Fall 2015

Explorations Volume 6 Fall 2015

Department of Ecology & Evolutionary Biology

ECOLOGY & EVOLUTIONARY BIOLOGY

Fall 2015

Volume 6

Explorations

The EEB Newsletter

Leading the Way

Prof. Susan Kalisz, Head

Susan Kalisz joined EEB in August as our new department head.

EEB is ideally situated to be on the forefront of Anthropocene research. Our department is in a geographic epicenter of diversity (Fig. 1), and we have the unique expertise required to lead the way in research that not only addresses basic scientific issues but also informs public policy.

Most scientists agree that Earth has entered a new geological period, the Anthropocene, named because human activities have dramatically altered the atmosphere, land, and water. Data from NOAA demonstrate that increased greenhouse gases have produced global warming trends (Fig. 2). Development, sprawl, and deforestation drive habitat loss and changes in ecosystem processes. Human travel and worldwide trade introduce exotic organisms that can fuel disease outbreaks or become invasive species. Human-mediated changes are profoundly altering the distribution and abundance of organisms, biodiversity, and ecosystem function.

Now is a critically important time to be working in ecology and evolutionary biology, and EEB has the research expertise needed to address these challenges. Our faculty (see initials), postdocs, and graduate students use myriad research approaches, including field, lab, and greenhouse experiments (GB, JB, SE, CK, SK, SR, JS, JW), models and simulations (PA, LG, MG, SG), consideration of conservation and policy decisions that alter biodiversity (PA, JF, CK, GM, DS), and collections-based inquiry (KH, BM, EdS, RS). We explore the mechanisms that generate and maintain genomic and phylogenetic diversity and drive speciation (BF, JF, MG, SG, BO), as well as ecosystem function (JB, GM, JS). We work in a wide range of habitats across multiple continents and in areas of high biodiversity. This provides opportunities to understand how biodiversity is generated and maintained (MG, BO), why it matters for evolutionary and ecological functioning (JB, SE, BF, JF, CK, SK, GM, SR, DS, JS), and insights for developing and enacting better conservation and management strategies (PA, SK, DS). We are fortunate to be in the Smoky Mountains region, famous for its natural beauty and biodiversity. EEB is poised to build programs, partnerships and facilities needed to train the next generation of researchers (ES), who can take on the biology of a changing world. We can deliver the ideas, models and data needed to grow scientific knowledge and inform environmental policy.

Examples of endemic and threatened species in East Tennessee.[3]

Since joining the department, I have been inspired by the extraordinarily talented faculty and bright students I have met. You will read about many of them and their successes in this newsletter. I'm delighted to be associated with an outstanding department, in a great university, at the foothills of the Great Smoky Mountains National Park. It's an exciting time to be a researcher in EEB!

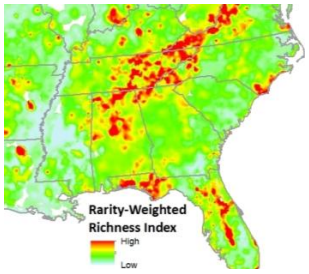
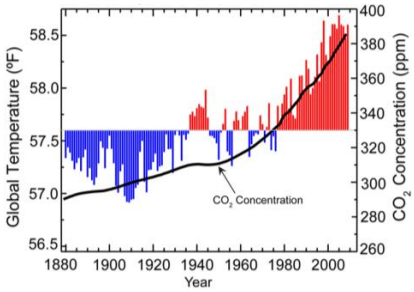


Fig. 1. Knoxville is surrounded by areas of high species richness (red).[1]

Fig. 2. Greenhouse gases and global temperatures are on the rise.[2]



1. NatureServe. 2013. NatureServe Rarity-Weighted Richness (RWR) Model of Critically Imperiled and Imperiled (G1 or G2) Species in the United States (Lower 48). Arlington, VA, USA.
2. National Oceanic and Atmospheric Administration. www.ncdc.noaa.gov/indicators.
3. A. *Trillium tennesseense*, endemic, critically imperiled wildflower; B. *Hygrocybe appalachianensis*, endemic mushroom (Photo credit: Mike Wood); C. *Eurycea junaluska*, vulnerable, endemic salamander; D. *Glyptemys muhlenbergii*, vulnerable bog turtle; E. *Pityopsis ruthii*, endemic, critically imperiled wildflower.

Inside This Issue

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

Biology Greenhouses: A New Era

Lecturer and greenhouse manager **Ken McFarland** retired in June. Ken has made the Greenhouse and Garden Facility what it is today; he leaves behind an enduring legacy. When Ken arrived at UT as a graduate student in the late 1970s, the Greenhouse Facility was in poor shape. The wooden frames were rotting, and the glass panels had been painted with permanent (not washable) white shading, making it difficult to grow anything but fungi. In one storm, the entire end of the greenhouse blew out. The greenhouse complex was rebuilt in 1981, with metal frames and glass panels fitted with shade cloth that could be rolled up or down. With this restored functionality, plants could again be grown for both research and teaching.

Ken McFarland addresses friends and colleagues at his retirement ceremony at UT Gardens in June.

Ken became the greenhouse manager in 1982. Under his direction, the greenhouses have thrived. The largest greenhouse contains economically important tropical plants, like the banana plant (yes, we eat the fruit!), vanilla orchid, coffee, tea, sugar cane, and more. The two smaller adjacent houses include faculty and student research projects. Greenhouse Four, now officially the Ken McFarland Greenhouse, holds xerophytic plants and student projects. A set of greenhouses on White Avenue provides additional space for faculty and student projects.

Gift funds have been established to further the development of the greenhouses (Ken McFarland Fund) and the gardens (Walter Herndon Garden Fund). Donations to these funds will help facilitate student interest and provide opportunities for plant studies in the biology program.

Today, the Greenhouse and Garden Facility provides an exceptional teaching resource for students at UT and beyond. The greenhouses hold specimens from all major phyla and provide living material for student observation and experimentation. Students become familiar with a wide range of plants and enrich their understanding of biology. For some students, their first experience of planting a seed happens in the biology greenhouses! The greenhouses also serve people outside UT, from primary school students to artists.

We are searching for a new, full-time greenhouse manager. With a growing emphasis on plants in all areas of biology, the greenhouse and its staff will be an essential resource for biology and beyond. The Greenhouse and Garden Facility has a bright and growing future.

Book: Guide to the Vascular Plants of Tennessee

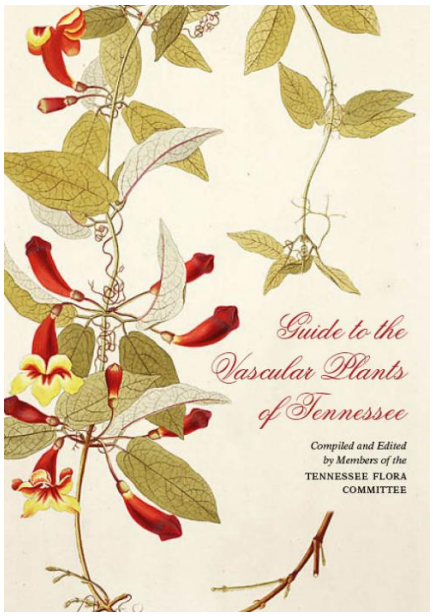


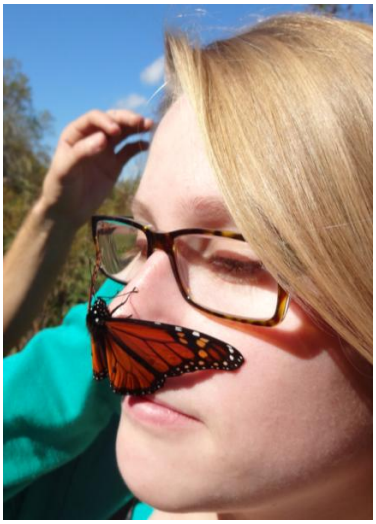
Image and article text from The University of Tennessee Press.

*Research Associate Professor **B. Eugene Wofford** (EEB) teamed up with other members of the Tennessee Flora Committee to write* Guide to the Vascular Plants of Tennessee *(University of Tennessee Press, 2015).*

The product of twenty-five years of planning, research, and writing, *Guide to the Vascular Plants of Tennessee* is the most comprehensive, detailed, and up-to-date resource of its kind for the flora of the Volunteer State, home to nearly 2,900 documented taxa. Not since Augustin Gattinger's 1901 *Flora of Tennessee and a Philosophy of Botany* has a work of this scope been attempted. The team of editors, authors, and contributors not only provide keys for identifying the major groups, families, genera, species, and lesser taxa known to be native or naturalized within the state (with supporting information about distribution, frequency of occurrence, conservation status, and more), but they also offer a plethora of descriptive information about the state's physical environment and vegetation, along with a summary of its rich botanical history, dating back to the earliest Native American inhabitants. Other features of the book include a comprehensive glossary of botanical terms and an array of line drawings that illustrate the identifying characteristics of vascular plants, from leaf shape and surface features to floral morphology and fruit types. Finally, the book's extensive keys are indexed by families, scientific names, and common names. The result is a user-friendly work that researchers, students, environmentalists, foresters, conservationists, and indeed anyone interested in Tennessee and its botanical legacy and resources will value for years to come.

Naturalists Club: Growth and Development

Like monarch butterflies taking their slow and steady journey from temperate North America to their tropical, high-altitude home, a small group of EEB undergraduates is keeping this generation of naturalists alive. The Naturalists Club recently re-emerged from hibernation, thanks to the efforts of former EEB undergrad **Mariah Patton** (BS 2014), under the supervision of Asst. Prof. **Charlie Kwit**. The club was started in the 1980s by **Les Jones** (BS 1994, Zoology), with Prof. **Gary McCracken**.



*Naturalists Club member **Cassie Overdorf** with her monarch butterfly friend in Cades Cove.*

This year, club members have plugged into our local, rich natural history with help from the Great Smoky Mountains Institute at Tremont (GSMIT). GSMIT President and CEO Jen Jones met with the club in September and piqued their curiosity in the naturalist opportunities available in the park. She invited club members to assist with monarch butterfly tagging during their fall migration.

GSMIT Citizen Science Coordinator Tiffany Beachy (MS 2008, Wildlife and Fisheries Science) met with club members in Cades Cove on a beautiful sunny morning in mid-October. Students received a brief lesson on monarch butterfly biology and netting techniques. Plenty of butterflies were netted and observed, including gulf fritillaries and Dianna fritillaries; but the star was a single monarch butterfly, which was caught, tagged, and released to continue its southerly journey.

Club members are clamoring for bird-watching outings, winter hikes, and involvement with the annual Spring Wildflower Pilgrimage in Great Smoky Mountains National Park. Kwit looks forward to assisting and promoting the club's interests in observing and appreciating the natural beauty of East Tennessee and beyond. In the coming year, watch for the establishment of a gift account in the club's name. To keep up with club news and highlights, follow us on Twitter **@UTKNaturalists**.

Growing Up (or Not)

Undergraduate Research: Christian Yarber

I am fortunate to have had many research opportunities in EEB. I have worked on topics ranging from social learning in garter snakes (Burghardt Lab) to anti-predator behavior in anoles (Echternacht Lab), but my current research is more computational. I began working with Assoc. Prof. **Brian O'Meara** last summer, after taking his macroevolution course. The O'Meara Lab creates and applies phylogenetic methods to answer macroevolutionary questions, which can be applied to almost any system or organism. Under his mentorship, I am completing my honors research thesis on how paedomorphism affects the evolutionary trajectory of different salamander species.

Paedomorphism is the retention of juvenile traits, such as gills and fin-like tails, in a sexually mature individual. Some species of salamander show only one adult form; either all individuals of the species transition to land, or all individuals retain juvenile characteristics. Other species display both adult forms, sometimes within the same population, depending on environmental conditions. My project focuses on how paedomorphism affects how salamanders have evolved. I wanted to know how keeping certain juvenile traits might influence extinction and origination rates and if these might be used to describe diversity patterns we see in the present.

*Both images show sexually mature barred tiger salamanders (*Ambystoma mavortium*): a paedomorphic individual (top) and a fully-developed terrestrial adult (bottom).*

In order to address this question, we compiled life history data for each of the 450+ described salamander species from online databases. Next, we mapped each of these species-trait pairs onto an evolutionary tree from the literature. We then provided our data to a series of mathematical models designed to estimate speciation, extinction, and transition rates between paedomorphic and non-paedomorphic states. One of the models, HiSSE, was co-developed by O'Meara here at UT. I hope to publish my results before starting grad school in the fall.

Beneath the Mistletoe

Graduate Research: Kathryn Massana

Biologists are interested in biodiversity and how it is distributed through space and time. Why do we find species in certain habitats? Does it depend on the geologic history of Earth, the dispersal ability of the organism, species interactions, or something else? Models in biogeography are often used to answer these types of questions.

Kathryn Massana (O'Meara Lab) has improved the dispersal-extinction-cladogenesis (DEC) model, a leading approach for assessing biogeography questions. Her new model, DEC*, yields better model fit and model adequacy, and it infers better speciation and extinction parameter estimates. She presented her research as an invited speaker at the Evolution 2015 Conference, in Brazil.

Massana is also working on a biogeography model that is more suitable for biological systems, by incorporating factors like dispersal agent, vegetation type, and landscape data. Her model is based on her NSF-funded research on the ecological factors affecting the distribution of New Zealand mistletoes. She considered their dependence on other organisms (through reliance on parasitic associations with trees and on birds to disperse seeds) and accounted for how the shape of the landscape affects their dispersal. Her work has implications on climate change biology (i.e., how dependence on dispersal agents affects extinction risk) and conservation biology (i.e., how invasive species affect the presence of mistletoes).

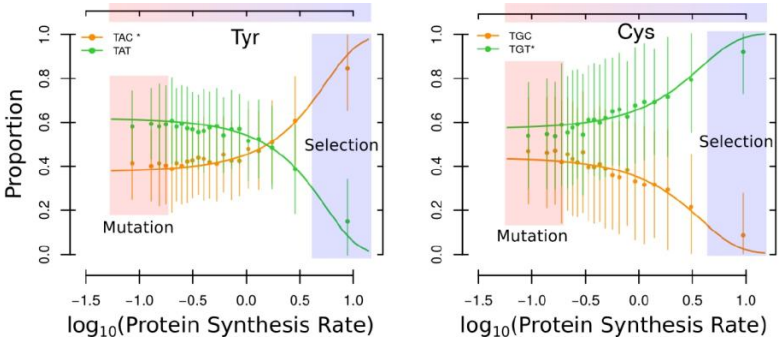
Katie Massana helps collect seahorses in Diamond Harbor, New Zealand, after collecting mistletoes in the area.

Massana studies how parasitism influences the evolutionary history of parasitic flowering plants. Her preliminary work shows that plants that are completely parasitic tend to be less diverse than plants that are not completely parasitic. In the future, she seeks to evaluate specific traits associated with parasitism, such as morphology, trophic mode, and degree of parasitism.

Mining the Genome

Faculty Research: Assoc. Prof. Mike Gilchrist

One of the main challenges facing biologists is determining how to extract meaningful information from the current flood of genomic data. The Gilchrist Lab approaches this problem by fitting mathematical models to the protein coding regions of a genome. The models span multiple biological scales, and fitting them to the data requires the use of high-performance computing. The results are estimates of biologically important parameters, such as biases in the rates of mutations between nucleotides, differences in translational efficiencies of protein assembly, and estimates of a gene's average expression level.



The frequency of synonymous codons for two amino acids, tyrosine (Tyr) and cystine (Cys), changes with the rate of protein synthesis. Codon use in genes with low expression levels tends to be driven by mutation bias, while codon use in genes with high expression levels tends to be driven by selection for the more efficient codon.

Gilchrist and colleagues have recently demonstrated that their estimates of gene expression are of equivalent quality to those generated in a wet lab. Until now, gene expression information could only be generated for the few microorganisms that can be cultured in a lab. This new approach opens the door for accessing such information for any sequenced organism. Because the degree of expression of a gene provides an indication of the importance of that gene, the ability to estimate gene expression from sequence data allows biologists to make inferences about the biology of unculturable microorganisms. In addition, the model provides more precise information on mutation bias and translational efficiency than wet lab techniques, thus illuminating how basic cellular machinery varies between species. Says Gilchrist, "One important insight from our work is that mutation bias can be more important than coding efficiency in determining which codons are used, even in genes with very high expression levels."

Graduate student **Cedric Landerer** has demonstrated that one can identify blocks of DNA that were transferred horizontally from one species of yeast to another. In the future, the Gilchrist Lab hopes to expand this approach so that it can be used to improve the categorization of metagenomic data (DNA sequences from multiple species mixed together within a sample) into their correct taxonomic groupings.

Flutter by, Butterfly

Faculty Research: Assoc. Prof. James Fordyce

Tropical rainforests are home to an exceptional diversity of plants and animals, especially insects. Although their diversity is high, their abundance is low, so characterizing and describing patterns of distribution and abundance of tropical insects requires long-term studies.

James Fordyce and colleagues have begun to characterize communities of fruit-feeding butterflies in the rainforests of Central and South America. Because their primary adult food resource is the juices of rotting fruit, these butterflies are relatively easy to trap. Fermented banana traps are placed in understory and canopy habitats, and they open the first week of each month. The current study in Costa Rica exceeds 14 years. New species have been recorded as late as 13 years into the study.

There is very little overlap in species composition between the canopy and the understory, with more than 95% of species found almost exclusively in one of the two habitats. Species turnover, the change in community composition from one trap site to the next, is much higher in the canopy compared to the understory. This pattern is observed both spatially and temporally. These results are consistently observed in Costa Rica, Ecuador, and Peru.

Higher turnover in the canopy becomes exaggerated in forest fragments. A trap study conducted over five years in "islands" of forest surrounded by banana plantations showed much higher turnover in canopy communities, compared to canopy communities in intact forests. Understory communities in forest fragments showed much lower turnover compared to those in intact forest. These results show how communities occupying different habitats are differentially affected by forest fragmentation.

Fordyce with Morpho achilles *in Argentina.*

This work led to the development of a sampling theory for tropical butterfly diversity. Last summer, Fordyce and colleagues participated in a working group in Peru, sponsored by Conservation International. They wrote a detailed sampling protocol to be used for rapid biological assessments. This chapter will be part of a book that will promote standardized sampling protocols for conservation organizations around the world.

On the Move

Faculty Research: Prof. Paul Armsworth

As the impacts of climate change reveal themselves, species and ecosystems are moving in response. This poses a fundamental challenge to conservation organizations: how do you conserve something that won't stay still?

Paul Armsworth is lead author on a paper in *Frontiers in Ecology and the Environment* which suggests that in order to cope, conservation organizations need to adapt like the organisms they seek to protect. As the climate warms and other global changes progress, species move outside their historical ranges, new ecological communities form, and ecosystems transition to new states. Scientists predict that these changes will accelerate in the future. "Organizations that are focused on conserving particular species in a particular place either need to change their business model or revisit their conservation priorities," said Armsworth.

Little Nutten Hook, an area protected by Scenic Hudson while planning for future sea level rise. Photo by Robert Rodriquez Jr.

The paper puts forward a number of new ideas for how conservation organizations might address the challenges they are facing. It also highlights success stories. For example, Scenic Hudson, an environmental and land conservation group in New York State, changed the way it prioritizes parts of the landscape for protection to better incorporate a changing climate, especially the impacts of sea-level rise. Sacha Spector, their director of conservation science, said, "Now when prioritizing sites for protection, we also look to acquire areas upslope, to open up the possibility for the habitats we are targeting to migrate as the climate changes."

Armsworth's research group specializes in developing new conservation planning tools to help organizations like Scenic Hudson design and target their conservation efforts. With the new paper, these EEB researchers are helping conservation groups ready themselves for the large changes to biodiversity and ecosystems that are coming.

Outreach: KidsU

EEB's graduate student group, GREBE, is active in outreach to the broader community, and one important role that EEB graduate students play is in the instruction of KidsU summer camps. In 2015, EEB graduate students taught and led three KidsU courses.

Jenn Bosco and **Angela Chuang** taught Animal Behavior for Grades 7-9. This class dove headfirst into topics such as foraging, competition, mating and courtship, and anti-predator behavior. Students imitated bats and moths to learn about foraging behavior and took on the roles of *Uta* lizards to learn about frequency-dependent selection in a classic system. On a fieldtrip to Ijams Nature Center, EEB postdoc **Ben Crain** taught students about the behavior of local birds.

Jess Welch and **Orlando Schwery** taught Vertebrate Zoology for Grades 4-7. Students compared skulls of various mammals, mastered herpetology through bingo, learned about taxonomy while classifying fish, and made connections between form and function while studying the morphology and natural history of birds. This class included fieldtrips to Ijams Nature Center and the Knoxville Zoo.

Evin Carter and **Todd Pierson** worked with Lindsey Hayter to teach Snakes Alive! Hands-On Herpetology for Grades 4-7. This course used preserved specimens to teach students how to identify amphibians and reptiles. With the help of Prof. **Sandy Echternacht**, they also used live animals to demonstrate interesting behaviors. A behind-the-scenes trip to the

Vertebrate Zoology students on a fieldtrip to the Knoxville Zoo.

Knoxville Zoo provided lessons about captive breeding and conservation. A trip to Ijams Nature Center let students observe amphibians and reptiles in the wild, including several box turtles (*Terrapene carolina*) tromping through the forest and gray treefrogs (*Hyla chrysoscelis*) sleeping in vegetation next to Lotus Pond.

KidsU is a great opportunity to actively engage the Knoxville community, and EEB grad student participation helps raise funds for GREBE travel awards. We look forward to teaching again in 2016!

Departmental News

EEB is entering an exciting period of development and growth under our new department head, **Susan Kalisz**. Searches are currently underway for **four** tenure-track faculty members and a greenhouse manager, to start in Fall 2016. It's a great time to be in EEB!

Congratulations!

Paul Armsworth, **Randy Small**, and **Joe Williams** were promoted from associate to full professor. **Brian O'Meara** was promoted from assistant to associate professor.

In Fall 2016, **Nina Fefferman** will join the EEB faculty as an associate professor (from Rutgers), and **Kimberly Sheldon** will join us as an assistant professor.

Prof. **Paul Armsworth** was awarded UT's Cox Professorship in July and received the UT Alumni Association's Outstanding Teacher Award in May.

Assoc. Prof. **Brian O'Meara** recently received an NSF Career Award, for a project that combines phylogenetic research and education. He also received an NSF Advances in Biological Informatics Development grant last spring.

Assoc. Prof. **Beth Schussler** received a 5-year NSF Research Coordination Network-Undergraduate Biology Education (RCN-UBE) award to create a national network of GTA (graduate teaching assistant) educators.

PhD students **Jordan Bush** (Simberloff Lab) and **Todd Pierson** (Fitzpatrick Lab) received NSF Graduate Research Fellowship Program (GRFP) awards. These prestigious fellowships provide students with three years of graduate school funding.

PhD student **Brian Looney** (Matheny Lab) has been awarded a US Department of Energy, Office of Science Graduate Student Research Award. He also received an NSF Doctoral Dissertation Improvement Grant (DDIG).

In 2014-15, EEB had 31 BS, 2 MS, and 3 PhD students finish their degrees. Congratulations to you all!

Master's Degrees: **Courteny Gorman**; **Shelby Ward**.

Doctorate Degrees: **Riley Bernard** (postdoc in Forestry, Wildlife, and Fisheries at UT); **Joshua Birkebak** (lab manager at ORNL); **Austin Milt** (postdoc at U. Wisconsin).

Alumni Focus

Jonathan Pruitt (PhD 2010)

Jonathan Pruitt is one of Popular Science *magazine's "Brilliant 10" of 2015, highlighting the top ten researchers in science, engineering, mathematics, and medicine under 40. He is an assistant professor at UC Santa Barbara.*

My training at UT started as an accident. I wanted to study territorial behavior of some kind in graduate school, and my undergraduate experiences had been in herpetology. I decided to work with **Susan Riechert** after a 30-minute meeting in her office. She outlined a recently discovered behaviorally polymorphic spider system, where within a single species individual spiders could exhibit either an asocial (aggressive towards conspecifics) or social (tolerant of conspecifics) behavioral tendency. Social individuals tended to be found in groups. Susan further conveyed that groups could also be composed of a mixture of types. I saw the potential for this system to answer long-standing questions in social evolution and frequency-dependent selection. Susan's descriptions during that first meeting formed the foundation of my dissertation and subsequent career. I still visit Knoxville every summer to conduct studies on group selection and societal collapse using these spiders.

I constructed a dream-team of academic advisers and collaborators at UT. **Ben Fitzpatrick** and **Jim Fordyce** were relatively new junior faculty with an open-door policy that I exploited on a (very) daily basis. If they ever close their office doors today, you can thank me. **Gordon Burghardt**, **Christine Boake**, and **Todd Freeberg** together were a behavioral ecology juggernaut with Riechert at the helm. With the friendship of other graduate students, graduate school (in retrospect) was a very pleasant experience.

I attribute my career success to the sense of community in EEB. It was never difficult to schedule a meeting with any faculty member, however famous. One could crash virtually any lab meeting or reading group upon request, and feel welcomed. Most importantly, one could depend on self-organized jaunts off-campus (e.g., The Sunspot, The Public House) after every Friday seminar, comprehensive exam, or defense. I've observed the cultures of a reasonably large number of ecology and evolution groups across the United States and Europe. There are few of them as collaborative, carefree, and inviting as UT's. I think people are better thinkers when they're happy. If it takes a village to raise a child, then it takes a department to inspire a successful career in academic biology. Thank you, EEB!

Giving Opportunities

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

Ecology and Evolutionary Biology Enrichment Fund

This fund 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:

To contribute online,
please visit **eeb.bio.utk.edu**
Near the bottom of the webpage, click

Contribute to a big idea. Give to EEB.

The EEB Enrichment Fund is selected by default. To give to other EEB funds, select "Other," and indicate the name of the fund.

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 mail a contribution to EEB, please make your check payable to The UT Foundation, and indicate the fund to which you would like to contribute on the memo line.

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For feedback or questions about the newsletter, please email us at **eebnews@utk.edu**

eeb.bio.utk.edu

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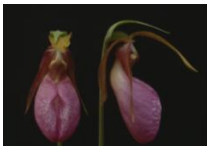
Wildflower Notecards

EEB has worked with retired botany professor Alan S. Heilman to develop a set of eight wildflower notecards. Each card features one wildflower native to Tennessee. The prices include shipping and handling within the US: $13 for one set, $24 for two sets, and $35 for three sets. Please visit **eeb.bio.utk.edu/wildflower-notecards** for information on how to purchase these notecards. All proceeds go to the EEB Enrichment Fund.










Celebrating our native biodiversity, these photos were taken in the Great Smoky Mountains National Park or along the Blue Ridge Parkway.

All photos are from The Botanical Photography of Alan S. Heilman, © Alan S. Heilman, © The University of Tennessee Libraries, 2011.

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