various campsite recipes pasted into the back for French Toast, Woodman's Stew and Bean Soup, among others. There was also a miniature Carnation® milk pamphlet that emphasized the benefits of creamed vegetables and how using this creamy milk in recipes will "cut down on your butter bills." However, after analyzing Professor Sinclair's grocery receipts, it appears the main staple of his team was bacon!

Another intriguing story was discovered in the 1899 field journal of the noted paleontology professor Richard Swann Lull. On Friday, June 2, 1899, while doing field work in Medicine Bow, Wyoming, Lull writes of hard rainstorms that sent his party running for cover around 4:00 pm. Soon after, 10 men on horseback arrived, armed with revolvers and rifles. They turned out to be a deputy sheriff and his posse looking for six train robbers who had held up a Union Pacific train called the *Overland Limited*. The thieves had used dynamite to blow open the train's safe and escaped with anywhere from $600 to $60,000. According to Wyoming law at the time, the penalty for dynamiting and robbing a railroad train was death or life imprisonment. The posse ate supper, waited for the rain to stop, and then continued its pursuit. The most fascinating tidbit is the newspaper clipping dated Saturday evening, June 3, 1899, that was sandwiched between the pages of Lull's journal entries. The clipping describes the robbery and Union Pacific's offer of a reward of $1,000 for each outlaw, dead or alive. The article goes on to say that the train robbers were from a remote hideout called Hole-In-The-Wall in the Big Horn Mountains. The head of these train robbers was a man named Robert Leroy Parker, aka Butch Cassidy.

EVOLUTIONS After School Students Intern in Yale Research Labs

Over the past several months, a team of Yale researchers has generously hosted science internships for several high school students from the Yale Peabody Museum of Natural History (YPM) EVOLUTIONS After School Program in ongoing research in their Yale labs. Under the leadership of EVOLUTIONS program head Jamie Alonzo, YPM Coordinator for Education Special Projects, these interns have been working on the "front lines" of science, conducting real research on everything from biodiesel to fish genetics. On Friday, August 27, 2010, at a YPM luncheon for family, friends and Yale staff, several of these student interns gave brief illustrated presentations highlighting their experiences. These reports are based on their presentations.

Michael Richmond and Luis Zaragoza
Sound School and Notre Dame High School

The EVOLUTIONS After School Program at the Peabody Museum presented us with an opportunity for an internship in the lab of Professor of Geology & Geophysics Mark Pagani. There we were given our own corner to work in, away from the rest of the students working on their own projects. The internship involves making biodiesel. We began in mid February of 2010. Professor Pagani had us start with understanding the chemistry behind the production of biodiesel. Currently, we are in the process of engineering the full-scale production of biodiesel. Our internship is unique in that we are the ones who do the research, come up with how to make the biodiesel, and design the system. In the other internships, the professors told the interns how, when, and what to do. In ours we decide what to do ourselves, with consent from Professor Pagani, of course.

What exactly is biodiesel? Biodiesel is a diesel fuel made from animal and plant fats. Most vehicles with an ordinary diesel engine can use this without any modifications. Biodiesel is also a cleaner burning fuel than fossil fuels and is a renewable resource; it is considered "green," or environmentally friendly. Once we understood the chemistry well, we tried making a small batch. There were many mistakes and we advanced slowly by trial and error. There was an instance early in the process in which we added too much base and ended up with a bar of soap, and another in which we blew up the container. We never really saw the errors as just mistakes, but rather ways in which not to make biodiesel. Our first successful batch was rewarding! Now we are on our way to producing it at a larger scale. The challenge for this year will be designing an automated system that will produce 15 gallons of perfect biodiesel.

We would not be here if it were not for Jamie Alonzo, head of the EVOLUTIONS After School Program, for hosting the internships. We thank Professor Mark Pagani for allowing us to pursue this project in his lab. And also thanks to the lab students who aided in our project!

Serena Sanchez
Hill Regional Career High School

I worked on two internships in the EVOLUTIONS After School Program. One was with Gillian Paul, a student at the Yale School of Forestry & Environmental Studies, who went to central Panama to visit an abandoned land pasture. There, Gillian collected pictures of the leaves of different plant species: *Tabebuia, Termanilia, Pachira,* and *Dalgergia.* Her objective was to see whether the amount of herbivory on each of the species depended on the species' traits, such as age, structure of the leaf, and the family it belongs to. The types of herbivory we were interested in were rolling, skeletonizing, mining, and chewing.

My contribution to the project was assisted by the software Image J (a public domain Java image processing program). Image J allowed me to use the pictures Gillian took in Panama to find the necessary calculations, such as the total amount of green left of the leaf, the perimeter of the leaf, the amount of herbivory on the leaf, and the percentages for all previously stated quantities. After I found my measurements, I input the numerical data into a spreadsheet. The spreadsheets containing such data were used to collect results and produce conclusions.

By being involved in this internship I learned how to use Image J, how to distinguish the different leaf species and their age, and I gained insight on a topic I knew an insignificant amount about.

In the other internship I was involved in this past summer, I had the opportunity to work with Professor Ruth Blake and post-doctoral associate Lisa Stout at the Yale Department of Geology & Geophysics. Dr. Blake and her team are involved with the study of oxygen isotope thermometry, which is the study of ancient temperatures using natural materials such as shells, bones, and teeth. My project focused on an oxygen isotope thermometer based on DNA; specifically, looking at phosphate. All living organisms contain DNA, therefore all living organisms contain phosphate. Phosphate is what stabilizes DNA and can be considered as its backbone. Phosphate can also reveal the temperature of the climate

an organism lived in. Just like DNA, it too, can act as a natural "thermometer." Yalitza Garcia, my undergraduate mentor from the University of Connecticut, and I decided to experiment with this concept. We went to a local fish market and bought a porgy. Our goal was to extract the phosphate from the "thermometers" within the fish. The scales, the teeth, and the bones are considered to be those thermometers.

In addition to my project, I also learned a variety of microbiology techniques, such as how to make a clone library, how to streak a plate, how to run a PCR (polymerase chain reaction), how to gram stain, how to run a gel electrophoresis, and how to complete a DNA extraction.

The people I met and the world of new knowledge I was exposed to made my summer an unforgettable one. Working with Dr. Blake, Dr. Stout, research assistant Mary Page, Gillian Paul, and Yalitza Garcia was truly a privilege that I will always be grateful for.

Peabody Welcomes New Curatorial Staff in Mineralogy


Fred E. Davis

Stefan Nicolescu has joined the Yale Peabody Museum of Natural History (YPM) as collections manager in its Division of Mineralogy. Originally from Transylvania, Nicolescu grew up in the Carpathians. Graduating in geology and geophysics from the Babe–Bolyai University in Cluj, he worked at several research institutes in Romania before he was hired by his alma mater first as a research scientist and later as a lecturer in ore deposits geology. In 1992 Nicolescu took a research assistant position at the University of Natal (now University of KwaZulu-Natal) in Durban, South Africa, and two years later moved to Sweden to earn his doctoral degree in mineralogy–petrology from the University of Gothenburg.

Nicolescu moved to the United States for postdoctoral studies at Washington State University in Pullman. In 2001 he switched professional fields and came for the first time to Yale, as a research scientist to run the former helium-dating laboratory in the Yale Department of Geology & Geophysics, where he worked with Pete Reiners. In 2006, when the lab relocated to the University of Arizona in Tucson, Nicolescu also went as "part of the furniture," moving to the Southwest with Reiners and the lab.

His "third life" in geology began in June 2010 when he became the YPM mineralogy collections manager. Nicolescu will oversee an historically important worldwide collection of more than 40,000 specimens, including suites of material from localities that no longer exist, early prospecting material, a collection of gemstones, a sizeable collection of Connecticut minerals, and a new petrology collection recently received from the Department of Geology & Geophysics. He jokes that his "prograde" metamorphosis from "lab furniture" to "museum exhibit" is now complete!

To learn more about the YPM mineralogy collections visit *www.peabody.yale.edu/collections/*.

Burying CO_2 Underground: Sequestering CO_2 with Mafic Rock

by Zhengrong Wang and David Bercovici

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The accumulation of anthropogenic CO_2 in our atmosphere is changing Earth's climate. The rising frequency and intensity of various kinds of extreme weather (e.g., hurricanes, cold and hot days), sea-surface temperatures, level of ocean pH (concentration of protons), among other effects, all can be related to the global warming largely derived from the increasing CO_2 concentration in the atmosphere. It is humanity's responsibility to find avenues to reduce its possible severe impact on life.

Currently, many geo-engineering methods have been proposed and some are under rigorous investigation, including releasing SO_2 gas into the atmosphere to block sunlight from reaching the Earth's surface, launching mirrors into space to reflect solar radiation, pumping iron into the ocean to crank up biological production of carbonate, injecting water vapor to synthesize white clouds that can reflect sunlight, using artificial photosynthesis to store CO_2 as an organic compound, and so forth. However, these techniques are either technically challenging, consuming large amounts of energy, or have unknown side effects that could worsen the current climate conditions. They are unlikely to be applied in the near future until the full spectrum of their outcomes has been systematically investigated and technical hurdles overcome.

Earth has been modulating its climate and CO_2 content in the air for more than 4 billion years before human intervention. This has been achieved by storing CO_2 in the ocean, organic matter (living and dead), and carbonate rocks. If this CO_2 were to be released, it is estimated that the atmospheric pressure would have been more than 215 times that of today and composed of predominantly CO_2. The balance between CO_2 in the atmosphere and hydrosphere/biosphere/lithosphere is subtly self-adjusted through Earth's climate, i.e., warm weather due to a high concentration of CO_2 in the atmosphere promotes silicate weathering, increases the alkali content of the ocean and facilitates the formation of carbonate, which reduces CO_2 in the atmosphere.

A team of scientists from various fields of geological sciences, including Jay Ague (geologist), David Bercovici (geophysicist), Shun Karato (geophysicist), Edward Bolton (geophysicist), Michael Oristaglio (geophysicist) and Zhengrong Wang (geochemist) from Yale University, and Wenlu Zhu (geophysicist) from University of Maryland and Kevin Johnson (geologist) from the University of Hawaii decided to evaluate the potential of expediting this natural process by reacting CO_2 with mafic rocks (basalts and garnet peridotites), which has several advantages over other methods. These rocks upon weathering release Ca, Mg and Fe, which neutralize dissolved CO_2 to form carbonate. One key advantage among them is that this reaction will release, rather than consume, energy (exothermic reaction). If the reaction rate is fast enough, the energy could be harvested for self-sustainable CO_2 sequestration. Significant amounts of mafic rocks occur on Earth's surface, amounting to a potentially large capacity. Undoubtedly, there are many unknowns that pose obstacles to its application, ranging from chemical reaction rates to mechanic properties of rocks. The scientists will be conducting lab experiments and establishing numerical models to hunt for the best chemical and physical conditions for this reaction, and identify strategies to cope with potential side effects. If this technique can be demonstrated in the lab and numerical models, it will be tested in the field in Hawaii. The US Department of Energy has funded this project for three years, providing $2.4 million to ride this adventure.

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A Polished garnet-peridotite (from South Africa, courtesy of Alexandra Andrews) under reflected light, 3 x 3 mm (pink: high-Cr garnet; green: high-Cr clinopyroxene; white: orthopyroxene; dark matrix: olivine/serpentine). This piece of rock came from a depth of about 40 kbar (~ 140 km). Very reactive with CO_2, it forms carbonate at room temperature.

B Talcott Pillow basalt (about 250 Ma) at Hartford basin (Meriden, CT, courtesy of Tony Fiorini). Round black rocks are pillow basalts. White rocks at the boundary or in the vein are clay minerals (such as zeolites) and carbonates precipitated from penetrating fluids.

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Combining Natural History Knowledge and Satellite Imagery to Predict Global Species Extinction Risk

Yale University researchers in the Department of Ecology and Evolutionary Biology have developed an integrative and innovative tool for biodiversity conservation in the face of global change: a statistical model that helps explain and predict the risk of extinction for nearly 90% of the world's 10,000 bird species.

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Visiting graduate student Tien Ming Lee and Professor Walter Jetz built the global model, the most comprehensive integration of its kind to date, to evaluate how ecological attributes and geographical context combine to make species more or less vulnerable to extinction in the 21st century. The study is published online in the Proceedings of the Royal Society B (*http://rspb.royalsocietypublishing.org/content/early/2010/10/12/rspb.2010.1877.abstract.*)

Building on the Red List of threatened species compiled by the International Union for Conservation of Nature (IUCN), Lee and Jetz used natural history and environmental data, species range maps and satellite imagery to identify key factors that put species at risk. The resulting model disentangles "static" natural history correlates of extinction risk from those due to rapid human-induced environmental change, such as expansion of agricultural lands.

Species traits such as large body size, specialized lifestyle, slow reproduction and a narrow geographic distribution are known to threaten species survival. So does human encroachment, which, though crucial, has never been quantified explicitly for so many species.

For instance, the small-sized Short-legged Ground-roller (*Brachypteracias leptosomus*) is found only on the island of Madagascar. According to the IUCN Red List, because the species is a moist tropical forest habitat specialist and has a very small population size, it is classified as vulnerable. Conversely, the same-sized Banded Kestrel (*Falco zoniventris*) is also endemic to Madagascar, but due to its less specialized habitat preference and larger population size, it is not presently threatened by extinction.

More critically, how these factors interact with each other to influence extinction risk of thousands of species had so far not been assessed quantitatively and at the global scale.

Two examples illustrate the interplay among key extinction risk factors. The Barred Eagle Owl (*Bubo sumatranus*), a mid-sized bird native to tropical Southeast Asia, is relatively rare throughout its range and, as satellite imagery indicates, suffers from heavy encroachment by humans. However, because its geographic range is very large, the species is not globally threatened. In contrast, the larger-sized Horned Guan (*Oreophasis derbianus*), suffers similar levels of encroachment, but because of its much smaller geographic range and its restriction to Guatemalan and Mexican cloud forests, the species is highly threatened with extinction.

Many of the species classified by IUCN as threatened are more common in some parts of the world, such as the species-rich tropics, than others. With the help of global-scale remote sensing data and advanced image analysis techniques, it is now possible to identify and measure with unprecedented rigor where humans have had a particularly devastating effect on the landscape even in remote and inaccessible tropical forests.

The model developed by Lee and Jetz opens the door for a more dynamic assessment of human-induced threat through real-time monitoring of land-cover change or even future land-cover projections. By measuring the relative importance of human encroachment on species threat level, the model can predict extinction risk in the face of ongoing as well as projected future change. The model may also be extended to other species groups besides birds, although more accurate data on species distributions and land-cover change would improve its effectiveness. Overall, such an approach for integrating and separating

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the different risk components will help with the estimation, and hopefully reduction, of future extinction risk of biodiversity.

A Barred Eagle Owl, photo by C.W. Ye

B Horned Guan, photo by Knut Eisermann

C Banded Kestrel, photo by Markren

D Short-legged Ground-roller, photo by Markren

ELTI: Capacity-building for Tropical Forest Conservation and Restoration

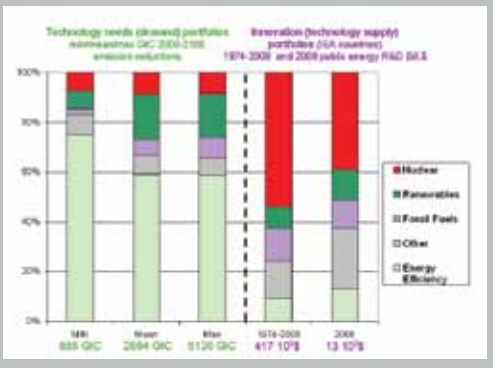
The Environmental Leadership & Training Initiative (ELTI), a joint program of the Yale School of Forestry & Environmental Studies (F&ES) and the Smithsonian Tropical Research Institute (STRI), whose mission is to enhance the capacity of decision makers and practitioners to conserve and restore tropical forests, is in its fifth year of activities. Since 2006, ELTI has held 34 courses, workshops and conferences in the Neotropics and tropical Asia, reaching over 1700 people. The program has also provided post-training support to over 50 alumni, affording these individuals additional opportunities to further deepen their understanding of key conservation issues and put into practice what they have learned during ELTI events.

ELTI's niche rests in providing capacity-building on strategies to conserve, restore and/or reduce impacts and threats to tropical forests outside of protected areas (PA). Historically, training on PA management has been more readily and consistently available than training on mechanisms to protect, rehabilitate, and sustainably manage ecosystems and biodiversity in working landscapes—areas that are subject to multiple uses and pressures, including commercial agriculture, logging, and large-scale energy and infrastructure development, among others. Recognizing, however, that a significant portion of biodiversity is found outside of formally declared PAs, ELTI training efforts build the capacity of individuals and organizations to promote the establishment of "sustainable landscapes," where key ecosystems and the services these provide are conserved, degraded areas are restored, and major impacts to natural systems are attenuated. Underlying all of ELTI's efforts is the maintenance or improvement of the livelihoods of those groups that live in or depend directly on forests.

Participants in ELTI's training events are people whose decisions and actions can have a profound impact on the way tropical landscapes are managed. And given ELTI's emphasis on promoting conservation outside of PAs, which are areas often slated for other productive or economic activities, most of these individuals come from sectors that do not necessarily have conservation as a primary mandate. For the most part, participants have academic, professional and life backgrounds in fields outside the natural or environmental sciences, such as agriculture, tourism, rural development, and energy, among others. Despite this, most leave ELTI's events with an enhanced sensitivity toward the value and importance of nature and with the knowledge, skills and tools to better manage tropical landscapes.

Within the realm of forest conservation, ELTI's Training Program, which currently operates in six countries, namely Panama, Peru, Brazil, Singapore, the Philippines and Indonesia, has developed courses, workshops and conferences on forests and climate change, and forest carbon project develop-

Changes in Energy R&D Needed to Combat Climate Change



Past and current investments into developing climate-friendly technologies (R&D, right) versus future technology needs (min/mean/max across scenarios, left) by technology category.

A new assessment of future scenarios that limit the extent of global warming cautions that unless current imbalances in research and development (R&D) portfolios for the development of new, efficient, and clean energy technologies are redressed, greenhouse gas (GHG) emission reduction targets are unlikely to be met, or met only at considerable costs.

The study identifies energy efficiency as the single most important option for achieving significant and long-term reductions in GHG emissions, accounting for up to 50 percent of the reduction potential across the wide range of scenarios analyzed. However, investment in energy efficiency R&D has typically been less than 10 percent of the overall public sector R&D budget in the countries of the International Energy Agency (IEA). Conversely, although nuclear energy accounts for less than 10 percent of the GHG emission reduction potentials across all scenarios, it has received some 50 percent of the total public investment in energy technology R&D.

The analysis, conducted by Arnulf Grubler from the Yale School of Forestry & Environmental Studies and School of Management, and Keywan Riahi, from the International Institute for Applied Systems Analysis (IIASA), Austria, and published in the inaugural issue of the journal *Carbon Management* (2010 1(1):79-87), compared historical and current government spending on R&D by the 28 member countries of the International Energy Agency, with a "needs"-based analysis of the technologies required to achieve long-term climate stabilization. The assessment is based on the analysis of a wide range of scenarios of future technology deployment rates under a range of future uncertainties and climate constraints.

"Current investments in energy technology R&D by the public sector, in all industrialized countries, are heavily biased in favor of nuclear energy, to the detriment of energy

ment, including Reduced Emissions from Deforestation and Forest Degradation (REDD). Training events on forest restoration have explored the science and practical application of reforestation with native tree species, agroforestry and silvopastoral systems, while events that promote impact and threat abatement have considered and engaged the controversial discussions regarding the effects of biofuels feedstock production on forests and climate. ELTI's Leadership Program, which provides additional professional development opportunities to alumni, has supported many former participants in establishing tree nurseries, reforesting degraded areas, developing integrated watershed management projects, and receiving additional training and mentoring from experts in the design of their own conservation initiative.

As ELTI moves into the second half of its fifth year of operation, plans are well underway to continue to provide training and follow-up support to key decision makers and field practitioners from the Neotropics and tropical Asia on REDD, native species reforestation, agroforestry and silvopastoral systems. ELTI will continue to serve as an "honest broker" of information, inspiring its audiences to protect and restore tropical forests and biodiversity.

(This article, written by Javier Mateo-Vega, Eva Garen and Cecilia Viana, was originally published in *Tropical Conservation Science* in October 2010).

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A Farmers from the central provinces of Panama discuss the uses and advantages of planting native trees. Panama, 2009.

B Participants of a Carbon Project Development course learn the basics of measuring carbon. The Philippines, 2009.

efficiency research," says IIASA energy expert Riahi. "Given their respective importance for future climate mitigation this is a significant imbalance. Based on current investments, we estimate that a five-fold increase in investment in energy efficiency is needed to address this imbalance. Importantly, if the current rate and allocation of investment in energy R&D is maintained there is a high chance that technology development will be insufficient to meet stringent GHG reduction targets."

While technological development is critical, the authors also emphasize the need for accompanying market deployment incentives for an aligned and consistent technology policy framework.

"The drastic emission cuts required to limit climate change will only be possible if we can achieve a major transformation of the energy system," adds IIASA co-author Grubler. "This will require the adoption of a range of policies and measures beyond an expanded and restructured energy technology R&D portfolio to include incentives for niche market applications and the large-scale deployment of climate-friendly technologies."

Because the future is inherently uncertain, the study uses a range of scenarios—22 in total—to examine what successful or unsuccessful adoption of different technologies (such as nuclear or carbon capture and sequestration) might achieve for reducing GHG emissions. The scenarios include a "do nothing" or business-as-usual scenario, where, for example, R&D policies remain uncoordinated and market incentives for new technologies to minimize emissions remain unchanged. The study concludes that a business-as-usual approach to energy technology R&D will make combating climate change very difficult and more costly, reducing both the likelihood of success and the political and social acceptability of a transition to climate-friendly, energy-efficient technologies.

Based on the scenarios, the authors outline a forward-looking energy R&D "portfolio" that they propose would provide the best hedging strategy for making sure future GHG emissions can be actually reduced and at reasonable costs. In order to achieve this goal currently unbalanced energy technology R&D portfolios need to change, reflecting the respective "option value" for future GHG mitigation of different options, which are particularly large for energy efficiency (see chart).

The study focused primarily on public or government-funded R&D, but the authors say the findings in terms of energy technology investment is similar to that of private sector investment, where there is a similar preference for large-scale supply-side energy technology investments, to the detriment of energy efficiency.

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Biological Research at Butterfly Farms in Costa Rica

In a recent trip to Costa Rica, Antónia Monteiro, assistant professor in the Yale Department of Ecology and Evolutionary Biology (EEB) and assistant curator of entomology at the Peabody Museum of Natural History (YPM), and Xiaoling Tong, Postdoctoral Associate, worked closely with butterfly farmers to collect larval samples at particular developmental stages from a variety of different species.

The two Yale biologists visited the oldest butterfly farm in Costa Rica, Suministros Entomologicos Costarricenses (*www.butterflyfarm.co.cr*), an exporting center for live pupae reared in the region's surrounding farms. The purpose of the trip was to sample larval wings from 20 different species of butterflies to later examine the expression of genes involved in the color patterning of the adult wings. Because the farm only exports live pupae, and the Yale biologists needed to examine larval patterns of gene expression, they arranged to collect the larvae directly from the farms, before they metamorphosed into pupae.

The analysis of gene expression in larval wings is part of a National Science Foundation-funded project, awarded to Monteiro and William Piel, YPM associate director of bioinformatics, with the goal of understanding how eyespot patterns evolved and diversified in Nymphalid butterflies. This group of butterflies includes the spectacular blue morphos, the crackers, and the owl butterflies, all displaying variable numbers of eyespots on their wings. One of the aims of the project is to examine to what extent wing spots of single color and eyespots, with concentric circles, express the same genes and represent variations of the same patterning process. Another goal is to test whether eyespot number diversity is accomplished by deleting eyespots from a

A *Morpho peleides*

B *Saturniid larve*

C *Colobura dirce*

putatively ancestral species with many eyespots, or, instead by adding eyespots to novel wing compartments over time.

Butterfly houses around the world import most live pupae from butterfly farms located in the tropics, and farms in Costa Rica are some of the oldest suppliers. Monteiro and Tong visited two of the largest farms in the area. Costa Rica is home to some 550 species of butterflies, and roughly 100 of these are farmed for export. The right food plants are grown in small fields, then enclosed in large net enclosures, and the adults released inside. The butterflies lay eggs and the larvae eat the food plants protected from most parasitoids and predators. Once a field of plants is devoured, no more adults are allowed inside until the plants recover. A different field is then used for growing the larvae. This system of field rotations resembles how larger herbivores, such as cows and sheep, are reared in traditional farms. Once the larvae reach the last larval stage they are taken indoors and fed cut plants, for closer monitoring of development. The pupae are harvested one or two days after pupation and sent to the Suministros for export. Roughly 80,000 to 120,000 pupae, provided by 150 different local farms, are shipped to butterfly houses in the United States and Europe every month.

Butterfly farmers, perhaps without realizing it, have much to contribute to basic biological research in the field of the evolution of development. The farms rear the same species year around and function as a stock center for butterfly biodiversity. But, more importantly, given the difficulty of rearing some of these tropical species in more northern latitudes, the farms provide a source of valuable biological material that can be sampled in large quantities, at any time, and at any stage of development. These farms are, thus, fantastic resources for researchers that are interested in delving into comparative aspects of developmental biology using butterflies as model species.

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D *Dryadula phaetusa (Nymphalidac)*

E *Hymadras arinome*

F *Archaeoprepona demophoon*

G *Hymadras februa*

H *Morpho peleides (Nymphaelidae)*

I *Tithorea tarricina*

For Fungi, Size Matters

Featured on postcards, the gorgeous leaf colorations induced by autumn's crisp chill make the perfect backdrop for a visit to New Haven. In September, branches bright with orange to red leaves already stand out from the green maple trees in the Science Hill neighborhood, and it is a sign of a colorful season once again.

Another readily visible but less frequently welcomed color on maple leaves is "spotted tar black" that begins as small yellow dots in early summer. Caused by fungi belonging to the genus *Rhytimsa*, tar spot is one of the easiest diseases of maple to diagnose. Also one of the least damaging fungal ailments to its host, many mycologists would prefer to call *Rhytimsa* endophytes (literally, "living-in-plants") instead of parasites or pathogens. The evolution of the morphology and life style of *Rhytisma* species and other leaf endophytes has attracted the attention of researchers in the Townsend lab at Yale's Department of Ecology & Evolutionary Biology (EEB).

Studies of symbiotic relationships between fungi and plants date to the very earliest days of mycological research, but most research has been performed on highly pathogenic fungi, underground mycorrhizas, and root endophytes. Recently, however, an astonishing diversity of fungal endophytes has been identified thriving within living leaves. If that alone does not seem surprising, a group of researchers recently found more than 1,000 fungal endophytes associated with a single tree in a tropical forest. Their mode of persistence and impact on the host remains mysterious.

Most research on ecological role that would resolve this mystery has been facilitated by studies of form and function in animals and plants. This approach is less frequently taken in fungi, due to their diversity and lability of form. The fungal kingdom includes many saprobes, plant pathogens, and endophytes, with shifts of ecological role occurring at many taxonomic ranks. Their complex reproductive morphologies are highly variable. Thus, the causes underlying their morphological diversity have been extremely challenging to elucidate. The old school taxonomy and classification of fungi, mainly based on similarity of morphol-

ogy, is easy to teach and practice. However, in many cases it classifies based on convergent function rather than the actual evolutionary history of fungi, leading to an underestimate of the remarkable ability of fungi to shift ecological roles during the course of evolution.

Taking advantage of molecular phylogenetic tools, scientists can now sort out the evolutionary history of fungi, especially those fungi whose morphological traits are simple or reduced and thus provide little to compare or contrast with potentially related species. Townsend's team analyzed DNA sequence data from fungal endophytes, epiphytes, and saprobes, including sister lineages that do not form visible reproductive structures on living plants, revealing a new relationship between body plan and endophytic lifestyle. Their discoveries were published in the journal *PLoS ONE* in 2009.

To explain what they found, first consider the tiny tar-spot symptoms on leaves of maples. These fungi develop within a dark stroma, immersed within host tissues, and the tar spots are their highly reduced fruiting bodies, from which they release spores. In contrast, species of its saprotrophic sister in the family Cudoniaceae produce large, bright fruiting bodies on leaf duff or mossy ground. Only molecular sequence data could reveal the close relationship between the Rhytismatales and the Cudoniaceae. No morphological characters had ever suggested such a sister relationship.

Molecular sequence data also demonstrated the lability of morphology in another family called the Hemiphacidiaceae that includes both leaf endophytes and pathogens. Previously, all fungi placed in this family produced small, simple fruiting bodies beneath the surface of leaves. Based on molecular data, *Heyderia* and *Chlorencoelia* species have been robustly placed within the family, despite the production by both species of large and fully developed fruiting bodies.

Similar morphological adaptation is also now recognized within even earlier-diverging lineages of fungi. Saprobic *Neolecta* species are occasionally referred to affectionately by mycologists as fungal dinosaurs, due to their apparent retention of ancestral characteristics, including production of large fruiting bodies on the ground. Nevertheless, pathogenic species of *Taphrina* that molecular sequence data has revealed are closely related to *Neolecta* produce naked spores on the leaf surface.

Townsend's research supports a theory that for leaf endophytes and pathogens, a small, covered fruiting body is an adaptation to the ecological constraints of limited physical support, strong radiation, and rapid evaporation. Intriguingly, the adaptation may be common to both sexual and asexual reproductive morphology in some endophytic lineages.

This commonality has brought Townsend and his team to start asking additional questions. Many fungi have sexual and asexual cycles in their life histories, and the genetic basis of both sexual and asexual development has received intensive attention. In general, asexual spore-bearing structures are very simple and significantly morphologically distinct from the more complex sexual fruiting bodies. But for some fungi, such as the *Holwaya* and *Ascocoryne*, the asexual fruiting bodies are prominent and composed of tissues homologous to the ascocarps. In contrast, sexual fruiting bodies of endophytic species of the *Rhytismatales* resemble the simple asexual fruiting bodies with which they are physically associated. One of the central questions in evolutionary developmental biology is how the same genes and often the same pathways may be activated to perform different developmental functions in different tissues and at different times. Would some of the same genes or pathways function in both in the development of sexual and asexual fruiting bodies in these fungi? How are those genes and pathways regulated (turned off an on) in divergent species? Coupled with detailed studies of asexual and sexual development in model organism *Neurospora crassa*, the Townsend team is prepared to find the answers using next-generation sequencing techniques to investigate the evolution of transcriptomes from diverse fungi manifesting similarly diverse body plans.

Will there be another golden age for in the evolution of development ("evo-devo") that goes beyond the study of convenient model fungi such as yeasts and *Neurospora*? Flashes of the tar spots through the gorgeous, thick golden foliage at the top of the Science Hill may tell.

A nine-minute short video with more detail on this research is accessible on the internet at "SciVee: making science visible". The URL for the video short is *www.scivee.tv/node/12902*.

Trees Out of the Rubble

By Marc Wortman

Originally published in *Environment:Yale*

In an impoverished land like Haiti, people view trees as a cheap source of cooking fuel and building materials. Trees also cover farming land or block other commerce. As a result, over the past sixty or so years Haitians have consumed virtually every tree in the countryside, leaving a fast-eroding rock garden that can't produce enough food for its own people. Sparked by urgent calls to rebuild the country following January's earthquake, a group of leaders in the effort to restore Haiti's blighted rural landscape came together at the School of Forestry & Environmental Studies (F&ES) for two days in May to explore ways to delink the cycle of poverty from environmental degradation.

Until the middle of last century, lush forests covered much of Haiti's rural landscape. With the forests now gone from all but about 3 percent of the mountainous countryside, tree crops like mangos and cacao have also virtually disappeared. With little to hold back the water, more frequent and more intense tropical storms in recent years have made natural disasters endemic within the watersheds where most farming occurs, notably floods which have killed thousands of people and wiped out harvests, most recently in 2004 and 2008. To sustain a malnourished population, aid programs often supplement Haiti's food supplies, sometimes undercutting efforts to encourage sustainable farming practices. Extended droughts have added pressure on farmers to plant food crops on every available bit of arable land to feed one of the West's most densely populated countries. The earthquake on January 12 that sent thousands of people fleeing out of the devastated capital city of Port-au-Prince into rural areas further sapped already scarce food supplies. The earthquake's horrifying destruction may have convinced world leaders, though, that concerted action was finally needed to tackle Haiti's many thorny rural environmental problems contributing to the nation's deep poverty. About 100 agroforestry and environmental experts, United States and Haitian government officials and aid organization leaders convened at Kroon Hall in May to explore ways to turn the real rubble left by the quake into the figurative soil needed to grow trees in Haiti once again.

"Deforestation is at the core of the issues driving poverty in Haiti," says F&ES lecturer and research scholar James Lyons '79, during a break in the meeting's sessions. "The restoration of the Haitian economy has to start with the restoration of the Haitian environment." Former U.S. president Bill Clinton now serves as the United Nations Special Envoy for Haiti. He agrees with Lyons, who was his Undersecretary for Natural Resources and Environment and head of the U.S. Forest Service. Even before the earthquake hit, Clinton asked him to formulate a strategy for sustainable restoration of Haiti's rural environment. But, says Lyons, restoring the forests "is not a simple problem." The misery accompanying the earthquake merely made coming up with solutions "that much more urgent," he says.

Lyons turned for help to his Clinton administration colleague and friend John Lewis. Lewis, who received a doctorate in anthropology from Yale in 1979, spent four years as a U.S. Agency for International Development (USAID) rural development officer in Haiti and later served, under President Clinton, as director of its Office of Agriculture and Food Security. Now he is a managing director at Terra Global Capital, an environmental strategy advisory and investment firm. He has advised the William J. Clinton Foundation on using global carbon reduction strategies as a means of supporting antipoverty and sustainable reforestation efforts in the developing world.

F&ES already had ties to the postearthquake relief effort. Haiti's ambassador to the United States, Raymond Alcide Joseph, had come to campus in the month after the earthquake to meet with F&ES faculty and students and others at Yale to discuss ways of helping Haiti recover. Learning about the Clinton Foundation's interest in pushing forward environmental restoration efforts, Dean Peter Crane urged Lewis and Lyons to follow up the ambassador's visit by convening a meeting at Yale. When Joanas Gue, Haiti's Minister of Agriculture, heard about the planned meeting, according to Lewis, he "jumped" at the opportunity to participate. With the support of the Clinton Foundation and World Vision International, the U.S. State Department's lead nongovernmental organization (NGO) for Haiti, Lyons and Lewis quickly organized the meeting of Haitian and American environmental and rural economics experts.

The immediate goal for the Yale conclave was to draft a strategic blueprint for a meeting between the Haitian Inter-Ministerial on Land Use Planning and President Clinton later in the summer in Port-au-Prince. That document was aimed at getting all the many NGO and government aid agencies, private companies and the Haitian and U.S. governments, which rarely cooperate and sometimes act at odds with one another, moving in the same direction. Speaking in French after the first morning's Kroon Hall sessions, Gue lauded what he calls "Yale's very fine initiative. This is an opportunity for strategic collaboration among all the actors. We need to define approaches that move all of us in the same direction."

Over the next two days, a series of speakers laid out the problems plaguing the Haitian countryside and explored long-term solutions in the works, as well as next steps for sustainable environmental restoration. According to Jean-Marie Robert Chery, a counselor at the Ministry of Agriculture, Natural Resources and Rural Development (MARNDR), the best-planned previous strategies have faced the daunting challenge on the ground in Haiti of gaining support from the thousands of often isolated small-plot farmers dotting the watersheds. The farmers and villagers lack what he terms "natural solidarity," without kinship, farmer's cooperatives or governmental structures representing their interests. He asks, "How do you intervene in the absence of local solidarity?" According to Chery, any attempt to convert farmland to trees for production of potentially profitable and environmentally more-sustainable agroforestry crops also needs to convince wary farmers that aid organizations and government officials would not abandon the effort before it took root. The various pro-

grams that speakers proposed would also need to provide farmers with enough income and food to survive while waiting for newly planted trees to mature and begin generating perennial income.

Jean Serge Antoine, deputy director of forest and land management at MARNDR, explains, "Farmers presently need everything—water, credit, border trees." He notes that most programs take into account only the downstream point of view, where the destruction and human catastrophes from flooding have been most apparent. He warns that any restoration program would need upland farmers to participate and "take ownership" of programs from the start. "If you overlook the needs of the farmers," he says, "it is worse than not trying. You will extend the cycle of poverty." He calls for programs that change cropping and agricultural production systems, but "any changes must be gradual to get farmer buy-in. To lift pressure on natural resources, you need to generate revenue-increasing opportunities."

Several academic experts and a number of representatives from international aid organizations described their existing efforts, including demonstration projects to plant border trees for plots that could also provide sustainable crops such as shade coffee, avocados and cocoa, as well as biomass for fuel. Lewis and others spoke about ways of using carbon offset credits from planting trees as a means of funding the long-term changeover needed in land use. Several private for-profit and nonprofit companies sent representatives to the May meeting, among them Timberland, the shoe and apparel maker; Mars, the candy manufacturer; and the Paradigm Project, developer of fuel-efficient, low-carbon cook stoves.

Considering the many promising ideas and willingness to back change in Haiti, Lewis says, "We have a pretty good idea of what kind of land use changes have to happen so that trees that take many years to grow don't have to compete with cultivation of small plots by farmers. But getting from here to there in this somewhat anarchic country will take a focused effort coming out of meetings like this. It can be done."

Heat Wave Deaths Highest in Early Summer

INTENSITY AND DURATION OF HEAT WAVES ALSO FACTORS IN MORTALITY RISK

The number of heat-caused deaths are highest when heat waves occur early in the summer and are hotter and longer than usual, according to a Yale study published in the journal *Environmental Health Perspectives* (*EHP*).

During the first heat wave of a summer, the risk of mortality increases 5.04 percent, compared to 2.65 percent for heat waves that occur later in the summer. Michelle Bell, a co-author of the study and associate professor of environmental health at the Yale School of Forestry & Environmental Studies, said that people may be less accustomed to the heat early in the summer and may not protect themselves against it, and that people most vulnerable to heat waves may succumb during the first one of the season.

"We found a higher mortality risk from heat waves that were either hotter, longer or earlier in the summer," said Bell. The average daily risk of non-accidental death increased by an average of 3.74 percent during heat waves that occurred during the study, from 1987 to 2005 in 43 U.S. cities. The mortality impact of a heat wave increased by 2.49 percent for each 1-degree Fahrenheit increase in mean temperature and 0.38 percent every day a heat wave dragged on.

The EHP article, "Heat Waves in the United States: Mortality Risk During Heat Waves and Effect Modification by Heat Wave Characteristics in 43 U.S. Communities," is available at *http://ehponline.org/article/info:doi/10.1289/ehp.1002313*.

Bell and Brooke Anderson, the study's co-author and a postdoctoral researcher at the Yale School of Forestry & Environmental Studies, defined heat waves as two or more days for which the average mean temperature exceeded the 95th percentile of temperatures for May through September for a given city during the 19-year study.

The risk of mortality was greater in the Northeast and Midwest than in the South. Bell said that even though it's hotter in the South, the risk of dying may be lower because air conditioning is more prevalent and people are more acclimated to the heat. Mortality did not increase at all during heat waves in several of the southern cities that were studied, including Charlotte, Dallas/Fort Worth and Tulsa.

In addition to variation across regions, the authors also found that mortality rates during heat waves of similar intensity and duration could vary from one year to the next within the same region or even within the same city. "Our findings have implications for decision-makers addressing the health burden of heat waves and for researchers estimating health effects from climate change," said Anderson.

The research was funded by a U.S. Environmental Protection Agency (EPA) Science to Achieve Results graduate fellowship, a National Science Foundation graduate fellowship, the National Institute of Environmental Health Sciences and the U.S. EPA through the Johns Hopkins Particulate Matter Research Center.

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Payments-for-Ecosystem Services Training in Brazil's Mata Altântica

Javier Mateo-Vega, Eva Garen and Cecilia Viana
Environmental Leadership & Training Initiative (ELTI) August 27, 2010

A joint initiative of the: Smithsonian Tropical Research Institute & Yale School of Forestry & Environmental Studies

Brazil's Atlantic Forest region—the Mata Atlântica—has been subjected to widespread land transformation for more than five centuries. This biodiversity hotspot harbors a remarkably diverse and unique flora and fauna comparable to that of other Amazon forest types. Yet the Mata Atlântica is considered one of the most threatened tropical landscapes in the world. Scientists advocate stemming the tide of deforestation and conserving the region's remaining forests. Despite notable advances, such as the recent declaration of four new protected areas and the expansion of an existing national park in the Mata Atlântica's Central Biodiversity Corridor, major challenges persist. For example, a coalition of legislators known as the "Ruralistas" is pushing to modify the Brazilian Forestry Code, which would exacerbate forest loss by diminishing the percentage of forest that must be protected on private lands, among other things. These and other initiatives illustrate persistent pressures that loom over the Mata Atlântica and other biodiversity-rich ecosystems throughout the country and the pressing need to develop viable strategies to protect and restore these resources.

The remaining forests in the Mata Atlântica region are insufficient to sustain key ecosystem services such as water purification and carbon sequestration, which support an already burgeoning population along Brazil's eastern coast. This region includes 70% of Brazil's population and some of the country's primary urban centers, such as Sao Paulo and Rio de Janeiro, which place exceptionally high demands on forest-generated services. Efforts to ensure the long-term existence of ecosystem services, therefore, must focus not only on protecting remaining patches of forest, but also on allowing natural regeneration to occur and promoting large-scale restoration of degraded lands.

Reforestation with native tree species, versus commercial exotics, is recognized and promoted as a primary strategy to restore degraded areas and support the continued provision of ecosystem services in the region. However, the costs of these initiatives, as well as efforts to protect and manage existing forests, are substantial. Suitable financing mechanisms have not yet been established. Payments-for-Ecosystem Services (PES) programs are a promising strategy. In a PES program, an individual or group that owns land where natural systems generate ecosystem services receives formal compensation—usually monetary—by guaranteeing the provision of the service to a willing buyer or beneficiary. The ecosystem service—e.g., water regulation, carbon sequestration and storage, and biodiversity maintenance—is sustained or generated by rewarding and promoting biodiversity-friendly land uses, such as forest conservation, reforestation, and management. The logic is that a payment made to a landholder via a PES program will provide the economic means and incentives to protect, manage, or restore a forested area. Payments by the recipients of the service, such as water bottling companies or agricultural industries, are often the principal source of funding for PES programs. PES programs also can generate concomitant benefits associated with forest conservation or restoration, such as protection of threatened wildlife species and their habitat.

In response to a growing interest in PES as a potentially sustainable source of funding for conservation and restoration efforts, the Environmental Leadership & Training Initiative (ELTI), a joint capacity-building program of Yale University and the Smithsonian Tropical Research Institute (STRI), recently organized two courses on PES with local partners. The courses were held in Recife, Pernambuco, and Porto Seguro, Bahia, in the northeastern and central portions of the Mata Atlântica region. ELTI worked alongside partner organizations Cepan, Amane, Conservation International (CI), Flora Brasil, RPPN Estacao Veracel, and Instituto Bioatlântica to engage more than 70 representatives from local government, NGOs, local communities, and academia on PES. Discussions focused on the viability of developing PES projects and state-level legislation to support and promote native species reforestation, forest conservation, and watershed protection and management initiatives that will contribute toward establishing and consolidating conservation corridors in the region. Participants examined the technical, social, economic, and political dimensions of implementing PES initiatives in the region, and particular attention was placed on analyzing the opportunities, complexities, and challenges of participating in emerging ecosystem-service projects and markets (e.g., carbon markets). Participants learned about resource and ecosystem service valuation and payment structures and also considered the mechanisms that must be instituted to ensure that rural communities and landholders can benefit from these initiatives. This latter issue was particularly relevant during the courses, as concerns mount about the potential impacts of PES and Reduced Emissions from Deforestation and Degradation (REDD) initiatives—i.e., projects that finance conservation of threatened forests and associated carbon stocks to mitigate the effects of climate change—on the livelihoods of forest-dependent communities in Brazil.

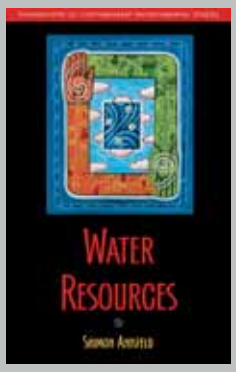
Both courses provided information and facilitated discussions to encourage relevant stakeholders to decide whether or not to develop PES programs and legislation for forest conservation and land restoration with native trees. Following the Recife course, the state-level law and policy on mechanisms to confront climate change (No. 14.090), which was being drafted and debated prior to the course, was modified to include the concept of

ecosystem services and to promote reforestation with native species and PES as a form of compensation for forest conservation. The law went into effect on June 14, 2010. During the course in Porto Seguro, members of the Steering Committee of "Protected Areas Mosaic of Southern Bahía," a part of the Central Biodiversity Corridor, began to draft a project concept proposal for a PES initiative at the level of the mosaic which will encourage landholders to participate in projects to restore and manage local forests.

Reforestation with native tree species, versus commercial exotics, is recognized and promoted as a primary strategy to restore degraded areas and support the continued provision of ecosystem services in the region.

Although there are conflicting accounts about how much of the Mata Atlântica actually remains, recent estimates, which include intermediate secondary and small patches of forest (less than 100 hectares), indicate that only 11.4% to 16% of the region has forest cover—most in small and isolated fragments. These fragments tend to be separated by land uses that continue to pose serious threats to remaining biodiversity, including extensive sugar cane, coffee, and eucalyptus cultivation, cattle ranching, and urban sprawl. The federal Brazilian Forestry Code and the Atlantic Forest Law require that remaining natural vegetative cover must be maintained, but deforestation and land degradation continues due to insufficient monitoring and enforcement.

The Mata Atlântica will not be able to recover or provide critical ecosystem services without active conservation, management and restoration efforts. Few significant patches of old-growth forest remain. Research has shown that secondary forests can take significantly more than 40 years to recover the structure of old-growth forests, even when species richness recovery is rapid. However, well-conceived, socially responsible PES projects might generate the revenue to finance these efforts and advance the recovery of this critically imperiled landscape and the ecosystem services it provides.



Water Resources

Shimon C. Anisfeld

Floods and droughts frequently garner headlines. But they are simply part of the multifaceted water crisis facing the world today. A new book with a simple title explains this much-discussed, but often-misunderstood, subject. *Water Resources*, by Shimon Anisfeld, a research scientist at the Yale School of Forestry & Environmental Studies, provides a comprehensive yet accessible primer for students and lay readers alike.

Anisfeld begins with the premise that people and water are deeply interlinked. Humans are composed mostly of water, as is the surface of the planet we live on. We use water in so many ways that we hardly notice our dependence on it for drinking, sanitation, irrigation, power production, and much more. Our lives and prosperity are dependent on a safe, adequate supply of water. Yet both human water systems and the natural ecosystems that underlie them are threatened from all directions: pollution, wasteful use, environmental degradation, global climate change, and political conflict.

Anisfeld addresses the principal ecological and human problems related to water. After introducing the basics of hydrology and water quality, he explores issues including flooding, scarcity, climate change, technologies, ecosystem degradation, human health, agriculture, industry, inefficiency and inequity, and political conflict. He notes that billions of people in developing countries today lack access to safe water and adequate sanitation, and they suffer from serious health consequences as a result. At the same time, scarce water is leading to tensions among states, countries, and regions throughout the world.

To ease this growing crisis, Anisfeld says, we must improve water resource management. He argues the key challenge is balancing competing demands for water, from drinking to navigation to ecosystem protection. This balancing act can be summed up by the "three Es"—*efficiency* (obtaining the maximum total benefits from the water resource), *equity* (distributing those benefits in a fair way), and *environment* (protecting and restoring productive aquatic ecosystems). With clear, easy-to-follow explanations, Anisfeld explores approaches to improving management, familiarizing readers with the most important debates in the water policy field.

If we have any hope of solving the water crisis, Anisfeld writes, we must first understand the scientific and political issues involved in managing water. And this means understanding the complex interactions of the natural and human worlds—where water comes from and how it is used. This is the ambitious goal of *Water Resources*.

About the Author

Shimon C. Anisfeld is Senior Lecturer and Research Scientist in Water Resources and Environmental Chemistry at Yale University's School of Forestry & Environmental Studies. His articles have appeared in major journals, including *Environmental Science and Technology, Journal of Sustainable Forestry,* and *Estuaries.*

Island Press was established in 1984 to stimulate, shape, and communicate the ideas that are essential for solving environmental problems. Publishing approximately 40 books and other information tools a year, we use a multidisciplinary, peer-reviewed approach that brings practical solutions to complex challenges like climate change, the depletion of our oceans, sustainable energy and agriculture, and species extinction. A nonprofit 501(c)3 organization, Island Press publishes for scientists, policy makers, environmental practitioners, students, journalists, and the general public.

Large Gaps Found in Public Understanding of Climate Change

Sixty-three percent of Americans believe that global warming is happening, but many do not understand why, according to a national study conducted by researchers at Yale University.

The report titled "Americans' Knowledge of Climate Change" found that only 57 percent know what the greenhouse effect is, only 45 percent of Americans understand that carbon dioxide traps heat from the Earth's surface, and just 50 percent understand that global warming is caused mostly by human activities. Large majorities incorrectly think that the hole in the ozone layer and aerosol spray cans cause global warming. Meanwhile, 75 percent of Americans have never heard of the related problems of ocean acidification or coral bleaching.

However, many Americans do understand that emissions from cars and trucks and the burning of fossil fuels contribute to global warming, and that a transition to renewable energy sources is an important solution.

Americans also recognize their own limited understanding. Only 1 in 10 say they are "very well-informed" about climate change, and 75 percent say they would like to know more about the issue. Likewise, 75 percent say that schools should teach children about climate change and 68 percent would welcome a national program to teach Americans more about the issue.

"This study demonstrates that Americans need to learn more about the causes, impacts and potential solutions to global warming," said study director Anthony Leiserowitz. "But it also shows that Americans want to learn more about climate change in order to make up their minds and take action."

The executive summary and full report are available online at *http://environment.yale.edu/climate/publications/knowledge-of-climate-change*.

The online survey was conducted by Knowledge Networks from June 24 to July 22, 2010, with 2,030 American adults 18 and older. The margin of sampling error is plus- or minus-2 percent, with 95 percent confidence.

Yale Journal Explores New Environmental Applications of ICT

New applications of information and communication technology (ICT) that could save society significant amounts of energy and money and reduce greenhouse gas emissions that are warming the planet are explored in a special issue of Yale's *Journal of Industrial Ecology*.

These applications exploit recent advances in ICT, such as social networking and Web 2.0, smart energy monitoring and geographic information systems, and are explored in depth in the special issue "Environmental Applications of ICT," published with support from the Leading Edge Forum of CSC, a global information technology services firm. The research examines the following:

- computer models that estimate quantities and types of residential energy use with striking geographic detail—to the zip code level;
- electronic systems that provide continuous appliance-level energy monitoring for households;
- smart irrigation technologies that lower the associated costs of water use and carbon emissions;
- energy-saving electronic control systems for small- and medium-sized manufacturers;
- applications of Web 2.0 for streamlining the organization of knowledge in industrial ecology; and
- Internet-based modeling of carbon-reduction technologies for use in large cities.

Additional studies in the special issue assess the environmental impacts of the ICT and entertainment and media sectors, investigate digital music technology's potential for reducing carbon emissions, and estimate the net environmental impact—considering the positive and negative—of the ICT industry.

"It is easy to see that information and communication technology is transforming our society," said Peter Crane, dean of the Yale School of Forestry & Environmental Studies. "This research brings insight and clarity to less-obvious dimensions of their environmental impacts."

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 emerging field of industrial ecology. It is owned by Yale University, headquartered at the Yale School of Forestry & Environmental Studies and published by Wiley-Blackwell.

Articles are free on the web at *http://onlinelibrary.wiley.com/doi/10.1111/jiec.2010.14.issue-5/issuetoc*. Journalists, students and representatives from developing countries or nongovernmental organizations can request a print copy of the special issue by writing to indecol@yale.edu.

Eric Masanet, deputy leader of the International Energy Studies Group at Lawrence Berkeley National Laboratory, and H. Scott Matthews, professor of civil and environmental engineering and public policy at Carnegie Mellon University, served as guest editors for this special issue.

The Leading Edge Forum (*www.lef.csc.com*) is a research and advisory program, focusing on the intersection of business, IT and management.

F&ES to Participate in Study on Singapore's Sustainable Development

The Yale School of Forestry & Environmental Studies (F&ES) and the National University of Singapore signed an agreement to collaborate on a study that will make recommendations for the sustainable development of Singapore.

The Urban Metabolism Study will estimate and map the flow of materials and energy in the Jurong Lake District, which was created in 2008 and is under long-term development, and explore how land use planning can incorporate resource-conservation strategies to minimize the use of, conserve and recover scarce resources. It will also recommend strategies to optimize the use of raw materials and energy to achieve a more sustainable urban environment.

The three-year study will be conducted in collaboration with Singapore's Urban Redevelopment Authority and Housing Development Board, and is supported by a $400,000 grant from that country's Ministry of National Development Research Fund.

The study will examine the various resources needed for different types of developments, such as public housing, commercial development and industrial estates, and how the waste generated from them can be recycled and reused for other productive purposes in the same environment.

The study is part of a series of seven research projects on sustainable urban development that were initiated last September. Coordinated by the Centre for Sustainable Asian Cities in the School of Design and Environment at the National University of Singapore, these research projects aim to develop innovative urban-planning strategies and design recommendations for the sustainable development of Singapore.

Peter Crane, dean of the Yale School of Forestry & Environmental Studies, pointed out that both schools have supported each other since 2001 through shared teaching, program planning and faculty and student exchanges.

"This new research collaboration takes the next step toward combining our strengths to create new knowledge for environmental management," he said. "Joining Yale's well-known expertise in industrial ecology with the leadership at the National University of Singapore in architecture and buildings creates a powerful team to help drive forward the global movement toward greener cities."

Heng Chye Kiang, dean of the School of Design and Environment at the National University of Singapore, said the Centre for Sustainable Asian Cities focuses on urban planning and design to come up with innovations for high-density environments.

"We envisage that these solutions will be applicable to many cities in Asia and other developing countries. This research study will provide critical information on the means to recycle materials generated in buildings, such as water, electricity and construction waste, so as to achieve a more sustainable built environment for Singapore."

The research study will be led by Kua Harn Wei, an assistant professor in the Department of Building at the School of Design and Environment, and Marian Chertow, associate professor of industrial environmental management at F&ES.

Professor Kua explained, "This study will help us understand how to increase the recycling rates of materials, water and energy at the district level. The research will also broaden our knowledge on 'urban mining,' in which materials, including construction wastes, can be reused in new developments at the end of their useful lives. Our research will also explore ways to improve existing recycling programs and eventually formulate strategies for reducing the generation of waste materials in buildings. We will also be focusing on the operational phase of buildings to identify, for example, opportunities for increasing efficiency in energy use."

Health of Green Buildings Questioned

Standards used to certify buildings as environmentally friendly are insufficient to protect human health, according to a report authored by John Wargo (Ph.D. '84), professor of environmental risk analysis and policy at F&ES.

Wargo said that although the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) certification program has been effective in encouraging energy efficiency, well-insulated buildings often contain chemicals, in high concentrations, released from building materials, cleaning supplies, fuel combustion, pesticides and other hazardous substances. The council's most prestigious platinum award, he says, does little to ensure that hazardous chemicals are kept out of certified buildings.

"The underlying problem is that thousands of different chemicals, many of them well-recognized to be hazardous, are allowed by the federal government to become components of building materials. Very few of these chemicals have been tested to identify their toxicity, environmental fate or the danger they pose to human health," he said.

The report, "LEED Certification: Where Energy Efficiency Collides With Human Health," was sponsored by the nonprofit Environment and Human Health (EHHI), founded by Nancy Alderman (F&ES '97). The report can be viewed at *www.ehhi.org/reports/leed/LEED_report_0510.pdf.*

EHHI recommends, among other things, that the board of the Green Building Council, which is composed of developers, engineers, chemical and materials manufacturers and architects, should include more experts in the area of human health and that the government should categorize building products to identify those that contain hazardous compounds, those that have been tested and found to be safe and those that have been insufficiently tested.

Environmental Studies Program's Summer Research for Undergraduates

Hilary Faxon (Yale '11)

Eli Mitchell-Larson EVST '12 hiking the slope of Mt. Magli with Lake Trnovacko in the background. This corner of the Balkans is the location of the Perućica primeval forest, an ancient ecological time capsule. Photo by Srdjan Markovi.

What do crunching data on Midwestern bison herd grazing patterns, practicing permaculture in rural New Mexico, and interviewing retired park rangers in Ecuador have in common? They were all part of summer environmental projects carried out by undergraduates with the support of the Environmental Studies Program's Summer Research Grants.

Summer experiences in the field, lab, or in the working world are an invaluable part of undergraduate education in environmental studies. Students both within and outside the Environmental Studies Program were encouraged last spring to apply for grants for a diverse array of projects with Yale faculty, environmental nonprofit organizations, government agencies and corporations. Awards were primarily based on the merit of the proposal with preference given to the seniors working towards their senior thesis. Twenty-five proposals were awarded funding ranging from $1,000 to $2,000 for projects in North America, South America, Asia, Europe and Africa. Candidates had to submit a short proposal and budget in March, and if they made it to the second round, were required to answer follow-up questions about feasibility and methodology posed by the review committee. The final awards were given in April.

Leslie Roberson's (Yale '11) research on sea turtle conservation and marine management in Honduras typifies the interdisciplinary, international approach of the projects as a whole. Leslie, fluent in Spanish, arrived in the country with a plan to spend a month scuba diving and assessing sea turtle populations in El Venado and Punta Raton, two small fishing villages on the South Coast. After tropical storm Agatha ravished the areas in late May, Leslie changed her focus to studying the species health in the Northern Bay Islands. While the turtles were still fascinating, the cultural meld of Afro-Caribbean heritage and the realities of environmental development in a disor-

CT Lake 2: Lily Twining EVST '11 and Derek West taking sediment cores from Linsley Pond, North Branford, CT for Lily's senior project Photo Credit by David Post.

ganized and tourism-driven area were even more interesting. "In Honduras, conservation has little to do with passing laws," Leslie wrote in her report. "Environmental degradation is wrapped up in a world of narco-trafficking and corruption." Still, Leslie is optimistic and devoted to the cause—when official channels and office hours did not get the job done, she sought answers and connections at the local bar and discovered that environmental protection efforts are being made. For example, while her American mentor Dr. Stephen Dunbar is the only scientist to have published data on Honduran sea turtles, a wealth of unpublished studies has been carried out within the community. Her experience this summer has led to a senior thesis, hopes for a Ph.D. in Coastal Management, and a devotion to promoting community-based environmental protection in developing nations.

Another international project was Eli Mitchell-Larson's (Yale '12) work on a Slovenian forestry research team measuring the health and growth rates of both ancient and infant forests. During the previous year, Eli had worked with the Yale Center for Earth Observation analyzing satellite images of Bosnian forests. The experience left him eager to get on the ground, and his team had the opportunity to do just that. As an assistant to Professor Tom Nagel at the University of Ljubljana, Eli used transponders, checked tree tags, and scaled mountains for aerial observations to chart the survival of old growth forests and the health of newly implemented "protection forests" throughout the country. Eli's favorite experience was making it to a mountaintop on the Austrian border with the other French, Polish and Solvene research assistants and seeing the difference between forestry for the two nations—large swaths of mountain spruce in Austria had been simply clear-cut and replanted without the more sophisticated forestry techniques the Slovenian team advocated. Eli stressed the value of getting out of the classroom that the grant provided, noting that the opportunity to live in a cabin without electricity and water in the very forests he had observed in computer labs at Yale not only challenged and excited him personally, but led to a new level of interest in and commitment to sustainable forestry.

Not all students traveled so far from home. Lily Twining (Yale '11) spent her summer based in New Haven with trips to Old Lyme and Branford to study a fish called the alewife, and how it may illustrate the environmental effects of the first European settlers to the region. Most alewife migrate seasonally from sea to inland lakes, but local species are landlocked, and have different traits from their seagoing relatives. Lily's research used isotopic ratio analysis of sediment cores from two local lakes to find paleoecological evidence that it was settlement and dam construction that landlocked these fish and she explored how that confinement changed the evolution of the species. Her preliminary results show a change in chemical composition in the water 300 to 400 years ago that is likely due to human agriculture and impact. She will continue with her analysis for her Environmental Studies Program's senior project.

Other students undertook a wide variety of projects at home and abroad in science, policy and environmental history. All found their experiences rewarding and life changing and they express their gratitude and appreciation for the generous support from the Environmental Studies Program and its numerous supporters.

Amanda Bennett '12 undeclared, *Climate Change and Grazing Konza,* Prairie Biological Research Station, Manhattan, KS

Sarah Armitage '12 undeclared, *Sustainability and Design: Scandinavian Style,* Danish Architecture Center, Copenhagen, Denmark

Luke Aronson '11 Environmental Studies, *Biofuels and Alternative Energy,* Verno Systems, Seattle, WA

Joanne Choi '11 Environmental Studies, *The Role of Microbial Symbionts in Jellyfish Reproduction,* Yale University, New Haven, CT

Frances Douglas '11 Environmental Studies, *Sanction Laws & Sustainable Development,* International Union for Conservation of Nature, Washington, D.C.

Andrew Eberle '11 Environmental Studies, *Seeing the Forest Through the Trees,* European Environmental Policy Nature Conservancy, Berlin, Germany

Hilary Faxon '11 Environmental Studies, *Perceptions of the Environment, Culture, and Spirituality Across Ethnicities,* Taos, NM

Reuben Fischer-Baum '11 Environmental *Studies, The Economic Benefit and Value of Urban Trees,* Istanbul, Turkey

Taylor Gregoire-Wright '12 Environmental Studies, *Weathering the Tide: Coastal Ecosystems, Policy & Climate Change,* Fundación Futuro Latinoamericano, Ecuador

Brittney Kajdacsi '11 Ecology and Evolutionary Biology, *Molecular Phylogeny of Endangered Galapagos Tortoises,* Yale Conservation Genetics Laboratory, New Haven, CT

Eli Mitchell-Larson '12 Environmental Studies, *Remote Sensing as an Important Tool for Managing Balkan Old Growth Forest,* University of Ljubljana, Slovenia

Caroline Nash '11 Environmental Studies *Ecological, Social & Political Implications of Dam Removal Kalamath Tribes,* Chiloquin, OR

Maclovia Quintana '11 Environmental Studies *Permaculture Promotes Sustainable Farming Communities in New Mexico,* Garden's Edge, Santa Fe, NM

Leslie Roberson '11 Environmental Studies *Saving the Tropics One Small Sea Turtle at a Time: Protective Turtle Ecology Center for Training, Outreach and Research,* Bay Islands, Honduras

Kalani Rosell '11 Environmental Studies *Sustainable Agriculture in Ethiopia,* Yale University, New Haven, CT

Hazel Scher '11 Environmental Studies *Converting Abandoned Real Estate in Urban Renewal,* University of California at Berkeley, Berkeley, CA

Catherine Sheard '12 Mathematics, *Ecology of Tropical Rainforests and Their Canopies,* Institute for Tropical Ecology & Conservation, Panama City, Panama

Dacia Thompson '12 Environmental Engineering, *Sustainable Farming Practices in the Tropics,* Semillia Nueva, Xela, Guatamala

Lily Twining '11 Environmental Studies, *Paleoecological Research on Keystone Fish Species,* Yale University, Old Lyme and Branford, CT

Charles Zhu '11 Environmental Studies, *Biking in the City: Relationship Between Urban Landscape & Cycling,* Gehl Architects, Copenhagen, Denmark

Julie Zhu '12 undeclared, Tropical Biology *Research,* Duke University Organization of Tropical Studies, La Selva, Costa Rica

STUDENTS AWARDED SWITZER, COMPTON FELLOWSHIPS

Three School of Forestry & Environmental Studies (F&ES) students were among 21 environmental scholars selected as Switzer Environmental Fellows by the Robert & Patricia Switzer Foundation. Four more students have been named Compton International Fellows for 2010-2011 by F&ES' Tropical Resources Institute.

The $15,000 Switzer Fellowship—awarded to master's students Stephen Blackmer (Yale '83), Kyra Busch and Michelle Lewis—is one of the nation's most prestigious academic awards for environmental leaders.

Over the past 25 years, Blackmer has held leadership positions with the Northern Forest Center, Northern Forest Alliance, Appalachian Mountain Club and Society for the Protection of New Hampshire Forests. He is pursuing a joint degree in religion and ecology and is interested in the role of religion in social change movements.

Busch wants to make sustainable food more accessible in urban and rural areas and is interested in environmental justice, community development and sustainable food systems. In New Haven she is developing a farm-based education curriculum and is training environmental educators in her role as the public schools program coordinator for the Yale Sustainable Food Project.

Lewis is pursuing a joint degree with the Yale Divinity School, and is trying to connect at-risk youth and juvenile offenders to the environment through their religions using popular culture. Before joining Yale, she spent 12 years as a U.S. park ranger.

The Compton Fellows are all first-year candidates for master's degrees in environmental management. They each received $11,250 from the Compton Foundation, which enables students from developing countries to conduct research on the environment and sustainable development that has links to the fields of peace and security and population and reproductive health.

Geofrey Mwanjela is conducting research on protected areas and their impact on the livelihoods of local communities in Tanzania. Ana Perea is working on how best to engage local communities in Mexico in the conservation and restoration of natural resources. Giancarlo Raschio is planning a comparative study of climate change mitigation and adaptation initiatives in Ghana and Peru. And Pablo Reed is researching whether the lands of indigenous communities in Ecuador could benefit from Reducing Emissions from Deforestation and Forest Degradation, a program designed to use financial incentives to reduce the emissions of greenhouse gases.

F&ES has had more than 60 Compton Fellows from 28 countries since 1995. "The Compton Fellowship program is a unique resource that helps F&ES attract students from developing countries and supports them in conducting cutting-edge research in and around their home countries," said Michael Dove, director of the Tropical Resources Institute and Margaret K. Musser Professor of Social Ecology.

DOCTORAL STUDENT RECEIVES AWARD

Philip Marshall, a School of Forestry & Environmental Studies doctoral student, recently received the Emanuel D. Rudolph Award from the Botanical Society of America. The award is given by the historical section of the society for the best student presentation or poster of an historical nature at its annual meetings. Marshall's presentation was "*Pinus strobus* L. and the historical utilization and management of southern New England forests, 1600-1938."

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We welcome submissions from faculty, staff and students.

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