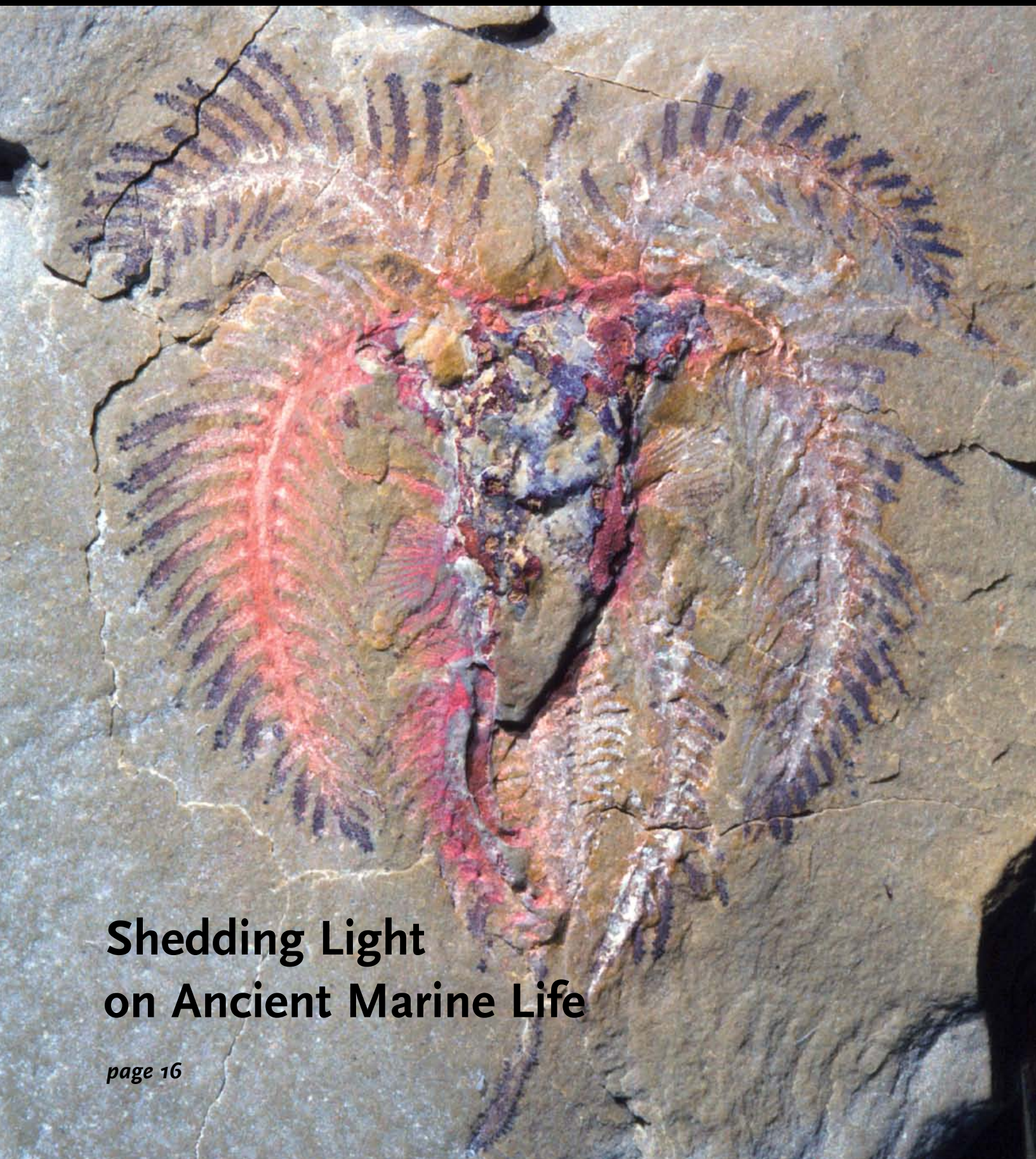
YALE ENVIRONMENTAL NEWS

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

fall 2011 · vol. 17, no. 1



Shedding Light on Ancient Marine Life

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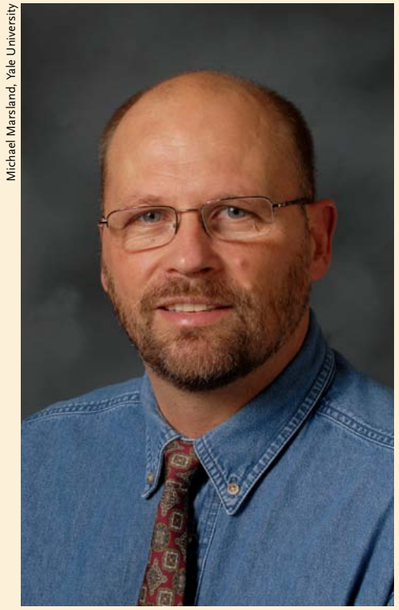


Michael Marsland, Yale University

OSWALD SCHMITZ, DIRECTOR

"On July 1 of this year, I was given the honor of becoming Director of the Yale Institute for Biospheric Studies."

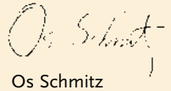
The Yale Institute of Biospheric Studies (YIBS), like the rest of Yale University, has undergone a three-year period of constraint because of the effects of the economic downturn on the endowment. I am deeply appreciative of my predecessor, Jeffrey Park, for stabilizing YIBS both programmatically and financially to ride out this period. Because of these measures, we are now in a great position to pursue new and exciting opportunities as the endowment recovers.

I was a junior faculty when YIBS was first created, and later served for a time as a director of the former YIBS Center for Computational Ecology (CCE). CCE no longer exists, not from lack of success, but rather because it fulfilled a strategic goal of YIBS. YIBS has an entrepreneurial mission and provides funding to catalyze innovative and often highly risky environmental research ventures so that scholars can develop the necessary proofs-of-concept to become competitive for external funding from public and private research foundations. CCE accomplished its goal of developing and testing new computational platforms to assist in the analysis of complex systems. Many of the insights and tools that emerged from this activity have now been embedded as core parts of research into biological and physical processes that shape the diversity of life. YIBS is now going through the exercise of closing down other Centers that have fulfilled their strategic goals, and at the same time, I have put out a call for faculty to gather and formulate proposals for the next round of innovative and exciting research ideas.

In many ways, graduate students are the threads that hold together the YIBS fabric. It is through their efforts that faculty from different departments are often drawn together to explore integrative research questions. I am committed to strengthening graduate student support for research in the environment in two important directions. First, YIBS has now established a permanent competitive small grant program—the YIBS Field Ecology Research Grants—to support pilot research by beginning graduate students. This is a critical time for these students because it offers them a chance to develop their own proofs-of-concept for ideas that will eventually become the core of their thesis or dissertation. Experience has shown that this kind of funding poises graduate students to be highly competitive for external funding in subsequent years. I have asked ecology and evolutionary biology professors David Post and Tom Near to oversee this grant program. Second, an inevitable consequence of conducting research is that we often make fascinating discoveries that unfortunately cannot be pursued given the terms and conditions of existing grant support. For doctoral students, pursuing these newly discovered avenues has the potential to enhance their dissertations by leaps and bounds. Recognizing again the entrepreneurial potential, YIBS will create a highly competitive large grant Doctoral Dissertation Improvement Grant program so that advanced stage doctoral students can have the opportunity to spend a year focused on enhancing the scientific quality of their dissertations through the exploration of their innovative discoveries. I have asked anthropology professor Rick Bribiescas to oversee this grant program.

A key part of YIBS is the Gaylord Donnelley Environmental Postdoctoral Fellowship program. This program provides the opportunity to bring exciting young scholars to Yale for two years so that they may enhance their scholarship in preparation for future professional careers in the environment. Postdoctoral fellowships normally are intended strictly to support research, however many postdocs hope to secure faculty positions that require teaching. Recognizing the need for such added training, YIBS is now facilitating the opportunity for Donnelley Fellows to teach a seminar course in their area of expertise. This will provide upper level undergraduate students the opportunity for intense and focused study on particular aspects of environmental science.

There are many other exciting initiatives that are being planned, and I will be sure to report on them in the future as they come to fruition. However, succeeding with any of these initiatives is impossible without the gracious support, encouragement and advice that I receive from members of the YIBS community at Yale, as well as members of the YIBS External Advisory Board. I deeply appreciate all of that support as I "learn the ropes" in my new role at Yale.



Os Schmitz

Expert in Energy and Transportation Joins Tenure-Track Faculty at the School of Forestry & Environmental Studies

An expert in energy and transportation has joined the tenure-track faculty at the Yale School of Forestry & Environmental Studies (F&ES). Kenneth Gillingham, assistant professor of environmental and energy economics, uses the tools of economics and statistics, along with expertise in energy and systems engineering, to analyze policies addressing the world's energy challenges.

His recent publications have focused on the adoption of solar photovoltaic technology, market failures in household energy efficiency and alternative fuels for transportation. Ongoing research delves into the effects of different policies on reducing greenhouse gas emissions from transportation."We're very pleased to have Ken join us," said Dean Peter Crane. "He's done important work on how consumers respond to changing gasoline prices, which has critical implications for a variety of policies aimed at reducing emissions from transportation."

Prior to joining Yale, Gillingham worked at the California Air Resources Board, White House Council of Economic Advisers, Stanford Energy Modeling Forum, Joint Global Change Research Institute of Pacific Northwest National Laboratory and Resources for the Future. He grew up in White Plains, N.Y., where his parents still live.

He also received a Fulbright Fellowship to study in New Zealand, where he conducted research on the economics and policy of solar energy technologies in that country. He holds a PhD from Stanford University, and taught "Economics of the Environment," a foundations course with an enrollment of approximately 100 students during the fall semester.

"I am most impressed by F&ES's energy and excitement about making a difference," he said. "With the resources that F&ES and Yale have to offer, I am in the perfect place to build my research career, while having the pleasure of teaching and guiding some fantastic students."

For more information about Gillingham's research, visit *environment.yale.edu/profile/kenneth-gillingham/*.

Swedish Research Council Announces Appointment of Geology & Geophysics Professor John Wettlaufer

John S. Wettlaufer, Yale scientist and professor in the departments of Physics and Geology & Geophysics, has been named the Tage Erlander visiting professor at Stockholm's Nordic Institute for Theoretical Physics (NORDITA) for the year 2012.

The Swedish Research Council announced Wettlaufer's appointment, which provides $350,000 to support graduate students, postdoctoral associates and visitors, and will underpin Wettlaufer's work on projects related to climate change, planetary accretion and fluid dynamics.

"I am humbled, enthusiastic, honored, and surprised," said Wettlaufer, an Alan M. Bateman Professor at Yale. "Humbled by the company of former Tage Erlander professors who are an extremely accomplished group. Enthusiastic because of the opportunity provided to expand and develop my research program both by the time allowed to focus and by the cross-cultural and cross-disciplinary opportunities afforded by it. Honored because Tage Erlander was the longest-serving prime minister of Sweden, and was largely responsible for the building of the compassionate society that it is today. Surprised to have been selected, given that a physicist is chosen only about once every five years."

A condensed matter theorist, Wettlaufer has research interests spanning statistical physics, applied mathematics, and astrophysics, biophysics and geophysics. He teaches in the Applied Mathematics program at Yale.

Wettlaufer spent the summer of 2010 in England, where a Guggenheim Fellowship supported his work at the University of Oxford's Mathematical Institute. There he worked on several projects related to climate change, including the construction of "physically realistic but mathematically solvable stochastic theories of abrupt climate change."

At NORDITA Wettlaufer will extend this climate research and pursue problems in planetary accretion and in lattice Boltzmann methods for electromagnetism and turbulent flows.

NORDITA is hosted jointly by Stockholm University and the Royal Institute of Technology. The core research areas are astrophysics, condensed matter, statistical and biological physics, high-energy and nuclear physics, and complex systems. Wettlaufer spent a previous sabbatical at NORDITA in 2008.

CONFERENCES, SEMINARS, SYMPOSIA

YIBS/ESC AND YCEI FRIDAY NOON SEMINARS

The Yale Institute for Biospheric Studies (YIBS) and the Yale Climate & Energy Institute (YCEI) combined to present a Friday noontime seminar series during the fall 2011 semester. The following are the speakers and their topics:

THE YIBS/ESC FRIDAY NOON SEMINARS:

Jeffrey J. Park, Professor,Yale Department of Geology & Geophysics: *Carbon-Cycle Feedbacks with Global Temperature: Warm Cola Versus Big Leaves* ■ **Gil Rosenthal,** Associate Professor, Department of Biology, Texas A&M University: *Mate Choice, Environmental Gradients and Hybrid Zone Dynamics in a Neotropical Freshwater Fish* ■ **Berat Haznedaroglu,** YCEI/YIBS Environmental Postdoctoral Associate, Yale Department of Chemical and Environmental Engineering: *Next Generation Transcriptiome Sequencing of Lipid Producing Microalgae* ■ **Ryan Garrick,** Postdoctoral Associate, Yale Department of Ecology & Evolutionary Biology: *Understanding the Past to Predict and Manage for the Future: Applications of Genetics to Galapagos Tortoise Conservation* ■ **Pincelli Hull,** Postdoctoral Associate, Yale Department of Geology & Geophysics: *Too Long for Ecology and Too Short for Geology: Understanding Ocean Ecosystem Dynamics on Time Scales Relevant to Modern Global Change* ■ **Nadine Unger,** Assistant Professor, Yale School of Forestry & Environmental Studies: *The Atmospheric Chemistry of Forestry for Climate Protection* ■ **Nina Lehr,** Gaylord Donnelley Environmental Postdoctoral Associate, Yale Department of Ecology & Evolutionary Biology: *The Evolution of Gene Expression Underlying Sexual Development in Fungi.*

THE YCEI FRIDAY NOON SEMINARS:

Daniel Schrag, Sturgis Hooper Professor of Geology at Harvard University, Professor of Environmental Science and Engineering, and Director of the Harvard University Center for the Environment: *A Path Forward on Climate and Energy*? ■ **Daniel Lashof,** Climate Center Director at the Natural Resources Defense Council and Edward P. Bass Distinguished Visiting Environmental Scholar, Yale School of Forestry & Environmental Studies: *Climate Change–Where Do We Go From Here?* ■ **David Sandalow,** Assistant Secretary for Policy & International Affairs, Energy Department: *Government's Role in Innovation* ■ **Robert Crabtree,** Professor, Yale Department of Chemistry: *Solar Fuel: Formation and Storages* ■ **Brice Lalonde**, Founder of the Ecology Generation Party: *From Stockholm 72 to Rio+12, Who has Spoken for Planet Earth Over the Last 40 years?*

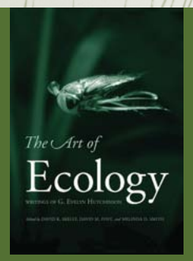
For the spring 2012 schedule of YIBS and YCEI Seminars, please visit *www.yale.edu/yibs/events_yibsesc.html*

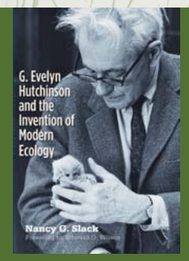
YIBS CENTER FOR THE STUDY OF GLOBAL CHANGE WEEKLY SEMINARS

The YIBS Program for the Study of Global Change's new director, Professor Mark Pagani, Yale Department of Geology & Geophysics, presented the Topics in Global Change Seminar Series during the fall 2011 semester with a focus on "Climate Sensitivity, Radiative Forcing, and Feedbacks: Modern and Ancient Perspectives." The following are the speakers and their seminar topics:

Jeffrey J. Park, Professor, Yale University, Department of Geology & Geophysics: *Ice Sheets, the Carbon Cycle and Climate Sensitivity: The View from Deep Time* ■ Robert Pincus, Research Scientist, University of Colorado, NOAA Earth System Research Laboratory: *What Ensembles of Climate Models Might (and Might Not) Be Able to Tell Us about Uncertainty in Climate Projections* ■ **Alexey Fedor**ov, Professor, Yale University, Department of Geology & Geophysics: *Beyond Traditional Climate Sensitivity: Understanding and Modeling the Early Pliocene Climate* ■ **Brian Soden**, Professor, University of Miami, Rosenstiel School of Marine and Atmospheric Sciences: *Recent Advances in Constraining Climate Feedbacks from Clouds and Aerosols* ■ **Andrew Scott**, Professor, Royal Holloway University of London: *Evidence of Fire Regimes in the Pleistocene of the California Islands* ■ **Peter Cox**, Professor, University of Exeter, College of Engineering, Mathematics and Physical Sciences: *Using Climate Model Spread to Our Advantage: Constraints on Tropical Forest Dieback from Interannual Variability in CO_2* ■ **Eelco Rohling**, Professor, University of South Hampton, National Oceanography Centre: *Temperature Sensitivity to Radiative Forcing of Climate over Several Glacial Cycles* ■ **Trude Storelvmo**, Assistant Professor, Yale University, Department of Geology & Geophysics: *Aerosols and Their Relation to Global Climate and Climate Sensitivity* ■ **Dan Lunt**, Senior Research Fellow, University of Bristol, School of Geographical Sciences: *Earth System Sensitivity through Geological Time: A Modeling Perspective* ■ **Ted Shepherd**, Professor, University of Toronto, Department of Physics: *Coupling between Stratospheric Ozone Depletion/Recovery and Climate Change* ■ **Drew Shindell**, NASA Goddard Institute for Space Studies: *Uses and Limitations of Radiative Forcing for Evaluating Climate Impacts*

For a list of spring 2012 seminar offerings and upcoming Program events visit the Program's Web site at www.yale.edu/yibs/research/CSGC.html.





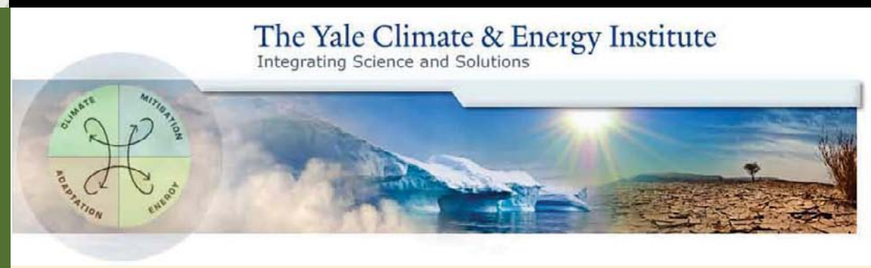
SYMPOSIUM HONORS G. EVELYN HUTCHINSON, "FATHER OF MODERN ECOLOGISTS"

On October 4, 2011, Professor of Biology Emerita Nancy Slack, ecologist and historian of science at The Sage Colleges, presented an Edward P. Bass Distinguished Lecture entitled "G. Evelyn Hutchinson and the Invention of Modern Ecology," based on her recent book of the same name (Yale University Press, 2011). Professor Slack offered a historical view of Hutchinson's life, noting in her presentation that "although Hutchinson is best known as the father of modern ecology, he himself felt that the term 'father of modern ecologists' was more true and fitting."

Slack's talk was followed by reminiscences of Hutchinson by Thomas E. Lovejoy, biodiversity chair at the H. John Heinz III Center for Science, Economics and the Environment, and Professor Leo W. Buss, Yale departments of Ecology & Evolutionary Biology and Geology & Geophysics, who as students at Yale both knew Hutchinson personally. The program concluded with insights from Professor of Ecology David Skelly, Yale School of Forestry & Environmental Studies, on how papers were chosen for the Hutchinson compendium *The Art of Ecology* (Yale University Press, 2011), edited by Skelly, Professor David Post and Associate Professor Melinda Smith, Yale Department of Ecology & Evolutionary Biology.

A link to the video of this lecture is available at *www.yale.edu/yibs/events_past.html.*

YALE CLIMATE & ENERGY INSTITUTE NEWS



Yale Climate & Energy Institute Forms an External Advisory Board

By Rajendra Kumar Pachuari, Director

On September 27, 2011 the Yale Climate & Energy Institute (YCEI) held the first meeting of its external Advisory Board, which was established earlier this year. The Board is chaired by Chad Holliday, former chairman of DuPont and currently chairman of Bank of America. It consists of 15 distinguished leaders drawn from business, civil society and academia. It is noteworthy that almost all those invited to join this Board accepted the invitation to be part of this body and that, except for two members, all were able to participate in the first meeting.

Yale President Richard C. Levin opened the meeting by welcoming the chair and members. He highlighted the rationale behind the establishment of the YCEI as an umbrella organization to coordinate and provide broad direction to work being done across campus in the fields of climate and energy, and to create university-wide linkages between various components of research and teaching in these areas. To acquaint the members of the Advisory Board with the nature and functioning of YCEI, brief presentations were made on projects currently in hand that are financed both by various external sources as well as through seed funding and postdoctoral fellowships granted by YCEI itself over the past two years. The projects covered a range of activities, including research related to energy use in buildings, mineral carbon sequestration, "fracking" for production of shale gas and its impacts on drinking water, and dengue fever and climate change.

A large set of suggestions and recommendations were provided by board members to the leadership of YCEI on new areas for the Institute to consider initiating activities in. It was also emphasized that given the current challenges faced by human society in the areas of climate change and energy, YCEI should consider enhancing its outreach efforts to inform the public on critical issues based on work being pursued on campus. Another important suggestion put forward emphatically by the Board was for YCEI to hire four to five distinguished individuals as YCEI core staff so they could lead research and training on specific fields of importance under YCEI's charter, and also help to project work that it does for the benefit of society and for raising the visibility of YCEI as an institution.

The YCEI Advisory Board is scheduled to meet once a year while the Directorate of the YCEI would stay regularly in touch with the chairman and members to seek advice, guidance and assistance from time to time. The next meeting of the Board is due to be held during the fall semester of 2012.

EVENTS

BIG FOOD: HEALTH, CULTURE AND THE EVOLUTION OF EATING
On view February 11 through November 30, 2012

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

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

MARTIN LUTHER KING, JR.'S LEGACY OF ENVIRONMENTAL AND SOCIAL JUSTICE
January 15 & 16, 2012

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.

DINOSAUR DAYS
Week of February 20, 2012

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 16, 2012

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.

EARTH DAY
April 20, 2012

The first national Earth Day celebration on April 22, 1970 raised environmental awareness and encouraged citizens of our planet to strive for healthy, sustainable surroundings. Learn from local organizations about simple actions that can protect the planet. *Marion Stoddart: The Work of 1000*, a 30-minute film about one woman's unwavering resolve to save a dying river, will screen at 2:00 pm.

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

A L. Jones (5)

Watching Butterflies at West Campus

By Lynn Jones, Museum Assistant

Butterflies are some of the most charismatic, beautiful and well-known insects from around the world. Staff from the Yale Peabody Museum of Natural History (YPM) have been making Yale's West Campus butterfly friendly and also keeping track of what species are around. In the early 1990s, staff at Bayer Pharmaceutical, the previous owner of the property, set up a wildlife management team to create a trail system, install bird nest boxes and establish a butterfly garden on campus. By the time that Coordinator Tom Parlapiano of the YPM Education Department began working at West Campus, the butterfly garden was overgrown and underpopulated. Parlapiano has spent the last two years clearing out the weeds, allowing flowers to flourish and planting enticing new plants. This hard work has paid off and butterflies are enjoying the results of these efforts.

The plants that have been added not only attract butterflies, but also combat the invasive weeds that thrive in the area. "The shallow dry soils...have made most introductions a challenge," Parlapiano explained. He has incorporated plants like sweet pepper bush, Joe Pye weed, black-eyed Susan and purple coneflower, all in the hope of attracting butterflies, wildlife, and Yale faculty and staff. Says Parlapiano, "The butterfly garden attracts people as well as butterflies, and its location at the top of the staircase encourages them to further explore the Oyster River corridor on campus."

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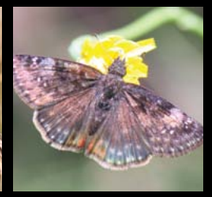

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The butterflies seen at West Campus belong to five families with worldwide distributions. The adult butterflies are nectar feeders that visit flowers for a meal and pollinate the plants at the same time. Adults lay their eggs on a variety of host plants, many of which are found on campus. One species visiting the garden is the monarch butterfly (*Danaus plexippus*). These bright orange and black butterflies have been seen cruising the edge habitats, quickly alighting on their host plant, milkweed. The monarch is a migratory species and travels 2,500 miles south to its Mexican overwintering site in the fall.

The giant swallowtail (*Papilio cresphontes*), a southern species, has been seen throughout the state this year in record numbers. In the past, this butterfly was rare and possibly a vagrant. Last year a small population in Fairfield County was the only reliable sighting. Records this year include many locations in New Haven County, including one sighting in the West Campus A-21 courtyard. Another species seen is a sachem (*Atalopedes campestris*), a small orange skipper. Scientists believe that its distribution has extended northward because of climatic temperature rises. After hurricane Irene, there have been a significant number of these butterflies on campus.

In total, staff have positively identified approximately 24 species of these "scaly-winged" insects. Butterflies were identified by observation this year, meaning staff have relied solely on quick glimpses through binoculars and the occasional picture. Next year there could be quite a few additional species as staff plan on netting butterflies to allow for closer observation. Some of the butterflies that will be netted could be added to the YPM research collection, creating a reference sample to enable future researchers to study which butterflies have visited West Campus.

A Monarch (*Danaus plexippus*)
B Pearl Crescent (*Phycoides tharos*)
C Sachem (*Atalopedes campestris*)
D Common Buckeye (*Junonia coenia*)
E Wild Indigo Duskywing (*Erynnis baptisiae*)

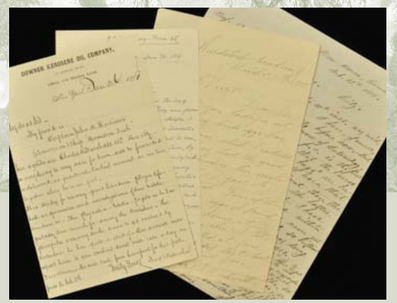
Peabody Museum Receives "Hidden Collections" Grant

By Daniel Drew, Museum Assistant, Division of Invertebrate Zoology, and Lawrence Gall, Informatics Manager, Division of Entomology

The Yale Peabody Museum of Natural History (YPM) has received a $409,000 grant from the Council for Library and Information Resources (CLIR) and the A.W. Mellon Foundation to electronically catalog its archives and special collections, and was one of 17 institutions to receive an award from CLIR and the Mellon Foundation. Beginning in early 2011 and under the direction of YPM's Assistant Director for Collections and Operations Tim White, a committee was formed to survey the archival holdings in YPM's Archives division and 12 curatorial divisions. The committee, composed of White, YPM Senior Conservator Catherine Sease, Head of the Computer Systems Office Lawrence Gall, Project Registrar Annette Van Aken and Museum Assistant Daniel Drew, was charged with developing a plan for the handling, storage and digital cataloguing of archival collections. Sease developed protocols for appropriate handling and storage, while Gall and Drew began to plan for digitally cataloguing using YPM's enterprise collections management system, KE EMu.

The YPM's archives are diverse and eclectic, covering the entire 145-year history of the Museum. The various archival special collections include, among other items, correspondence, field notebooks, maps and manuscript drafts of early curators such as O.C. Marsh and Addison E. Verrill, as well as documentation related to the day-to-day operations of YPM's divisions. These archives and special collections are an integral part of each division's traditional research holdings. For example, the Division of Invertebrate Zoology has catalogued much correspondence and many field notebooks as part of its ongoing work, which can be directly connected to many of the Division's invertebrate specimens. Notably, through the many letters sent to Verrill, it is possible to determine the origin of specimens now housed in the Division, as well as gain a better understanding of which specimens were sent in exchange. In one case, specimens of fairy shrimp, part of invertebrate zoology collections since the 1880s and long suspected to be type specimens (specimens used for the original species description), were confirmed as such by a letter sent to Verrill.

The importance of archival collections extends beyond YPM and its divisions. Much of these materials originate from Yale faculty and staff, many of them experts in their respective fields who are often the subject of historical accounts and biographies. These personal archives provide insight into their lives and research and are of great interest to those interested in the history of science. The CLIR grant awarded to YPM will make possible appropriate storage and organization for the archives and ensure their accessibility for years to come. As these archives are catalogued, they will become available through Yale's finding aid database to a wide range of researchers and historians. As the project progresses, Van Aken, Drew, Museum Assistant Nathan Utrup and other staff will document interesting discoveries among the archives on the blog "From DNA to Dinosaurs" *(http://fromdnatodinosaurs.blogspot.com)*.



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A Examples of original correspondence sent to Yale's first professor of zoology, Addison E. Verrill. Photograph courtesy of Eric Lazo-Wasem.

B A sampling of historical photographs from the archives of the YPM Division of Anthropology. Photograph courtesy of Jessica Slawski.

Art and Science Collaborate to Create "Ecological Symmetries"

The idea for the latest exhibition of natural history themed art on view at Yale's Class of 1954 Environmental Science Center—"The Fabric of Life—Ecological Symmetries" by John Arabolos—began in October 2010 when Arabolos was approached by Yale Peabody Museum of Natural History (YPM) Assistant Curator of Entomology Antónia Monteiro, Associate Professor, Yale Department of Ecology & Evolutionary Biology, about using digital images of exotic butterfly specimens at the YPM to create Arabolos's signature complex patterned artwork. For the artist, the concept was an exciting, yet daunting, opportunity for a collaboration of art and science resulting in a new interpretive aesthetic in exploring and investigating both the natural environment and, in this case, specific species.

Arabolos's artwork investigates the "chaotic" patterns in nature that have "self-similarity"—that is, compositional elements readily identifiable as the same, yet different in size and scale and existing randomly within space at any given moment. He uses symmetry as a tool to bring order out of randomness. The resulting patterns, created electronically from digital imagery, though organic in origin, are abstractions manipulated from nature that defy identification. The artwork forces the viewer to rely on subliminal past empirical experiences and observations to respond to what he or she is seeing. And everyone sees something individualized and different.

The digital images of specimens used by Arabolos to create these works are taken from a research project of Monteiro and YPM Informatics Director William Piel. The project, funded by the National Science Foundation, aims to explore the evolution of color patterns on the wings of butterflies from the family Nymphalidae and focuses primarily on the origin and evolution of eyespots, the patterns of concentric circles of color on the margin of the wings of many nymphalid butterflies. Dr. Monteiro offered the use of digital photographs from her research team's work and granted Arabolos access to a Web site of 14,853 images, from which Arabolos's first selection of 21 different butterflies was quickly reduced to 14 species. The final seven photographs used to create the artwork on exhibit were selected according to aesthetic attributes, including color, contrast, pattern, form outline, size and scale. Four to six artworks were created from each image to provide a variety of interpretive representational images specific to each butterfly.

John Arabolos is a Professional Designer and Artist-in-Residence in the Department of Art and Design at the University of New Haven. He creates his work from materials that come out of the natural environment. "Art for me has always been about the investigation of our natural world and the way we perceive and relate to it," says Arabolos. "It not only has to do with the process of conceiving ideas and creating, but is also about the metaphysical act of experiencing and becoming. As an artist, I want to bring the observer to the phenomenological brink or edge where abstraction becomes subjective and identifiable."

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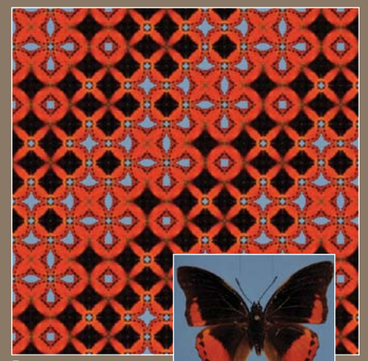

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A Chlosynejanais, DMPR-1x1, 42 in. by 42 in. © 2011 John Arabolos

B *Chlosyne janais* (Drury) (YPM ENT 413426) from Hondo, Medina County, Texas, USA. The ventral (underside) pattern of the butterfly, shown here, was used for the Arabolos artwork. Photo: A Monteiro/Yale

C Melitaeaphoebe, VMPR-1x1-CC, 30 in. by 30 in. © 2011 John Arabolos

D This specimen of *Melitaea phoebe* (YPM ENT.412850) is from Vallombrosa, Italy. The ventral (underside) pattern of the butterfly, shown here, was used for the Arabolos artwork.Photo: A Monteiro/Yale

E Charaxes_anticlea, DMPR-2x2, 42 in. by 42 in. This artwork was chosen for the cover of the July 2011 issue of *Nature Genetics*. © 2011 John Arabolos

F This specimen of *Charaxes anticlea* (Drury) (YPM ENT.814546) used for this artwork is from Monianku, Kisii, Kenya. A Monteiro/Yale

"The Fabric of Life — Ecological Symmetries" was on view through December 5, 2011. Four of the artworks from this exhibition have been selected this year for the covers of the July, August, October and November issues of the journal *Nature Genetics.* **Arabolos is the author of *Chaotic Symmetries: The Artwork of John Arabolos* (Herlin/GIST Press, March 2005) and is working on a second book based on his The Fabric of Life Series. You can see additional art by John Arabolos at *http://arabolosart.com* and *http://artfolionow.com*.**

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Colloquium on Urbanization in Ancient Africa Brings Together New Scholars

By Lauren Lippiello, Department of Near Eastern Languages and Civilizations, and Douglas P. Park, Department of Anthropology and Co-Director, Saharan Archaeological Research Association

Graduate and post-graduate students gathered at the Yale Peabody Museum of Natural History (YPM) on April 8–9, 2011, for the Urbanization in Ancient Africa Colloquium, which brought together new scholars from around the world to explore the conception, appearance and function of different forms of urbanity on the African continent. Presentations included material on urban communities from Senegal to Egypt, Libya to Tanzania, and spanned the period from 4000 BC to AD 1700.

Although the study areas are separated by thousands of miles and roughly five millennia, cultural comparisons encouraged lively discussion and prodded individual speakers to consider intervening variables that otherwise may not have been realized. Colloquium topics were grouped into two distinctive, yet not mutually exclusive, sessions.

First, lecturers presented material on the spatial distribution of people, architecture and materials across the landscape and considered the centrality and human response to environmental and climatic stressors. The day's lectures began with keynote speaker Professor John C. Darnell, Chair, Yale Department of Near Eastern Languages and Civilization, and his discussion of unique forms of ancient Egyptian urbanism. Speakers on this first day of talks were Elizabeth Hart (University of Virginia), Douglas Post Park (Yale University), Peter Coutros (Yale University), Jamie Inwood (Yale University), Andrea Zerboni (Università degli Studi di Milano), Lucia Mori (Università di Roma), Maria Gatto (Yale University) and Matthew Pawlowicz (University of Virginia). Several talks incorporated advanced technology such as remote sensing and GIS (Geographic Information Systems) models.

On the second day of the colloquium lecturers focused on the implications of specialization on urban development, including the appearance and frequency of elite and non-elite objects. These talks discussed new contributing factors to urban centers, such as trade relationships and the role of canonized religion. Keynote speaker Professor Roderick McIntosh, Yale Department of Anthropology, began the day's events by discussing the urbanism in the Niger Delta. Speakers on the second day were Brian Clark (Rice University), Lauren Lippiello (Yale University), Nikolas Gestrich, Kevin MacDonald and Jane Humphris (University College London), Jack Stoetzel (University of Virginia) and Annalisa Christie (University of York). At the end of the colloquium, discussion sections led by discussant Jason Nesbitt (Yale University) focused on adapting definitions of urbanism to include the relational dichotomy, as well as the interdependence, between urban centers and their associated hinterland.

The Urbanization in Ancient Africa Colloquium was generously sponsored by donations from the William K. and Marilyn M. Simpson Endowment for Egyptology, the Dean's Graduate Student Symposium Fund, YPM, the Easton Country Day School and the Yale Department of Anthropology, as well as anonymous donors. In particular, the organizers thank the Easton Country Day School for its support and for the attendance of several high school students on the first day of the colloquium. We would also like to express our gratitude to the keynote speakers, Professor John Darnell and Professor Roderick McIntosh.

Colloquium proceedings will be submitted for publication to the Yale University Publications in Anthropology series (published by the Yale Department of Anthropology and YPM, and distributed by Yale University Press).
For information contact organizers Lauren Lippiello (lauren.lippiello@yale.edu) and Douglas P. Park (douglas.park@aya.yale.edu).

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A At Ghueita Temple in Egypt extensive mud-brick structures dating to the Graeco–Roman Period (under later medieval and early modern structures) surround the earlier sandstone temple, which is ascribed primarily to the reigns of Darius I and Ptolemy III. Evidence of earlier occupation at Gebel Ghueita and its adjacent environs, particularly the remains of what seems to have been an extensive industrial complex in the late Middle Kingdom (not pictured), suggests the region was a center for intensive specialized production (see www.yale.edu/egyptology/ae_gebel.htm). Photo: J.C. Darnell

B Prehistoric urban settlement clusters dating from 500 BC to AD 1000 situated around modern Timbuktu in Mali, West Africa may represent a seasonal urbanism affected by the high and low floods. During the high flood season populations coalesced onto natural rises, creating settlements as large as 100 hectares. During the low flood season people moved out onto the landscape to take advantage of natural resources. Photo: Doug P. Park

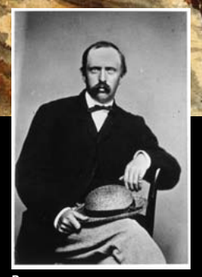
C This small Garamantian compound built at the fringes of the oasis of Fewet (in southwestern Fezzan, Libya) has been excavated and conserved by the Archaeological Mission in the Acacus and Messak. Photo: Andrea Zerboni

D A view of the Ghat Oasis in Libya and, in the background, the Tadrart Acacus. Photo: Andrea Zerboni

E A late Stone Age (Neolithic) hilltop settlement in the Tichitt region of Mauritania. Similar sites are found across the southwestern Sahara, from the Tichitt Cliff region in Mauritania to the lakes region in Mali. Photo: Peter Coutros

F This aerial view of the modern city of Jenne in Mali shows the unique form of West African urbanism that can be documented in archaeological contexts. The Iron Age occupation of Jenne Jeno, about one kilometer to the southeast, is similar in size and layout to the modern city, and has evidence of intense specialization in craft and subsistence production. Photo: Roderick J. McIntosh

A



B

Moving Marsh's Dinosaurs into the 21st Century

By Christopher Norris, Senior Collections Manager, Division of Vertebrate Paleontology, and Marilyn Fox, Chief Preparator, Division of Vertebrate Paleontology

Othniel Charles Marsh, the nation's first professor of paleontology, served at Yale from 1866 until his death in 1899. He is widely recognized as one of the founding fathers of the science of paleontology and his obituary in *The New York Times* cited his "marvelous achievements in paleontology" and ranked him among the "greatest scholars and investigators" and "distinguished naturalists" of the age. Marsh's greatest legacy is the massive collection of dinosaur fossils that are the core of the Yale Peabody Museum of Natural History (YPM) fossil vertebrate collections. Dating back to the 1870s, these fossils are some of the first dinosaur specimens collected in the American West and include such familiar names as *Apatosaurus* (*Brontosaurus*), *Allosaurus*, *Stegosaurus* and *Triceratops*. Over the course of his career Marsh accumulated 769 dinosaur specimens and named 344 new species and 161 new genera of fossil vertebrates.

The status of these fossils as a significant cultural treasure of the United States has been recognized through the award of a $450,000 Save America's Treasures Grant to YPM to secure their long-term preservation. These grants, which are funded through the National Park Service and the Institute of Museum and Library Services, are intended to preserve the physical fabric of American history, supporting the restoration of nationally significant historic sites and special collections across the country. While it is more usual to think of the dinosaur collection in terms of its scientific value, it has also played a critical role in the history of science. Prior to the 1870s, dinosaur specimens were rare. The wealth of specimens obtained by Marsh helped to raise the profile of the group and lay the foundations of today's public fascination with dinosaurs. This fascination continues today; since 2005, the YPM Division of Vertebrate Paleontology has welcomed more than 1,800 members of the public on behind-the-scenes tours of the collection.

Unfortunately, the room that currently houses the largest dinosaur specimens conforms in all too many ways to the caricature of a museum storeroom: it is a dark, damp, and dirty basement room. The specimens are subject to damaging relative humidity that ranges from nearly 70% in summer to almost 20% in the winter, and which can vary by up to 20% in 24 hours. This lack of climate control causes a multitude of problems. Most of these dinosaur specimens were prepared in the late 1800s and early 1900s; the preparators working on them used adhesives made from animal hides and other organic glues. These glues become unstable when exposed to the high relative humidity in the YPM basement, causing the glue to fail and specimens to disintegrate. Handling even the smallest bones can result in disaster as old adhesives fail. The specimens are currently kept on open racks. These were state-of-the-art in 1927, when the fossils were moved to the basement, but today the rusting metal-grated shelves are warped and difficult to move without causing damage to the fossils. The fossilized bones, some over four feet (more than a meter) in length and weighing several hundred pounds, present formidable challenges for handling, a problem magnified by overcrowding.

A previous National Science Foundation funded project enabled the Division to clean, re-glue and create support bases for all of these specimens, but could not address the environmental conditions in the room. The Save the America's Treasures Grant will enable YPM to move the Marsh dinosaur collection to a refurbished space with new environmental controls and state-of-the art compactorized storage, securing its long-term safety and stability. The level of conservation and care that results will ensure greater access to this historically and scientifically important collection and the information it holds, making these materials available to researchers, educators, students and the public.

The fossil collections at Yale are the most tangible part of Marsh's immense and ongoing legacy to the nation and a vital resource for scientific research, education, and outreach. The funding from the Save America's Treasures program will ensure that they continue to amaze and inspire future generations.

To learn more about the YPM Division of Vertebrate Paleontology and its collections, visit http://peabody.yale.edu/collections/vertebrate-paleontology.

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A Arthur Lakes, one of the early collectors for O.C. Marsh, is known for his watercolors of collectors digging dinosaurs, such as this painting, "Kennedy and Reed with Dinosaur Bones. Como Bluff, Wyoming, 1879." Many of the specimens that will be moved with the support of the Save America's Treasures Grant were collected by these men. Photo: YPM Archives

B Yale's Othniel Charles Marsh described many of the most famous American dinosaurs. Collectors working for Marsh excavated thousands of fossil bones. Photo: YPM Archives

C Marsh's dinosaurs in their current storage. Photo: M Fox

D Overcrowded vertebrae are hard to handle, increasing the risk of breakage. Credit: M Fox

E An earlier NSF grant enabled the YPM Division of Vertebrate Paleontology to stabilize and make support bases for all the fossil bones. Old glues had disintegrated and many bones were in pieces. Photo: M Fox

F One of the reconstructed specimens with its illustration from *Marsh's Dinosaurs*, a 1966 publication by John Ostrom and John McIntosh that republished Marsh's original lithographic drawings of fossils from the collection. Photo: M Fox/Yale University Press

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Diversity, Extinction and Response — Prospecting for Fossils Near the K–T Boundary

By Jessamy Doman, Yale Department of Anthropology Graduate Program, and Tyler Lyson, Yale Department of Geology & Geophysics Graduate Program

The discovery in 2010 of a ceratopsian brow horn that could be the youngest dinosaur fossil yet found and the subsequent paper about it ("Dinosaur Extinction: Closing the '3 m Gap'" by T.R. Lyson, A. Bercovici, S.G.B. Chester, E.J. Sargis, D. Pearson and W.G. Joyce in *Biology Letters*) garnered considerable media attention and response from the scientific community. The authors argued that the presence of these dinosaur fossils so close to the K–T (Cretaceous–Tertiary) boundary gives greater support to the theory that a meteorite impact approximately 65.5 million years ago ultimately caused the mass extinction of a range of biota, including the non-avian dinosaurs. An alternative theory is that the extinction was gradual and the dinosaurs were already dwindling, or even extinct, before the impact.

With the goal of finding more complete specimens to further establish the position of these specimens relative to the K–T boundary and gain a better understanding of the ecological effects of the meteorite impact, a Yale team of scientists returned to the area in Fallon County, Montana, where the brow horn ceratopsian dinosaur (the same group that includes the well-known *Triceratops*) was found. Fieldwork by YPM Curator of Vertebrate Zoology Eric Sargis, a professor in the Yale departments of Anthropology and Ecology & Evolutionary Biology, graduate students Stephen Chester (Anthropology), Jessamy Doman (Anthropology) and Tyler Lyson (Geology & Geophysics), and Yale undergraduates Rae Ellen Bichell ('12, Anthropology), Greg Mittl ('12, Molecular Biophysics & Biochemistry) and Natasha Vitek ('11, Geology & Geophysics) yielded abundant dinosaur remains, including the articulated skeletons of several different species. The great diversity of dinosaurs living alongside one another at the end of the Cretaceous period adds support to the asteroid impact theory as the explanation for the demise of the dinosaurs.

A crucial aspect of the fieldwork was to determine the exact position of the K–T boundary and the vertical placement of the recovered fossils relative to this boundary. Unfortunately, the K–T boundary cannot be seen in the field, but instead must be identified by relatively complex laboratory analyses. One of the easiest ways to find it is by analyzing microscopic fossil pollen, which is ubiquitous in the sediments of this geologic period. The boundary is marked by an extinction of Cretaceous plants, followed by a spike in the pioneering ferns, which are the first plants to re-inhabit a post-disaster area (such as landscapes altered by a volcanic eruption or meteorite impact). The team, which collaborated with pollen expert Dr. Antoine Bercovici of the China University of Geosciences, collected sediment samples near each dinosaur skeleton. Pollen from each sample, currently being processed, will provide data that will pinpoint exactly how far each skeleton is below the K–T boundary.

The great diversity of dinosaurs living alongside one another at the end of the Cretaceous period adds support to the asteroid impact theory as the explanation for the demise of the dinosaurs.

The scientific value of the study site lies not only in the many fossils found, but also in the significant periods the fossil-bearing sediments represent. The area captures information not only on the last of the Cretaceous biota and its demise, but also about post-impact ecological recovery—a time interval not well sampled. In the earliest Paleocene, a river ran through this area, depositing the remains of plants, fish, crocodiles, champsosaurs, turtles, lizards and archaic mammals. Members of the Yale team spent hours on hands and knees meticulously scouring the ground for fossils—a grueling but necessary task, for some of the smallest mammal teeth recovered are no more than a few millimeters in size. This effort resulted in the recovery of many exciting plant and animal fossils, including several well-preserved mammal jaws. The locality also provided a means to test a new device kindly designed and built by Lyson's father, Ranse Lyson. Affectionately known as "The Bubbler," this device uses a more efficient and environmentally friendly method than traditional techniques to screen-wash the buckets of sediments collected at the site: air, rather than water pressure (usually from a garden hose) agitates the sediment, the finer particles are washed away, and the coarser rock with the fossils are left behind, saving hundreds of gallons of water and many hours of labor. The Bubbler worked tirelessly throughout the field season, producing buckets of washed fossils that are yet to be sorted. Each fossil has the potential to better flesh out what we know survived into, and what was living at the beginning of, the "Age of Mammals."

The team of Yale scientists will build on these past several years of research and continue to visit this fossil-rich area. The interest and controversy surrounding dinosaur extinction re-ignited by this discovery highlights the importance of Yale's research on this critical time period and the site's potential for further significant finds. With the pollen analysis and more detailed fossil identification now underway, expect more exciting results to follow soon.

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A Paleobotanist Antoine Bercovici collects pollen samples near a *Triceratops* skull (foreground). Photo: Jessamy Doman

B Jessamy Doman (left), Tyler Lyson (middle) and Antoine Bercovici (right) sitting on the K–T boundary in Montana. Photo: Antoine Bercovici

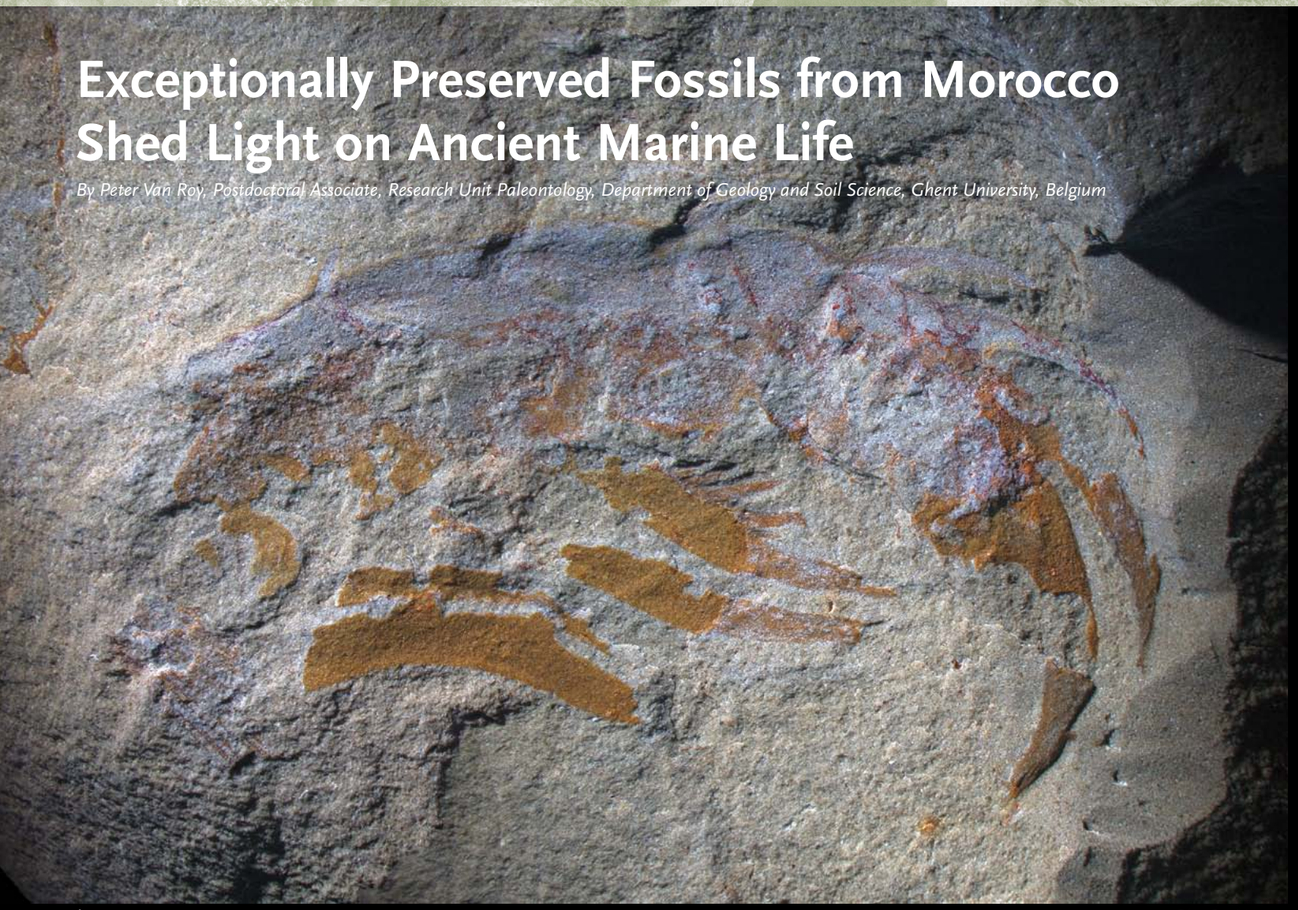
C Yale graduate students Jessamy Doman (left) and Tyler Lyson (right)—and "The Bubbler." Photo: Erik Freeman

D The Yale team scours the Cretaceous surface in search of small fossils. Photo: Erik Freeman

E Antoine Bercovici (left) and Yale undergraduates Greg Mittl (middle) and Natasha Vitek (right) collect pollen samples near a dinosaur locality. Photo: Erik Freeman

Exceptionally Preserved Fossils from Morocco Shed Light on Ancient Marine Life

By Peter Van Roy, Postdoctoral Associate, Research Unit Paleontology, Department of Geology and Soil Science, Ghent University, Belgium



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P Van Roy (4)

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A Anomalocaridids used these spinose grasping head appendages (YPM IP.227644) to capture their prey.

B The prize beast: a giant anomalocaridid (YPM IP.226637) from the Fezouata rocks. The specimen is missing most of its head. When complete, the animal would have been at least 4 feet (120 centimeters) long, larger than any of the examples among Cambrian Burgess Shale-type fossils.

C A marrellomorph arthropod, probably belonging to the genus *Furca*. Marrellomorphs are also typical of the Cambrian. This specimen is from the Museum of Toulouse, France.

D The oldest known horseshoe crab (YPM IP.227586). With the exception of a few relatively minor differences, this example is already very similar in structure to modern horseshoe crabs, showing that advanced forms are present in the Fezouata rocks alongside animals typical of the Cambrian.

E From left to right: Jakob Vinther, Peter Van Roy and Derek Briggs in the field in Morocco.

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Patrick J. Orr

Under normal circumstances, only the hard or shelly parts of animals are preserved as fossils. This means that our knowledge of the biodiversity of ancient seas is incomplete because most animals are soft bodied and normal "shelly" preservation provides a biased view of past life. Fortunately this is not always the case. In exceptional circumstances, soft-bodied organisms are preserved in minute detail, and sometimes down to the subcellular level. Such sites of exceptional preservation are of primary scientific importance and provide a much more complete picture of the composition, ecology and evolution of organisms through time.

The fossil record is particularly incomplete during the 25-million-year interval of the Ordovician when the so-called Great Ordovician Biodiversification Event (GOBE) took place and the GOBE is one of the pivotal events in the history of life in the oceans. While nearly all animal phyla appear in the fossil record during the Cambrian explosion, during the succeeding Ordovician period, about twice as many new orders of animals were added, the number of families tripled, and genera increased nearly four-fold. This massive hike in biodiversity, at a rate faster than at any other time before or since, went hand in hand with greatly increased complexity in behavior and community structure. The GOBE was generally believed to have resulted in the replacement of the animals typical of the Cambrian.

Exceptionally preserved faunas are not evenly distributed through time, and while they are relatively common during the Cambrian (542 to 488 million years ago) and Jurassic (200–146 Mya), they are extremely rare during the Ordovician (488–444 Mya). Until recently only a handful of Ordovician soft-bodied biotas were known, all dating to the Middle and Late Ordovician. Those sites represented unusual environments, and the faunas they yield are not representative of normal, open marine Ordovician communities.

The contribution of exceptionally preserved fossils to unraveling the GOBE was rather limited until now because of their scarcity. This is where the Fezouata fossils, known from dozens of excavations mostly north of Zagora in southeastern Morocco, come in. Exceptionally preserved fossils were first discovered in the Fezouata rocks some time during 2002 by a local fossil collector named Mohammed Ou Said Ben Moula. Moula is a highly skilled collector with an uncanny ability to locate exceptionally preserved fossils in the vast expanses of the desert north of Zagora. Over the years, I have developed a close working relationship with Moula, who graciously keeps all exceptionally preserved specimens he finds for review by the Yale Peabody Museum of Natural History (YPM).

Some 480 to 470 million years ago, the Fezouata animals inhabited the muddy sea floor on the outer shelf off the ancient continent of Gondwana, in an area that was then almost directly at the South Pole. The animals were buried by clouds of fine sediment, which may have been set in motion by massive storms. The soft parts were replaced by the mineral pyrite (an iron sulfide, FeS_2), but this was converted into a mix of iron oxides and hydroxides by weathering. This lends the fossils their attractive vivid yellow, orange, red and brown colors.

The Fezouata animals inhabited normal, open marine settings that supported a high biodiversity. During a National Geographic-sponsored field season in 2009, we discovered that the Fezouata biota includes virtually all types of animals present in the famous Cambrian Burgess Shale deposits, alongside more derived forms. Burgess Shale-type faunas consist of basal, stem group organisms that look bizarre to our modern eyes. The quintessential examples of these are the spectacular giant predatory anomalocaridids, with their pair of raptorial appendages, circlet of toothed plates surrounding the mouth and elongated, segmented bodies with lateral flaps used for swimming. Most Burgess Shale-type animals were thought to have disappeared after the Middle Cambrian, but our discoveries indicate that they had an important influence on the diversity and ecological structure of much younger marine communities.

The exceptionally preserved fossils seem to tell a different story to the more common shelly forms that show a dramatic turnover between Cambrian and later faunas. At the same time, the presence of a significant number of more advanced, typically post-Cambrian taxa alongside forms familiar from the Burgess Shale is evidence that the GOBE was far more rapid, at least among soft-bodied animals, than has been appreciated.

With an international team of researchers, including YPM Director Derek Briggs, the G. Evelyn Hutchinson Professor of Geology and Geophysics, and Yale alumnus Jakob Vinther (Ph.D. '11, now at the University of Texas at Austin), we continue to study the ever-expanding cache of fossils collected from the Fezouata rocks (now funded by a grant from the National Science Foundation). Every year hundreds of new specimens and many new taxa are added to the thousands of Fezouata fossils already in the YPM collections. We are assured of many more years of exciting discoveries, allowing us to gain a much better understanding of one of the most dramatic events in the history of marine life.

A

Peabody Museum Hosts 60th Annual Meeting of The Lepidopterists' Society

By Lawrence Gall, Informatics Manager, Division of Entomology, and Head, Computer Systems Office

This summer the Yale Peabody Museum of Natural History (YPM) hosted the 60th Annual Meeting of The Lepidopterists' Society, an international organization dedicated to the study of butterflies and moths (the order Lepidoptera). From June 22–27, 2011, approximately one hundred attendees from six countries participated in the meeting activities. Larry Gall, head of YPM's Computer Systems Office and informatics manager in the YPM Division of Entomology, served as chair for the meeting.

Conference paper and poster sessions were held both in the main lecture hall at Yale's Osborn Memorial Laboratory in New Haven and the B-25 auditorium at Yale's West Campus. Other meeting activities included a collections tour and barbecue at West Campus, open houses in the Entomology Division collections at the Class of 1954 Environmental Science Center, and a banquet in the YPM Great Hall. The variety of field trips available to the meeting attendees included visits to butterfly watching "hot spots" at New Haven's West Rock Ridge State Park, at Killingly, Connecticut, and at Westchester County's Ward Pound Ridge Reservation in New York; moth hunting at night at Hamden's Brooksvale Park; and a butterfly census of Redding, Connecticut, part of the annual Fourth of July Butterfly Counts program held across North America by the North American Butterfly Association.

The Lepidopterists' Society meetings offer a combination of technical and nontechnical presentations from lepidopterists both inside and outside academia. The 2011 meeting continued that tradition with a synergistic mix of presentations on topics as diverse as range declines and conservation of Lepidoptera, the genetics of speciation in swallowtail butterflies, photographic safaris in South America, caterpillar crypsis and crowding, sexual coyness in satyrine butterflies, and the original colors of fossil moths. The research activities of Antónia Monteiro, assistant professor in Yale's Department of Ecology & Evolutionary Biology and assistant curator in the YPM Division of Entomology, and eight of her Yale students and colleagues, were featured prominently among the presentations.

The Society holds competitions at its annual meetings to recognize excellence in research by young lepidopterists. The 2011 co-winners of the Harry Kendon Clench Award for best student presentation were Virginia Tilden from Pennsylvania State University ("Grassland restoration and management for the reintroduction of the Regal Fritillary, *Speyeria idalia*") and Erica Westerman from Yale University ("Premating experience changes mating patterns in a butterfly"). The 2011 winner of the Alexander Klots Award for best student poster was Caroline Polgar from Boston University ("The effect of climate change on the flight times of lycaenid butterflies in Massachusetts").

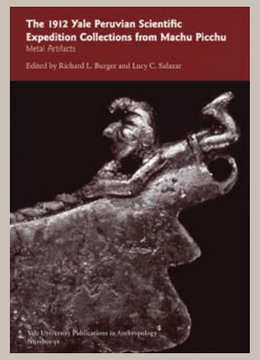
On a historical note, The Lepidopterists' Society has long had a Yale connection. The Society was co-founded by the late Charles Remington, who served for four decades as a professor in the Yale Department of Biology and as YPM Curator of Entomology. Remington and his close friend Harry Clench started the Society at Harvard University in 1947 when Remington was finishing his doctoral studies, and it grew and developed rapidly after he joined the faculty at Yale (in 1948). Charles and his wife Jeanne edited the Society's publications during its formative years and were instrumental in shaping the Society's primary goal and purpose: to "promote the scientifically sound and progressive study of Lepidoptera by...facilitating the exchange of specimens and ideas by both the professional worker and the interested amateur in the field" (from the March 24, 1947 letter announcing the establishment of the Lepidopterists' Union, as the Society was briefly initially known).

B

A The logo for the 60th Annual Meeting of The Lepidopterists' Society designed by Antónia Monteiro, features the African satyrid butterfly *Bicyclus anynana* (Butler).

B A montage of lepidopterists visiting and conducting research in the collections of the YPM Entomology Division in the Class of 1954 Environmental Science Center at the 2011 annual meeting. Photos: L Gall

New from the Yale University Publications in Anthropology Series



The 1912 Yale Peruvian Scientific Expedition Collections from Machu Picchu: Metal Artifacts

Edited by Richard L. Burger and Lucy C. Salazar

With contributions by Robert B. Gordon and Bruce D. Owen

Yale University Publications in Anthropology 91
ISBN 978-0-913516-27-0

This book is the second in the Yale University Publications in Anthropology series dedicated to the materials recovered early in the 20th century by Hiram Bingham III and the Yale Peruvian Scientific Expeditions. Edited by Richard L. Burger, Charles J. MacCurdy Professor of Anthropology, director of graduate studies, chair of the Yale Council on Archaeological Studies, and curator of anthropology at the Yale Peabody Museum of Natural History (YPM), and Lucy C. Salazar, research associate in the Yale Department of Anthropology, this volume focuses on the rich assemblage of metal artifacts from Machu Picchu and evidence of metallurgy at the site. At Machu Picchu the Inca resettled multi-ethnic retainers from remote provinces to operate their estate and gathered those skilled in metallurgy to supply their people with metal products fabricated from copper, tin and silver. The culmination of nearly two thousand years of independently developed indigenous American metal technology, these were not accoutrements of nobility, but quotidian possessions of the retainers who staffed the royal estate.

The innovative research contributed here by Robert B. Gordon, senior research scientist and Professor Emeritus of Geophysics and Applied Mechanics, in the Yale Department of Geology & Geophysics, and Bruce D. Owen, lecturer in the Department of Anthropology, Sonoma State University, examines material that has barely been available in the literature and provides new patterns and interpretations revealed by an impressive array of new artifact and analytical data, making this work a strong addition to the knowledge of Andean prehistory, and the Inca in particular.

Laboratory study of these artifacts shows the result of a path of metal technology that developed independently of the better-known and widely studied evolution of metallurgy in the Old World. This research shows the metal sources, the smelting technique, and the methods that Peruvian artisans used to fabricate tools, household and personal items, weapons and symbols of prestige and power. These American artisans mastered the techniques of making bronze alloys that they cast into tools such as axes and chisels, or forged into finely finished, delicate products such as tweezers. They learned the technique of depletion silvering to form a silver surface on copper-base alloys containing as little as 25% silver, a technique also developed independently in both Anatolia and Japan.

The book also includes an extensive illustrated typological comparison of artifacts from various Inca sites. More than 120 maps plotted from a database of over 10,000 metal artifacts outline the geographic distributions of many metal artifact types across the Andes. Rather than identifying an imperial style of quotidian metals, these maps suggest that some metal objects at Machu Picchu were generically Andean, others were recognizably exotic, referring to known or unknown distant places, and still others referred to Cuzqeño or Inca identity at a folk rather than imperial level. These analyses bring a new range of low-tech, accessible interpretive tools to bear on the quotidian metals found at sites throughout the Andes. The maps, illustrated metals typology, and extensive tables provide a baseline for interpretations at other sites that will help the quotidian metal artifacts of the Andes speak to us in new and interesting ways. Clearly presented, yet technical and descriptive, this book, the most thorough effort so far at a synthesis of the metalwork of the central Andes, is a significant contribution to foundation work in this area.

The Yale University Publications in Anthropology series embodies the results of research in the general field of anthropology directly conducted or sponsored by the Yale University Department of Anthropology and the YPM Division of Anthropology. The series, published by the Yale Department of Anthropology and the YPM, is supported by the Theodore and Ruth Wilmanns Lidz Endowment Fund for Excellence in Scholarly Publications, dedicated to the dissemination of scholarly research and study of the world and its cultures. Available titles in the Yale University Publications in Anthropology series are distributed by Yale University Press. To order call (800) 405-1619 or visit *http://yalebooks.com*.

Bear-palooza

By Greg Watkins-Colwell, Collections Manager, Division of Vertebrate Zoology

In autumn 2008, the Yale Peabody Museum of Natural History (YPM) received three black bear specimens donated by the Connecticut Department of Energy and Environmental Protection (CT DEEP). Since then, these specimens have been stored in a freezer. On April 27, 2011, they were thawed for a massive group effort to prepare them as skeletal specimens and tissue samples for the YPM Division of Vertebrate Zoology research collection.

The American black bear (*Ursus americanus*) is a species that is rebounding in the Northeast. It is estimated that there are now hundreds of black bears living wild in Connecticut, and in a state as densely populated with humans as Connecticut, interactions between people and bears are inevitable. The CT DEEP frequently receives calls about nuisance bears during the year, and while most interactions are benign, some require intervention. CT DEEP personnel may attempt to haze bears away from problem sites, or may capture and relocate bears short distances. Occasionally, an individual bear will repeatedly cause problems, even after being hazed, and must be euthanized by wildlife officers. As the bear population has grown, the number of bears struck and killed by vehicles has risen, and vehicle-killed and euthanized bears are stored by the CT DEEP and may be made available to researchers and educators.

On June 2, 2011, after several days of thawing, specimen preparation on the bears began. The project, nicknamed "Bear-palooza," involved YPM staff, a curator from the Division of Vertebrate Zoology, a curatorial affiliate, Yale undergraduate and graduate students, and YPM volunteers, who all became preparators for the day. The project required coordination of all 15 participants, as well as oversight by the Yale Office of Environmental Health and Safety, whose West Campus space was used not only to thaw the specimens, but also for the preparation.

It is estimated that there are now hundreds of black bears living wild in Connecticut, and in a state as densely populated with humans as Connecticut, interactions between people and bears are inevitable.

Preparation of a specimen for a museum collection involves removal of the skin and organs, removal of major muscle groups, and collection of samples of tissue for DNA extraction and analysis. Once the specimens were skinned and the major muscle groups removed, they were packaged and refrozen for further preparation at a later date. In September 2011 the specimen preparation resumed and additional muscles were removed and the specimens were dried and placed in the dermestid beetle colony in YPM's Osteology Preparation Lab, a common method used for cleaning skeletal material.

There are relatively few specimens of black bear in collections and this is especially true of collections representing New England sites, where the species had been nearly extirpated. The YPM Division of Vertebrate Zoology houses a mammal collection of 14,284 specimens, of which 44 are black bears. Of these, 12 are from New England. The three specimens prepared during Bear-palooza, including tissue samples, are catalogued within YPM's mammal collection, bringing the total number of Connecticut black bears in the collection to four. These specimens are made available to researchers from around the world and could prove useful for studies of systematics and population genetics, as well as many other research projects.

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A Assisting in the specimen preparation were (from left to right) Vertebrate Zoology Museum Assistant Susan Hochgraf, volunteer Brian Roach, and Vertebrate Zoology Collections Manager Greg Watkins-Colwell. Photo: Susan Hochgraf

B Nuisance bears raiding birdfeeders, like this black bear in a New Hartford backyard, is an increasingly common problem in Connecticut. Photo: Melissa Ruszczyk

B

Undergraduate Summer Internships at the Yale Peabody Museum: Student Reports

The Yale Peabody Museum of Natural History (YPM) was pleased to once again award research internships to Yale University undergraduates for the summer of 2011. These interns worked on research projects under the guidance of Yale scientists who they selected from an expanded list of potential mentors in several Science Hill departments. Projects were either of a student's own design, or part of an ongoing program in a laboratory or research collection. Additionally, students were encouraged to pursue fieldwork to augment their study and, in some cases, add material to YPM divisional collections. As part of the fulfillment of their internships, the students submitted essays about their research experience.

The following students received a 2011 summer internship: Peter Flynn (Yale '14) worked with Associate Professor of Ecology & Evolutionary Biology and YPM Curator of Vertebrate Zoology (Ichthyology) Thomas Near to analyze the molecular phylogeography of longear sunfish. William Gearty (Yale '14) worked with YPM Division of Invertebrate Paleontology Senior Collections Manager Susan Butts to investigate historical patterns of silicification, a type of fossilization in which original shell material is replaced with silica, using the Division's Stratigraphic Collection and published occurrences to connect silicification with changes in ocean chemistry. Aspen Reese (Yale '12) studied morphological variation in a small mammal, the pika, with Professor of Anthropology and YPM Curator of Vertebrate Zoology (Mammalogy) Eric Sargis and conducted her fieldwork in Mongolia and Alaska. Mia Yabut (Yale '12) studied the taxonomy of shrimp-like crustaceans with YPM Division of Invertebrate Zoology Senior Collections Manager Eric Lazo-Wasem and conducted her fieldwork in Bermuda and the Bahamas.

INTERNSHIP PROGRAM EXPANDS

Although for several years YPM has offered research internships to Yale undergraduates, there is continual interest from students at other institutions for opportunities to work in the Museum collections and the Museum is now working with several Connecticut institutions to provide working internships for their students. Rather than receiving an internship with a financial incentive, the students work during the school year and obtain academic course credit from their home institution. YPM benefits by having highly motivated students assist divisional staff on projects that otherwise might not be accomplished. This year internships were offered to students from Quinnipiac University and Southern Connecticut State University. Sacred Heart University and Western Connecticut State University will soon become participating institutions.

profile

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Peter Flynn

A Peter Flynn at work in the Class of 1954 Environmental Science Center. Photo: Near Lab

B A longear sunfish (*Lepomis megalotis*) from Coosa River, near Wetumpka, Alabama, USA. Photo: © 2007 Mike Cline/ CC BY-SA 2.5

profile

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William Gearty

A Will Gearty points to a silicified fossil in the Invertebrate Paleontology collection. Photo: Susan Butts

B Silicified bryozoa with rock matrix completely dissolved (Permian of west Texas, USA). Photo: Susan Butts

C Silicified gastropods weathering out of limestone (Ordovician, North America). Photo: Susan Butts

Peter Flynn (Yale '14)

For 10 weeks this summer I worked in the lab of Associate Professor of Ecology & Evolutionary Biology and YPM Curator of Vertebrate Zoology (Ichthyology) Thomas Near looking at the molecular phylogeography of *Lepomis megalotis* (longear sunfish), with the additional support of the Yale Peabody Museum of Natural History (YPM). Phylogeography is the historical processes that are responsible for the current geographic distribution of individuals. My research was achieved by comparing the geographic distribution of individuals with the patterns associated with their gene genealogy.

Lepomis megalotis is a widespread inhabitant of eastern North American waters. The relationships of the geographic variants of *L. megalotis* have been misunderstood for many years and the systematics of this species were unclear. One specific problem is whether the generally recognized subspecies of *L. megalotis*—the central longear sunfish (*L. megalotis megalotis*) and the northern longear sunfish (*L. megalotis peltastes*)—should be classified as separate species. My research, in which I compared the geographic distribution of the *L. megalotis* samples collected with their respective specific DNA sequences, eventually helped determine the status of *L. megalotis* megalotis.

I used DNA sequences to infer phylogenies and determine the evolutionary processes that are congruent with the observed patterns. The sampling was already complete and I used previously collected fish DNA samples from the collections in the YPM Division of Vertebrate Zoology. For this analysis I used Qiagen DNAeasy kits (Valencia, CA, USA) to isolate nucleic acids and worked with specific primers according to the genes I was amplifying with PCR (polymerase chain reaction). For sequencing, I used a mitochondrial gene (ND2) and two nuclear genes (S7 and Rag). The Science Hill DNA sequencing facility and the WM Keck Foundation Biotechnology Resource Laboratory, both at Yale University, completed the DNA sequencing. The sequence data was analyzed with standard phylogenetic software programs (MrBayes and Garli).

By the end of the summer, I had generated a substantial dataset for the two nuclear genes (Rag and S7) and the mitochondrial gene (ND2). During the rest of the school year, using this data, I will determine the exact genetic divergence of the *Lepomis megalotis* with *L. peltastes* and hopefully produce a paper on the systematics of this species group. The lab work and analysis of DNA sequences that I learned from this research are broadly applicable to any study incorporating DNA sequence data and phylogenetic analysis.

William Gearty (Yale '14)

This summer, I worked with Senior Collections Manager Susan Butts of the Division Invertebrate Paleontology at the Yale Peabody Museum of Natural History (YPM), and Richard Krause, a postdoctoral associate in the Yale Department of Geology & Geophysics, on a research project that involved the analysis of the prevalence of silicification across the Paleozoic Era. Silicification is the process by which the original shell material of a fossil dissolves in an acidic environment and is replaced by the precipitation of silica into the resulting cavity in the fossil. Like all forms of taphonomy (the process of fossilization), silicification is affected by different factors in the environment where it is takes place, such as climate and global ocean chemistry. Also, the formation of silica fossils is mediated by the composition and structure of the original shell material, as well as depositional factors such as permeability, porosity, lithology and stratigraphy. The occurrence of silicified fossils is much more prevalent in the Paleozoic, disappearing in the fossil record as you move through the younger strata and more recent time periods. This may have something to do either with the abundance of carbonate shelly fossils or the abundance of available silica mineral during the Paleozoic. However, there is no agreement on the exact reason(s) for the many silicified fossils from the Paleozoic, but not afterward.

The YPM Division of Invertebrate Paleontology Stratigraphic Collection contains invertebrate fossils organized by age. These have been acquired over at least 150 years and include irreplaceable specimens from localities now lost or inaccessible. In testing the fossils for silicification, I used acid to determine whether the fossils still contained the original calcium carbonate material or had been silicified. Also, because silica is harder than metal, the fossils were tested by scratching them with metal. Finally, because silica is also more resistant to weathering, the fossils often stand out in relief. When the testing was completed, I was able to record my data across multiple individual time periods and show the changes in the prevalence of silicification across the Paleozoic.

Additionally, I reviewed articles published in the *Journal of Paleontology*. This literature search, like the physical testing, was extremely valuable in increasing the number of data points and widening our field of study. Each paper represented an additional specimen, and the literature search produced very similar data to the physical specimens.

By the end of the summer, patterns began to emerge and our results showed that silicification was most prevalent in the Middle to Late Ordovician, the Late Silurian and the Middle Permian. Possible explanations for these ranges include global climate changes and mass extinctions, and in fact, modern hypotheses of prehistoric global climate seem to correlate very well with our data. Additionally, a drastic decrease in silicification near the end of the Permian period correlated with the largest mass extinction of Earth's history. There are also other possible correlations, however, the true reasons for these changes are still unknown.

Dr. Butts and Dr. Krause plan to pursue this research and publish a paper on this material. I have finished my portion of the project, and I hope to see great results from my efforts. Hopefully, this will lead to a better understanding of relationships between the climate and environments in the past.

profile

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Aspen Reese

A Aspen Reese conducting fieldwork, Eldridge Mountain, Alaska. Photo: Kyndall Hildebrandt

B A pika among the rocks at Eldridge Mountain, near Eagle, Alaska. Photo: Aspen Reese

profile

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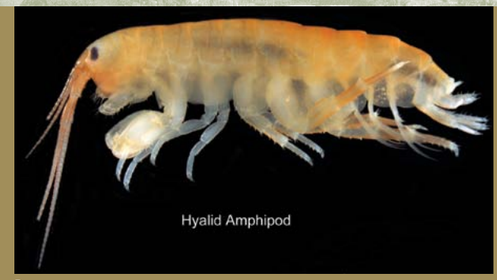


B

Mia Yabut

A Mia Yabut collecting amphipods near the Bermuda Institute of Ocean Sciences. Photo: Lourdes Rojas

B The amphipod *Parhyale hawaiiensis* (YPM IZ.053809) from Bermuda. Photo: Lourdes Rojas

Aspen Reese (Yale '12)

I spent my summer researching the pika (*Ochotona*) in preparation for my senior thesis later this year. Pikas are small lagomorphs, related to rabbits and hares, that come in two ecological varieties: one that lives in rocky, high alpine environments and one that lives in grassy steppe. Both consume grass and prepare hay piles, which they live off during the winter when they are active below snow. Pikas in alpine habitats live in the crevices between boulders near grassy areas, while those in the steppe create their own burrows. My project was to investigate whether there are morphological and behavioral differences in these species that correlate with their ecological type. To do this I studied both museum specimens and live, wild pika with the support of the Yale Peabody Museum of Natural History (YPM) internship, the Yale College Dean's Research Fellowship in the Sciences, and the Yale Environmental Summer Fellowship.

The museum work in the mammalogy collections of the YPM Division of Vertebrate Zoology was guided and overseen by Eric Sargis, professor of anthropology and YPM curator of mammalogy and vertebrate paleontology. My research involved a series of 23 measurements of postcranial elements intended to highlight areas where ecological adaptations would be expected, including forelimbs for digging and hindlimbs for leaping. In addition to the YPM collections, I measured pika specimens borrowed from other natural history museums, and I also visited the Smithsonian Institution's National Museum of Natural History in Washington, DC, the American Museum of Natural History in New York City and the Natural History Museum in London to access other specimens that could not be taken on loan.

To supplement the morphological analysis, I designed observational research to quantify the behavioral differences between the ecotypes and conducted field research in the steppe of central Mongolia, where Pallas's pika (*Ochotona pallasi*) and Daurian pika (*O. dauurica*) are known to occur. Unseasonably late blizzards prevented me from collecting a useable data set, but the experience taught me much about the difficulties of fieldwork.

In August I spent three weeks in interior Alaska studying the collared pika (*Ochotona collaris*), research that was much more fruitful. The trip was a collaboration organized by the University of Alaska Museum and the Smithsonian Institution to re-survey a site that naturalists had visited more than a hundred years ago. I assisted in the collection of small mammals, including collared pika, hoary marmots (*Marmota caligata*), ermine (*Mustela erminea*) and hundreds of northern red-backed voles (*Myodes rutilus*). In addition, we saw many of the large mammals Alaska is known for, including wolves (*Canis lupus*) and grizzly bears (*Ursus arctos*), and observed both adults and cubs.

When not collecting specimens or battling the Alaskan elements, I scored pika locomotive behavior in the field and also produced video footage, which I will use for more detailed analysis to quantify the locomotor regime of *Ochotona collaris*. I hope to be able to use this data to show the importance of leaping in the pika's locomotor repertoire. Should hindlimb adaptations known to correlate with leaping motions be observed in the skeletal analyses, this data will prove useful in illustrating evolutionary themes.

My work will continue through the school year as I finish collecting data and begin to analyze it under the supervision of Dr. Sargis. I plan to write my senior thesis for submission to a peer-reviewed journal in the spring and to continue to use the lessons I learned this summer about field- and specimen-based morphological research as I continue my science education in graduate school.

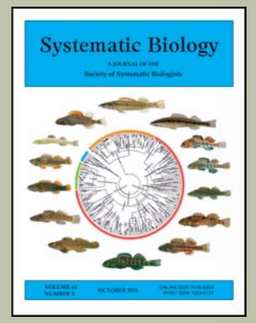
Mia Yabut (Yale '12)

I have spent the past year studying amphipod taxonomy and systematics in the Yale Peabody Museum of Natural History's (YPM) Division of Invertebrate Zoology. This summer I was able to experience fieldwork firsthand during my six-week internship, sponsored by YPM and my residential college, Silliman. My research focuses on a family (Hyalidae) of amphipods and its component genera, several of which are in need of revision. With my advisor Eric Lazo-Wasem, YPM Senior Collections Manager, I spent part of my internship in New Haven learning new photography and permanent slide-making techniques and preparing for work in the field. In addition, I learned all aspects of writing a species diagnosis and complete taxonomic description. These lessons were very useful as my work progressed, and I am certain to use these methods as I prepare my senior thesis during this academic year.

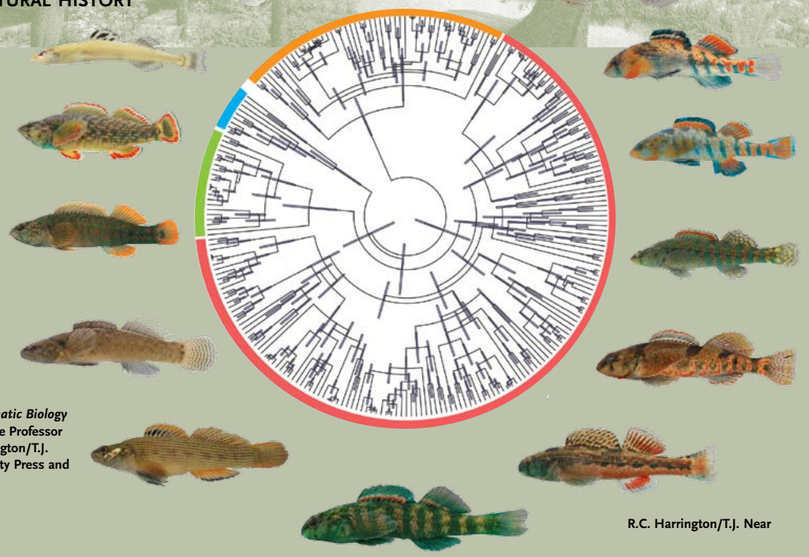
To continue this taxonomic research and strengthen YPM's holdings of hyalid amphipods, it was important to obtain fresh material, especially for any molecular analyses to be done later. A review of YPM holdings of amphipods identified targeted genera in Bermuda and possibly the Bahamas. For the first leg of my fieldwork, I stayed at the Bermuda Institute of Ocean Sciences (BIOS), where, with the help of Lourdes Rojas, YPM Invertebrate Zoology Museum Assistant, I collected amphipods and other invertebrates in the adjacent shallow waters. After three days of collecting, we returned to New Haven with more than a dozen samples containing hundreds of specimens. Afterward I spent several weeks photographing, dissecting and sorting my samples, and I plan to continue illustrating and describing these specimens for my senior project.

The second half of my fieldwork was done at San Salvador Island in the eastern Bahamas. I stayed at the Gerace Research Center and collected throughout the island for five days. The initial goal in visiting San Salvador was to collect hyalid amphipods and determine whether one genus in particular, *Parhyale*, occurs on the island. We believed that given the broad worldwide distribution of this genus, it should be found in the Bahamas. However, I did not find specimens of *Parhyale* on San Salvador Island, which is interesting in light of its occurrence in the neighboring Florida Keys and Bermuda. I was primarily working alone for the five days in San Salvador, so I was really able to immerse myself in fieldwork and practice collecting techniques I learned in Bermuda. In addition, I snorkeled throughout the island and explored gorgeous coral reefs while I searched for amphipods!

The last leg of my summer research was a trip to the Museum für Naturkunde in Berlin to visit Dr. Oliver Coleman, who is a pioneer of electronic illustration techniques—specifically of amphipods. Although I had read his articles and practiced his published techniques, the time I spent working with Dr. Coleman proved invaluable to planned digital illustrations I will make in the upcoming year. This fall I will continue my work on amphipods for my senior undergraduate research, implementing the many techniques I learned this summer into my current research as I review and revise some of the hyalid genera.



The October 2011 issue of the journal *Systematic Biology* featured a graphic representation of Associate Professor Tom Near's phylogeny of darters. R.C. Harrington/T.J. Near. Used by permission of Oxford University Press and the Society of Systematic Biologists.



R.C. Harrington/T.J. Near

Collaboration Produces Notable Study of the Origins of the Diversity of Freshwater Darters

By Richard Harrington, Yale Department of Ecology & Evolutionary Biology Graduate Program, and Greg Watkins-Colwell, Collections Manager, Yale Peabody Museum Division of Vertebrate Zoology

With more than 1,000 species of freshwater fishes, North America is home to the most diverse assemblage of temperate freshwater fish in the world. Recently, Thomas Near, an associate professor in the Yale Department of Ecology & Evolutionary Biology and an associate curator at the Yale Peabody Museum of Natural History (YPM), led a collaboration that has made a significant contribution to our understanding of the origins of the spectacular diversity of North American fishes—the publication of a molecular phylogeny of the darters (Percidae: Etheostomatinae).

Darters are an evolutionary radiation of nearly 250 species endemic to eastern North America. Most darters inhabit rivers and streams in fast-flowing riffles and shoal habitats, and are primarily benthic, meaning that they spend most of their time in the bottom layer of water among rocks and substrate. These relatively small species of fish (most are only two to three inches in length) have surprisingly diverse color patterns, inspiring the 19th century naturalist Stephen Forbes to say that "what the hummingbirds are in our avifauna, the 'darters' are among our fresh water fishes."

Phylogenies are hypotheses of how species are evolutionarily related to each other, and are an integral tool used to understand aspects of biological diversity, such as behavior, morphology and the geographic distributions of species. Traditionally, biologists relied on morphological data to decipher relationships among species. Today a rapidly growing field of research that does this uses DNA sequence data to construct phylogenies. An advantage of DNA sequences over morphological characters is that they can provide a large amount of data for which we can mathematically model evolutionary change (such as mutation rates) through time. However, because of the high cost of obtaining sequence data, phylogenetic studies of large groups of organisms are often limited in their scope, relying either on sequences from a single gene or only from a subset of all organisms in the group.

The darter phylogeny was published in October 2011 ("Phylogeny and temporal diversification of darters (Percidae: Etheostomatinae)," by Thomas J. Near, Christen M. Bossu, Gideon S. Bradburd, Rose L. Carlson, Richard C. Harrington, Phillip R. Hollingsworth, Jr., Benjamin P. Keck and David A. Etnier, *Systematic Biology* 60(5):565–595). This study is notable for its nearly complete species sampling of multiple genes for such a large evolutionary radiation. Of the 248 species of darters, this study was only missing three—two are distributed in Mexico and the other species was endemic to Maryland (and likely was extinct by the dawn of the 21st century). With nearly complete sampling, this study represents the most thorough multi-gene phylogeny for an evolutionary radiation this large. Using the multi-gene data and techniques that calibrate DNA sequence evolution rates with fossil data, Near and his co-authors produced estimates of divergence times and relationships for all of the major groups of darters. They found that most of the major darter lineages had diverged by the late Eocene (about 40 million years ago). Results from this study also support the hypothesis that hybridization has been a more common feature in darter evolution than previously realized, with approximately 12% of darter species carrying mitochondrial genomes that were transferred from other species as a result of hybridization. The authors identified both recent and ancient instances of hybridization in darters.

The study represents a collaboration between Near and several graduate students, YPM collections staff, and researchers at other institutions. Undergraduate students from Yale and other institutions participated in the project via supervised research and as YPM curatorial assistants sorting and cataloguing the large collection created during the study, which added more than 1,767 lots of darter species (totaling over 14,700 individual specimens) to the holdings of the YPM Division of Vertebrate Zoology. Before Near's arrival in 2006, YPM's darter collection consisted of only 67 specimen lots (350 individual specimens). Additionally, the study created an impressive tissue collection representing the diversity of species and populations within the darters, as well as outgroups and other fish taxa that previously did not exist at Yale. It is now arguably one of the most complete tissue collections of darters in the United States. Specimens and tissue samples from this project are catalogued as part of the YPM collections and are available to researchers across the world.

Beyond giving us an advanced understanding of the relationships at the tips of the darter "tree of life" and among the major darter lineages, this type of phylogenetic study can provide a starting point for future research on basic biological and evolutionary questions. Darters are broadly diverse in ecological habitat use, feeding behaviors, mating systems and geographic distributions. With knowledge of their relationships, we are better equipped to identify and study the mechanisms that generate this diversity.

$5.5 Million for Yale Reforestation Program Environmental Leadership & Training Initiative

A Yale program that aims to restore tropical forests and the livelihoods that depend on them has received a six-year, $5.5 million grant from the Arcadia Fund to continue its work in Latin America and Southeast Asia.
The Environmental Leadership & Training Initiative (ELTI) for Biodiversity Conservation in Tropical Forest Regions trains environmental managers and local decision-makers to support conservation efforts where forests have been cleared and exploited in Borneo, Brazil, Colombia, Panama, the Philippines and Sumatra.

"With Arcadia's renewed support, ELTI will continue to empower and inspire conservation leaders in the tropics to restore and conserve forests and biodiversity in transformed landscapes," said Mark Ashton, ELTI's principal investigator and a professor of forest ecology at the Yale School of Forestry & Environmental Studies (F&ES).

Yale has directed the program in collaboration with the Smithsonian Tropical Research Institute and the National University of Singapore since 2006. The Arcadia Fund grant will extend the life of the program to 2018. Since its launch, ELTI has trained 2,293 people in the neotropical countries of Brazil, Honduras, Panama and Peru, and in the Southeast Asian countries of Singapore, Thailand and the Philippines.

Although the global rate of deforestation has slowed over the past decade, the tropics have been transformed by the industrial farming of soy, oil palm, tea, sugar cane and beef cattle, unsustainable logging, oil exploration, mining, infrastructure development, land cleared for subsistence farming and colonization, and forest fires caused by these activities.

The grant will train government ministers, indigenous peoples, farmers and representatives of international conservation nongovernmental organizations to rejuvenate forests, which provide water, wildlife habitat, carbon sequestration and climate mitigation, open space and recreation, food and shelter.

The program also will restore and conserve thousands of hectares of remnant natural and secondary forests in the Philippines, Panama, Indonesia and Brazil, rehabilitate marginal agricultural lands with native tree species, and implement sustainable land uses, such as agroforestry and silvopastoral systems, in agricultural and cattle-ranching areas of the Philippines, Colombia, Brazil and Panama.

"These restored areas will be used to improve the connectivity between remaining patches of natural and secondary-growth forests and create riparian corridors that protect waterways and resources," said Ashton.

ELTI will also launch an online training program that will significantly expand the program's audience of university students and professionals worldwide on tropical forest restoration and conservation on transformed lands. Web-based training is increasingly being used to reach people who are unable to take part in formal academic programs or who are better served by programs that provide greater flexibility.

Beginning next April, the program will add more than 40 courses, workshops and conferences in the Neotropics and tropical Asia, reaching 2,500 more decision-makers and practitioners. ELTI will also support more than 50 alumni of the program to put into practice forest restoration and conservation initiatives.

"We're grateful for the Arcadia Fund's support, because it will allow ELTI to rehabilitate lands that are critical to the health of the planet and whole societies," said Peter Crane, F&ES dean.

Arcadia is the charitable fund of Lisbet Rausing and Peter Baldwin. Since its inception in 2001 Arcadia has awarded grants in excess of $200 million. Arcadia works to protect endangered culture and nature. For more information about ELTI, visit their Web site *environment.yale.edu/elti*.

U.S. Rivers and Streams Saturated with Carbon

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

Rivers and streams in the United States are releasing enough carbon into the atmosphere to fuel 3.4 million car trips to the moon, according to Yale researchers in *Nature Geoscience*. Their findings could change the way scientists model the movement of carbon between land, water and the atmosphere.

"These rivers breathe a lot of carbon," said David Butman, a doctoral student and co-author of a study with Pete Raymond, professor of ecosystem ecology, both at the Yale School of Forestry & Environmental Studies. "They are a source of CO_2, just like we breathe CO_2 and like smokestacks emit CO_2, and this has never been systematically estimated from a region as large as the United States."

The researchers assert that a significant amount of carbon contained in land, which first is absorbed by plants and forests through the air, is leaking into streams and rivers and then released into the atmosphere before reaching coastal waterways.

"What we are able to show is that there is a source of atmospheric CO_2 from streams and rivers, and that it is significant enough for terrestrial modelers to take note of it," said Butman.

They analyzed samples taken by the United States Geological Survey from over 4,000 rivers and streams throughout the United States, and incorporated highly detailed geospatial data to model the flux of carbon dioxide from water. This release of carbon, said Butman, is the same as a car burning 40 billion gallons of gasoline.

The paper, titled "Significant Efflux of Carbon Dioxide from Streams and Rivers in the United States," also indicates that as the climate heats up there will be more rain and snow, and that an increase in precipitation will result in even more terrestrial carbon flowing into rivers and streams and being released into the atmosphere.

"This would mean that any estimate between carbon uptake in the biosphere and carbon being released through respiration in the biosphere will be even less likely to balance and must include the carbon in streams and rivers," he said.

The researchers note in the paper that currently it is impossible to determine exactly how to include this flux in regional carbon budgets, because the influence of human activity on the release of CO_2 into streams and rivers is still unknown.

The research was funded by NASA, the National Science Foundation, the United States Geological Survey and the Yale School of Forestry & Environmental Studies.

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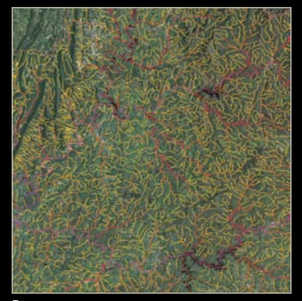

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A NASA Landsat Satellite image of the Mississippi (NASA)

B Stream lines from the NHDPlus Dataset colored by stream order (David Butman, Yale University)

C Titanium dioxide tracer addition to small stream (Diana Karwan, Stroud Water Research Center)

C Titanium dioxide tracer addition to small stream (Diana Karwan, Stroud Water Research Center)

D Small stream at the Harvard Forest LTER (David Butman, Yale University)

E Early Spring on the Connecticut River (David Butman, Yale University)

F Weir installed at Harvard Forest (William Sobzak, College of the Holy Cross)

G Ice out on the Yukon River, Pilot Station Alaska (David Butman, Yale University)

Deforestation Causes Cooling in Northern U.S. and Canada

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

Deforestation, considered by scientists to contribute significantly to global warming, has been shown by a Yale-led team to actually cool the local climate in northern latitudes, according to a paper published in *Nature*.

"If you cut trees in the boreal region, north of 45 degrees latitude, you have a net cooling effect," said Xuhui Lee, the study's principal investigator and professor of meteorology at the Yale School of Forestry & Environmental Studies. "You release carbon into the atmosphere by cutting down trees, but you increase the albedo effect—the reflection of sunlight."

Lee and a team of researchers from 20 other institutions found that surface temperatures in open areas were cooler because snow cover reflected the sun's rays back into outer space, while nearby forested areas absorbed the sun's heat. At night, without the albedo effect, open land continued to cool faster than forests, which force warm turbulent air from aloft to the ground.

"People are debating whether afforestation is a good idea in high latitudes," said Lee. "If you plant trees you sequester carbon, which is a benefit to the climate system. At the same time, if you plant trees you warm the landscape because trees are darker compared to other vegetation types. So they absorb solar radiation."

The researchers calculated that north of Minnesota, or 45 degrees latitude, the temperature decreased by an average of 1.5 degrees Fahrenheit. On the other hand, deforestation south of North Carolina, or 35 degrees latitude, appeared to cause warming. In addition, Lee said that "statistically insignificant" cooling occurred between these two latitudes.

The researchers collected temperature data from a network of weather stations in forests from Florida to Manitoba and compared results with nearby stations situated in open grassy areas that were used as a proxy for deforested land.

"The cooling effect is linear with latitude, so the farther north you go the cooler you get with deforestation," said Lee.

David Hollinger, a scientist with the United States Department of Agriculture Forest Service, and study co-author, said, "Another way to look at the results is that the climate cooling benefits of planting forests is compounded as you move toward the tropics."

The researchers call for new climate-monitoring strategies. "Because surface station observations are made in grassy fields with biophysical properties of cleared land, they do not accurately represent the state of climate for 30 percent of the terrestrial surface covered by forests," the study says.

The study, "Observed Increase in Local Cooling Effect of Deforestation at Higher Latitudes," can be viewed at *www.nature.com/nature/journal/v479/n7373/full/nature10588.html.* The study was supported, in part, by grants from the U.S. Department of Energy and the Yale Climate & Energy Institute.

Yale Journal Tempers Concerns about Availability of Lithium and Rare Earth Metals

Yale's *Journal of Industrial Ecology* recently published articles addressing concerns about the availability of key resources for clean technology. The adequacy of supplies of lithium, a crucial component of lithium-ion batteries, expected to be widely used in electric vehicles, has been debated in the press as electric cars grow in popularity. In "Global Lithium Availability," researchers from the University of Michigan and the Ford Motor Company comprehensively analyzed global lithium resources and compared them to global lithium demand. They concluded that even with a rapid and widespread adoption of electric vehicles, lithium resources are sufficient to support demand until at least the end of this century. The findings were discussed in *The New York Times* electronic edition and a prominent environmental news service and then picked up by investment, research and development, and environmental blogs and news services.

In a related vein, an article by Thomas Graedel, Clifton R. Musser Professor of Industrial Ecology at the School of Forestry & Environmental Studies (F&ES), and doctoral student Xiaoyue Du in F&ES, quantifies the rare earth metals contained in neodymium-iron-boron (NdFeB) permanent magnets—used in wind turbines, computers, and automobiles— from 1983 when permanent magnets were first manufactured, to 2007, when the market for permanent magnets was well developed. While rare earth metals are indispensible in modern technology, very little quantitative information is available on their use in permanent magnets. Drawing on historical data on permanent magnets from China, Japan, the United States, and Europe, Du and Graedel provide the first estimates of global in-use stocks for four rare earth elements—praseodymium (Pr), neodymium (Nd), terbium (Tb), and dysprosium (Dy)—in NdFeB magnets. They find that these stocks, if efficiently recycled, could provide a valuable supplement to geological stocks as they are almost four times the 2007 annual extraction rate of the individual elements.

The *Journal of Industrial Ecology* can be found online at *jie.yale.edu/articles.*

From left: Sharon Smith, Shereen D'Souza, Sarah Uhl and Laura Bozzi. © Matthew Garrett

F&ES Students Named Switzer Fellows

Four School of Forestry & Environmental Studies students were named Switzer Fellows. The students, doctoral candidate Laura Bozzi and master's students Shereen D'Souza, Sharon Smith and Sarah Uhl, are among 20 Switzer Environmental Fellows who will each receive $15,000 from the Robert and Patricia Switzer Foundation, which recognizes emerging environmental leaders.

Jen Sokolove, chair of the board of the Switzer Foundation said, "The heart of the Switzer Foundation is about supporting environmental leaders who are able to think across traditional disciplinary boundaries and shape the future of environmental science, policy and study."

Laura Bozzi's research addresses mountaintop removal mining for coal in Appalachia. She has investigated the legal, regulatory, economic and technological factors that have combined to make mountaintop removal one of the most contentious environmental issues in the United States. She's interested in how policies on surface mining have shaped how and where mining takes place, as well as how local citizens, environmental groups and industry have responded to those policies over time. She graduated from Yale College with a degree in ecology and evolutionary biology and holds a master of environmental management degree from F&ES. Before returning to Yale for her Ph.D., Laura was a groundfish fishery policy analyst at the Pacific Fishery Management Council. She also was a Knauss Marine Policy Fellow for the National Oceanic and Atmospheric Administration's Science Advisory Board.

Shereen D'Souza works to support justice and equity in global and local food and farming systems. Her research focuses on how best to support poor farming communities participating in carbon-finance initiatives in the Global South. This summer she conducted research in Kitale, Kenya. Before graduate school, she spent 10 years as a food-justice activist and advocate and spent three years as an agriculture volunteer with the Peace Corps in Honduras. She holds a bachelor's degree from Georgetown University's School of Foreign Service, a certificate in permaculture design from Merritt College and a certificate in ecological horticulture from the U.C. Santa Cruz Center for Agroecology and Sustainable Food Systems.

Sharon Smith is an organizer and trainer in movements for global justice, human rights and environmental sustainability. As a program advisor for the Brower Youth Awards at Earth Island Institute, she co-produced an Emmy Award-winning series of short films, called *Natural Heroes*, which featured the inspiring stories of people committed to the environment. The series has been shown on PBS and the Sundance Channel, reaching an estimated 90 million viewers. She is the author of the book, *The Young Activist's Guide to Building a Green Movement and Changing the World*, published by Ten Speed Press. She holds a bachelor's degree from U.C. Berkeley in anthropology and in conservation and resource studies.

Sarah Uhl is studying the health effects of toxic chemicals, particularly endocrine disruptors. Her research explores the degree to which factors, such as an individual's age, race and socioeconomic status, are associated with a susceptibility to the metabolic and reproductive health effects of phthalates and bisphenol-A. She spent four years working for the nonprofit Clean Water Action, where she spearheaded the Coalition for a Safe & Healthy Connecticut, an alliance of citizens, health professionals, workers, environmental justice leaders, educators, scientists and faith communities committed to replacing toxic chemicals with safer alternatives in everyday products and in industry. She holds a bachelor's degree in environmental and evolutionary biology and in environmental studies from Dartmouth College.

A

Environmental Studies Students Pursue Exciting Summer Research

Every year, the Yale Environmental Studies (EVST) program supports summer fellowships for students interested in conducting research or exploring new training opportunities around the world. This year's group of exceptional EVST students were engaged with a wide variety of topical areas, from green building design in London, to giant panda conservation in Sichuan, China, to urban river restoration at the Smithsonian Anacostia Community Museum in Washington, DC. Here we provide three brief summaries of student fellowships. Visit the EVST Web site (www.yale.edu/evst) and explore the exciting array of work all EVST students are doing.

B

C

A Bang Hed (left) and Ma Deh (right) sift through sea grass seedlings that Bang Hed has cultivated in his make-shift platform at the entrance of the mangroves. We later planted them in exposed mud areas to serve as food for dugongs.

B Interviewing Pu Yai Nom, the leader of a very successful community mangrove forest in a neighboring village called Tong Tasae. We are sitting in a sala (an open-pavilion) in the middle of the restoration zone of their community forest, discussing the history and challenges that Pu Yai Nom faced in fighting for the establishment of the community forest.

C Ma Deh and I comb Had Yao Beach for mangrove propagules to plant, storing them in used rice bags. These propagules are dropped by trees and, pushed by the currents and tides, washed up onto the beach. We collected over 200 that day.

A

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C

A Sheep waiting to be scanned for pregnancy on Hilton Reeve's sheep farm outside of Taupo, New Zealand.

B That's me, wearing the protective gear that Regional Council members are required to have on when monitoring logging sites. This particularly site was a few minutes outside the town of Taupo, New Zealand. I'm standing in front of logs that are most likely bound for China.

C Lower Tama Lake with Mt. Ruapehu in the background. Viewed from the Tama Lakes trail in the Tongariro National Park on the North Island of New Zealand.

A

B

C

A The Noatak River, just south of Noatak village.

B Park Service ranger station near the mouth of the Kelly River, about 10 miles downstream from Ashby's home.

C The boat Ashby built pulled up on the bank in front of his home.

Holly Butler spent five weeks in Taupo, New Zealand, working with the Waikato Regional Council to learn about the work they do to prevent nitrogen runoff, promote sustainable forestry and manage riparian zones. Her study was focused around Lake Taupo, the largest freshwater lake in New Zealand, located at the center of the North Island.

Holly learned about management policy through conversations with council staff in the Taupo office and by reading policy documents. She traveled with the staff on field visits to logging and riparian sites, and also traveled to speak to farmers throughout the Lake Taupo catchment and surrounding area. In these farm stays, she heard firsthand accounts of what farmers in New Zealand thought about new environmental protection policies and the stresses they face in dealing with them.

Reflecting on her experience, Holly writes: "When I look back on my experience, I don't just see pictures and remember what it looked like—I see beef cows that Mike and Sharon Barton are getting ready to send for processing. I see a pasture covered with an invasive weed that Alex Richardson is worried will destroy his winter crop. I see a farm that Hilton Reeve won in a government ballot and has improved with dedication ever since. Thanks to the support of this fellowship, Taupo, New Zealand, is not just a page in the Lonely Planet guidebook for me anymore—it is full of people and ideas that I know I will revisit."

For **Alyssa Cheung**, the idea for her summer fellowship application grew from her study abroad experience in Thailand. She knew that she had a passion for coastal zone management, and it became clear that Thailand would be a prime location to explore the concept of community-based mangrove management. During the summer she lived in a small fishing village called Ban Chao Mai in the Trang Province on the western coast of Thailand. Her goal was to develop a better understanding of how these community management models worked, how effective the management structure was, and what obstacles villagers faced in this management.

Alyssa's host grandmother, Ma Deh, and her grandmother's brother, Bang Hed, acted as the village naturalists and were her guides in her visits into the mangrove forests. They traveled to the mangroves in a small boat and walked through deep mud to reach their destination, where they gently pressed mangrove propagules and sea grass seedlings into the ground to restore the degraded forests. She also interviewed community members, which underscored how complex this management system for mangrove restoration truly is.

In writing about her experience in the field Alyssa explained: "Although I learned a great deal about mangroves and community forests, I think the biggest lesson for me was gaining experience in performing independent research. I spent weeks reading about field research techniques and speaking to my adviser, but nothing could have prepared me for the experience of living on my own in a foreign country and trying to learn from the environment around me. It is exhausting trying to process new things and trying to make meaning of everything I observed, both on a personal level as well as for research purposes. I learned that being a student gives you incredible access to all types of resources, and that people are much more willing to speak to you. I realize that some of the best learning is through participating and following the people around you, not simply conducting interviews. And most important of all, I learned how to step outside of my comfort zone and simply connect with people on a human level—an invaluable experience that really makes me look at the issue that I am studying in a very real and tangible light, and reminding me of why these problems need to be examined and understood."

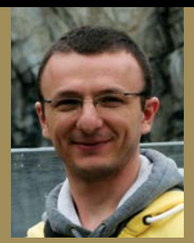
Exploring the management of traditional consumptive uses of national parklands established by the Alaska National Interest Lands Conservation Act (ANILCA) has been a longtime passion for **Reid Magdanz**. With the help of the Environmental Studies fellowship he was able to spend the summer of 2011 researching these issues in both the city of Anchorage and the small community of Kotzebue, Alaska. In addition to library research, Reid interviewed nearly twenty National Park Service and other federal agency employees in both locations, local leaders and subsistence users in Kotzebue, and residents, elders and leaders of Noatak, an Iñupiaq Eskimo village where he spent two days.

Perhaps the most exciting experience of Reid's summer research was arranging to meet with an Iñupiaq man named Ricky Ashby, who lives on an inholding in a national preserve near Noatak. Ashby has lived there year-round since 1997 and has a long history with the US National Park Service. Reid visited in hope of learning about Ashby's history with the Park Service, in particular his efforts to secure a permit to construct a small, seasonal cabin at his fish camp a few miles downstream from the inholding where he lives. Ashby generously shared both his food and his knowledge, and throughout Reid's visit repeated his desire to see more of the younger generation on the land.

Reid was able to document subsistence living in Noatak. The influence of the subsistence way of life was in evidence in nearly every house he visited. At one stop, he was served caribou stew with a side of black meat (seal). Other families cleaned berries or made jam while he chatted with them. And despite their proximity to one of America's most highly touted wilderness areas, he learned that many Noatak residents paid it little attention, telling him things such as "Park Service? I don't know much about Park Service...I think they have that place by Kelly [a ranger station]." Or, "I don't know where the border is. I hunt where the caribou are." Thinking about his goals for this research, Reid wrote, "It is my deepest belief that the National Park Service should be doing all it can to protect and promote the sort of life he [Ricky Ashby] lives. I hope the research I conducted last summer and the paper that I will write this year will help ensure that there will always be a Ricky Ashby on the Noatak River."

DONNELLEY AND YIBS POSTDOCTORAL NEWS


GHILARDI


HAZNEDAROGLU

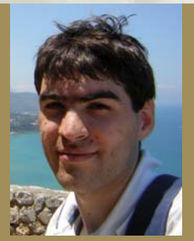

KRUTA


LEHR


LONGRICH


NIEMILLER


ROSAUER


SPADA


ZARNETSKE

Adrian Ghilardi, PhD, is serving as a Gaylord Donnelley Environmental Postdoctoral Associate in the Yale School of Forestry & Environmental Studies (F&ES) and is working with F&ES Professor Robert Bailis. Dr. Ghilardi received his doctorate from the Universidad Nacional Autónoma de México. His research has been directed toward understanding the spatial patterns of both wood fuel availability and harvesting within the broader areas of energy poverty and forest degradation. His current research at F&ES focuses on completing ground truthing and calibrating an innovative GIS-based tool for modeling wood fuel extraction dynamics and the expected vegetation response to projected disturbances. In parallel with this, Dr. Ghilardi is exploring cost-effective geostatistical approaches to relate remotely sensed data to ground-based forest inventory data, with a view to mapping the spatial distribution of forest degradation driven by wood fuel. Previous results have caught the attention of several government and nongovernment institutions as well as nongovernmental organizations, as this approach may provide the missing input for carbon offset projects involving fuelwood and charcoal-efficient devices and sustainable forest management strategies.

Berat Z. Haznedaroglu, PhD, is serving as a Yale Institute for Biospheric Studies Environmental Postdoctoral Associate in the Yale Department of Chemical & Environmental Engineering (CEE), and is jointly supported by the Yale Climate & Energy Institute. Dr. Haznedaroglu received his doctorate from the University of California, Riverside, and is working with CEE Associate Professor Jordan Peccia. His previous work was on the fate and transport behavior of several important zoonotic pathogens, particularly *Salmonella typhimurium*, one of the most important outbreak causing pathogens, in aquatic systems. His work, published in top-tier environmental engineering journals, was the first comprehensive study on *Salmonella's* fate and transport, one of the most important outbreak causing pathogens. Dr. Haznedaroglu's research at Yale addresses today's high energy demands by exploring the possibilities of enhanced biofuel production from lipid-enriched microalgal species. He focuses on two fundamental aspects of microalgae biofuel production—functional genomics and population dynamics—using next generation DNA sequencing technologies such as 454 pyrosequencing and Illumina-Solexa sequencing. He is specialized in describing the transcriptome of microalgae toward optimized expression of key genes of lipid synthesis. The outcome of Dr. Haznedaroglu's research should mark a significant advancement in biofuel research by providing the necessary tools to explore functional genetics in lipid-enriched microalgae.

Isabelle Kruta, PhD, is serving as a Gaylord Donnelley Environmental Postdoctoral Associate in the Department of Geology & Geophysics with G. Evelyn Hutchinson Professor of Geology & Geophysics Derek Briggs. Dr. Kruta is a graduate of the Universita degli studi di Modena and Geggio Emilia in Italy, where she earned a Bachelor of Science degree, and received her doctorate in paleontology at the Museum National d'Histoire Naturelle in Paris, France. Dr. Kruta is also affiliated with the American Museum of Natural History (Lerner Gray Post Doctoral Fellowship), working with Neil Landman.

Dr. Kruta works on cephalopods paleobiology and paleoecology and more precisely on ammonites. Her main interest is on feeding structures (buccal mass elements), their function and their use for reconstructing ammonite feeding habits as well as phylogenies. While at Yale, Dr. Kruta will work on the role and importance of this fossil group in the Mesozoic food web and also how the feeding habits affected the radiation and extinction of ammonites. Finally, she will try to correlate ammonoid evolutionary history with the radiation and extinction of other groups such as plankton and plankton feeding fishes.

Nina Lehr, PhD, is serving as a Gaylord Donnelley Environmental Postdoctoral Associate in the Department of Ecology & Evolutionary Biology (EEB) with Assistant Professor Jeffrey Townsend. Dr. Lehr has studied fungal biotechnology at the University of Kaiserslautern, Germany, and received her doctoral degree in plant-microbe interactions from the University of Tuebingen. Her work has been directed toward understanding the interactions among Norway spruce, the root rot fungus *Heterobasidion* spp. and soil bacteria, with the goal of discovering potential biocontrol agents, work that has resulted in various publications and is successfully continued in Germany. Dr. Lehr continued her work on the *Heterobasidion* pathosystem as a postdoctoral researcher in Professor Fred Asiegbu's laboratory at the University of Helsinki, Finland. Awarded a research fellowship from the German Research Foundation (DFG), Dr. Lehr moved on to the laboratory of Professor Gero Steinberg at the University of Exeter, UK, where she focused on molecular fungal cell biology by investigating the importance of endocytosis and recycling in the corn smut fungus *Ustilago maydis*. As an EEB Donnelley postdoctoral associate Dr. Lehr will investigate the evolution of gene expression underlying the sexual development in fungi. Understanding the transcriptional basis of fungal development and differentiation and what drives evolution of this process provides a key framework for understanding how organisms function in their environment.

Nicholas Longrich, PhD, has recently served as a Gaylord Donnelley Environmental Postdoctoral Associate in the Yale Department of Geology & Geophysics with Professor Jacques Gauthier. As a Donnelley postdoctoral associate, he published papers on a range of subjects. Dr. Longrich has named several new dinosaurs, including the dome-headed *Texacephale*, the giant horned dinosaur *Titanoceratops* and the ornate *Mojoceratops*, and has also described evidence of cannibalism in *Tyrannosaurus rex*. However, the main focus of his work has been understanding the diversity of Cretaceous ecosystems and how they were affected by the asteroid impact that wiped out the dinosaurs at the end of that period. In a recent paper Dr. Longrich and his colleagues examined how birds were affected by the mass extinction, showing that instead of becoming extinct gradually, archaic birds remained diverse during the final million years of the Cretaceous period and then vanished completely when the asteroid hit. Because only a handful of bird lineages seem to have survived, this study suggests that the asteroid almost wiped out the birds as well as the dinosaurs and had a profound effect on the evolution of the group. Dr. Longrich's current research has shifted to lizards, and he and his colleagues are trying to determine whether the extinction might have had a similar effect on their evolution.

Matthew Niemiller, PhD, is serving as a Gaylord Donnelley Environmental Postdoctoral Associate in the Yale Department of Ecology & Evolutionary Biology (EEB) with Associate Professor Thomas Near. Dr. Niemiller received his doctoral degree in ecology and evolutionary biology from the University of Tennessee, Knoxville. His work has been directed toward species delimitation in morphologically cryptic taxa, resolving phylogenetic relationships for clades of subterranean vertebrates (salamanders and cavefishes) and investigating patterns of eye and pigment loss in subterranean organisms. As a Donnelley EEB postdoctoral associate, Dr. Niemiller will investigate the evolution of troglomorphy (the suite of morphological, physiological and behavior changes associated with living in subterranean environs) in cavefishes in a multidisciplinary framework using morphological, physiological, phylogenetic and genomic approaches to examine the ecological context of this repeated phenomena in subterranean organisms.

Dan Rosauer, PhD, is serving as a Gaylord Donnelley Environmental Postdoctoral Associate in the Yale Department of Ecology & Evolutionary Biology (EEB). Dr. Rosauer received his doctorate in biological science from the University of New South Wales, Australia, and is working with EEB Associate Professor Walter Jetz. Dr. Rosauer's research in the fields of biogeography and biodiversity informatics includes new methods to account for the evolutionary relationships between species in analyses of the spatial structure of biodiversity, particularly to inform conservation priorities. These include techniques to model the degree of relatedness between the species assemblages found in different areas, and to map centers of phylogenetic endemism. He is currently studying phylogenetic endemism in the world's terrestrial mammals to identify those places where a large portion of mammal diversity is restricted to a small region, applying current and prehistoric environmental data to identify the key drivers of endemism in terrestrial mammals.

Federico Spada, PhD, is serving as a Yale Institute for Biospheric Studies Environmental Postdoctoral Associate in the Yale Department of Astronomy with Professor Sabatino Sofia. Dr. Spada received his graduate degree in astrophysics in 2010 from the University of Catania in Italy, where he developed a numerical model of the angular momentum transport in the solar interior mediated by magnetic fields. At Yale, his main goal in his work with Professor Sofia is to constrain the effect of the solar variability on climate change. The interior of the Sun undergoes structural variations on time scales of years or longer, which affect the total amount of radiation received by Earth. Modeling these variations is currently beyond the capabilities of standard stellar codes. Dr. Spada is developing a new two-dimensional version of the Yale Rotating Stellar Evolution Code that will be capable of treating rotation, magnetic fields and turbulence with a relative accuracy of one part per million or better. This tool will be necessary to interpret the data, to which Professor Sofia has privileged access.

Jay Zarnetske, PhD, is serving as a Gaylord Donnelley Environmental Postdoctoral Associate at the Yale School of Forestry & Environmental Studies (F&ES), where he is working jointly with professors Peter Raymond and James Saiers. Dr. Zarnetske, who received his doctorate in water resource science and ecosystem informatics from Oregon State University, is an ecohydrologist interested in the hydrogeomorphic template of catchment ecosystems—how hydrology and geomorphology control ecosystem structure and function. For example, his previous research showed how arctic tundra stream hydrology and biogeochemistry are responding to climate change. Further, his theoretical work shows how physical hydrologic transport and biogeochemical transformations are fundamentally linked in stream ecosystems, and that the coupling can control the net transformation and export rates of key nutrients and pollutants in streams. The objective of Dr. Zarnetske's postdoctoral research is to elucidate how river flow regimes (timing, magnitude and frequency) control catchment nitrogen and dissolved organic carbon exports of major river networks in the United States under past, present and predicted climate regimes. This project will help develop ecological-flow relationships at multiple scales that will inform global nitrogen and carbon cycles as well as water quality conservation measures, which in turn conserve freshwater and marine biodiversity.

The Challenge of Hunting Tropical Hummingbirds

By Christopher J. Clark, Ph.D.

For the second day in a row, it rained all day. Two assistants and I were in Guatemala, having driven to a small town called Magdalena Milpas Altas, high in the mountains. From the town we slogged up a steep, muddy trail to the summit of a mountain, Cucuruchu. Had we been unladen, the hike would take a bit over an hour. With the high-speed camera, sound recorder and other heavy gear weighing us down, it took over two hours to ascend. Our target was the Wine-throated Hummingbird (*Atthis ellioti*), a hummingbird that lives only above the trees on mountain ridges and summits of the mountains of the Guatemalan highlands. We were wet, muddy, and exhausted, and thanks to the rain, there were no displaying hummingbirds.

For the past two years as a Yale Institute for Biospheric Studies (YIBS) Environmental Postdoctoral Associate, I have pursued some of the world's most poorly known hummingbirds through the deserts, scrub, and mountains of Central and South America. The species I'm after in particular are the woodstars, part of the "bee" hummingbirds, a group of about 35 species that range from Alaska down through northern Chile and Argentina. They are called "bee" hummingbirds because that's what they sound like when they fly, and most are scarcely larger, the smallest birds in the world. When I'm searching for woodstars and catch a fleeting glimpse of something that turns out to not be a woodstar, it's usually a large beetle or bee buzzing by, and not a bird—birds are too big. Tiny size and relative scarcity means that for most of the woodstars, no one has ever sought them out or studied them in particular. In fact, a famous ornithologist, Van Remsen, once told me "only a fool would study the woodstars." Here I was, standing in the rain, Van Remsen's fool.

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From my Ph.D. research on North American species, I knew that woodstars probably made loud sounds with their tails. These are not the 'humming' sounds for which hummingbirds are named. Rather, during a courtship display, the male dives for the female, spreading and shutting the tail while making distinctive sounds with vibrating tail-feathers during each tail-spread. These displays were already described for the North American species, including what time of year they breed (early summer), and what habitat to find them in. Because these basic aspects of their biology were already known, these species were mostly easy for me to study. And, each species has a unique display.

For my postdoc, I chose to try a harder project: recording the courtship displays of woodstars. Setting up the trips requires detective work. In many cases I didn't even know what time of year they breed, other than from an offhand comment from another ornithologist, or a record of a nest from a century-old paper. Once I know when to look, the next question is where. The rugged mountains of Central and South America are full of wonderful, diverse habitats, but this means there are a lot of places to check. Males usually have very specific types of habitat where they prefer to set up their courtship territories. They sometimes even lek, meaning that all of the males gather in one small spot (the lek) to display. The females of each species all know where the local lek is, but I don't. The only way to find a lek is to look, persistently. On my recent trip to Guatemala, I chose one morning to bushwhack my way up the side of a long, steep hill. It was covered in thick grass and bushes, and so steep that I had to scramble on hands and knees in places. As I paused to rest partway up the hill, I wondered why I had wasted the morning on this useless struggle, getting scratched, dirty, and bug-bit. But when I arrived at the top of the hill, covered in sweat, legs trembling from exhaustion, I found a small lek of the Slender Sheartail (*Doricha enicura*), the species I was after! Even better, I found a farmer's trail that would make the return far easier than my initial, ill-advised route. But that rainy morning on Cucuruchu, finding the Wine-throated Hummingbird wasn't the problem, it was getting them to display.

Getting displays is sometimes easy, and sometimes not. Endangered species I've tried have actually been easier than some supposedly common ones. The Chilean Woodstar (*Eulidia yarrellii*) is critically endangered, with a worldwide population that is now probably less than 250 birds, and shrinking fast. It lives in tiny oases in the Atacama Desert of far northern Chile, and is threatened by habitat loss as farmers cut down its favorite bushes to grow tomatoes. For me, one big reason to do this research now is that there may never again be an opportunity to record the natural history of this and many other vanishing species before they are lost due to habitat loss or other risks. Appreciating biodiversity comes from learning about it. The Chilean Woodstar divulged its mating habits particularly easily. One lek had five males that spent the better part of the day displaying, so getting sound recordings and video was easy. Many others were not so simple, and so even after I have found some males on territory, there are no displays. This most often occurs because the weather is bad, as was true on that day on Cucuruchu. The males don't display much in the rain.

Fortunately they breed at the end of the rainy season, and after a week of dry weather, we returned to Cucuruchu on a gorgeous day. Instead of grey clouds and blowing wind greeting us at the summit, a spectacular vista of the countryside below awaited and the Wine-throated Hummingbirds were back, singing every few minutes through the day. I was able to get a large sample of sound recordings in a few hours, and interestingly this species is an exception: unlike its sister species, it does not sing with its tail feathers, but rather, vocally. My postdoctoral supervisor Richard Prum, Yale's William Robertson Coe Professor of Ecology & Evolutionary Biology, and I recently published a paper in *Science* describing some of the aerodynamics of how woodstar tail-feathers generate sound. The next big analysis will examine how display behaviors and tail morphology together co-evolve on the evolutionary tree of these species. Before that, I'm hoping to squeeze in a few more trips. Fieldwork has its many miseries: mud and rain, or too much sun; getting eaten by chiggers, mosquitoes, flies; dirty, sweaty, stung and cut, car problems, and above all, the uncertainty of whether the birds can be found, or will display. But to be the first person to ever see the courtship display of an exotic species makes them all worth it.

See a video that includes some of the sounds I study at: *www.youtube.com/watch?v=MPaVjhUsdAw*.

C

A Male Chilean Woodstar *(Eulidia yarrellii)*, Photo: Anand Varma.

B View from Mt. Cucuruchu in good weather, Photo: Jacob Berv.

C Male Wine-throated Hummingbird *(Atthis ellioti)*. Photo: Anand Varma, varmaphoto.com.

BASS DISTINGUISHED VISITING SCHOLARS

MOOERS

WING

EDWARD P. BASS DISTINGUISHED VISITING ENVIRONMENTAL SCHOLARS APPOINTED

Director of the Yale Institute for Biospheric Studies, Os Schmitz, is pleased to announce the appointment of two Edward P. Bass Distinguished Visiting Environmental Scholars to serve during the spring 2012 semester.

Arne Mooers, Professor of Biodiversity at Simon Fraser University, is joining the Yale Department of Ecology & Evolutionary Biology (EEB) during the spring of 2012 as an Edward P. Bass Distinguished Visiting Environmental Scholar. Professor Mooers, a leading authority in phylogenetic inference and the use of phylogenies for conservation, was nominated by EEB professors Thomas Near and Walter Jetz, and will collaborate with them and with professors Michael Donoghue and Jeffrey Townsend from EEB, Professor Jacques Gauthier in the Department of Geology & Geophysics, and William Piel, Cryo Collections Manager at the Peabody Museum of Natural History, among others.

Professor Mooers has an intriguing perspective on "Conserving the Tree of Life" and his contributions range from classic work on extinctions and phylogenetic tree shape to the use of phylogenies in conservation and language evolution, combining complex evolutionary theory and methods in molecular evolution with a large array of questions in evolutionary and ecological biology. He studies organisms from fruit flies and butterflies to lemurs and birds, and he has addressed concepts and themes such as metapopulations, phylogenetic tree balance, macroevolution, ecological speciation, sexual selection, biogeography, and evolutionary distinctiveness. We look forward to having Professor Mooers as a Bass Distinguished Scholar during the spring 2012 semester.

Dr. Scott L. Wing, in the Department of Paleobiology at the Smithsonian Institution, is joining the Yale Department of Geology & Geophysics (G&G) during the spring of 2012 as an Edward P. Bass Distinguished Visiting Environmental Scholar working with Professor Leo Hickey.

Dr. Wing is an internationally recognized paleobotanist who specializes in paleoecology and paleoclimates. With over 70 papers and two co-authored books, he has long been a leader in the study of terrestrial paleoecology and climates of the early Cenozoic. About eight years ago, he became the first to find and explicate the terrestrial record of the Paleocene-Eocene Climatic Maximum (PETM), a short-term and extreme warming event, and its effect on the biota and soils of the northwestern United States. He is a highly collaborative researcher who can bring resources from numerous fields to bear on complex problems such as the PETM. While at Yale, he will have the opportunity to interact with a broad cross-section of ecologists, geochemists and paleontologists from Yale to help him develop ideas for the book that he is writing on PETM. One of the areas that he wishes to explore is how to get society to react to crises, such as sea level rise, that occur on a scale of hundreds to thousands of years. We are happy to have Dr. Wing serving as a Bass Distinguished Scholar during the spring 2012 semester.

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