Department of Ecology & Evolutionary Biology
COLLEGE OF ARTS & SCIENCES

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# Explorations

## Celebrating Diversity

**by Prof. Gary McCracken, Head**

The greater spear-nosed bat, Phyllostomus hastatus, is one of almost 1,200 known species of bat. At up to 100g, this omnivorous bat is the second largest bat species in the Neotropics.

In the past year, EEB has reflected on its mission and launched a new strategic plan identifying "the evolution and maintenance of biodiversity" and "the future of biodiversity" as core focus areas for research and teaching. As ecologists and evolutionary biologists, we work to document the world's biodiversity, to understand its origins and the interconnections that make our world resilient, and to do what we can to preserve it.

Mirroring our appreciation of biodiversity and rich and essential relationships in nature, EEB looks for and celebrates diversity in our department. We value the diverse perspectives of our faculty, students and staff, whose broad backgrounds and places of origin enrich our academic life and make us a stronger department. Below, we provide a brief history of the rise of women in the department, and on page 7 we profile alumna Jean Brennan, as one example of the widespread influence the women of EEB have.

Between these articles, we showcase some of EEB's efforts to address our core mission. We share our knowledge of the natural world through outreach projects, and we train successful undergraduate researchers. Our faculty and graduate researchers investigate biodiversity at scales from genes to ecosystems.

One of our strongest advocates of biodiversity received some deserved recognition this year: Dan Simberloff, Nancy Gore Hunger Professor of Environmental Science in EEB. In 2012, Dan was both initiated into the U.S. National Academy of Sciences and awarded the 2012 Margalef Prize, the world's premier award to an ecologist. Dan is currently the only member of the National Academy at UT and the eighth recipient of the Margalef Prize.

## Trailblazers

Women have played an important part in EEB (and its predecessors) since 1927. That's when Willa Ames, our first female student, graduated with an MA in Botany. Our departmental alumni records indicate that only five male students received degrees before Ms. Ames. One MS and four BS degrees were awarded between 1914 and 1927.

Our first female undergraduate was Marjorie Shipe, who graduated in 1929 with a BS in Botany. Ms. Shipe went on to get her MS in Botany at UT two years later, becoming our first double-degree earner of either gender.

Gender balance in the early years of the department is surprising; 40% of the degrees awarded in the 1920's went to females. However, one must consider the raw numbers, (two females out of five total graduates) and remember that small numbers skew percentages.

Gender balance decreased every decade from the 1920's until an all-time low in the 1960's (only 20% of the 334 degrees were awarded to females). But since then, the presence of female students in the department has increased. In the 2000's, we finally reached gender equality; 51% of our 182 students were female. The decrease in the total number of degrees awarded is largely the result of the departmental restructuring (EEB, BCMB, and Microbiology) during that decade.

**Inside This Issue**


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|---|---|---|---|---|---|---|---|
| Mulholland Endowment | 2 | Outreach | 2 | Undergraduate News | 3 | Graduate Research | 4 |
| Faculty Research | 4-5 | Retiring Faculty | 6 | Alumni Focus | 7 | Giving Opportunities | 7 |


*Banner image: Lycopodium digitatum (Fan clubmoss) 0621, The Botanical Photography of Alan S. Heilman, © Alan S. Heilman, © The University of Tennessee Libraries, 2011.*

# Mulholland Endowment

We are honored and excited that EEB is home to the new Dr. Patrick J. Mulholland Post-Doctoral Fellowship in Environmental Sciences! Pat Mulholland joined the Environmental Sciences Division (ESD) of Oak Ridge National Laboratory (ORNL) as a Research Associate in 1979 and rose to Distinguished Research Staff Member during his 33 years there. Pat studied stream ecosystems; he was best-known for his long-term research on the Walker Branch Watershed on the Oak Ridge Reservation. Pat's work influenced policy discussions of acid precipitation, nitrogen deposition effects, and climatic variability and change.

Pat was an active adjunct faculty member in UT's Graduate Program in Ecology, and subsequently EEB, since 1988. He mentored numerous postdoctoral research associates and graduate students. Pat was a strong advocate for early-career scientists and UT-ORNL collaborations.

Tragically, but fittingly for a world-famous environmental scientist, Dr. Patrick J. Mulholland died on Earth Day, April 22, 2012.

In honor of Pat's enduring scientific legacy, this endowment will support a postdoc in conducting collaborative research in ecology or environmental sciences, focusing on pressing environmental issues related to global change, with EEB faculty and ORNL staff. We are particularly grateful to Cathey Daniels, Pat's wife, and Dr. Gary Jacobs, former Director of ESD, for their vision and efforts in making the Mulholland fellowship a reality. Top biology programs in the US have endowments to support post-doctoral fellows; UT has now joined their ranks. This is the first post-doctoral endowment in UT's College of Arts and Sciences.

Gifts from Pat's family, friends and former colleagues have established the endowment with a 5-year goal of reaching $100,000. Ultimately, we hope to increase the endowment to at least $1.5 million so that its interest income can fully fund the post-doc fellowship. For information on how you can help us in this ambitious goal, which will enhance our research efforts, further cement our collaborations with ORNL, and honor Pat, please see page 7 of the newsletter.

# Outreach: Boo at the Zoo

**by Veronica Brown**

One of the keys to successful conservation education is teaching young children before negative opinions become engrained. Since bats are some of the most disliked and misunderstood animals, members of the McCracken lab frequently talk to local school and scout groups about the importance of bats to the environment. The largest such outreach event occurs every October during Knoxville Zoo's "Boo at the Zoo" festival, which attracts thousands of children across several evenings of trick-or-treating. Since 2007, EEB has run an educational booth at this event, and many children now look for our booth to see what new things we have to show them.

One of the booth's most popular activities allows kids to "see" in the dark to find their dinner like a bat. Kids can compare the wingspans of the smallest bat, the bumblebee bat, to the largest bat, the Malaysian Flying Fox, which has an almost 6-foot wingspan. Kids can look through a "bat picnic basket" at some of the things bats like to eat: beetles and moths for the insectivorous bats, fruit and nectar for the fruit bats, and fish for the fishing bats. For families that want to take bat conservation home, we have a demonstration bat house and tips on how to build one successfully. We teach children the importance of never touching a bat, or any wild animal, because of diseases like rabies, but we stress that a bat flying in the sky cannot hurt them. We also educate about White-Nose Syndrome, a disease that is killing bats across North America and is currently being studied in the McCracken lab.

A Boo at the Zoo visitor hunts for "moths" like a bat, using an ultrasonic navigator for the blind to simulate echolocation.

EEB faculty, staff, graduate students, and undergraduates, as well as students from other science departments, staff our booth, with each person finding a way to incorporate his or her own background into discussions with the children. For example, EEB graduate students with botany backgrounds enjoy talking about plants that are pollinated by bats.

Children often pull their parents to our booth saying, "We did this at my school. You have to see – it is so cool!" Each year we leave Boo at the Zoo knowing that we have gotten a few more kids interested in science and conservation. It makes our efforts worthwhile, and we hope to inspire even more people in the future!

# Undergraduate News

## Science Fest

The second annual USA National Science and Engineering Festival was held in Washington, DC in April 2012. EEB and NIMBioS teamed up to present two interactive booths, one on intra-specific variation in plants and one on fungi. The festival is the largest national celebration of science to date, featuring over 3,000 interactive exhibits and over 100,000 visitors during the two-day event. Many Science Fest attendees were families, but several teachers were there to pick up ideas for their classrooms. The aim of the festival is to ignite and invigorate a spark for science among our youth.

Sarah Wood, an undergraduate in the Classen Lab, and Kelly Sturner of NIMBioS manned a booth focused on intra-specific variation (variation within a species). Booth visitors measured leaf length, width, and shape, as well as plant height, in plants of the same species but with different genotypes, taken from Tennessee and Connecticut. Participants saw first-hand how variation within a species is often as significant as variation across species. "When thinking about conservation of biodiversity, it is not only the number of species protected, but also ensuring that there is a diversity of genotypes within that species," said Sarah Wood.

Emily Austin and Jessica Bryant, Classen Lab graduate students, manned a booth which taught Science Fest attendees about fungi and their role in decomposition. Visitors were able to touch, smell, and measure logs in various stages of decay. Older students graphed wood density while younger students had fun making observations. A second grader from DC noted, "Wood gets squishier and squishier, like bugs have been eating it."

EEB undergraduate Sarah Wood and Kelly Sturner (NIMBioS) with their booth on intra-specific variation at the Science Fest.

The team also met with Hunter Bethea, a legislative assistant of Sen. Bob Corker (R-TN). The group spoke about how participation in federally-supported science education and outreach programs, such as NSF research experiences for undergraduates, led them to pursue science careers and to give back by participating in science outreach. Bethea was impressed to see real examples of how federal funding enriches science education, benefits the public and inspires the next generation of scientists.

## In the Field


Undergraduate Stephen Nelson samples water snakes along the Hiwassee River, to study the transmission of ranavirus.

EEB has been working to enhance undergraduate education by increasing resources toward and faculty involvement in undergraduate research.

In 2010-11, there were 81 undergrads doing research under 20 EEB faculty mentors. Students do research for a variety of reasons. Some are fulfilling an honors program requirement; others simply want real lab experience. As Jen Schweitzer's student Hannah Long said, "I knew that doing an undergraduate research project would expand my knowledge… and give me direct, hands-on experience doing science."

Students usually decide whether to do research in their third or fourth year and often select a mentor who taught one of their earlier EEB courses. Students can apply for grants from the Chancellor's Office and Office of Research to provide $2000 in funding for their research. Thanks to the generosity of our alumni, EEB has been able to match these University awards, providing applicants with $4000 of total research money. Student research topics range from host-pest relationships to fish locomotion to disease ecology to gene expression to plant-soil feedbacks.

Many undergraduate researchers intend to pursue a graduate degree in an EEB-related field. Mary Glover, who did an undergraduate research project under Ben Fitzpatrick, is just one of many examples; she is now a graduate student in Biological Sciences at Notre Dame. When asked how her research changed her understanding of science, she said, "I learned… the importance of presenting an experiment in a way that clearly and simply represents the conclusions of the study and is easy to understand."

# Paper, Rock, Scissors

## Graduate Research: Mark Genung

No two individuals of a species are exactly the same. Distinct genetic makeups (genotypes) interact with environmental factors to determine the observable characteristics (phenotypes) of an individual. But what factors maintain the variety of phenotypes present in most species, and what environmental factors affect phenotypes?

Graduate student Mark Genung addressed these questions by studying how plant-neighbor interactions were affected by genotype. He planted native goldenrods in pairs: one genotype of *Solidago altissima* next to one genotype of *Solidago gigantean.* He found that, within species, certain genotypes were more successful than others; however, the hierarchy of genotype performance in a focal species was dependent upon the genotype identity of its neighbor. In other words, the interacting genotypes behaved like the choices in a game of paper-rock-scissors; there was no dominant genotype, and the "winning" genotype couldn't be guessed until the identities of both interacting genotypes were known. This suggests that the genetic identity of neighbors can determine how a plant's genotype is expressed to create the phenotype that we see.

Although these types of genotype by genotype (G x G) interactions were known to occur, Mark extended the outcome of the genotype interactions and showed that G x G interactions could predict rates of pollinator visitation to a focal plant. This means interacting plant genotypes can have unique effects on other species in the community, such as bees and butterflies.

Recognition of the significance of G x G interactions has important implications for coevolution and conservation biology. For example, if genotype performance depends on the identity of neighbors, then many genotypes can persist, not just one dominant genotype. Additionally, because the persistence of genotypes may rely on the genotypes of neighbors, genotypes and G x G interactions may be biological units worthy of conservation strategies.

*Mark finished his PhD under Jen Schweitzer and Joe Bailey in the spring. He is now a postdoc in EEB.*

Native East Tennessee goldenrods.

# Home Field Advantage

## Faculty Research: Jen Schweitzer

Populus trees benefit from growing in their parents' soil.

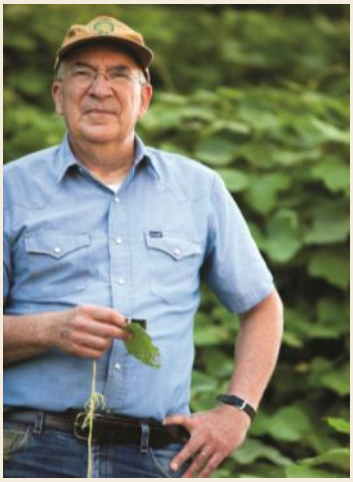
As coaches know, playing in your home arena can improve the odds of winning by more than 10% due to familiarity of the court, fan support and other intangibles. Plants too can experience "home-field advantage," where they grow or reproduce more when grown in soils where their mother plant grew. Plants can also experience "home-field disadvantage," where they grow or reproduce less well at "home." In biology, these effects are called feedbacks; they occur because plant species have traits that can influence the soil conditions or even the organisms that live in the soil in which they grow. For example, plants with symbiotic fungi (which help them acquire water and nutrients) can experience improved growth in subsequent generations, whereas plants might experience hindered growth if they acquire diseases from their parents' soil.

Schweitzer lab graduate students Clara Pregitzer (MS, 2010) and Emmi Felker-Quinn (PhD, 2012) have found evidence that feedbacks can help determine genetic variation in plants that affect their future success in a particular area. In a native *Populus* species, Pregitzer[1] found that feedbacks from the soil microbial community enhanced the success and genetic variation of seedlings even though the "home" soil was less fertile overall. Felker-Quinn[2] found a similar effect in some but not all populations of the invasive 'tree of heaven.' The research revealed one population experienced negative feedback that reduced their success, suggesting that this population may not persist over time.

These studies, and others from the Schweitzer lab, suggest that "home-field" advantages and disadvantages may have important consequences beyond a win or a loss for an individual plant. Feedbacks may influence whether invasive plant species can persist in new habitats after introduction; they may affect whether plant species can shift their ranges as climates change. Thus, there are both ecological and evolutionary consequences of the "home" field.

*1. Pregitzer, C.C., J.K. Bailey, S.C. Hart, J.A. Schweitzer. 2010. Evol. Ecol. 24:1045-1059.*
*2. Felker-Quinn E., J.K. Bailey, J.A. Schweitzer. 2011. Ecol. 92:1208-1214.*

# Invasion



Dan Simberloff was elected to the National Academy of Sciences in May and received the Margalef Prize (the top prize in ecology and environmental science) in Oct. 2012.

A small group of ecologists led by Mark Davis at Macalester College has argued for several years that efforts to study and manage invasive non-native species are misguided. They maintain that (1) most invasions do not have harmful environmental impacts; (2) both native and non-native species become invasive; (3) some non-native species are useful to conservation; and (4) attempts to manage invasions are futile, in the face of increasing travel and trade that carry hitchhiking organisms around the globe. Their work has attracted much attention and can potentially influence policy. My students, colleagues and I have undertaken several studies to examine these propositions, three of which have recently come to fruition.

To examine whether native species are as invasive as non-native species, we conducted a detailed literature search of forty primary journals. After identifying the publications (through 2007) that reported invasive species in the United States, we found that native species occasionally do become invasive, but they are 40 times less likely to do so than non-native species. Further, when native species become invasive, it is usually in the wake of other human impacts on the environment. An example is that several species of juniper invade grasslands in the wake of fire suppression, heavy grazing by livestock, or both[1].

## Faculty Research: Dan Simberloff

In a second study, we addressed the matter of introduced species aiding conservation. We found that such cases do exist: e.g. endangered bird species nesting in invasive trees, or rare butterflies feeding on introduced host plants. However, reports of inimical impacts of introduced species far outnumber those of beneficial impacts. Furthermore, in each case of reported benefits, there are other impacts, some of which are detrimental. One would have to tally the full ecosystem impact of an invasion to determine if it is of net conservation benefit[2].

I recently helped convene a workshop of Europe's leading invasion biologists. The paper published from the meeting[3] outlines substantial progress in understanding the full impacts of invasions, particularly recent research on aboveground-belowground interactions. It also cites many advances in managing terrestrial, aquatic, and marine invasions and includes a discussion of how to deal with criticisms of invasion science.

1. Simberloff D., et al. 2012. *Ecology* 93:598-607.
2. Vitule J.R.S., et al. 2012. *Cons. Biol.* 26:1153–1155.
3. Simberloff D., et al. 2013. *Trends Ecol. Evol.* 28:58-66.

# Fish Heads

## Faculty Research: Darrin Hulsey

Humans only have a few joints and muscles that readily move while we eat, but fish generally have over 30 muscle and skeletal elements that move in a coordinated fashion when they feed. Fish feeding events also happen over incredibly short timeframes (< 20 milliseconds). How do such complicated but coordinated structures evolve?

The Hulsey lab studies the evolution of complex organismal structures, focusing largely on the feeding apparatus of fish. Since there are over 25,000 species of fish, particular feeding habits have often evolved repeatedly, allowing the ability to test similar hypotheses in a large number of evolutionarily independent groups.

We experimentally determine the feeding efficiency of fish and model different feeding structures as simple machines, like levers and force-resisting structures. We then test these models with experimental data to see whether fish jaws exhibit the theoretically predicted mechanical tradeoffs. By applying these methods, we can study adaptations in predator-prey interactions and consider both predatory abilities and anti-predatory defenses.

Darrin demonstrates how his jaws function differently from the jaws of a jaguar cichlid in Honduras.

Our work also uses population genetics and phylogenetic trees to create historical maps for understanding when and how traits arise. Some traits have a genetic basis, while others are heavily influenced by environmental factors. We are introducing new genomic tools into the lab that will allow us to better understand the underlying origin of functional novelties.

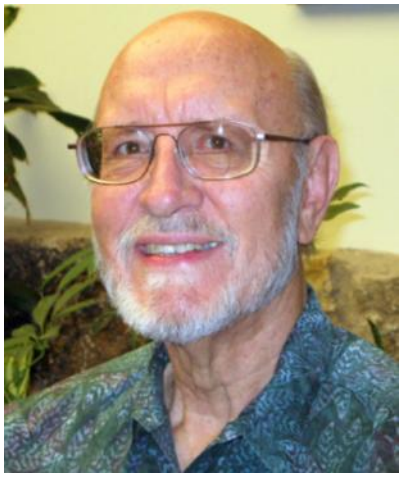
***To view high-speed footage of fish feeding, please visit www.youtube.com/user/fishlabutk.***

# Moving On

## Tom Hallam

**by Prof. Louis J. Gross**

Thomas Hallam was hired in 1977 to build a program in mathematical biology, with an emphasis on ecology. Tom built not just a research group but a "family" here in math ecology, attracting several new faculty to UT (including me) and talented graduate students in both the Math Department and the Graduate Program in Ecology.



Tom Hallam retired from EEB this year, after 35 years at UT.

Tom co-led one of the most influential series of courses and workshops in mathematical biology ever held, from 1982 to 2000. The series, held at The International Centre for Theoretical Physics in Trieste, Italy, introduced over 1500 researchers, mostly from developing countries, to current mathematical research in biological fields, including ecology, epidemiology, evolution, environmental science, conservation biology and natural resource management. The series enhanced UT's reputation as one of the main centers of research in math biology and brought a number of new international students to Knoxville. Tom also helped form The Institute for Environmental Modeling (TIEM) at UT. This interdisciplinary group was one of the first research groups anywhere dedicated to the application of mathematical and computational methods to environmental issues.

Tom moved his group to EEB soon after the Department was formed. Not long after this, Tom became head of EEB. Through regular threats to resign, Tom managed to wend concessions from the UT administration. In addition to maintaining and obtaining new faculty positions, Tom "negotiated" the means to significantly enhance the stipends for EEB graduate students. This is a major reason why we have been (and are still) able to compete with the leading programs in the US for top graduate students.

Tom set a tone of compassion and comradeship that continues to this day in EEB. He understood and encouraged the importance of a life outside of academia. While Tom has "really" retired now, his mentorship of so many in EEB, his capacity to foster collegial solutions to challenges, and his ability to make the diverse connections between fields that characterize modern biology research and education will serve us in good stead as we strive to continue Tom's efforts to further enhance EEB at UT.

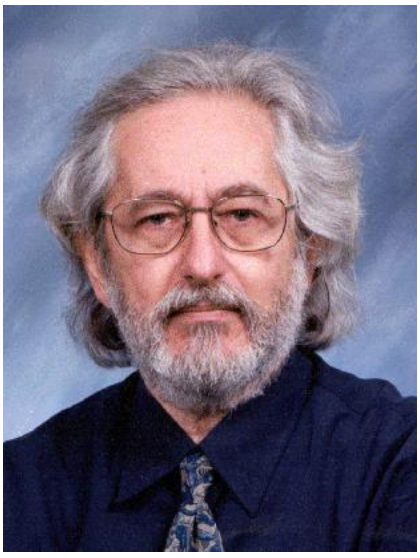
## Neil Greenberg

**by Prof. Gordon Burghardt**

Neil Greenberg and I met at professional meetings before he came to UT's Zoology Department in 1978. He was a fellow reptile aficionado with an ethological background, but he also had a strong grounding in neuroscience and brain mechanisms in *Anolis* lizards. We became friends and jointly taught the Comparative Animal Behavior course for over 20 years. He was instrumental in the development of the Ethology Graduate Program, before the EEB department was reorganized. Neil had a way of asking questions that challenged both students and faculty, by striking deep at the heart of some of our normal assumptions and ways of thinking. But Neil never tried to trump or trick a student; he merely helped us avoid being focused on details at the expense of the more inclusive wonders our work might reveal.

Neil loved studying lizards, but he was also fascinated by art. He drew the wonderful stipple portrait of a green iguana for the Afterward of *Iguanas of the World* (eds. Burghardt & Rand). He designed the logo and t-shirt for the annual Animal Behavior Society meeting in 1981, when UT hosted it. His interest in the relationship between art and science grew over the years, and he developed the now iconic course "Art and Organism," which has been taught to students from all areas of Arts & Sciences.

Neil served as Director of University Studies and was instrumental in organizing the Environmental Semester in Spring 2005 that introduced many sustainable practice ideas to campus. The high-profile "Make Orange Green" campaign, which emphasizes green buildings, energy efficiency, and recycling, owes much to the attention generated through Neil's efforts. This, among other accomplishments, will be a major legacy he leaves us.



Neil Greenberg retired from the EEB faculty in July 2012, after 34 years in the department and its Zoology ancestor.

# A Champion of Conservation

**by Jean Brennan (PhD Zoology 1995)**

My academic background is in the area of ecology, population biology, and evolution. While my research pursuits have been varied (including primate behavior, mongoose ecology, evolutionary genetics of large mammals, and sea otter population biology), I have always been motivated by my love of nature and support of environmental protection.

After graduating from UT, I joined WWF as a research associate and lived in a remote field camp on Borneo, until one event profoundly changed the direction of my career. I witnessed the environmental destruction of millions of acres of tropical rainforest. Fires were started intentionally to clear land cheaply, but they burned out of control. Peat burning on the forest floor released toxic pollutants, covering much of Southeast Asia in dense smog for several months. The country was in chaos and economic collapse, and the health impacts were extensive. The experience crystallized a realization: effective environmental protection needs to be achieved at the national policy level, and I needed to refocus my scientific efforts.

My graduate training at UT served me well as I transitioned into the policy realm. I had developed solid scientific expertise and the ability to think like a scientist: how to frame a problem, articulate the underlying assumptions, and pursue a systematic approach toward a solution or explanation. These skills enabled me to pursue an American Association for the Advancement of Science Fellowship to gain experience in working at the interface of science and policy. I served as a Diplomatic Fellow with the U.S. State Department and later was hired as a Science Officer for the U.S. Agency for International Development (USAID). While at State I worked with the Intergovernmental Panel on Climate Change (IPCC) and served at the UN Negotiations on climate change. I was one of a select number of scientists recognized "for contributing to the award of the Nobel Peace Prize for 2007 to the IPCC."

I now work for the U.S. Fish and Wildlife Service as part of a national agenda initiated to efficiently coordinate conservation efforts. The initiative divides the nation into 22 Landscape Conservation Cooperatives (LCC); I am the Coordinator for the Appalachian LCC, which spans 15 states. Each LCC is self-directed and crosses political and organizational boundaries to help wildlife and natural resource managers achieve conservation goals at a landscape-level, beyond the jurisdictions and resources of any one agency or partnership. The focus of conservation science has shifted to achieve large-scale conservation across a matrix of various land-uses, human benefits, and environmental services. This shift in science and management represents a transformational time in the history of conservation, and I am honored to be able to play a role.

# Giving Opportunities

EEB has several departmental funds to support our vision of excellence in science education.

## EEB Enrichment Fund

This fund (still called the "Zoology Enrichment Fund" on some UT websites) is the primary departmental account. It supports instructional and academic programs within the department, including

- Undergraduate and graduate research;
- Travel funds for students to participate in meetings and workshops;
- Other departmental activities that are in need of support.

If you have specific philanthropic goals, you may wish to consider one of EEB's other funds, a few of which are listed here:

**Mulholland Post-Doctoral Fellowship in Environmental Sciences**
**Graduate Research in Ecology and Evolution Fund**
**H. R. DeSelm Graduate Award Fund**
**D. Etnier Ichthyology Museum Fund**
**L. R. Hesler Herbarium Support Fund**
**Field Botany Fund** *(also supports ecological field work)*

If you would like more information about any of these funds, or if you wish to support a fund not shown here, please contact the EEB office (865-974-3065) or the College of Arts and Sciences (865-974-2365).

**To contribute online, please visit**
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***Be sure to designate the EEB Enrichment Fund or type the name of the fund of your choosing.***

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## Congratulations, Graduates!

Congratulations to the 43 EEB undergrads who graduated in 2011-12! Congratulations also to the nine graduate students who graduated in 2011-12:

Master's Degrees: **Amanda Allison** (Teaching Fellow, in Milwaukee, WI) and **Nicholas Buckley** (Lab Coordinator, Pellissippi Community College).

Doctorate Degrees: **Lawong Balun** (Professor, Papua New Guinea University of Technology), **Melissa Cregger** (Postdoc, University of Illinois at Urbana-Champaign), **M. Steven Furches** (Asst. Prof. at Lincoln Memorial University, Harrogate, TN), **Audra Galasso**, **Mark Genung** (Postdoc, EEB, UT), **Emmi Felker-Quinn**, and **Jason Robinson** (Postdoc, University of Illinois at Urbana-Champaign).

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