THE UNIVERSITY OF MICHIGAN
DEPARTMENT OF ECOLOGY AND EVOLUTIONARY BIOLOGY

NATURAL SELECTIONS

VOLUME 6 NUMBER 2 SPRING 2009

Early Career Scientists Symposium 2009:

Using Phylogenies in Ecology

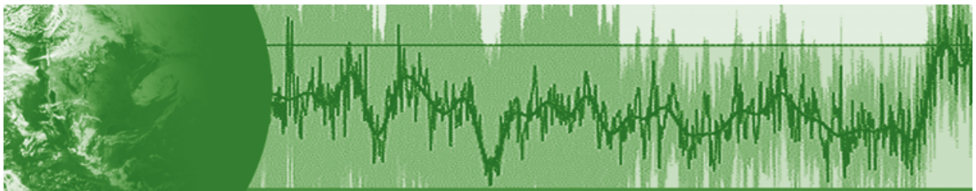
ANN ARBOR – How does the evolutionary history of a species influence its interaction with other species? What are the mechanisms of such influences and how does ecological context influence further evolution? What are the consequences of the feedback between ecology and evolution for community structure and dynamics?

The fifth Early Career Scientists Symposium on March 14, 2009, examined how phylogenies have been integrated into the field of ecology, providing an evolutionary perspective on the origin and maintenance of ecological communities. Symposium participants addressed a range of questions using systems from across the Tree of Life.

ECSS showcases the work of researchers who are just getting started, from finishing graduate students to first or second year assistant professors. Nine outstanding scientists were selected to present their research. The speakers traveled from as far away as the Xishuangbanna Tropical Botanical Garden in Kunming, China and the Universitat Autònoma de Barcelona, Spain. Over 130 individuals registered for the event.

"It was a wonderful opportunity to see the great diversity of approaches being used to understand how evolutionary history structures communities," said Professor Deborah E. Goldberg, EEB chair and a co-organizer along with Professor Christopher Dick and graduate students Celia Churchill and Brian Sedio.

For more information: http://sitemaker.umich.edu/ecss2009/home



EEB's multi-faceted climate change research

Global warming – more inclusively "climate change" – has become a household term that conjures up images of thunderous calving glaciers and starving polar bears stranded on icebergs. Myriad other climate change consequences are occurring from pole to pole across our great planet from below ground environments to changes in the upper reaches of our atmosphere.

In U-M's EEB department, you don't have to look far to find professors and students diligently studying the effects of climate change on everything from epidemic disease to carbon storage in terrestrial and aquatic ecosystems, to the shifting ranges of mammals in northern Michigan.

Knute Nadelhoffer

George Kling

Let's begin our journey at the top of the world in the Arctic where Professors Knute Nadelhoffer and George Kling study the effects of climate change on carbon balances in tundra ecosystems. Releases of carbon dioxide (CO_2) and methane (CH_4) from decomposing peat in the far north can add significantly to the greenhouse gas content of the atmosphere.

"Soils store about twice as much carbon as vegetation, so a lot of my work is focused on soil processes," said Nadelhoffer. Soils and vegetation together store about three times as much carbon as exists in the atmosphere as CO_2. "Understanding the biology of what retains and stores carbon in plants or soils or what causes the carbon to be respired into the atmosphere as CO_2 or CH_4 is key to understanding how terrestrial ecosystems interact with the climate system."

The Arctic tundra where they work is north of the "tree line" and is mostly covered in knee-high grasses, herbs and shrubs. Most of the carbon is stored in peat, a rich organic soil, which ranges from meters to hundreds of meters deep. Much of the peat has been accumulating for some 12,000 years, slowly removing carbon from the atmosphere in the process.

"Now that the climate is warming in the Arctic, we need to know whether the peat is going to continue to form or whether it's going to decompose faster than it forms as climate warms," Nadelhoffer said. "To the extent that the soil gets warmer and drier, we expect that the peat will decompose faster." Cold, wet conditions slow the decomposition of Arctic soil.

Nadelhoffer and Kling inserted a low-energy radioactive isotopic label (^{14}C or "carbon-14"), into the peat so they could measure how carbon cycles through peat and how it's held or released into the atmosphere. They are currently analyzing a massive data set and publishing papers to provide insights into how arctic peat changes under different experimental situations.

"Soils store about twice as much carbon as vegetation, so a lot of my work is focused on soil processes."

"There's a big uncertainty as the summers lengthen and warm, whether that balance may be tipped, whether

see climate, page 3

chair's notes

Deborah E. Goldberg
Elzada U. Clover Collegiate Professor and Chair, Ecology and Evolutionary Biology

Dear Friends,

I start this letter on a somber note: David Bay, the "photographer-at-large" for EEB and its predecessor departments for 34 years, died on February 21 at the too, too early age of 60. David was known and loved by many faculty and students in biology for over 34 years and we miss him every day. He was one of the kindest, most generous people I know and could always make any of us laugh and feel the joy of life (as in the picture he took accompanying this article). We had a wonderful celebration of his life on February 28 at the Matthaei Botanical Gardens. Well over 100 people attended and his brother, Allen Bay, said it best for all of us: "we love the photographs, but we *really* love the photographer." David's wife, Susan Campbell, whom many of you may remember from her days as the business manager of the Biology Department in the 1980s, has established a fund in EEB in memory of David to support the photographic and graphic needs of our graduate students. For those of you who would like to contribute, details are on page 6, along with more about David.

On a happier note, it always gives me great pleasure to talk about the accomplishments of our wonderful faculty, students, and staff. This year, Jianzhi (George) Zhang and Paul Dunlap were both promoted to full professor in EEB. And two faculty with "dry appointments" in EEB were tenured and promoted to associate professor: Noah Rosenberg of the Department of Human Genetics and Johannes Foufopoulos in the School of Natural Resources and Environment. Our newest Collegiate Professor is George Kling, who has named his professorship after the distinguished limnologist Robert Wetzel. Dr. Wetzel was on our faculty in the 1990s and, sadly, died in 2005. John Vandermeer became our first Distinguished University Professor and will name his professorship after Asa Gray, one of the founders of North American botany, who was the first professor appointed to the University of Michigan Ann Arbor campus in 1838. John also won the Imes and Moore Faculty Award for exceptional contributions toward recruiting and mentoring graduate students in the natural sciences who come from disadvantaged and non-traditional backgrounds. Trisha Wittkopp won the 2010 Russel Award, which is the highest honor given to junior faculty at U-M and rewards stellar scholarship combined with outstanding teaching. Phil Myers won a Provost's Teaching Innovation Award for his work on the Animal Diversity Web (animaldiversity.ummz.umich.edu) and Ryan Bebej won an outstanding Graduate Student Instructor Award. Our new Frontiers Master's Program (see our last issue) won a Distinguished Diversity Leaders Award and Jim LeMoine, lab manager of Knute Nadelhoffer, won an Outstanding Research Mentor Award. Finally, Chris Psujek, currently student administration manager of the undergraduate Program in Biology, won the Kay Beattie Distinguished Staff Award—the most prestigious staff award in LSA. Many of you will remember Chris, who has worked with undergraduates in biology since 1983.

In research news, we decided to focus on research on carbon dioxide and climate change by EEB faculty in this issue of Natural Selections. Besides the five faculty we had room to include in the cover article, many other faculty incorporate this most important topic into their research and teaching. For example, Mark Hunter and his students and our newest faculty member, Jeri Parrent, both look at different aspects of how increasing CO_2 influences symbioses between plants and fungi. Chris Dick and his students examine changes in historical tropical tree distributions using molecular phylogeographic methods and use those results to predict future changes in distributions with climate change. Earl Werner and his students use long-term data on amphibian distributions at the ES George Reserve to relate population dynamics to climate. And (when I'm not being an administrator!), I work with an international group conducting experiments on climate change effects on alpine vegetation in Norway. Knute Nadelhoffer, whose Arctic research is included in the feature article, also studies temperate forests to understand how biological and physical processes interact to determine when forests are a sink for atmospheric carbon.

Finally, I want to thank you all for your continuing generosity to the department and let you know about a new opportunity (yes, I know, the Capital Campaign has ended, but our needs continue). President Coleman has established a new 1:2 match for contributions to international travel and learning by undergraduates. Because so many of our faculty conduct field research around the world, this is a tremendous chance to help our students get experience working with those faculty in places such as Peru, Cameroon, Madagascar, Mexico, Norway and many other exciting locations. EEB's fund for undergraduate international travel is off to a great start thanks to an exceptionally generous gift from one of our 1961 graduates in zoology.

Have a wonderful summer and I look forward to hearing from you.

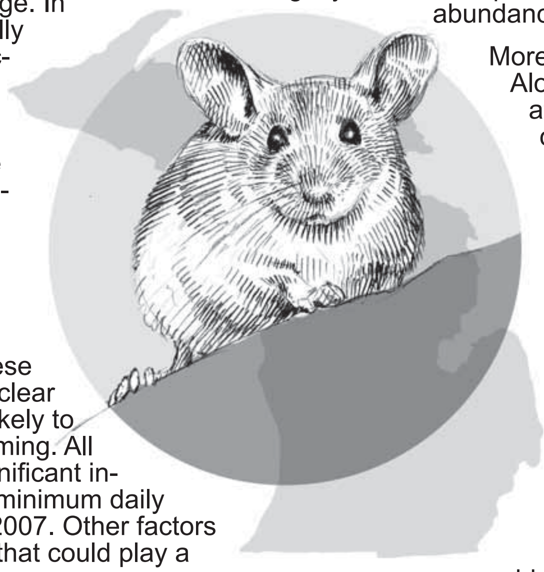
climate change

climate from cover

respiration may be stimulated more than photosynthesis," Nadelhoffer explained.

Most of Kling's research focuses on land-water interactions, asking many of the same questions that Nadelhoffer asks, except with a focus on aquatic systems. Lakes were thought to be carbon neutral until Kling demonstrated that lakes actually release more $C0_2$ into the atmosphere than they take in.

Using museum specimens and notes and data from live trapping over the last 30 years, Professor Phil Myers has documented the rapid expansion of the ranges of some small mammal species northward in the northern Great Lakes region, apparently in response to climate change. In the process, these historically southern species are replacing their northern counterparts. White-footed mice and southern flying squirrels, for example, have extended their ranges northward over 225 kilometers in the last 29 years.



The various species Myers studies make up the majority of forest-dwelling small mammals in the region. These shifting ranges represent a clear example of change that is likely to be caused by climactic warming. All 16 UP sites studied had significant increases in average annual minimum daily temperatures from 1970 – 2007. Other factors considered by researchers that could play a role in the population changes were regeneration of forests following the logging and fires of the late 1800s – early 1900s and changes in the human population. However, neither of these explanations appears to be as influential as climate change.

"When you read about changes in flora and fauna related to climatic warming, most of what you read is either predictive—they're talking about things that are going to happen in the future—or it's restricted to single species living in extreme or remote environments, like polar bears in the Arctic," said Myers, "but this study documents things that are happening right now, here at home."

According to Myers, whose paper was published in the June issue of the journal *Global Change Biology*, "We're talking about the commonest mammals there, mammals that have considerable ecological impact. They disperse seeds, they eat seeds, they eat the insects that kill trees, they disperse the fungus that grows in tree roots that is necessary for trees to grow, and they're the prey base for a huge number of carnivorous birds, mammals and snakes. At present, we know too little about the natural history of species in the northern Great Lakes and about the dynamics of the communities in which they live to predict the long-term effects of these fundamental changes in mammal fauna. Whatever their future consequences, however, they suggest that warming-induced biotic change is already well underway across a broad region of North America."

Crossing over the Atlantic Ocean, halfway around the globe, Professor Mercedes Pascual has been analyzing the effects of climate change on malaria in the East African highlands with her former postdoctoral fellow, David Alonso, who is now at the University of Gronigen in The Netherlands. In previous work, Pascual and collaborators analyzed temperature data for the highlands and found a slight upward trend of half a degree from 1950 - 2002. This research also showed that these slightly warmer temperatures can increase abundance of mosquitoes.

More recently, Pascual and Alonso began looking at the effect of increased temperatures on malaria disease levels. Most climate change models of disease look toward future scenarios; Pascual's is looking to the recent past to see whether climate change has already had an effect.

A long-term series of monthly hospital malaria records was available for one location in the Kenyan highlands. They found very few cases in the 1970s, some increase in the 1980s, and much larger epidemics in the 1990s.

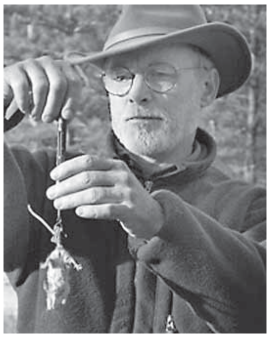
"There seems to be a change in the mean and size of epidemic, in terms of the number of cases," Pascual said. "We were interested in quantifying whether the small increase in temperature could account for the increase in cases."

The researchers have created a model for malaria transmission that takes their data on mosquito abundance and gives implications for the levels of infection in the humans.

"When there is warming in the model, the size of the epidemic tends to be much larger," Pascual said. She noted that although temperature can explain a significant amount of the change, it does not necessarily explain all. Other factors that can contribute to changes in disease patterns are drug resistance, immigration, land use changes and more.

The research is focused on the highlands because these regions are on the edge of the distribution of the disease. In other words, temperatures cool in the higher altitudes as you go up the mountains and at a certain point, sufficient mosquitoes can't be sustained to transmit

see climate page 7



Phil Myers

"When there is warming in the model, the size of the epidemic tends to be much larger."

Glaciers, goldenrods and the Great Lakes

Imagine a massive sheet of ice a mile high covering much of the northern hemisphere, essentially wiping out all life in its wake. At the height of the last Ice Age, which ended some 18,000 years ago, this was the forbidding scene over much of North America and Eurasia. What had to happen, after an event so colossal, to bring us to where we are today with the richness of species around us? Have you ever wondered how the wide variety of plants that we see every day arrived here?

Jess Peirson

EEB Ph.D. candidate Jess Peirson ponders that question daily. Broadly stated, he is studying how plants responded to glaciation and past climatic change. As an undergraduate student, Peirson studied floristics in southern Ohio fens (wetlands supplied by calcium-rich groundwater). The vegetation there is similar to areas much farther north and is thought to be similar to the landscape during early post-glacial times.

"That's what initially started my thinking about glaciation, how plants moved, and plant geography," Peirson recalls. Now, the Great Lakes region (GLR) and its endemic flora (plants restricted to the region) are his model systems.

The glacial history of the region has provided a geologically dynamic system to study. The immense weight of the ice sheet carved great basins into the land surface and depressed the Earth's crust. Since glacial retreat, drainage outlets and lake levels have changed tremendously, creating a mosaic of current and former water bodies. The resulting 16,000 kilometers of shoreline and the other unique, post-glacial habitats in the GLR are home to many of the region's rare and endemic plants.

"It's important to figure out what's there and what we need to protect."

Peirson's research is focused on goldenrods, in particular the *Solidago simplex* species complex. Plants in this group tolerate extremely harsh environments. In the GLR, different varieties have adapted to distinct shoreline habitats like sand dunes and limestone outcrops. Some distinctive populations with an inland distribution are found only in the dry, acidic sands of northern Michigan's jack pine barrens.

All of these different populations are included within a very broadly defined *S. simplex* in the current taxonomy because of their overall physical similarity, but this may not reflect their evolutionary history or current biology.

"From a conservation perspective, this is potentially problematic. When plants are erroneously lumped together, it obscures the real patterns of plant diversity and abundance," he explained. "In the GLR, some of the more charismatic endemic plants are listed as federally endangered and protected under the Endangered Species Act. Because *S. simplex* has been so broadly defined, it appears widespread throughout the region. If these plants are actually several different entities, then they are not nearly as widespread as they appear to be and may deserve protection.

"It's important to figure out what's there, and what we need to protect," Peirson said.

After analyzing data from U-M Herbarium specimens, Peirson realized that in addition to being adapted to different habitats, plants in the GLR appeared to flower and fruit at different times. In order to compare herbarium results to those from the field, he tracked flowering in wild sand dune and jack pine barren populations in northern Michigan.

"I'd leave at six in the morning and I'd get back around eight or nine in the evening," he remembers of his weekly excursions. "I listened to a lot of NPR."

Results from the field confirmed herbarium data results. Plants in the two habitats had completely different reproductive phenologies.

Peirson also examined flowering in plants grown in a common garden at the U-M Matthaei Botanical Garden. This helped identify whether differences in the plants were genetically based versus plastic responses to their environment. Even after several years of growing alongside each other, the differences not only persisted but in some cases became more pronounced in the garden.

To place this regional diversity in a broader context, Peirson has been working on the phylogeography of the species complex across its entire North American distribution. This will help him answer questions about how the species diverged into the different recognized varieties. Did an ancestral *S. simplex* migrate into the region and then diversify into the different habitats? Or was it more complex – did already differentiated plants migrate in from different refugia?

To address these questions, he's collected specimens from across North America, from western Canada to southern Arizona and from the southern Appalachian Mountains to New Brunswick.

"I've probably driven over 30,000 miles," Peirson said. "I think that's the best part, doing the field work."

Peirson has studied the plants' migration patterns through chloroplast DNA markers that are transmitted through the seeds. Based on his findings from 375 individuals, he believes there were at least two migrations of *S. simplex* into the GLR. It is hard to say definitively from where because of the lack of fossil

see glaciers, page 7

faculty profile

Fungal ecologist investigates amphibian declines

Professor Timothy James' laboratory is investigating the population genetics and genomics of a fungal pathogen that goes by the nickname *Bd*—currently number one on "the most wanted list" for frog and salamander lovers. *Bd* is charged with causing a disease called chytridiomycosis, which played a central role in the extinction of several species of amphibians, and continues to wreak havoc. Enter the North American bullfrog, alias *Rana catesbeiana*, and you may have found *Bd*'s partner in crime. Another suspect goes by the name *Xenopus*, a genus of frogs from Sub-Saharan Africa also known as "strange foot."

"Amphibian disease is an extremely important problem that requires immediate action to understand where the disease came from and how it spreads," said James, who joined the EEB ranks in January 2009 as a result of the search for a fungal biologist. Once the disease is better understood, steps can be taken to conserve amphibians.

Batrachochytrium dendrobatidis (*Bd*) is in the phylum Chytridiomycota. Almost all fungal spores disperse through the air; what distinguishes chytrid spores is that they swim, an ancestral trait as seen in protozoa. In fact, up until the 1990s, chytrid were considered protozoa, but as a result of further study, they have been reclassified as true fungi.

Amphibian disease caused by *Bd* wasn't specifically noticed until 1998 and has since spread globally at a breakneck pace. James is part of a large collaborative research effort looking at the North American bullfrog, which has been relatively resistant to the chytridiomycosis and is an invasive species in Asia, South America and western North America. The researchers are taking multiple strains of the fungus from around the world to characterize their genetics. The complete genome sequences of two strains of the fungus are already available. Using DNA markers, they are trying to understand the population genetics of the disease. Are bullfrogs a source population? Are they spreading the disease? The most likely vector is something that can catch the disease, be relatively resistant to it, and carry the disease into a novel habitat and infect other species.

Another suspect goes by the name Xenopus, a genus of frogs from Sub-Saharan Africa, also known as "strange foot."

"We believe that the bullfrog could be a carrier of the chytrid," James said. "It can't explain the entire distribution of the disease because the bullfrog is not in Australia or South Africa, but we know the disease is there."

James believes that mass importation and exportation of amphibians has contributed to the disease's ubiquity and rapid spread. The disease grows on amphibian skin so it spreads relatively easily by contact, such as when frogs mate. Amphibians breathe through their porous skin, which could help explain the disease's dire consequences. Additionally, global climate change has been linked to species extinctions in cloud forests in Central America, and there is some speculation that this is caused by climate-driven *Bd* epidemics.


Timothy James

"There is further speculation that as global warming continues, the pathogen can have more dramatic effects on amphibian populations due to, for example, increased crowding in amphibian populations as ephemeral ponds dry."

The other possible culprit under the microscope in James' lab is *Xenopus*, a frog that is widely exported for scientific research, aquaria, and pregnancy tests. Like the bullfrogs, *Xenopus* are resistant to the chytrid disease.

If James and his collaborators are able to explain how the disease is spreading and where it comes from, these results could have enormous implications for amphibian conservation strategies.

Another current area of research interest for James is in the evolution of mating systems in fungi. Something really fascinating happened a long time ago in the evolution of fungi that led to a phenomenon called heterokaryosis, he explains. Heterokaryosis is a mating product of fungi—a cell containing two genetically different nuclei.

"Why the nuclei of these heterokaryons don't fuse is a huge mystery," James said. "It's pretty bizarre, but at the same time, the group that evolved this nuclear separation has been highly successful, representing more than 95 percent of all known fungal species."

James is investigating the consequences of the heterokaryons, such as competition between nuclei in the same cell, also known as genomic conflict. This research leads to philosophical questions such as, what constitutes an individual in fungi? A mycelium is a

see fungi page 7

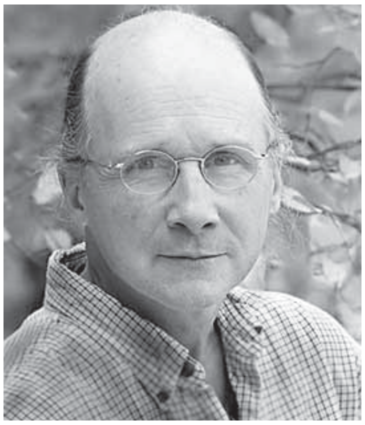
Mushroom sex and promiscuity
Did you know that mushrooms aren't male and female? They have many different mating types in a single species. Each mating type can mate with all other mating types but not with individuals of the same mating type. Potential partners communicate and attract each other by secreting small proteins called pheromones. After fusing, the mycelia (network of filaments) determine if they are compatible based on whether they have different mating types. If they are compatible, they grow together as a heterokaryon (explained in accompanying article) until they fruit and produce a mushroom and live happily ever after.

david bay

"We love the photographs, but we *really* love the photographer"

David Bay was the self-described "photographer-at-large" for 34 years for the Department of Ecology and Evolutionary Biology and its predecessor departments. He died Feb. 21 at the age of 60.

Born May 17, 1948, Bay was a fixture around the U-M campus, touching the lives of hundreds of faculty, students and staff with his expertise, humor and gift for friendship. Bay assisted with and enhanced the work of many professors, graduate students and staff with his photographic skills, keen eye for graphic design, and consulting. He expertly photographed subjects from microscopic DNA segments to his life-size colleagues.



"He was like a one-man band here at the university," his long-time friend Lee Nyboer said. Nyboer, who worked at Ford Motor Company as a photographer for 30 years, remembers the days of Bay working two enlargers simultaneously pumping out tons of black and white prints in his darkroom. Then the world turned to slides as the popular medium and Bay created and mounted thousands of them running his own Ektachrome processing line. After slides came digital photography, which has improved dramatically since its inception. "These were all huge changes in the industry requiring less and less people in the process," Nyboer said. "Dave went with the changes and he always felt that there were plenty of things for him to do here," he said.

"When I asked David, when are you going to retire, he would say, 'Well, I'm having too much fun.'"

"As a photographer, he had an uncanny ability to identify with his subjects and make them more than only appearances. As a person, he combined humor with friendship and created a bond with all those he worked with," said Professor John Vandermeer.

Bay is survived by his wife Susan Field Campbell, two sons, Spence and Joseph, four grandchildren, six siblings, and many other family and friends. Campbell met Bay at work 25 years ago. "Somewhere I went from being his "short friend Sue" to being more and eight years ago he left Ann Arbor to live with me in Ypsilanti," she said. "To paraphrase Elizabeth Barrett Browning, how do I miss thee? Let me count the ways…"

He loved Nikon cameras, riding his BMW motorcycles, working on his sailboat and sailing with family and friends. He led a Cub Scout troop and coached baseball and soccer teams for his sons. Bay pitched for a biology softball team called RunDNA in the 1980s – 90s. Teammate and former postdoctoral fellow David Wells, an associate professor at Yale University, said, "Our times on the field and the post-game at Ashley's are some of my favorite memories of that time. The world is a much duller place without David in it."

"There is nothing on campus that does NOT bring me smiles of David," said Sheila Dunn. "His scout troop painting the lines for art fair, any motorcycle, any old beat up Volvo, any especially beautiful plant, flower or frost pattern, any campus "character." It is David's free spirit and zest for life that leaves me missing my co-worker and friend every single day."

David Bay and Susan Campbell

Contributions in Bay's memory can be made to the Department of Ecology and Evolutionary Biology David Bay Photography Fund (www.eeb.lsa.umich.edu/eeb/alumni/giving.html) to support the needs of graduate students in photography and graphics.

EEB's outstanding graduate paper:

Insights into the self-promotion of invasive species

Kudos to graduate student Emily Farrer who won this year's $500 Most Outstanding Publication Award for "Litter drives ecosystem and plant community changes in cattail invasion." The paper was published in the journal *Ecological Applications*, Volume 19, Issue 2 (March 2009).

Farrer and her advisor and co-author Professor Deborah Goldberg, explored several scenarios that could cause the changes in ecosystem processes that precipitate the expansion of invasive species and the subsequent decline in native species diversity. The mechanisms of native species decline they considered were anthropogenic (the result of human activity), competition from the invader, or invader-induced environmental change. They examined applicability of each of these possibilities in three Great Lakes coastal marshes invaded by hybrid cattail (*Typha x glauca*).

Their findings suggest that litter from the hybrid cattail can cause the changes in ecosystem processes that are usually attributed to anthropogenic nutrient loading and that *T. x glauca* does not displace native species through competition for resources, but rather affects them through its litter. In addition, because *T. x glauca* plants were taller when grown with their own litter, their results suggest that this invader may change the environment in ways that benefit itself and may promote its own invasion.

climate change

climate from page 3

the disease.

"As the temperature warms, these are areas where we expect to see most of the change as the disease is able to move up the mountain," she explained.

Her research has implications for other highlands that may be experiencing this phenomenon. As Pascual described in a forum in the April 2009 issue of *Ecology*, people have historically settled in places like the East African Highlands and Ethiopia to escape disease, leading to high populations in some of those regions. Because of low past exposure to malaria, these populations haven't developed much immunity. The concern is that if climate change makes these areas more fit for mosquito breeding and pathogen development, there may be many more people getting sick and perhaps dying. Their hope is that by anticipating these changes, steps can be taken to alleviate the spread of disease.

Venturing further east, much of Professor Catherine Badgley's interests are centered in a plateau in northern Pakistan, where she has been involved in a 30-year study of fossil mammals. About eight million years ago, the region changed dramatically from humid forests and woodlands, a home to giraffes, apes, rhinos, and much more, to a monsoon grassland. Most herbivorous species became locally extinct due to the drastic change in vegetation.

What happened can be reconstructed from the chemistry and wear of the teeth of the plant-eating mammals, as well as the geological duration of each species during the period when vegetation was changing. The teeth provide evidence of the animals' diets, revealing whether they switched to eating the newly abundant grasses when their favored fruits and broad-leafed plants were no longer available.

"The work has value not only in reconstructing Earth's past, but also for understanding what may lie ahead if current climate trends continue," Badgley said. "Climate change is going to produce changes in ecological structure of all sorts of plants and animals around the world, now as in the past. The fossil record can help us understand how much—or how little—climate change is necessary to produce changes in ecosystems."

"Climate is something we still don't understand well enough to make detailed predictions, but from all the various scenarios and predictions that have been made, it looks like we're on one of the more frightening trajectories. We've got to change it," Nadelhoffer summed up.

Mercedes Pascual

Catherine Badgley

fungi from page 5

collective word for the network of filaments, or hyphae, of a fungus. The question is, is a mycelium a single individual or is it a population of individuals? Is each nucleus contained in the cells an individual?

James says his research looks at mycelia as being collective populations of nuclei, with implications for the evolution of populations, social structure and communication.

"Probably the most interesting thing will be to study how these nuclei communicate with each other and whether that is involved in determining cooperation or competition." If the nuclei are competing and behaving selfishly by over-replicating themselves, mycelia won't grow as well. If the nuclei cooperate, mycelia have a higher combined reproductive fitness.

James is curator of fungi at the University Herbarium and plans to teach Biology of Fungi this fall.

"What I like about fungi so much is that we know so little, in part because there are so few mycologists. There is a whole kingdom of organisms, probably as diverse, if not more diverse, than plants. Almost everything you do is new to science, in terms of observations that have never been made and species that have never been described."

In his free time, James plays basketball, gardens, hunts for mushrooms and home brews beer – using the yeast fungus, naturally.

glaciers from page 4

evidence, but he speculates that the plants dispersed from refugia in the Rocky Mountains and from cryptic refugia south of the glaciated region. The common hypothesis that plants generally survived in the southeastern United States and migrated north doesn't seem to be correct for the *S. simplex* species complex.

"As a general summary, it appears that these populations are highly differentiated and probably should not be called the same species," Peirson said. However, there are still many questions to answer before the plants can be reclassified. Peirson's research is on the leading edge of this effort.

Peirson's field research is complete, and he is focusing on writing his thesis. "Eventually, I would like to work as a research scientist or research curator at a museum of some type, maybe a faculty position," he said. Peirson has received a U-M Rackham Predoctoral Fellowship and a National Science Foundation Doctoral Dissertation Improvement Grant.

Researching on the shores of Michigan's lakes with the U-M Biological Station

The University of Michigan
Department of Ecology and Evolutionary Biology
Kraus Natural Science Building
830 North University
Ann Arbor, MI 48109-1048
USA

MLSA

NONPROFIT
ORGANIZATION
U.S. POSTAGE
PAID
ANN ARBOR, MI
PERMIT NO. 144

Printed on 100% recycled, post-consumer paper using vegetable-based inks. Please recycle.

Editors: Deborah Goldberg, Nancy Smith
Writer and editor: Gail Kuhnlein
Production, illustration: John Megahan