BROWN

# Ecology & Evolutionary Biology

**Brown University, Providence, Rhode Island**

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## Letter from the Chair

By Mark Bertness

It has been another busy, but exciting year in EEB. Change is in the air.

The largest change is that our founder Doug Morse will retire this summer. All good things I guess come to an end. We owe Doug a huge debt for the vision and selfless leadership he has given Brown since 1979. We owe our very existence and success to his altruism and thank him and Elsie for their warm egalitarian spirit that has given EEB its personality. Fortunately, Doug won't be going far – about 20 ft. Doug won't really be retiring either or giving up his spot on the bike rack, but will be downsizing to make room for Amy Austin, who will be joining us this summer.

With the arrival of Osvaldo Sala the Environmental Change Initiative has begun generating change and excitement. Next fall ECI will search for a new faculty member (one of three over the next 3 years) and will cosponsor with EEB and the Watson Institute an international symposium on climate change research. Osvaldo was also a coordinating lead author of the recently released Millenium Ecosystem Assessment. (see Osvaldo's piece on page 5).

Beth Brainerd has also arrived this spring and along with Tom Roberts is quickly building momentum and renewed energy in our already outstanding morphology group.

Our relationship with the Marine Biological Laboratory also continues to grow (see pp. 6-9 for new joint appointments). Next year two EEB courses taught by MBL faculty will debut – Ecosystem Modeling taught by Ed Rastetter and Climate Change Biology featuring contributions by six MBL faculty. We have also just admitted our second class of students into the Brown/MBL joint graduate program.

We are in the design phase of remodeling the 4th and 5th floors of the BioMed Center and the first floor of MacMillan Hall for EEB lab space for Evolutionary Biology, Morphology and Ecosystem studies, respectively. So over the next two years our perennial space shortage will be partially alleviated.

This spring Jen Hughes received a Moore Foundation Fellowship to continue her microbial diversity work. She has taken the lead in EEB's cosponsoring of "Bioblitz", with the Rhode Island Natural History Survey, a biodiversity survey to be held this June at the Haffenreffer Estate.

## Undergraduate Honors Thesis Presentations

**Leslie Herrmann:** *Evolutionary rates in human disease genes.* Advisor: M. Przeworski

**Samuel Holzman:** *Larval development, gene flow, and the regulation of northern range limits around Cape Cod, Massachusetts.* Advisor: M. Bertness

**Alex Hurtado:** *Scaling of bone microstructure: an interspecies study of haversian systems.* Advisor: S. Swartz

**Johanna Kowalko:** *Biochemical flexibility and the adaptation to environmental heterogeneity in the acorn barnacle,* Semibalanus balanoides. Advisor: D. Rand

**Ming-Ming Lee:** *An investigation of the mechanical properties of bat wing bones.* Advisor: S. Swartz

**Mary Matsumoto:** *Insulin signaling and ovariole number in* Drosophila melanogaster. Advisor: M. Tatar

**Kathryn Maurer:** *Above-ground and below-ground: interactions between soil microbes and two* Brassica *species.* Advisor: J. Hughes

**Lietta Nicolaides:** *Oxidative stress resistance in mitochondrial genome introgression strains in* Drosophila. Advisor: D. Rand

**Jon Puritz:** *The* Fundulus *among us: examining the origins of clinal variation in* Fundulus heteroclitus. Advisors: D. Rand and J. Witman

**Lauren Seckel:** *Convergences in scapula morphology in small bounding mammals.* Advisor: C. Janis

**Eric Tong:** *Coevolutionary dynamics within an* Escherichia coli *– T-phage model system.* Advisor: J. Hughes

**Elizabeth Winograd-Cort:** *Latitude and genetic associations with developmental traits in* Arabidopsis thaliana. Advisor: J Schmitt

## In the Greenhouse

By Fred Jackson

Spring is construction time at the Plant Environmental Lab (greenhouse), slated to start in mid May. The original "headhouse" area will be renovated to house 4 new growth chamber units. The Schmitt lab will have 3 new E7/2 Conviron water-cooled units. All new units will have *Arabidopsis thaliana* plants growing in them for future grant-supported projects. These new growth chambers and renovations are the result of Johanna Schmitt's new grant research funding. We are all excited to double our growth chamber space to accommodate new plant experiments for the department.

Mark Johnson will house his lab's new environmental growth chamber unit in this area so he may continue pollination experiments.

Speaking of experiments in the greenhouse, Devon

Bradley, a graduate student in the Hughes lab, is investigating the relative influence of pathogen diversity and nutrient heterogeneity on plant diversity using a model community of four *Brassica* species, a fungal pathogen, and a bacterial pathogen. After just one generation, communities grown in the presence of disease were significantly more diverse than uninfected communities! She is currently tending to the 9,600 seeds that compose the 3rd generation and plans to continue the experiment through 4 or 5 generations. Good luck, Devon!

## Dave Baier's Museum Trip to China

I traveled to China for two weeks last November to examine fossils of early birds and closely related theropods housed at the Institute of Vertebrate Paleontology and Paleoanthropology in Beijing, using grants from the Paleontological Society and Sigma Xi. I was greeted at the IVPP by my extremely hospitable colleague, Zhonghe Zhou. He provided me with my own office space, microscope, and unlimited time with the available specimens during my visit. These fossils provide insights into key morphological changes on the line to birds and offer a means of testing hypotheses about how bird flight evolved. In particular, my studies of the shoulder joint of extant archosaurs (birds and alligators) show that a ligament (AHL) evolved to play a novel functional role in maintaining shoulder stability during flight. By studying the skeletons of extinct early birds and feathered dinosaurs, I was able to collect data that will allow me to reconstruct the relationship of this ligament to other key features of the shoulder joint. A better understanding of how the AHL became integral for shoulder function will help evaluate hypotheses of the behavioral precursors of avian flight.

In our spare time, Faye and I were able to explore Beijing and the surrounding area including an adventurous bus trip to the Great Wall, bird watching at the Summer Palace and Purple Bamboo Park, and an unending stream of superb restaurants. However, we did break down and visit one of the ubiquitous KFC's in Beijing for a taste of home.

## Graduate Student Research

By Eric von Wettberg

Between non-native species introductions and landuse practices that obliterate some forms of landscape heterogeneity, we live in an age of increasing global homogeneity that has been dubbed the homogocene. There are a variety of threats to local variation, both direct threats to the survival of endemic species and threats to the maintenance of genetic variation within species. To understand how local variants arise and are maintained, I use a mix of experimental, molecular, and quantitative genetic techniques to determine the extent to which potentially adaptive traits track environmental factors in the face of gene flow.

In my dissertation research I am examining patterns of differentiation in native and introduced populations of jewelweed *Impatiens capensis*. I have begun by conducting a survey of population differentiation between open canopy and forest understory stands of *Impatiens* across southern New England and have found unexpected patterns of differentiation. I am now using molecular markers to understand how gene flow affects these patterns of population differentiation.

In addition, I have found that the responses of *Impatiens* to simulated foliage shade are related to responses to early-life light cues, and that these relationships may affect the evolution of open canopy and forest understory forms. *Impatiens* plants growing in forest sites must emerge as seedlings through a layer of leaf litter by expanding their stem, while those in more open sites can invest less in their stems. Elongation to penetrate a layer of leaf litter is mediated by the same light-sensing machinery as avoiding shade. I am manipulating leaf litter and foliage shade cues in greenhouse experiments to understand the relationship of these two light-mediated elongation responses.

Our native *Impatiens capensis* was brought to England as an ornamental plant and subsequently escaped. I traveled to England last summer to collect seeds of *Impatiens capensis*, and am currently growing them in the Plant Environmental Lab with Fred and Brian. I will use quantitative traits measurements and molecular markers to determine if there is evidence of a bottleneck resulting from introduction, and to determine if local adaptation has occurred in the new range. In addition, I have been working with Novem Auyeung (ScB ’05) and Lisa Mandle (expected ScB ‘06.5) to understand if domesticating *Impatiens* increases their invasiveness and why so many species of ornamental *Impatiens* are not invasive. I am also continuing a running collaboration with our former postdoctoral associate, Heidi Huber, now at the University of Nijmegen, on phenotypic plasticity and the invasion of *Impatiens* in Europe.

In addition to my work with *Impatiens*, I have been collaborating with several undergraduates on projects with rare New England species. By comparing allozyme and quantitative genetic differentiation in the Northern Blazing Star, *Liatris scariosa*, Kelly Gravuer (ScB ‘02), Annie Schmitt, and I have found suggestive evidence that mowing management leads to greater differentiation in leaf shape than expected by patterns of gene flow inferred from allozymes. I am hoping to apply these same comparative techniques to restoration of Eastern Silvery Aster *Symphyotrichum concolor* on Nantucket. In addition, Matt Vadeboncouer (ScB ‘03) and I are continuing to work with *Liatris*, by building on Matt’s honors undergraduate work to examine the effects of prescribed burning, mowing, and propagule pressure on establishment of *Liatris*.

# News Update

**Andrew Altieri** was awarded the John G. Peterson Fellowship for the 2004-2005 academic year. It is a merit based fellowship awarded to one senior graduate student within the Biomed division each year.

**Katie Becklin,** research assistant in the Bertness lab, is off to do her Ph.D. at Washington University in the Fall.

**Mark Bertness** has been appointed as Visiting Chair in Ecology, University of Groningen, Holland and also Fellow in the Center for Advanced Studies in Ecology and Biodiversity at the Catholic University of Santiago and is on the Board of Directors – Marine Biological Association of the United Kingdom.

**Keryn Bromberg** was awarded an EPA Star Fellowship.

**Caitlin Crain** was awarded The Walter B. Jones

Memorial Award for Excellence in Coastal and Marine Graduate Study, sponsored by NOAA. She was also awarded the Switzer Environmental Fellowship award.

**Thomas Flatt** has received a Postdoctoral Research Fellowship from the Roche Research Foundation. He has been invited as a speaker at the 2006 Symposium "Metamorphosis: A Multi-Kingdom Approach", organized by the Society for Integrative & Comparative Biology in Orlando, Florida and has been invited to be an International Reader/Referee for the Australian Research Council.

**Jen Hughes** received an award from the Gordon and Betty Moore Foundation for marine microbiology research. The Gordon and Betty Moore Foundation is a philanthropic organization supporting initiatives in education, scientific research, and the environment. Jen's unsolicited grant was one of a handful made in the field of marine microbiology, judged to be an area of particular concern by the Foundation because of the area's increasingly perceived importance in understanding the health and productivity of the ocean. The aims of the Foundation's initiative in marine microbiology are to generate new knowledge regarding the composition, function and ecological role of microbial communities in providing the basis of the ocean's food webs and in facilitating the flow of nitrogen, carbon and energy in the ocean.

**Andrew Irving** will be starting in May, as a new postdoc in the Bertness lab. He received his Ph.D. from the School of Earth & Environmental Sciences at The University of Adelaide in Australia.

**Christine Janis** was appointed Associate Editor for *Evolution* in 2004 and Advisor for the Japanese television program "Miracle Planet II".

**Douglass Morse** became an Associate Editor for the Journal of Insect Biology.

**Heather Reed** started as a new postdoc in the Hughes lab in February. Heather received her Ph.D. from the University of Georgia.

**Molly Przeworski** became an associate editor for the journal PLoS Genetics.

The Rand lab hired two new postdocs: **Kristi Montooth**, received her Ph.D. from Cornell University in 2004, started in March and **Colin Meiklejohn,** received his Ph.D. from Harvard University in 2003, started in January.

**Marc Tatar** was a speaker at the National Academy of Sciences, 16th Annual Beckman Frontiers of Science Symposium, at Irvine, CA (November 2004).

**Bioblitz! On June 17th and 18th,** our field area, the Haffenreffer Estate in Bristol, will be host to the Rhode Island Natural History Survey's annual "Bioblitz", an event in which members attempt to inventory as many species of animals, plants, and microbes as possible over a 24-hour period. The purpose of Bioblitz events is multifold: to start an inventory of the species present within a restricted area (thereby providing insight into the biodiversity present), to introduce the public to the organisms that live about them, and to have a good time in the process. In addition to the serious tallying, members of the survey will lead visitors on field trips of the area. Specialists able to identify certain groups of organisms are always at a premium, which demonstrates the shortage of competent taxonomists, the group absolutely essential to making accurate and comprehensive biodiversity estimates. So, if you have that rare expertise, or if you want to contribute in other ways, join us at Haffenreffer.

## New EEB Faculty Member

By Osvaldo Sala

I started at Brown in early January just in time for the blizzard of the year. I am now dividing my time pursuing three complementary tasks. I am Professor at EEB, Director of the Environmental Change Initiative, and Director of the Center for Environmental Studies. As an EEB Professor, I advise students, teach classes, and continue with my research. My interests in ecology span from the arid ecosystems of Patagonia to global change issues with a focus on ecosystem-level questions including primary production, ecosystem-water dynamics, and most recently, biodiversity and ecosystem functioning. I am using a diverse set of tools in pursuing those interests ranging from field manipulations to ecosystem-simulation models.

One of the specific topics that I pursued throughout my career is that of the controls of carbon cycling. Primary production shows important lags in its recovery after droughts masking the relationship between primary production and annual precipitation. To explore the ecological mechanisms determining the lags, we established large-scale field experiments in Patagonia where we reduced incoming precipitation from 25% to 80% and followed these treatments with a simulated wet year. We experimentally replicated the lags observed in time series and identified biogeochemical and structural constraints that result from drought and bound the increase in production during wet years.

I am also very interested in studying the effects of changes in biodiversity on the functioning of ecosystems. Again, we established experiments in the field where we manipulated plant and microbial diversity. Our experiment was the first that used natural ecosystems and we found that the effect of plant-species diversity on primary production is much larger in natural ecosystems than previously reported using artificial plant communities. Our results highlight the consequences of losing biodiversity for the functioning of natural ecosystems and for their ability to provide goods and services.

Another area of my interest has been the development of scenarios of biodiversity change in the next century. These exercises required interaction with human demographers, economists, modelers and ecologists in an exciting and dynamic exchange. Our four scenarios do not represent predictions of the future but depict alternative pathways that society may take. The scenarios provide estimates of the costs and benefits of these alternative pathways for biodiversity and complement similar exercises for food production and availability of clean water and carbon sequestration.

The Environmental Change Initiative (ECI) is a new program on campus designed to foster interdisciplinary research in the area of environmental sciences. As an initiative, the ECI navigates among existing departments and centers, attracting faculty and students to work on new interdisciplinary problems. The ECI is an inclusive program drawing human resources from EEB, Geology, the Center for Environmental Studies, the Ecosystem Center of the Marine Biological Lab, Sociology, Economics, Public Health, the Population Studies Center, and many other units. Faculty and students will be attracted to work under ECI because of the excitement of tackling novel interdisciplinary problems that nobody could have approached independently. ECI has also a budget that could provide seed moneys for interdisciplinary research and will be hiring three new faculty in the next three years. The first search will start this fall.

The Center for Environmental Studies (CES) is a well-established institution at Brown with a 24-year history of accomplishments. The Center hosts two popular concentrations and an active Masters program. The CES includes numerous faculty members with a broad range of interests from ecology to community health. The Environmental Studies curriculum reflects the breadth of its faculty and confronts students to a variety of issues ranging from environmental economics to community health and ecosystem analysis.

I see a lot of complementarity and potential synergism among my different activities with my research feeding into my teaching and both closely interacting with the ECI and CES. I am quite excited to be at Brown and I am looking forward to increase my interactions with my colleagues and students.

## Linda Deegan

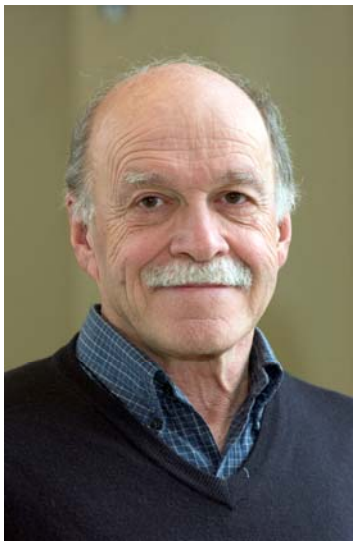
**The Ecosystems Center, MBL**

My research focuses on understanding the relationships between ecosystem dynamics and animal populations. I investigate how changes in ecosystem structure and function affect animal communities and how animals, through migration, feeding, or other activities, can regulate or modify biogeochemical cycles. I think about these questions across a broad suite of ecosystems, both fresh and marine, from the Arctic to the tropics. I am particularly interested in the role that large mobile predators, such as fish and crabs, play in aquatic ecosystems and how modification by humans has altered the capacity of ecosystems to support them. I examine issues ranging from the importance of fish in exporting nutrients from estuaries to the open sea, to the effect of habitat degradation on fish communities in coastal embayments, to the response of upper trophic levels to increased nutrients in arctic streams. My research combines the ecosystem perspective of energy and nutrient flows with traditional population and community dynamics. I use a variety of approaches to address these questions including large scale ecosystem manipulation experiments, broad correlation of ecosystem structure with animal abundance, life history and species composition, as well as state-of-the-art techniques such as measuring the natural abundance stable isotopes and flows of $^{15}N$ tracers in food webs. I often integrate these differing approaches using dynamic models of ecosystems or fish cohort abundance to determine how animals and ecosystems interact.

I often work in coastal ecosystems because they are a dynamic interface between terrestrial and oceanic systems, are one of the most productive ecosystems in the world and are heavily used by humans. The sustainability of coastal ecosystems in the face of widespread environmental change is an issue of pressing concern throughout the world. I investigate the basic controls on coastal productivity, as well as how human alteration disrupts these basic controls. My research on the effects of development in the uplands on fishes and their habitats has been used to develop policies on nitrogen loading in coastal ecosystems. I have established that the loss of estuarine fish species and declines in abundance is related to upland development that results in nitrogen loading and loss of seagrass habitats along the temperate eastern seaboard. We have seen this pattern repeated over a decade of work in Waquoit and Buttermilk Bay and in estuaries throughout Buzzards Bay and Chesapeake Bay. This has led us to develop an Index of Estuarine Biotic Integrity based on fish communities that is applicable from New England to Chesapeake Bay. In a large-scale ecosystem manipulation experiment, we demonstrated that the effects of nutrient enrichment were expressed through the overgrowth of phytoplankton, epiphytic algae and macroalgae that compete with seagrass for light and space. Declines in structural complexity alter predator-prey interactions, resulting in higher mortality of nekton and less transfer of primary production to higher trophic levels. The end result is a biotically impoverished, less productive estuary. One important finding is that standard measures of water quality are not sufficient to forecast the impacts of nutrient enrichment on fish populations or their habitats.

Currently I am investigating the role of animals in moderating the response of coastal ecosystems to eutrophication. Large motile animals may play an important role in biogeochemical cycles by creating a patch-mosaic of benthic areas in alternating anoxic and oxidized states. The disturbance of the benthic anaerobic/aerobic layer may stimulate denitrification, thus decreasing the effects of excess nutrient loading. Flounder, rays, green crabs, and horseshoe crabs are examples of animals that through their behavior could provide this function in Atlantic coast estuaries. Many of these species are currently being overfished, indicating that there may be a synergistic effect of biotic impoverishment and the effect of nutrient over-enrichment in salt marsh systems. At the Plum Island Long-term Ecological Research site, I am currently doing whole-ecosystem manipulations of nutrient loading and the biotic community to test this hypothesis. This information may lead to a new understanding about the synergistic effects of nutrient loading and species alterations in coastal ecosystems.

John Hobbie
The Ecosystems Center, MBL



I was forced by Nature to become interested in bacteria. This came about during my postdoctoral study of plankton in Arctic lakes testing the hypothesis that algae survived the winter under ice by taking up dissolved organic compounds from lake water. It soon became apparent that in lakes bacteria outcompeted algae for sugars, amino acids, and other compounds and, in fact, were so efficient that they kept the concentration of each compound to less than a tenth of a micromole per liter. Moreover, the same was true of estuaries and oceans. I went with the winners and from then on, I have studied microbes in water and soils from an ecosystem perspective. That is, my goal is to uncover and quantify the role of microbes in ecosystems.

Today I take part in projects that use measures of bacterial numbers, growth rate, and species presence to obtain data on bacteria in rivers, lakes, and estuaries.

We use the information to look at responses of bacteria and bacterial communities to natural changes, such as the changes in salinity in an estuary, and to experimental manipulations, such as the eutrophication of a salt marsh. With the help of scientists at Brown and at the MBL's Bay Paul Center we hope to add measures of various forms of RNA to tell which microbes are actually active under various environmental conditions.

During my work at the Arctic LTER (Long Term Ecological Research) site in northern Alaska, I recently became interested in a different type of microbe, the fungi that form symbiotic relationships with plant roots. Soil fungi in general obtain energy and nutrients by breaking down the soil organic matter, the remnants of plants and animals. Some species of mushrooms are symbiotic, living in a mutually beneficial association with the roots of many types of plants. The roots and fungi are called mycorrhizae. These fungi obtain sugars from the plant roots and, in return, provide nitrogen and phosphorus to the plant. Although most of the plants in the world are mycorrhizal, little is known about how important the symbiosis is in providing the nutrients that are in short supply for the growth of the plants. In particular, the transfer of nitrogen has been difficult to measure. At the Arctic LTER site we have developed a new approach that makes use of the natural abundance of $^{15}N$, one of the two stable isotopes of nitrogen. In biochemical reactions inside the fungal threads or hyphae, the two isotopes are fractionated so that amino acids with low amounts of $^{15}N$ are transferred to plants while the fungi, including their mushroom fruiting bodies, gain high amounts of $^{15}N$. From this study we are able to quantify that 70-90% of plant nitrogen moves from the soil to plants via fungi. In return for the nitrogen, the plants donate some 8-15% of their photosynthate to the fungi.

## Jerry Melillo

The Ecosystems Center, MBL

As Co-director of The Ecosystems Center at the Marine Biological Laboratory (MBL) in Woods Hole, I headed MBL's team that worked with Brown staff to develop the new Brown-MBL Graduate Program in Biological and Environmental Studies. I have been at the MBL for 30 years focusing on global warming and climate change and related science policy.

I am interested in how human activities are altering the biology and chemistry of terrestrial ecosystems. My studies take me around the world, from the tropics of Brazil to the Swedish subarctic. I study carbon and nitrogen cycling in terrestrial ecosystems by using a combination of large field experiments and computer simulation models. Both are critical to understanding how climate change might affect our world in the future.


Soil warming study at the Harvard Forest

Together with my colleagues, I am presently conducting a soil-warming experiment at the Harvard Forest in western Massachusetts and a carbon dioxide enrichment and plant and soil warming experiment at the Abisko Research Station in northern Sweden to study the effects of global warming on soil carbon and nitrogen dynamics, plant growth, and potential feedbacks to the climate system.

In addition to field research, I am using computer simulation models to help answer the many "what if" questions related to the effects of future climate change. The models not only synthesize and integrate a lot of information, but they help give rise to new field experiments.

My colleagues and I are using the results of our field experiments and our computer simulation models to explore the consequences of a range of stresses, such as climate change, ozone pollution and acid rain, on the forests of New England. How will forest growth be affected? Might some tree species do better than others, such that the composition of our forests will change? Will the quality of water draining from the affected forests be diminished? Along with other Ecosystem Center scientists I am collaborating with Chinese researchers to explore similar questions about the forests of China.

Working with Brazilian scientists, we are studying how the clearing of rainforests of the Amazon Basin for pastures and soybean fields affects the rate at which climate-changing greenhouse gases such as carbon dioxide and nitrous oxide are emitted to the atmosphere. We are also studying the links between land-cover and land-use changes, stream water quality, and biodiversity in the streams.

For the last 10 years, Ecosystems Center staff and I have collaborated with economists, atmospheric chemists and physicists, and ocean scientists at MIT to build a large model that couples the land, oceans, and the atmosphere with a projected set of economic futures. Our group focuses on the terrestrial portion of the model.

In the late 1990s, I temporarily left the MBL to serve in Washington as the Associate Director for Environment in President Clinton's Office of Science and Technology Policy where I directed programs on environmental monitoring of ecosystem health and advised the administration on natural resource and pollution issues. I am currently President of the Ecological Society of America, Past-President of the Scientific Committee on Problems of the Environment (an international organization that conducts assessments of emerging environmental issues) and was recently elected to membership in the American Philosophical Society.

## Ed Rastetter

The Ecosystems Center, MBL

My interests are in the regulation of ecosystem processes through the interaction of element cycles. Over the last 19 years, my perspective on ecosystem regulation has been focused by an emerging paradigm in ecology based on resource optimization. I anticipate that this paradigm will develop into a broadly synthetic theory of ecosystem regulation that will unify concepts from biogeochemistry, ecophysiology, and community and population biology.

The basis of the Resource Optimization Paradigm is that organisms have a limited set of internal assets (biomass, proteins, carbohydrate…) that they can allocate toward acquiring resources from the environment (carbon, nitrogen, water, light…). The optimum allocation of these assets is one where all resources in the environment equally limit production; otherwise, the organisms would be expending too many assets toward the acquisition of a resource that was not limiting and could therefore increase production by reallocating those assets toward a limiting resource. Changes in resource availability and plant requirements through time complicate this picture, but the overall concept still applies. Selective pressure should strongly favor organisms that approach an optimum-allocation pattern. As a result, resources are taken up in proportion to the metabolic requirement of the organisms, which links element cycles to one another and synchronizes their rates of cycling through ecosystems. This concept of optimization and the resulting linkage among element cycles serves as the theoretical foundation for most of my work over the last 19 years.

I will be teaching a graduate-level course in dynamic modeling of ecological systems next year, which will include a 3-week immersion at Woods Hole in January, followed by an independent project to be completed in the spring semester.

Ecology is progressively becoming more quantitative. Training in statistical methods in ecology has been well established in most colleges and universities. However, training in dynamic modeling of ecological systems is generally lacking. I view this lack of training as a major deficiency that is hindering progress in ecology. There are many problems in ecology whose solution is only accessible through modeling (e. g., predictions of long-term trends in ecosystem function in response to global change). Models are also excellent heuristic tools for helping researchers to assess gaps in the state of knowledge about an ecosystem and pose new questions that are rigorously framed. In science we basically do three things; we build hypotheses, we test hypotheses, and we apply what we have learned to practical problems in the real world. Models play an important role in all three of these tasks, and the course will focus on all three of these aspects.

Building hypotheses: Hypotheses are nothing more than models. Granted, those models are not necessarily mathematical. However, if we are interested in developing a quantitative understanding of our world, then by definition those models eventually have to be mathematical.

Testing hypotheses: Field scientists are often faced with trying to distinguish between alternative hypotheses. It is not always obvious what test will best distinguish among them. However, if the hypotheses can be formalized in a model, then various tests can be simulated on the computer and the one that best separates among the alternatives can be identified.

Application: There are lots of examples of applied models in ecology. One that is particularly timely is the prediction of the future state of the globe under various scenarios of fossil-fuel use and the resultant increase in $CO_2$ in the atmosphere. To assess the various options, a model is needed to quantify the carbon stored under the alternative management options.

Models underlie everything we do in science. Sometimes these models are not particularly quantitative, and some very important work has been done without reference to a formal mathematical model. However, as questions become more complex and the answers sought become more quantitative, the ability to formalize ideas into a mathematical framework becomes very valuable.

# Spring 2005 Seminars

Brown Bag Seminars usually catch up on research and work in progress within EEB, and the more formal colloquium series features speakers from outside the University.

## Brown Bag Seminars

February 4 **Frank Nelson,** Research Assistant, Brown University. *Influence of length on force output in the lateral gastrocnemius muscle during running.*

February 11 **Bruce Bryan,** Graduate Student, Brown University. *Does mitochondrial haplotype affect sperm competition in* Drosophila*?*

February 18 **James Palardy,** Graduate Student, Brown University. *Heterotrophy in stony corals.*

February 25 **Jose Iriarte,** Graduate Student, Brown University. *Kinematics of slow-turning maneuvering in bats.*

March 4 **Karen Carleton,** Associate Professor, University of New Hampshire. *Visual systems in cichlid fishes: using opsin genes to get a cichlid eye view.*

March 11 **Alan Bergland,** Graduate Student, Brown University. *Factors influencing the seasonal life history of the pitcher-plant mosquito,* Wyeomyia smithii.

March 18 **Devon Bradley,** Graduate Student, Brown University. *The influence of pathogen-resource interactions on plant community diversity.*

March 25 **Andrew Altieri,** Graduate Student, Brown University. *Life on grass: cordgrass facilitates the invertebrate community of cobble beaches.*

April 8 **Rima Izem,** Assistant Professor, Harvard University. *Variation in continuous reaction norms: Quantifying directions of biological interest.*

## Monday Colloquia

February 7 **Jason Hodin,** Friday Harbor Labs. *Expanding networks: hormones, nitric oxide, efflux transporters and life history evolution.*

February 14 **Nancy Pollard,** Carnegie Mellon University. *Characterizing human motion for animation and robotics.*

February 28 **Craig Randal Linder,** University of Texas. *Why can't species behave? Creating methods for reconstructing hybrid speciation.*

March 7 **Osvaldo Sala,** Brown University. *Spatial and temporal controls of carbon cycling in arid and semiarid ecosystems.*

March 14 **Andrew Pershing,** Cornell University. *Right whales, wrong time? Ecosystem variability in the Gulf of Maine and the fate of the Northern Right Whale.*

March 21 **Anne Bronikowski,** Iowa State University. *Demographic, behavioral, and physiological evolution in mice bred for high voluntary exercise.*

April 4 **David Anderson,** Wake Forest University. *Evolution of siblicide in Nazca Boobies.*

April 11 **Andreas Heyland,** University of Florida. *Thyroid hormone signaling in metamorphosis and nervous system function.*

April 18 **Elizabeth Dumont,** University of Massachusetts-Amherst. *From ecology to engineering: the evolution of frugivory in bats.*

April 25 **Jeffrey Dukes,** University of Massachusetts-Boston. *Ancient roots and modern consequences of global environmental changes.*

May 2 **John Hermanson,** Cornell University. *Long-legged locomotion in the grassland niche.*

# New Publications

**Agrawal, AA, JK Conner & JR Stinchcombe.** 2004. *Evolution of plant resistance and tolerance to frost damage*. Ecol Lett 7:1199-1208.

**Agrawal, AA, N Underwood & JR Stinchcombe.** 2004. *Intraspecific variation in the strength of density dependence in aphid populations.* Ecol Ent 29:521-526.

**Altwegg, R, S Dummermuth, BR Anholt & T Flatt.** 2005. *Winter weather affects asp viper* Vipera aspis *population dynamics through susceptible juveniles.* Oikos 110:55-66.

**Bergland, AO, M Agotsch, D Mathias, WE Bradshaw & CM Hozlapfel.** 2005. *Factors influencing the seasonal life history of the pitcher-plant mosquito*, Wyeomyia smithii. Ecol Ent 30:129-137.

**Donohue, K, L Dorn, C Griffith, E Kim, A Aguilera, CR Polisetty & J Schmitt.** 2005. *Environmental and genetic influences on the germination of* Arabidopsis thaliana *in the field.* Evolution 59:740-757.

*- The evolutionary ecology of seed germination of* Arabidopsis thaliana: *variable natural selection on germination timing.* Evolution 59:758-770.

*- Niche construction through germination cuing: life history responses to timing of germination in* Arabidopsis thaliana. Evolution 59:771-785.

**Gaucher , EA, LG Graddy, T Li, RCM Simmen, FA Simmen, DR Schreiber, DA Liberles, CM Janis and SA Benner.** 2004. *The planetary biology of cytochrome P450 aromatases.* BMC Biol 2:19.

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