Spring 2007

Spring 2007

Features work by Naushad Ali, Shane Stadler, James Garvey, Michael Lydy, Don Sparling, Dale Vitt, Sara Baer, David Gibson, and other researchers.

PERSPECTIVES

SPRING 2007 | RESEARCH AND CREATIVE ACTIVITIES

SOUTHERN ILLINOIS UNIVERSITY CARBONDALE

THE NATURE OF ECOLOGY

Environmental Research at SIUC

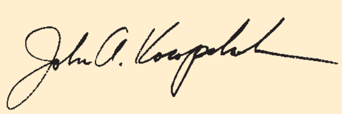
ALSO: COLD FRONT ✤ WORDSMITH ✤ SPECIAL AGENTS

Environmental research at SIUC has deep roots. They predate 1950, when the Cooperative Wildlife Research Laboratory and what is now the Fisheries and Illinois Aquaculture Center were founded, and when the University was developing Little Grassy Campus (now Touch of Nature Environmental Center), an outdoor "laboratory" for research and hands-on learning.

Perspectives has published dozens of stories related to environmental protection, from clean coal technology to water supply modeling. This theme issue takes a look at species monitoring ("Saving the Sturgeon"), habitat restoration ("Pure Prairie League"), ecosystem response to climate change ("To Have and To Hold"), and the effects of pesticides on aquatic organisms ("In Our Own Back Yards"). A bonus article ("Cold Front") concerns not ecology, but an advance in physics that has everything to do with the environment: development of an alloy for energy-saving, solid-state refrigeration.

Many of the faculty featured here are affiliated with our new Center for Ecology (**www.ecology.siu.edu**), which is off to a robust start. The center has attracted external funding for six undergraduate summer internships this year. It also has landed a $1.8-million research training grant from the National Science Foundation. This five-year project will recruit new graduate students to partner with high school teachers from local school districts. The teams will conduct environmental research during the summer at—where else?—Touch of Nature, and will work on curriculum development during the school year.

Finally, our new Middle Mississippi Wetland Research Field Station, just across the Mississippi River from Cape Girardeau, Mo., is now up and running (**fisheries.siu.edu/wetland**). SIUC is managing this 1,400-acre state-owned site for work on river floodplain ecology, management, and restoration—issues of considerable public concern.



John A. Koropchak
Vice Chancellor for Research and Graduate Dean

Southern Illinois University Carbondale

www.siuc.edu

Interim Chancellor
John M. Dunn

Vice Chancellor for Research and Graduate Dean
John A. Koropchak

Associate Vice Chancellor for Research and Director, Research Development and Administration
Prudence M. Rice

Perspectives • Spring 2007

Perspectives: Research and Creative Activities at Southern Illinois University Carbondale is published twice a year, in spring and fall, by the Office of the Vice Chancellor for Research/Office of Research Development and Administration (ORDA).

To be added to our mailing list, obtain back issues, or request permission to reprint material, contact Marilyn Davis, Editor, ORDA, Mail Code 4709, SIUC, Carbondale, IL 62901, (618) 453-4540, mdavis@siu.edu. Back issues also may be found at www.siu.edu/~perspect.

For information about the research program at SIUC, visit www.siu.edu/~ovcr, or contact John A. Koropchak, Vice Chancellor for Research and Graduate Dean, (618) 453-4551, koropcha@siu.edu, or Prudence M. Rice, Director, ORDA, (618) 453-4531, pmrice@siu.edu.

Editor: Marilyn Davis, ORDA

Contributors: Marilyn Davis, ORDA; Tim Crosby, K. C. Jaehnig, Sun Min, and Tom Woolf, University Communications; Ruth Slottag, School of Medicine

Art Direction: Jay Bruce, Univ. Communications

Designers: Jay Bruce and Shawna Moyers, Univ. Communications

Photography: Russell Bailey, Steve Buhman, and Jeff Garner, Univ. Communications, except where noted.

COVER: Two landscapes by Kay M. Pick Zivkovich, associate professor of communication design, illustrate this issue's environmental theme. Top: "Terra Firma," 2007, monotype, 7x16". Bottom: "Impressions Durables" (Lasting Impressions), 2007, monotype, 7x16". Both pieces were part of an exhibit called "Earthside" at Componere Gallery in St. Louis, Mo., in April 2007. Montage by Jay Bruce.

PERSPECTIVES

Spring 2007 | Research and Creative Activities
Southern Illinois University Carbondale

Contents

ResearchSurvey

02

Speeding Breeding • Special Agents • Wordsmith • Decision Point • Cultural Legacy • Family Recovery • Trisomy Help • Bearing Witness • Now Hear This • Kudos

FeatureStory

08

Cold Front
A newly developed alloy is more promising than any other materials to date for energy-saving refrigeration.

SpecialEcologyIssue

10

Saving the Sturgeon
An SIUC zoologist argues for better protection of the fish that nets us caviar.

In Our Own Back Yards
Pesticides called pyrethroids threaten the ecological balance of aquatic systems, but homeowners can do much to solve the problem.

To Have and To Hold
Peatlands sequester huge amounts of carbon, which gives us a vested interest in studying and preserving these ecosystems.

Pure Prairie League
Determining "best practices" for prairie restoration also helps researchers advance the field of ecology.

SPEEDING BREEDING

Crop researchers trying to produce new soybean varieties with specific qualities can do the job faster and more cheaply with help from SIUC.

Khalid Meksem, a biotechnologist with the Center for Excellence in Soybean Research, Teaching and Outreach in the College of Agricultural Sciences, has received a three-year, $500,000 grant from the U.S. Department of Agriculture's National Research Initiative to set up a center where mutant plants are bred and screened for desirable genetic changes.

Meksem and his colleagues will store both the genetic profiles and the mutant seeds for use by other scientists in the United States and abroad. The center will employ undergraduate, graduate, and postdoctoral students, training them in plant genomics.

A new technique called TILLING—"targeting induced local lesions in genomes"—makes the center's work possible. The lesions, created in soybean seeds by soaking them in a chemical that can rearrange the seeds' DNA, indicate that mutations have taken place.

While conventional breeders have used chemicals to create mutations for decades, they did not have today's high-powered scanning and imaging machines that can pinpoint the exact location of a particular mutation on a particular gene. The new technology also allows scientists to figure out exactly what the targeted genes do, making it much easier to help breeders select for particular traits when producing new varieties the old-fashioned way.

▲ **These soybean plants came from the same "parent," but they don't look much alike. Biotechnologist Khalid Meksem works with such "mutant" plants, hoping to breed new lines with helpful new traits.**

Over the next three years, the TILLING center will produce 6,000 mutant plants from each of two soybean cultivars: Williams82, the standard for this kind of research, and Forrest, a variety much used in the nation's southerly growing regions.

For the past three years Meksem's lab has been fine-tuning the TILLING procedure to make it much more efficient and reliable in producing enough mutants to work with without compromising the seeds' germination rate.

Meksem anticipates the project will provide crop researchers with 15 to 30 variants of each gene in the soybean genome over the grant period.

Research results are posted at **www.soybeantilling.org,** where scientists can search the center's collection of mutants either by gene or by physical appearance. ✚

More info: Dr. Khalid Meksem, meksemk@siu.edu.

—K. C. Jaehnig

SPECIAL AGENTS

It happens thousands of times each day on the SIUC campus. Individuals hurrying to classes converge on a sidewalk intersection. A collision appears imminent, but as they approach the intersection they each make tiny adjustments in their speed and direction and use various means to communicate their intended paths to each other. Usually, they avoid crashing into each other.

An SIUC computer science professor and his students are developing cutting-edge approaches aimed at helping machines behave in similar, cooperative ways.

Since the 1980s, Henry Hexmoor has looked for ways to translate the complex social and psychological mechanics of human behavior into the binary language that runs computers, and apply these techniques to artificial intelligence and robotics.

The work involves studying social theory and assigning numerical values to what humans would consider "emotions" or "values." Assigning values allows Hexmoor to build mathematical models that relate such concepts to machines.

"There are rules that govern human society. We mimic those in computers," Hexmoor says.

He and graduate students Kishore Thakur and Gaurav Tuli work as a team to program their robots to deal with complex problems by using human ways of thinking. They want to find ways to make multiple machines—called "agents"—work independently but cooperatively to achieve a single objective.

One such experiment, for example, replicates the sidewalk dilemma, where several robotic agents are trying to pass through roughly the same space at roughly the same time. A video of the experiment shows the robots heading toward one another from different parts of a room, but in the last seconds they manage to miss one another.

"We engineered them so that thousands of times per second they look at the situation and make changes," Hexmoor says. "In the end, they come up with a solution that's good for everyone."

Not surprisingly, the U.S. Department of Defense has long held an interest in Hexmoor's work, as it readily applies to the complex issues at work in many theaters of combat where multiple "agents" seek to identify and engage multiple "targets." It also lends itself to military operations that emphasize off-site control of remote equipment, such as Predator unmanned aircraft.

Hexmoor has received about $2 million in research grants over the years. Most recently, he received a $35,000 subcontract from the U.S. Air Force Research Laboratory to examine human control of a "community" of five robots. His students will assist him in writing the software for the project.

His work also is applicable to many peacetime pursuits. For example, he was part of a team working for NASA on "personal satellite assistants," or PSAs. The small machines are designed to fly around a spacecraft, such as the International Space Station, and "sniff" for leaks. The machines work together, communicating in order to triangulate the location of any detected leak. NASA's Ames Research Center is testing the system.

More info: Dr. Henry Hexmoor, hexmoor@siu.edu.

—Tim Crosby

▲ **Henry Hexmoor's research combines social theory with computer science to build cooperative robots. The model shown here has the capacity to learn and teach itself new problem-solving techniques.**

WORDSMITH

Rodney Jones, professor and distinguished scholar of English, has received the 2007 Kingsley Tufts Poetry Award, which carries a $100,000 purse.

The award, given by Claremont Graduate University in California, is the largest monetary prize in the nation for a mid-career poet and one of the most prestigious in the world for poetry. Presented to Jones at an April awards ceremony in Los Angeles, it recognizes his most recent book, *Salvation Blues: 100 Poems, 1985-2005,* published last year by Houghton Mifflin. Jones selected 76 of the book's poems from his earlier collections; the remaining works are new poems.

Jones was "excited, surprised, and delighted," by the recognition, he said.

"I have always written, not for money or prizes, but because I love words and imagination and the truth. I was humbled in that I knew I was lucky, that there are many wonderful poets, and that such decisions are never easy."

Never easy, but time and time again Jones has earned top honors for his talents. In past years he has won the Harper Lee Award, the National Book Critics Circle Award, the American Academy of Arts and Letters Jean Stein Award, the Academy of American Poets Lavan Younger Poets Award, and a Guggenheim Fellowship. One of his books also was a finalist for a Pulitzer Prize.

"The University has supported me and other writers in many ways: most directly, by granting time to think, to read, and to write; but less directly, by supporting the community of writers—both students and faculty—who have thrived here over the years," he said. "Writing is solitary work, but no writer exists without the support of others."

▲ **Rodney Jones.**

Jones's past collections of poetry include *Kingdom of the Instant* (2004), *Elegy for the Southern Drawl* (1999), *Things That Happen Once* (1996), *Apocalyptic Narrative* (1993), and *Transparent Gestures* (1989), all from Houghton Mifflin, as well as *The Unborn* (Atlantic Monthly, 1985) and *The Story They Told Us of Light* (Univ. of Alabama Press, 1980).

A native of Alabama, Jones earned a bachelor's degree from the University of Alabama at Tuscaloosa and a master of fine arts degree from the University of North Carolina at Greensboro. He joined the SIUC faculty in 1985.

—Sun Min

▲ Copernicus (left; played by senior Jacob Rost) meets some renowned figures of the future in *Copernicus Rising.* *Photo by Bob Holcombe.*

DECISION POINT

Student playwright Michael Rose isn't cowed by big ideas. In his latest work, astronomer Nicolas Copernicus, nearing death and unsure whether to publish his revolutionary theory of a Sun-centered planetary system, hallucinates himself into the future.

With Galileo as his guide along the space-time continuum, Copernicus learns that his work would ignite controversy and incur the wrath of the Church. He also learns that some of his scientific heirs, such as Einstein, would see their own work turned to the purposes of war.

Is one person's truth-telling worth such consequences?

That's the dilemma Rose has his main character wrestle with in the play *Copernicus Rising,* which premiered at SIUC's McLeod Theater last fall. As Copernicus asks himself, "Who am I to dare to shape the universe?"

Rose wanted his play, a historical drama infused with surreal comedy, to both entertain and educate. "Copernicus and his theories changed everything, not just science but philosophy," Rose says. "Suddenly, human beings were no longer the center of the universe, and the implications of that were huge."

Why Copernicus?

"I was doing some visualization exercises [to generate ideas] and I had a mental picture of an old man sitting in a stone tower looking at the stars," Rose says. "I didn't know who he was. I began doing reading on astronomy and that led me to Copernicus.

"There were so many aspects of his life that lent themselves to drama. He was handed his finished [book] on his deathbed."

Rose's plays have been performed in several venues. Most recently, a short play of his called *Antarctica* was staged at the regional Kennedy Center American College Theater Festival in Milwaukee in January.

He credits his peers and mentor David Rush, head of the playwriting program, for much of his success. "SIUC has made me stretch as an artist, and I've found myself working in [new] genres and styles," he says.

Rose's next big idea: to start his own theater company after he graduates this May. ◆

—Marilyn Davis

CULTURAL LEGACY

An archaeological team led by an SIUC researcher made international news late last year by uncovering the first ancient Peruvian knives ever excavated scientifically.

SIUC anthropology professor Izumi Shimada and his crew recently unearthed 22 graves approximately 1,000 years old in northern Peru. The tomb complex contained artifacts from the Sicán culture, including the first "tumi" ceremonial knives ever discovered by archaeologists rather than looted by thieves.

The discovery will enable study of the tumi, Peru's national symbol, in its original setting. "It will allow archaeologists to study the roles tumi knives played in the lives and deaths of the ancient inhabitants of Peru," says Susan Ford, chair of SIUC's anthropology department.

Shimada is the world's top expert on the culture of two ancient Peruvian peoples, the Moche and the Sicán, both of whom predated the Inca empire. The Sicán, who lived along the north coast of what is now Peru between about 800 and 1300 A.D., produced alloys of gold, silver, and arsenic-copper on an unprecedented scale in pre-Hispanic America.

Shimada's excavation of a Sicán religious and ceremonial center, begun more than 25 years ago, is the longest continuous archaeological project in South America, funded in part by such agencies as the National Science Foundation and the National Geographic Society. The project has discovered pyramids that served as tombs of the elite, and it has shed much light on the culture of the Sicán.

It also led to the founding of the Sicán National Museum in Ferreñafe. The museum's director, Carlos Elera Arevalo, codirected the new excavations with Shimada. Their work led to the recent discovery of the graves, which were "clearly from the social elite," says Shimada.

The latest finds, especially those of the tumi knives, attracted international attention last November. In December 2006, Shimada received the Distinguished Service Medal from the National Congress of Peru for his three decades of scientific contributions to Peruvian archaeology. ◆

More info: Dr. Izumi Shimada, ishimada@siu.edu, or see the Spring 2002 issue of Perspectives, www.siu.edu/~perspect/02_sp.

—Tom Woolf; Sun Min

Photo © Maurizio Granados

▲ Izumi Shimada.

FAMILY RECOVERY

With the help of a new grant, SIUC researchers have begun evaluating and improving treatment methods for methamphetamine addicts who are parents.

Shane Koch, associate professor of rehabilitation, is leading the SIUC team on the three-year project, which is funded by the U.S. Department of Health and Human Services through the Illinois Department of Children and Family Services.

DCFS received $1.5 million to help Franklin-Williamson Human Services Inc. expand outpatient treatment of adult meth users in four rural Southern Illinois counties. While Franklin-Williamson focuses on treatment, DCFS is providing services such as parenting training and home visits to help recovering addicts strengthen and preserve their families.

The SIUC team's role is to evaluate these agencies' efforts in order to improve them. What treatments and services are most effective in helping meth addicts recover? The team is using its $300,000 share of the grant to help field addiction counselors find out, by gathering and analyzing data derived from their work with the addicts.

The goals are to find proven, data-supported methods to improve treatment for addicts while narrowing the traditional gap between counselors in the field and researchers, Koch says.

"We want to develop cutting-edge treatment for parents, thereby improving the quality of life for kids," he says. "When the parents are doing meth, there are all kinds of toxicity issues, abuse, and neglect. So there are all kinds of ways this project can help individuals."

Other SIUC team members include administration of justice professor George Burruss, three doctoral students, and a postdoctoral researcher.

Meth can cause serious health problems. But Koch wants people to know that there are hopeful options for treatment.

"The bright news about meth is that people are getting better," he says. "A piece of this research we're doing is [to] demonstrate [that] meth addiction can be treated successfully." ✚

More info: Dr. Shane Koch, dskoch@siu.edu.

—Tim Crosby

TRISOMY HELP

A survey of parents whose children have an extra chromosome will generate not just facts but hope, its developer believes.

"Seven or eight years ago, if you Googled Trisomy18 (shorthand for the presence of a third chromosome on the 18th pair), all you would find would be autopsy photos," says Deborah Bruns, assistant professor of special education.

"We hope that our survey will generate data [for] both professionals and families to offset that gloom-and-doom scenario. There are children who survive, and they're doing well."

Children with trisomy disorders are severely disabled. They have cardiac, respiratory, and gastrointestinal problems, and most don't make it to their first birthday. Through extensive networking, however, Bruns found many children who defied the stereotype, some even living into their preteen years.

To help these children function as well as possible, parents need resources.

"Because doctors and other professionals saw these children as 'hopeless' cases, medical help and other interventions and services often weren't readily offered or given," Bruns says.

With some funding from several trisomy support groups, she set out to change that with the TRIS project ("tracking rare incidence syndromes"). The project's website, **www.coehs.siu.edu/tris,** offers information concerning family services, treatment options, educational assistance, and more.

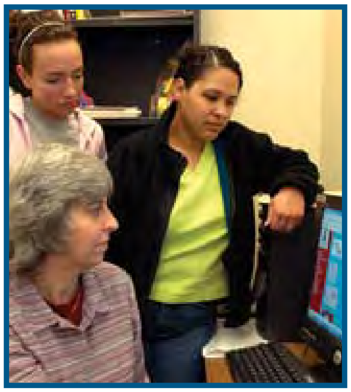
The online TRIS survey is the project's foundation, collecting information on parents' demographics, their experiences with pregnancy and birth, family relationships and support systems, medical conditions and therapeutic needs, specialists, educational programming, and developmental milestones.

That last feature should provide both help and hope to parents as survey results are analyzed and information on the website updated.

"I want to give these kids credit for what they can do," says Bruns. "If nothing else, this will let families have a truer picture of what awaits them, and it will give medical, educational, and therapeutic professionals a better understanding." ✚

More info: Dr. Deborah Bruns, dabruns@siu.edu.

—K. C. Jaehnig



Deborah Bruns and her research assistants—Emma Markshausen (left), a senior, and graduate student Evelyn Barrientos-Perkins—analyze and post data to help parents of children with trisomy disorders.

KUDOS

Geographer Benedy Dziegielewski, an internationally known expert on water resources planning, has been tapped as an adviser to the Metropolitan Water District of Southern California (MWD), one of the world's largest water suppliers. MWD provides water to 17 million people in parts of Los Angeles, Orange, San Diego, Riverside, San Bernardino, and Ventura counties. Dziegielewski is helping the district develop an overall water supply and system strategy to enable it to accurately forecast and meet water demands.

The federal Rehabilitation Services Administration, part of the U.S. Department of Education, honored the SIUC Rehabilitation Institute with its 2006 Commissioner's Award. The award recognizes innovation, collaboration, effectiveness, and distribution of curriculum materials. The institute's research and service activities include investigating treatment approaches for autism, methamphetamine addiction, traumatic brain injuries, and gambling disorders. Three rehabilitation faculty members currently edit national scholarly journals, and associate professor Carl Flowers (left) serves as president of the National Rehabilitation Association.

Obstetrics expert Donald Torry has received a five-year, $1,112,650 grant from the National Institute of Child Health and Human Development to continue his research on preeclampsia, a common obstetric complication that causes premature deliveries and can endanger the mother's life. Torry's work aims to determine how to boost expression of genes needed for blood vessel formation in the uterus, which could potentially lessen the severity of preeclampsia and allow more time for the pregnancy to continue.

Physiologist Andrzej Bartke has been awarded a five-year, $1,592,850 grant from the National Institute on Aging for his research on the genetic and nutritional control of aging. Bartke will evaluate the responses of normal mice and long-lived mutant mice to calorie restriction, which can extend life span by reducing insulin release and improving insulin sensitivity. The research could lead to the development of new therapies to protect against the effects of aging in humans.

Cultural anthropologist Jonathan Hill has been awarded a National Endowment for the Humanities fellowship to digitize hours of cassette recordings he made in the 1980s of the music and rituals of the Curripaco, an indigenous people living along a tributary of the Amazon River in Venezuela. The recordings will become part of the "Archiving Significant Collections" project at the Archives of Indigenous Languages of Latin America, housed at the University of Texas at Austin. The sound files will be posted with accompanying transcripts, translations, photographs, and notes.

David Rush, associate professor of theater and head of SIUC's playwriting program, has won first place in the 2007 Firestone Theatre New Play Contest. Rush's submission, *One Fine Day,* was selected from among hundreds of applications. The play, which was produced on campus in April, will be produced by the Stage Left Theater in Chicago.

The American Physical Society named physicist F. Bary Malik (below) the recipient of its 2007 John Wheatley Award. The biennial award honors scientists who have contributed to the development of the field in Third World countries. An expert in theoretical physics, Malik has collaborated on research projects with colleagues from Argentina, Bangladesh, India, Jordan, Pakistan, and many other countries, and he has organized countless international conferences. He was named SIUC's Outstanding Scholar in 1996.

BEARING WITNESS

Journalism faculty and students at SIUC are expanding a photodocumentary course centered on a troubled Southern Illinois river community into the multimedia realm.

Led by journalism instructor Phillip Greer, who worked more than 24 years at the *Chicago Tribune,* The Cairo Project is combining five previous semesters of student photojournalism on Cairo with student news reporting in print and online formats.

With each subsequent class, students will continue telling the town's story with words and pictures. Several faculty are assisting with the project, which aims to showcase the best student work while raising awareness of Cairo's struggles and exploring possible solutions.

Located at the confluence of the Ohio and Mississippi rivers, Cairo was a bustling riverboat stop and vibrant trade center in the late 1800s. Decades later, however, the community was torn by racial strife during the civil rights era. Blacks boycotted white-owned businesses, and many whites moved away.

Over the years the city's condition deteriorated. A once-thriving downtown gave way to boarded-up buildings, and the city's remaining residents are largely low-income.

Greer says the project is an opportunity for the University to support the region. "[Cairo] has been very receptive to our students and many people really opened up their lives to us," he says. "In turn, our students really care about Cairo."

The School of Journalism is working with SIUC's Paul Simon Public Policy Institute to possibly coordinate other endeavors, such as meetings with the public and lawmakers, aimed at raising Cairo's profile and looking for ways to help the community.

More info: Mr. Phillip Greer, PGreer19@siu.edu.

—Tim Crosby

Equipment sits in decay at Cairo's abandoned hospital. ***Photo courtesy The Cairo Project.***

Kathleen Campbell (center) has found a possible preventive agent for hearing loss from chemotherapy and noise exposure. ***Photo courtesy SOM.***

NOW HEAR THIS

A compound made from an amino acid present in fermented protein, such as that in cheese or yogurt, could help prevent hearing loss in groups ranging from soldiers to accident victims to cancer patients.

Otolaryngologist Kathleen Campbell, a surgery professor and director of audiology research for the School of Medicine, has been awarded three U.S. and five international patents for therapeutic uses of the amino acid, known as D-methionine.

Campbell's research with lab animals has found that D-methionine is effective in reducing hearing loss from very loud and long-term noise exposure.

"If clinical trials find it works in humans as well as it does in animals, permanent hearing loss from prolonged loud noises and accidents such as military gunfire and automobile airbag detonation could be prevented for many people around the world," Campbell says.

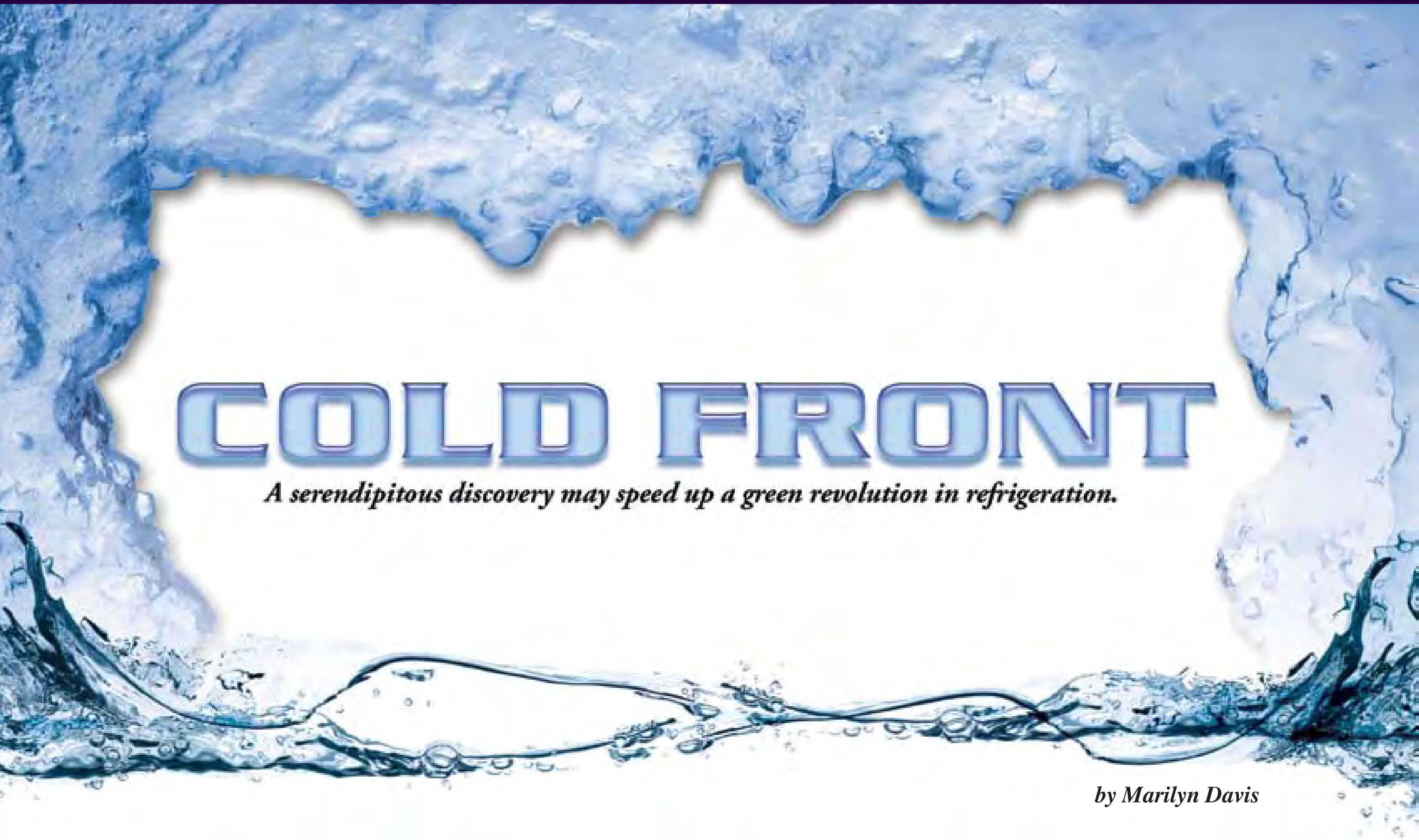
Her research also has shown the compound to be effective in animals against hearing loss caused by cisplatin, an anticancer drug used in chemotherapy. Around 50 percent of ovarian cancer patients and 30 percent of lung cancer patients receiving cisplatin develop hearing loss.

The patents for D-methionine have been licensed by Molecular Therapies Inc. in Ann Arbor, Mich., which has developed a proprietary oral suspension formulation called MRX-1024. The company is currently conducting two Phase II clinical trials in India for D-methionine protection from hearing loss caused by cisplatin chemotherapy and by a particular class of antibiotics.

Campbell's work on hearing-protective agents has been funded by grants from the National Institutes of Health.

More info: Dr. Kathleen Campbell, kcampbell@siumed.edu.

—Ruth Slottag, SOM



COLD FRONT

A serendipitous discovery may speed up a green revolution in refrigeration.

by Marilyn Davis

In keeping our milk fresh and our veggies crisp, refrigerators of the future may also enable us to be more energy-independent. How? By using magnets and alloys, not compressors, to chill out.

SIUC physics professors Naushad Ali and Shane Stadler have received a four-year, $620,000 grant from the U.S. Department of Energy to optimize an alloy they've developed that is far better than any others to date at magnetic cooling.

Under the influence of a magnetic field, certain alloys become magnetically "organized" and heat up. When the field is removed, they lose that magnetic organization and cool down. The phenomenon is called the magnetocaloric effect. If the heat generated by the magnetic field is drawn off—by water, for example—the material will get colder upon the removal of the field than it was to start with. Hence: solid-state refrigeration.

Scientific devices have exploited the magnetocaloric effect for years. But only now is industry taking the first steps toward commercial cooling devices that rely on magnets rather than on compressed gases like ozone-depleting Freon and its modern replacements (which may still have some ozone-depletion effects).

Why has it taken so long?

In most materials, the magnetocaloric effect kicks in at temperatures far too low for consumer applications. Materials now being used for first-generation prototypes of commercial magnet-based refrigerators *do* work at room temperature, but they're expensive and require the power of an electromagnet.

The research team led by Ali and Stadler may have solved both problems. They have modified a common alloy so that at room temperature, under the influence of an ordinary permanent magnet, it yields a whopping magnetocaloric effect. The cooling potential is huge, greatly exceeding that of any other known material near room temperature. The researchers reported their findings in the journal *Applied Physics Letters* last year.

The discovery grew out of the two physicists' work with so-called "shape-memory" alloys, which expand or contract under a magnetic field and return to their original shape when the field is removed. Such alloys are used as magnetically controlled actuators for mechanical devices. "No one had really explored their magnetocaloric effects," Stadler says.

Assisted by doctoral student Mahmud Khan and others, Ali and Stadler were trying to get this structural change to take place at room temperature in an alloy made of nickel, manganese, and gallium. They found that replacing a small amount of the manganese with copper did the trick, and it also made the transition take place in a very pronounced way.

That got them wondering about the possible magnetocaloric effect of this alloy.

From left: Naushad Ali, Shane Stadler, Igor Dubenko, Mahmud Khan, and Arjun Pathak are working on a cool new alloy.

Materials susceptible to magnetic cooling undergo both a change in structure and a change in magnetic organization. In shape-memory alloys, these transitions usually take place at very different temperatures. But by experimenting with different proportions of copper, the research team was able to "tune" their new alloy so that the structural and magnetic transitions occur at the same temperature.

"When this happens, the refrigeration effect is the largest," Ali says.

Current prototypes of magnet-based refrigerators use alloys made with the rare-earth metal gadolinium. "It's a good material," Stadler says, "but it's very expensive, and it's more toxic than our material."

In contrast, the component elements of the SIUC team's alloy are abundant, affordable, and relatively nontoxic. Plus, the alloy is easy to make.

How would a refrigerator based on such an alloy work? Here's a likely scenario.

A rotating disk that incorporated the alloy in some of its sectors would pass through a magnetic field. As a part of the disk containing the alloy entered the field, the alloy would heat up. A heat exchanger using water or some other liquid would carry away the heat. As the alloy moved out of the magnetic field, it would cool below room temperature, chilling a nearby food compartment.

The system's advantages would be simplicity and efficiency.

"It could very well be that, in the end, making these systems commercially would be cheaper and easier than making current compressed-gas systems," Stadler says.

"The mechanism would be very simple. There would be few moving parts. There would be no compressor; you'd just need a small motor to turn your disk, and maybe a circulator. You'd have no worry about gas leaks or anything like that, so it would be better for the environment."

Running this type of cooling device would be cheaper, too—another environmental benefit, since refrigerators are among the most energy-hungry appliances that consumers own.

"It would be much more energy-efficient," Stadler says. "For the same amount of electricity going into the process, you'd get a much greater cooling effect. These materials are already at 70 percent [efficiency], and they're not even developed to the point where they're optimized." (The efficiency yield with a compressed-gas system is about 40 percent.)

SIUC is filing for a patent on the material and its potential applications. However, more work needs to be done before the alloy can be commercialized.

For example, the researchers are trying to expand the temperature range at which the magnetocaloric effect can take place. They're doing that by experimenting with variations of the alloy and of the fabrication process.

Besides Ali, Stadler, and Khan (who has done many of the measurements of the alloy's properties), the team includes master's student Arjun Pathak; visiting Canadian scientist Igor Dubenko; and three Brazilian physicists based in Rio de Janeiro.

Understanding why this particular alloy possesses such unusual properties would be an important step forward in taking the magnetocaloric effect out of the laboratory and into the marketplace, Stadler says. Therefore the researchers will study the material on the atomic level by using powerful synchrotron radiation sources at two national laboratories.

"Our plan is to find out the magnetic character of each [type of atom] as the material goes through the various transitions, and determine the difference between a material that shows a high magnetocaloric effect and one that doesn't," Stadler says.

"We're trying to figure out what's happening—how, when, and why these transitions occur. If we can do that, then we can predict what it takes to optimize the effect."

Seed funding for this research came from the Department of Physics and SIUC's Materials Technology Center, with additional grant funding from the Petroleum Research Fund and from Research Corporation, a scientific foundation based in Tucson. For more information: Dr. Naushad Ali, nali@physics.siu.edu, or Dr. Shane Stadler, sstadler@physics.siu.edu.

Saving the Sturgeon

by Tim Crosby

What will it take to prevent a population crash in the Middle Mississippi River?

The sturgeon, whose fierce, bony appearance betrays its prehistoric roots, is highly prized for its eggs—caviar. Ever since overseas beluga sturgeon populations crashed, prompting the United States to restrict caviar imports, demand for Mississippi River shovelnose sturgeon eggs has soared. A mature female can yield about a half-pound of eggs, which in turn would sell for almost $300, creating a strong incentive for commercial fishing operations.

For the last six years, zoologist James Garvey, who works with SIUC's Fisheries and Illinois Aquaculture Center, has studied the sturgeon living in the Middle Mississippi River—roughly from Memphis to St. Louis. Lately, what he's finding alarms him: populations of both the shovelnose sturgeon and the federally endangered pallid sturgeon are reaching a critical point.

"The harvest, during the last two or three years, has been increasing exponentially," says Garvey, whose research is funded by the U.S. Army Corps of Engineers. "We're not sure recently implemented regulations will go far enough [to protect the fish]. My fear is that…the population [is] at a stage when it might collapse, and that can happen very quickly."

That's exactly what happened in the Lower Mississippi River, and sturgeon harvesting is now off-limits from Mississippi's northern state line to the Gulf of Mexico.

Research by Garvey and his students, who often work in conjunction with sturgeon fishing operations, has focused on such things as the fishes' typical location in the river, their feeding habits, and what water flow rates they prefer.

The research also has revealed mortality rates, which Garvey says have increased greatly among the mature, breeding-age fish that sustain the overall population. The mortality rate for shovelnose sturgeon has

A shovelnose sturgeon fingerling. Top: James Garvey is concerned about a possible crash of sturgeon populations in the Middle Mississippi River. Bottom: Doctoral student Rob Colombo holds a mature pallid sturgeon.
Photos courtesy James Garvey.

risen to 30-35 percent, meaning that a mature fish has a 35 percent chance of dying in any given year (including from harvesting). That rate, Garvey says, is now affecting the overall population.

"For the first time, we're starting to see the number of juvenile sturgeon declining," he says. "This means for every increment the mortality rate increases in the mature population, we'll see an equal effect in the juvenile population."

Worse yet, the endangered pallid sturgeon—slightly larger and paler than the shovelnose—is dying at about the same rate as the shovelnose, even though fishing is supposed to be off-limits everywhere for this species.

The two species "look a lot alike," says Garvey, "and when [pallid sturgeon] are younger it's very difficult to tell them apart from the shovelnose. Also, a mature pallid is a little larger, which means it has more eggs. There's a lot of evidence that they're being illegally harvested. Law enforcement is trying hard to stem the tide, but it's such a big system that they're having trouble."

As the sturgeon migrate from the Memphis area up to the Chain of Rocks area north of St. Louis, where they spawn, "they're continually hit by fishing," says Garvey. He believes that states bordering the Middle Mississippi need to enact tougher regulations on catch limits as a means of preserving both species. This may also be the only option to protect shovelnose sturgeon as a long-term resource for fishing operations.

"We want to make sure we utilize the resource in a wise and sustainable way," Garvey says. "The data show that what the population needs now are some really good regulations, or even a temporary closure."

If the population collapses, the effects might be disastrous.

"There's the obvious economic impact on the fishing industry," Garvey says. "But there's also the ecological [impact]. With a lot of species, we don't know what role they play in the system until they're gone."

Then too, he adds, "there's the simple aesthetic value of having the sturgeon around. This is a fish that has been around essentially since the dinosaurs."

For more information, contact Dr. James Garvey, Fisheries and Illinois Aquaculture Center, jgarvey@siu.edu.

SIUC fisheries and ecology research can range more widely—and do it more safely—with the recent acquisition of a new 25-foot, state-of-the-art research boat.

The University and the U.S. Army Corps of Engineers (USACE) paid for the $175,000 boat, which researchers in the Fisheries and Illinois Aquaculture Center will use to navigate the Mississippi and Ohio rivers, and perhaps beyond.

Currently, researchers use large, open johnboats to traverse the rivers' unforgiving waters. Zoology professor James Garvey, who was instrumental in obtaining the USACE grant, says the new boat will be a huge improvement.

"[It] will provide a much safer working environment for us. It will also allow us to keep our electronic equipment inside instead of exposed in an open boat," he says.

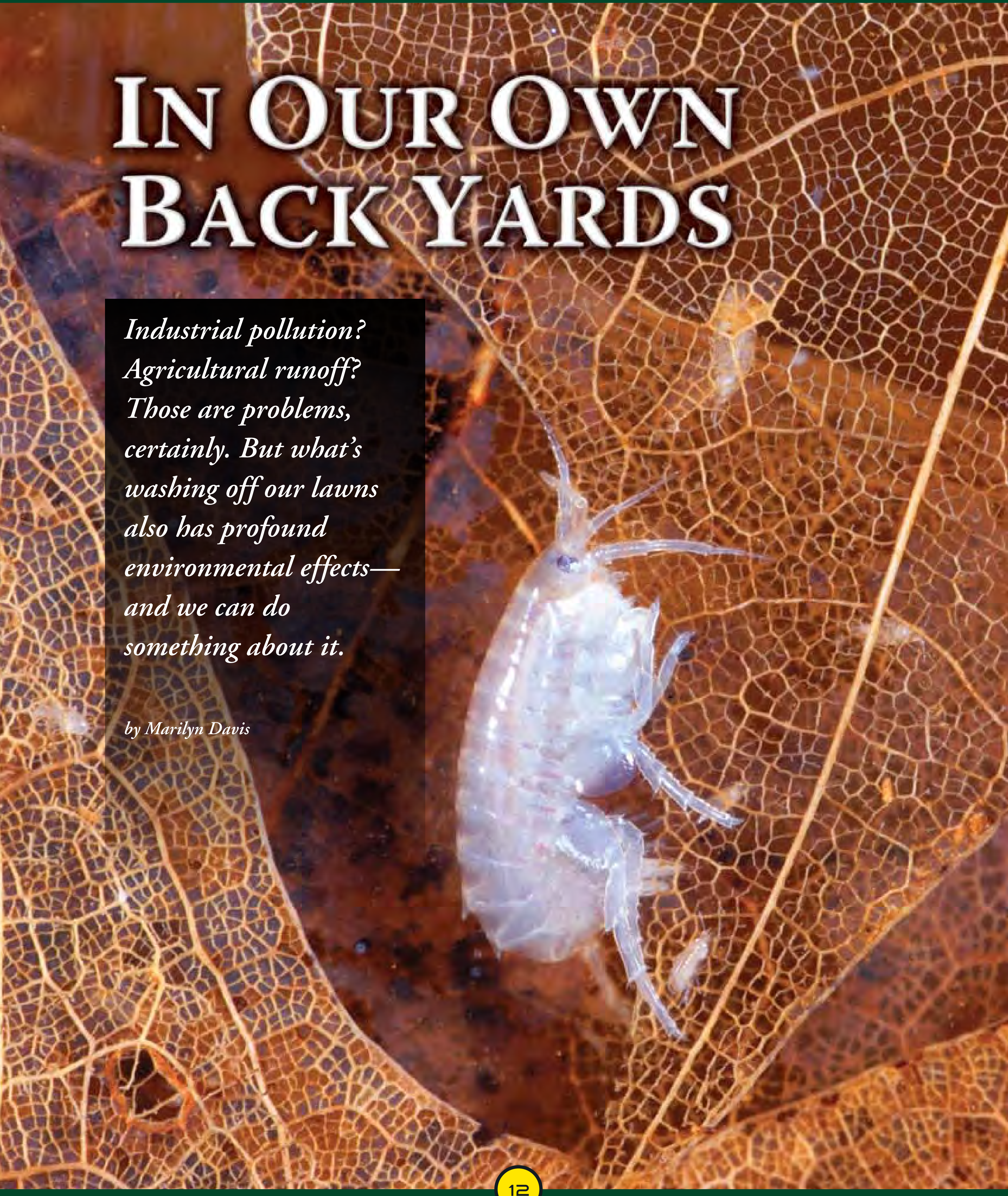
Garvey adds that the new boat's range makes it possible to conduct research as far south as New Orleans, if necessary.

The University will store the boat at the recently established Middle Mississippi River Wetlands Field Station, a 1,400-acre research site near East Cape Girardeau that the University manages under an agreement with the Illinois Department of Natural Resources.

Taken together, the field station and the new boat underscore the University's commitment to leading research on the Mississippi and Ohio rivers, two cultural and economic treasures of Southern Illinois, says John Koropchak, SIUC's vice chancellor for research.

—Tim Crosby

In Our Own Back Yards



Industrial pollution? Agricultural runoff? Those are problems, certainly. But what's washing off our lawns also has profound environmental effects—and we can do something about it.

by Marilyn Davis

Living in tanks in the basement of the Life Science II building are some modern equivalents of the canary in the coal mine.

They're tiny freshwater invertebrates—bright-red midge larvae, threadlike aquatic worms, and shrimp-like amphipods—that dwell at the bottom of streams and ponds. These modest creatures, a key link in the aquatic food chain, may look insignificant. But if they're not thriving, it's a warning sign that all is not well with an ecosystem and bigger problems may be on the way.

Our streams and lakes absorb a constant incoming chemical stew, from farm-field runoff to factory effluent to the life-saving medications we take and excrete. Although most polluting compounds are present at very low concentrations in water, little is known about their storage in bottom sediment or about how that affects organisms and ecosystems.

Along with various fish and tadpole species, the midges, worms, and amphipods serve as aquatic "guinea pigs" for environmental toxicologist Michael Lydy and his students. Working with contaminated sediments from water systems, Lydy's team seeks to determine what pollutants and combinations of pollutants account for toxic effects. With colleagues in California, they have been the first to uncover risks from a group of widely used pesticides—and to push for solutions to the problem.

Lydy, a zoology professor affiliated with SIUC's Fisheries and Illinois Aquaculture Center, has done toxicology studies involving heavy metals, explosives, pharmaceuticals, herbicides, and other pollutants. For instance, he and SIUC zoologist Richard Halbrook have shown how PCBs (polychlorinated biphenyls, a class of industrial compounds) in lake sediment at Crab Orchard National Wildlife Refuge are accumulating up the food chain—moving from emerging insects to tree swallows, and from gizzard shad to great blue herons.

◀ ***Hyalella azteca*, a quarter-inch-long crustacean, is one of the indicator species an SIUC research team is using to study the effects of pesticides and other chemicals in aquatic sediment.** ***Photo by Scott Bauer, courtesy the U.S. Agricultural Research Service.***

In another project, Lydy and SIUC zoologist James Garvey have discovered that young male sturgeon with elevated exposures to PCBs and first-generation pesticides like DDT (which, though banned, persists in the environment) develop sexually more like females, impairing their reproductive ability. Working with pallid sturgeon in the Mississippi River below St. Louis, Lydy says, "We're finding ovaries in 8 to 12 percent of male sturgeon." That's bad news for an already-endangered species.

On a more positive note, Lydy's lab has found that channel catfish cope quite well with TNT residues, breaking them down rapidly instead of accumulating the chemical in their flesh. That's good news for fishermen who eat their catch.

Lydy's lab also has found that the popular antibiotic Cipro appears to be relatively benign in aquatic environments, thanks partly to low concentrations. It's an open question, however, whether microbes in streams are developing "superbug" resistance to the antibiotic, which could pose problems.

Pesticides, however, are the major focus of Lydy's recent work, particularly a third-generation class of insecticides called pyrethroids. Farmers use them to control insect pests, but we consumers use them too—on our lawns, in our houses, on our pets—to kill everything from grubs to fleas. There are seven kinds of pyrethroids, and the typical can of bugkiller contains at least two, notes doctoral student Andrew Trimble.

It turns out that pyrethroids (pronounced pie-REE-throids) can decimate certain invertebrates that are indicators of water quality. Surprisingly, suburban homeowners are bigger offenders in this environmental scenario than farmers are, at least in the region he's studied, Lydy says.

Lydy's work with pyrethroids, done in conjunction with the University of California, Berkeley, has focused on California's Central Valley, home to farmland and urban areas alike. The research is slated to expand across the country soon.

Pyrethroids break down quickly in water or air, but they will bind tightly to sediment, where they stay intact for months. That's why Lydy's testing focuses on bottom-dwelling invertebrates.

Little is known about pollutants' storage in aquatic sediment or about how that affects organisms and ecosystems.

The three species used for aquatic sediment testing are standards in environmental toxicology. They cover the waterfront in terms of getting a good picture of toxicity, Lydy explains: "They reside in different niches within the sediment. They have different exposure routes, they're eating different things, and the bioavailability of a contaminant (how much is actually available to be taken up by organisms) is going to be different for each."

The tiny amphipods, crustaceans that are related to pill bugs, graze on the surface of the sediment. The midge larvae live just under the surface, where they filter nutrients from the sediment. And the worms tunnel headfirst down through the sediment, essentially "digesting" it directly.

Michael Lydy and his students are working to understand the effects of pesticides and other pollutants on aquatic organisms—and also how to reduce the amount of pollutants in aquatic systems.

These lifestyle differences lead to different sensitivities in these species, Trimble says. "The [aquatic] worms are very useful for long-term, high-concentration exposure studies. *Hyalella* (the amphipod species) would be useless for that, because you'd kill every one of them in a matter of hours." But with low concentrations, that same sensitivity makes *Hyalella* a model test species.

Lydy, postdoctoral fellow Jing You, and UC Berkeley biologist Don Weston began their pyrethroid investigations by collecting sediment from streams, irrigation canals, and ponds in 10 agricultural counties in the Central Valley. Lab tests exposing amphipods and midges to the sediment showed that one-third of the samples were toxic to one or both of these species—in some cases killing off every individual.

When Lydy and You tested the samples for the presence of 26 different pesticides, they found pyrethroids in three-quarters of them. Levels were high enough to account for 70 percent of the amphipod deaths and 40 percent of the midge deaths, the research team calculated.

"Pesticide manufacturers argue that pyrethroids bind so tightly to sediment that they're not bioavailable to organisms," Lydy says. "We've found that they are bioavailable, they are taken up by invertebrates, and they're incredibly toxic. Less than one part per billion will kill [*Hyalella*]. That's like taking a drop of water and putting it into a swimming pool."

The team went on to find that suburban drainages in part of the Central Valley had even bigger toxicity problems with pyrethroids. In this study, they collected sediment from creeks that drained a typical subdivision in Roseville, Calif.

"We had *Hyalella* living in a stream prior to the subdivision being built," Lydy says. "It was built, and then they were gone. If you go above the subdivision, the *Hyalella* are fine."

Lab testing showed that the sediment samples were high in pyrethroids. In fact, more than 90 percent of the samples were lethal to *Hyalella.*

The drive for a perfect lawn is the main culprit in suburban contamination. Manufacturers' decision to market fertilizer, herbicide, and pesticide in one multipurpose package means that many homeowners and gardening services are applying bugkiller to residential lawns needlessly, or much more often than they need to.

Regrettably, many homeowners also think that the more insecticide you apply, the better, Lydy says. And it's common for homeowners to wash off their spreaders in driveways, where the runoff flows directly into storm drains. Pyrethroid runoff is less of a problem in agricultural areas because farmers are well educated about how much insecticide to apply, Lydy says. They don't overuse the product; they know that's an extra cost with no benefit.

"There really was no concern about pyrethroids before Don's and my work," Lydy says. "California knew they had a problem with toxic sediments, but they didn't know the cause of the toxicity. Don and I were the first to say that the controlling problem is pyrethroids. We explained [the majority] of that unexplained toxicity, and now we have a new grant to explore the remaining toxicity issues, looking at other classes of compounds."

It's a measure of Lydy's professional reputation that two of his current graduate students, Trimble and master's student Amanda Harwood, hold prestigious STAR fellowships from the Environmental Protection Agency. Several other graduate students, an undergraduate research assistant, a visiting student from Finland, and two postdoctoral fellows round out the team.

His lab is unusual among environmental toxicology labs in the scope of its research, Lydy says. It is particularly known for its chemistry expertise: the ability to isolate and identify pollutants present in toxic sediment and to improve analytical techniques.

Lydy and his students also run dose/response tests with species to determine levels and causes of toxicity. They analyze susceptible animals to find out how a given chemical has its effects. They monitor field sites for reductions in species. They study how contaminants move in the environment and to what extent they're bioavailable. Finally, they're researching ways to reduce contaminant discharge into streams from suburbs and farms.

The lab's greatest challenge and greatest strength is teasing out which chemicals in a mix are doing the most damage, and how chemicals interact to harm organisms. Sometimes two toxic chemicals act synergistically, boosting toxicity far above what you'd expect by simply adding together the hazards of the individual compounds. Sometimes a benign compound will increase a second compound's toxicity, a phenomenon called potentiation. And sometimes, if you're lucky, two chemicals in combination will reduce or neutralize each other's toxicity.

To take one example, Trimble has used *Hyalella* to investigate the toxicity of second-generation organophosphate insecticides in combination with atrazine, a ubiquitous herbicide. By itself, atrazine has little to no toxicity to *Hyalella* in the concentrations he's using. But its presence makes organophosphates more toxic to the species, he's found.

The drive for a perfect lawn is the main culprit in suburban contamination.

(Such potentiation may underlie Gulf War Syndrome, Trimble says, in which no chemical agent by itself has been shown to be the smoking gun.) He is now testing the effects of pyrethroid mixtures on *Hyalella.*

When Trimble analyzed sediment samples from California streams containing various pesticide residues—not just pyrethroids, but also older pesticides—he found that pyrethroids topped the list in their toxicity to invertebrates. One called bifenthrin, used for termite control and lawn care, appears to be the most problematic, information that might help manufacturers reformulate their products or regulators set limits.

If even 1 percent of the bifenthrin a single homeowner put on the lawn on a Saturday afternoon washed down a storm drain, it would take at least half a million gallons of water to render it harmless to *Hyalella,* the research team reported in late 2005. "And that's just one application by one person," Lydy says.

Part of Trimble's STAR project will address how pyrethroids move in the environment. Do they preferentially bind to coarse sediment? Fine? Super-fine? Do they prefer sediment with a high or low organic matter content? The answers will improve toxicologists' sample-collection protocols so that they don't miss pyrethroid residues.

Amanda Harwood, the other STAR Fellow, is investigating exactly how pyrethroids affect the test species, an area of research called toxicokinetics. "It's one thing to do toxicity testing and see how many animals die," she says. "It's more interesting to see how the organism processes the chemical." Understanding how the pollutant does its damage could help mitigation efforts down the line.

Harwood's research also is adding another useful technique to what's called Toxicity Identification Evaluation, or TIE: the initial screening of toxic sediment or water samples to begin pinpointing the toxic agent or agents. It's time-consuming and expensive to extract and identify chemical compounds from samples, Harwood explains. Thus, faced with unknown toxicity in water or sediment, scientists rely first on TIE procedures—quick, easy tests to help narrow their search for the suspects.

In tests exposing midge larvae to sediment contaminated by pyrethroids, Harwood found that raising the temperature of her samples decreases mortality. This is an unusual result, Lydy says. "For most chemicals, if you increase the temperature of your samples by 10 degrees, you see an increase in toxicity. That's because the organism respires more at a higher temperature and takes in more of the toxic chemical."

Testing of sediments in California's Central Valley has taken place in subdivisions (top, Roseville, CA) and in agricultural areas. Pyrethroid pesticides are a significant problem in both areas. ***Photos courtesy Don Weston.***

Pyrethroids, he explains, are nearly unique among toxic compounds in doing the opposite. The TIE procedure, then, would be to expose larvae to toxic sediment at two different temperatures, then see if fewer of them die off at the higher temperature. If so, the sediment should be tested for pyrethroids. If not, this potential cause of toxicity can be ruled out.

Harwood's ongoing toxicokinetics work will allow her to determine *why* deaths from pyrethroids decrease with higher temperatures. That will shed more light on these chemicals' mechanism of action.

Identifying the source of toxic sediments in the Illinois River downstream from Chicago, a new project for Lydy's team, will rely initially on TIE procedures. Mussels and

(cont. on page 17)

PESTICIDES OFF THE BEATEN PATH

Extremely low concentrations of pesticides and their breakdown products are harming amphibians in California, an SIUC ecotoxicologist has found.

"It's no secret that, worldwide, amphibian populations are declining," says Donald Sparling, zoology professor and associate director of SIUC's Cooperative Wildlife Research Laboratory. "Many species have been exterminated in the last 20 years. Habitat destruction has been a major cause, but disease and contaminants are also worldwide problems."

Frogs and toads, with their permeable skin, are especially sensitive to their surroundings and are considered early-warning indicators of environmental problems.

Most of California's native frog and toad species are in trouble. "The hardest-hit areas are from central to southern California, especially east of the Central Valley," Sparling says. These are primarily agriculture-intensive areas, or places downwind of agricultural activity.

Before Sparling came to SIUC, he worked as a biologist with the U.S. Geological Survey. One of his last projects there was to supervise a sort of round-robin experiment in California. Deborah Cowman, a graduate student at Texas A&M University, moved clutches of frog eggs between ponds in Lassen, Sequoia, and Yosemite national parks. She found that, no matter where the eggs originated, many more of the hatched tadpoles died in Sequoia than in Lassen, with Yosemite falling in between.

The translocation experiment showed that genetic differences between populations weren't the cause. Instead, she and Sparling went on to find that pesticide levels in these parks tracked with the mortality rates: Sequoia had the highest levels, followed by Yosemite and then Lassen.

What are pesticides doing in these supposedly pristine places? They are literally floating in from the Central Valley, where they are sprayed from planes. Some of the aerosol droplets drift east, perhaps hitching a ride on dust particles, and end up in snowfall in the Sierra Nevadas. Not coincidentally, Sequoia is the park closest to the Central Valley.

With USGS funding, Sparling and master's student Jill Hunt are finding that even very low pesticide concentrations are problematic. Their lab work focuses on chlorpyrifos, the most widely used pesticide in the state, and on endosulfan, which seems to be the most toxic to amphibians.

For several species, they've established an important benchmark figure called the LC50: the concentration of a contaminant that will kill 50 percent of the individuals exposed to it. Take endosulfan, for example: the LC50 is a little over 3 parts per billion (ppb) for the Pacific treefrog and Western toad. But it's less than 1 ppb for the foothills yellow-legged frog. In fact, that level kills 90 percent of yellow-legged hatchlings before they get past the tadpole stage, the researchers found.

Amphibians can tolerate higher levels of chlorpyrifos: 12 ppb for the yellow-legged frog; 20 ppb for the treefrog. (The higher tolerance of the latter may explain why the Pacific treefrog is one of only two frog or toad species not showing a significant decline in California.)

The foothills yellow-legged frog in tadpole stage. *Photo © Gary Nafis and CaliforniaHerps.com.*

But that's only part of the chlorpyrifos story. Aquatic bacteria and ultraviolet rays both break down chlorpyrifos into a compound called chlorpyrifos-oxon. This breakdown product is *100 times* more toxic to amphibians than the original compound, Sparling and Hunt have determined. "Nobody had ever looked at toxicity of the oxon form before," Sparling says.

Not surprisingly, species that spend more of their lives in the water are in greater danger of extinction, Sparling says. For example, it's so cold where the mountain yellow-legged frog lives that it spends two summers as a tadpole. Sparling's studies were included as supporting data when this species was listed as endangered.

In other research, Sparling and master's student Tab Bommarito are investigating what's killing off the extremely rare Barton Springs salamander in Austin, Texas—a totally aquatic species that lives only in one spring-fed wading pond in an Austin park.

The likely threat? Particles of coal-tar and asphalt sealants washed from a nearby parking lot. These petroleum-derived substances contain PAHs (polycyclic aromatic hydrocarbons), which can cause genetic damage that leads to cancer or other diseases. Sunlight—specifically, ultraviolet B radiation—increases PAH toxicity about 100-fold.

From left: Tab Bommarito, Donald Sparling, and Jill Hunt are investigating the role that contaminants such as pesticides are playing in the decline of amphibian species.

"We don't yet know how toxic these contaminants can be," Sparling says. "These sealants are used throughout the nation, often close to wetlands, so this research could have implications for other species."

Since the salamander is so rare, Bommarito and Sparling are using two very similar species as research surrogates. They're exposing these individuals to different concentrations of sealant particles in sediment, then looking at DNA damage, survivability, and behavioral responses.

Even very low pesticide concentrations are problematic for frogs, toads, and salamanders.

PAHs also kill the little crustacean *Hyalella azteca* (see main article), a key food source for salamanders. The contaminant may be accumulating up the food chain, or the salamanders may be dying because their food source is disappearing. Either case underscores the importance of studying the effects of contaminants on the smallest of the small.

Why care about something as little and scarce as the Barton Springs salamander?

"All species have a role in the ecosystem, whether they serve as predator or prey," Sparling says. "If we see a major group of vertebrates in severe decline, that's a significant portent for the health of the environment in which we live. We hope that what we learn from research on a single species will have applications to many other species that are facing similar exposures.

"We're building [the picture] piece by piece."

—Marilyn Davis

For more information, contact Dr. Donald Sparling at dsparl@siu.edu.

other invertebrates once abundant in this stretch of river have been disappearing, and the Illinois Department of Natural Resources wants to know what is killing them. It could be one or a combination of any number of things, from pesticides to heavy metals.

And because the pyrethroid problem is unlikely to be unique to California, Lydy's team will soon begin another new project, analyzing sediment samples from a number of cities across the country. If problems turn up, they'll seek grant funding to do more extensive testing.

Left: Doctoral student Andrew Trimble and master's student Amanda Harwood were awarded prestigious STAR fellowships from the Environmental Protection Agency to study the effects of pesticides on aquatic organisms. Right: Amanda Rothert, an undergraduate, prepares to do sediment toxicity testing with the pesticide chlorpyrifos.

Lydy and his team stress that their research isn't aimed at banning chemicals or eliminating pesticide use. "We're saying, apply pesticides in a manner where you're going to minimize the impact on non-target species," Lydy says.

How to do that with pyrethroids? Lydy, Weston, and several colleagues will evaluate the results of various strategies—so-called "best management practices"—to reduce the amount of pyrethroids entering streams from farm fields.

Planting vegetation in drainage ditches as buffers to sediment movement is one option. Diverting runoff into managed wetlands is another. The team also will investigate using a special material on farmland that causes sediment to settle out before it reaches creeks or streams.

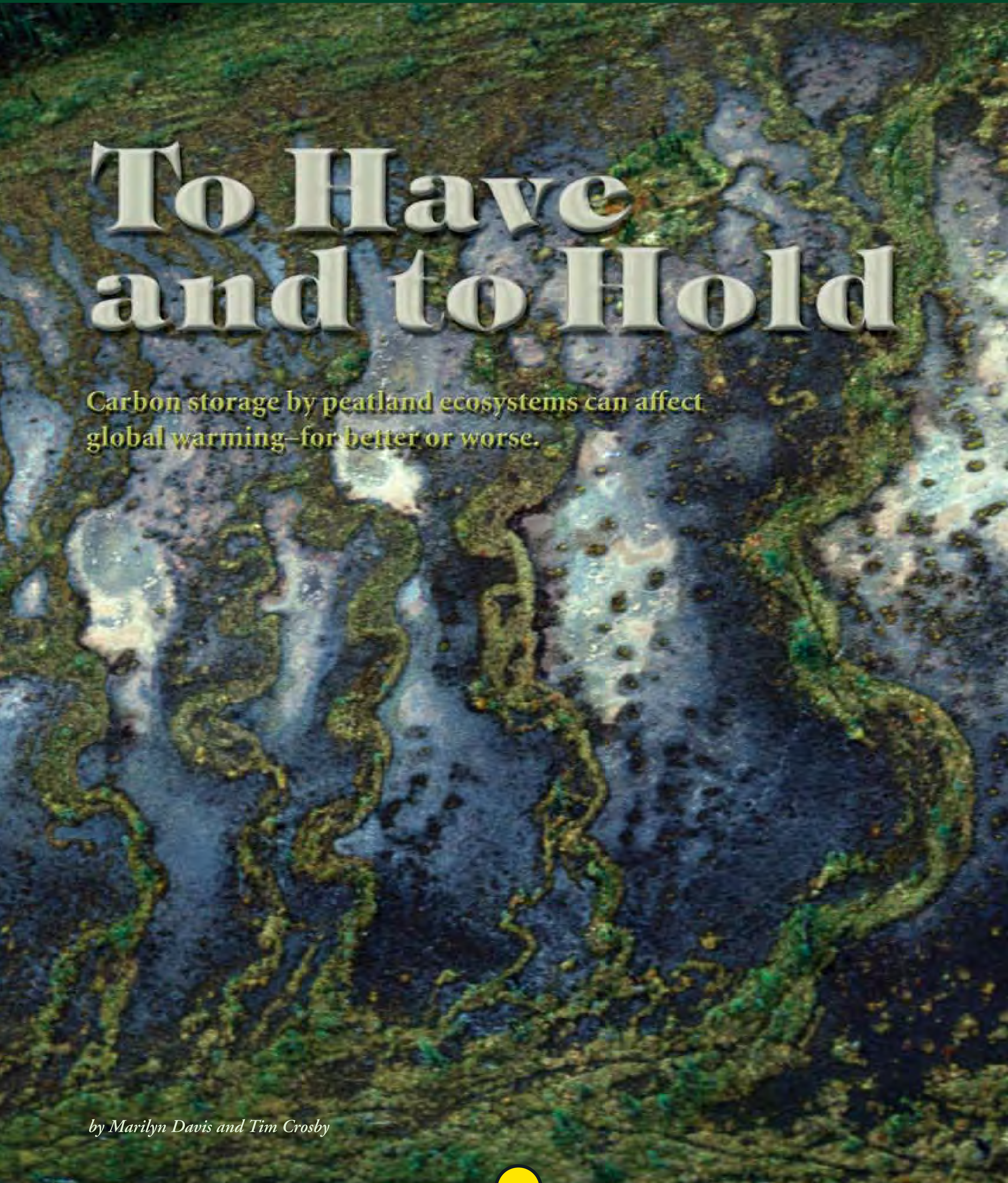
These experiments will be carried out on test fields in several California counties. The team hopes to dramatically reduce the toxicity of sediment downstream from the fields. Again using *Hyalella,* Lydy will test the success of these efforts.

But it's in the suburbs that mitigation practices could make the biggest difference, Lydy says. Educating homeowners and lawn services will be key. Already, thanks to Weston and Lydy's research, California is requiring pesticide manufacturers to re-register their pyrethroid formulations for both agricultural and residential use and to adopt new labeling requirements for products containing pyrethroids.

Consumers can help by using as little bugkiller on their lawns and gardens as possible, following package directions precisely, making sure they (or their lawn services) don't apply pesticide when it's likely to rain, and not rinsing off spreaders on concrete.

This is one environmental problem the average person has the power to affect—starting today.

Dr. Michael Lydy's research has been funded by the U.S. Geological Survey, the Environmental Protection Agency, the U.S. Army Corps of Engineers, the U.S. Dept. of Agriculture, the State of California, the Illinois Waste Management and Resource Center, and other agencies. For more information, contact him at mlydy@siu.edu. K. C. Jaehnig contributed to this story.



To Have and to Hold

Carbon storage by peatland ecosystems can affect global warming–for better or worse.

by Marilyn Davis and Tim Crosby

Peat bogs might conjure images of misty, swampy wastelands. But an SIUC biologist wants you to think of them as giant stores of carbon that can have a major impact—good or bad—on global temperature.

Dale Vitt, professor and chair of plant biology, has worked for more than 30 years in Canada, Siberia, and other places to understand what makes these ecosystems tick. With funding mostly from the National Science Foundation (NSF), he and longtime scientific collaborator R. Kelman Wieder, a Villanova University biologist, have studied peatland formation, nutrient cycling, and carbon storage—the latter a pressing issue in an age of global warming.

Peat bogs and related peat-forming wetlands called fens (precursors to bogs) are found over large expanses of the far north. They are great reservoirs of carbon. Peat, which has been used as fuel since prehistoric times, is about 50 percent carbon, and deposits can be many feet deep.

"About one-third of the world's soil carbon is in these northern peatlands," Vitt says. "If all of it were released, it would double the carbon dioxide in the atmosphere."

During photosynthesis, plants draw CO_2 from the air. The carbon gets tied up in plant biomass. When bacteria break down dead plant material, they release the carbon, again as CO_2. In most ecosystems decomposition keeps pace with plant growth.

Not so in peatlands. Bogs and fens develop when thick vegetation grows in a waterlogged area. The bacteria in this oxygen-depleted water work more sluggishly, and some of the dead plant matter, instead of decomposing, builds up as peat. *Sphagnum* mosses are the species key to peat formation. Most bogs also host trees—usually spruces, which have special fungi that help them wrest nutrients away from the moss.

Carbon dioxide acts as a "greenhouse" gas, holding in the planet's heat and warming the environment. Because of peatlands' ability to store carbon, they affect how much CO_2 is in the atmosphere. In the lingo of climate change, they are helpful carbon "sinks" because they take in more CO_2 than they emit.

But they are very sensitive to climate change, Vitt says. "Raising the temperature just a little bit or changing precipitation regimes just a little bit could change [the system]" from a sink to a carbon source.

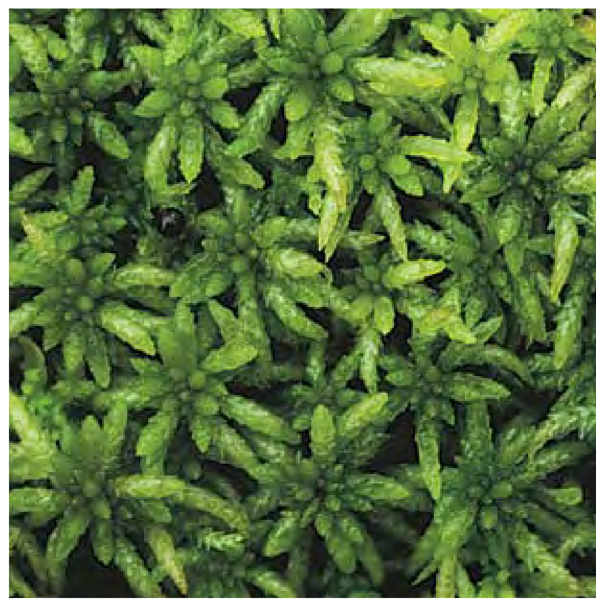
Across vast areas of western Canada, bogs and fens make up 40 to 70 percent of the landscape, interspersed with forest. Wieder, Vitt, and their students have established dozens of field sites in northern Alberta to study peatlands—most recently, the effects of wildfires on bogs.

Hydrologically speaking, bogs are islands. Peat buildup raises them above their surroundings, so they get no water runoff from neighboring areas. All of their water and nutrients come from the air.

The peat in bogs therefore holds a record of atmospheric deposition over time, as well as vegetation changes over time. That enables the team to study how bogs respond to climate variability and how they recover from wildfire over years and decades.

Despite being wetlands, bogs can burn during the dry season. Over the long term—maybe every 100 or 200 years—a bog actually needs to burn in order to keep its trees from getting too dense and drying it out. But the carbon released by fire adds to the global warming problem. And climate change models predict bigger, more frequent, and more severe fires in Canada, says doctoral student Brian Benscoter, as well as a longer fire season.

◀ **An aerial view of a fen in Canada. Peat bogs and fens store considerable amounts of carbon. The fate of these wetlands could affect global warming and climate change.** ***Photo by Dale Vitt.***



▲ ***Sphagnum*** **mosses (above,** ***Sphagnum fuscum;*** **below,** ***Sphagnum papillosum*****) are key to peat formation.** ***Photos by Dale Vitt.***

Vitt notes that it's possible to calculate what's called a "fire return interval"—how often, on average, a given area will burn. Tiffany Bone, one of his undergraduate students, did a tree-ring study at 45 peat bogs in Alberta in 2004-05. The longest fire interval she found was less than 150 years.

▲ **From left: Zicheng Yu (Lehigh Univ.), undergraduate Tiffany Bone (SIUC), graduate students Susan Faller and Brian Benscoter (SIUC), Dale Vitt (SIUC), and Kelman Wieder (Villanova Univ.) in the field in Alberta, Canada.** ***Photo by Bin Xu.***

Peatlands started forming in North America thousands of years ago, but it appears that any given bog periodically burns and starts over, like a phoenix rising from the ashes.

"This is a much faster dynamic than anyone ever thought," Vitt says, "and climate change may make it even faster" by shortening fire return intervals.

"When fire goes through a peatland, it kills all the trees and most of the vegetation, and it burns off carbon that was stored [in the peat]," Vitt says. "But decomposition continues.

"So all of a sudden you're going from a carbon sink to a carbon source. As things start to regenerate, how long does it take this ecosystem to make up for what it lost? No one knew."

Benscoter, who holds a three-year STAR Fellowship from the Environmental Protection Agency to study post-fire peatland recovery, tackled this question by doing peat-core and other analyses.

"It takes between five and 10 years for the peatland to become a sink again, where it's taking in more carbon than it's letting out," he says. "But it takes more than 70 years for the original carbon [store] to get back to where it was before the fire."

That means extra carbon in the atmosphere for decades.

Benscoter has found that the lie of the land affects carbon release during wildfires. Bogs are an essentially flat landscape made up of small hummocks and hollows. The elevation difference is less than two feet. But as Benscoter explains, "That creates a gradient of distances from the water table, and different species of *Sphagnum* separate themselves along this gradient."

Hummocks, being higher, are drier. The *Sphagnum* species that can grow there form dense mats that hold water like a sponge. Wildfires, unless they're very severe, burn only the top of the moss on hummocks.

Hollows usually are watery, so their *Sphagnum* species don't need to be water-holding specialists. But during the dry season, hollows can dry out. In a fire, Benscoter found, they burn almost twice as much as hummocks do, releasing much more carbon. "The mosses just go up like a candle," he says. And hollows take longer to begin accumulating peat again.

What's the significance of the fire studies? If you know the rough ratio of hollows to hummocks in a bog, you can better estimate the carbon released by a fire and how long it will take the bog to recover. Such information will become increasingly important for scientists trying to model climate change and decision makers trying to put the brakes on global warming.

To aid their efforts, says Vitt, "We want the whole picture of what happens to peatlands post-fire."

Another threat to bogs is air pollution in the form of excess nitrogen. And since bogs are the only ecosystem to receive all of their nitrogen from the air, they offer a unique opportunity to "differentiate [the ecological effects] of what comes from the atmosphere and what comes from other sources," Vitt says.

To understand how the peatland system changes with more and more nitrogen, doctoral student Bin Xu is adding different levels of nitrogen to field plots. He's then tracing the movement of the nitrogen to see how it's used and where it's stored. He's also looking closely at shifts in microbial communities, since most plants other than mosses rely on microbes to make nutrients available to them.

Peat is full of nitrogen, yet peat bogs are considered nitrogen-limited environments. That's because the *Sphagnum* grabs the nitrogen and hoards it. Other plants, besides the spruces, can't get a foothold.

If extra nitrogen deposits onto a bog, perhaps from vehicle or power-plant emissions, the mosses will initially grow more. But eventually they reach a point where nitrogen leaches out of the moss.

"Once you pass the nitrogen limits for *Sphagnum*, nutrients become readily available [in the system]," Xu says. "That could change the microbial and plant communities, affecting ecosystem functioning."

When other plants get well established, says Vitt, "they overtop and shade the mosses, the *Sphagnum* dies, and the whole system breaks down."

What's the tipping point for a bog? The research team has determined that it's about 14 kilograms of nitrogen per hectare (roughly 2.5 acres). Western European nations that would like to restore their harvested peatlands are out of luck, because nitrogen deposition there is high. Fortunately, says Vitt, "We're not anywhere close to the limit in western Canada."

That could change, however. Underlying many of the bogs in Alberta are oil-rich sands, which are being intensively surface-mined. Mining not only destroys peatland, but its industrial and transportation processes emit nitrogen, which deposits on surrounding peatlands.

Wieder and Vitt have industry funding to monitor the effects of nitrogen, as well as to study how best to restore peatlands. Restoration is no simple matter, as doctoral student Rose Bloise can tell you. Simply creating a wetland in northern Canada is not going to net you a peatland down the road, her research shows.

"If we're going to re-create peatlands today, maybe we can learn some lessons from how they form naturally," Vitt says. "Rose's project has been to look at natural, undisturbed peatlands and marshes [non-peat-forming wetlands] and see how they got started.

Top: A recently burned bog showing differential effects of fire on hummocks (light brown) and hollows (black). ***Photo by Brian Benscoter.*** **Middle: A relatively young bog (foreground), 21 years post-fire, with an older bog in the background. The trees are spruces.** ***Photo by Bin Xu.*** **Bottom: A bog "island" with spruce trees (largest dark area) surrounded by a fen (tan).** ***Photo by Dale Vitt.***

"Of the 26 peatland sites she studied, it turns out that *none* started out as marshes. They started out as uplands; then the water table rose and saturated the surface soil."

Reclaiming a peatland, then, will take much more than "some water and a few cattails," Vitt says. It will take complicated reconstruction of the original hydrology and topography to make conditions favorable for peat formation.

To reach deeper deposits of oil-bearing sand, some companies are now using steam-injection wells. The potential for peatland restoration may be much better for these smaller sites. Vitt and Wieder just received a new industry grant to look at that issue. "The next [phase] of our project is to help oil companies develop methods to put in infrastructure that's less invasive than it's been in the past," Vitt says.

Pooling knowledge about peatlands is important if we're to preserve these ecosystems. Wieder and Vitt recently edited a book, *Boreal Peatland Ecosystems* (Springer, 2006), that gives a thorough overview of peatland characteristics and management. With an NSF Research Coordination Network grant, they have started a website called PEATNET to link together experts and provide scientific and financial resources. And another NSF grant to Vitt and Wieder helped fund efforts to coordinate U.S.-Russian research on Siberian peatlands.

Meanwhile, Vitt and his students are preparing for their next field trip to Alberta, where they'll expand the number of sites they're studying.

With so much carbon at stake, Vitt says, "We should think carefully about what we do with bogs." ✚

For more information, contact Dr. Dale Vitt, Dept. of Plant Biology, at dvitt@plant.siu.edu.

Pure Prairie League

Most of America's tallgrass prairie was plowed under in the past two centuries. Now SIUC ecologists are studying what works best for prairie restoration, and why.

by Marilyn Davis

Big bluestem, switchgrass, purple coneflower, rattlesnake master. The names may be familiar to us from books, nature preserves, and even home gardens. But in their native habitat, these and dozens of other prairie plants gave way to farm fields long ago.

Only remnants are left of the expansive grasslands that amazed early pioneers. Illinois once boasted a quarter of North America's tallgrass prairie. Today, for every thousand acres that grew here before European settlement, only one remains—most often in the form of small strips bordering railroads. And across the Great Plains, less than 5 percent of native prairie survives.

Now, many groups are trying to restore prairie on worn-out agricultural land. "The interest from the government's perspective is conserving soil and water resources. Then there are a lot of private organizations, like The Nature Conservancy, interested in restoring and protecting biodiversity. And it begins with the plants," says Sara Baer, an SIUC biologist with expertise in prairie plants and soils.

Baer and David Gibson, a fellow SIUC plant biologist, study prairie restoration for its own sake and for what it can tell them about ecological principles: how communities of plants are assembled; what factors affect the balance of species, filtering out some while enabling others to dominate; and how diversity affects ecosystem functioning.

Most prairie restoration sites rely on cultivars: seed from prairie grasses that the U.S. Department of Agriculture collected and then bred over the years. The USDA selected for certain traits, such as robust growth, that may or may not be what's optimal for restoring a diverse prairie. And the breeding process itself inevitably changes the plants from their native counterparts, which also may affect restoration efforts.

With a five-year, $445,000 National Science Foundation grant, Baer and Gibson are carrying out experimental restorations at three sites. Multiple plots at each site will allow them to compare the effects of planting cultivars and wild seeds for three common prairie grasses—big bluestem, little bluestem, and Indian grass—under the same soil and climate conditions.

Several years ago, Baer (then doing doctoral research at Kansas State University) and Gibson were separately uncovering evidence that cultivars varied in potentially important ways from native-grown grasses. In Southern Illinois, one of Gibson's students was finding genetic differences between cultivars and wild seed. Another student, studying cultivar and non-cultivar prairie grasses on reclaimed mine land, was finding differences in photosynthesis rates. And Baer, studying sites restored with cultivars, was finding "much higher productivity and higher biomass than we measured in native prairie."

That's not necessarily a good thing. Prairie plants are typically slow to get established. Grasses that grow faster and taller than normal may outcompete non-grass species, such as wildflowers, important for a diverse, healthy, sustainable prairie.

"It's easy to restore productivity," Baer says, "but restoring diversity is very difficult."

The number of species at a site, called species richness, is half of the biodiversity equation. The other half is "evenness": the relative abundance of those species.

"You need them both," Gibson says. "An agricultural field might have a lot of different sorts of weeds, but it's still low diversity because it's mostly corn or wheat." Native prairies are very diverse, and provide habitat for a wide range of creatures, because many plant species are abundant.

Small-scale grassroots prairie restorations by local volunteers have given rise to rules of thumb about best practices, such as using wild seed collected within so many miles of the site to be restored. But little research has explored their validity.

"From a practical standpoint, we're hoping to provide some scientific basis for making better decisions about restoration practices," Gibson says. "From a theoretical standpoint we hope to learn more about how plant communities are assembled. What we find with tallgrass prairie may have relevance for other ecosystems."

Baer, Gibson, and a cadre of students are restoring sites near Carbondale, near Belleville, Ill., and at the Konza Prairie Long-Term Ecological Research site in Kansas. At each of the sites, they've planted plots with cultivated or wild seeds for the three grasses they're studying, along with different pools of wildflower seeds.

Some years previously, Gibson, doctoral student Danny Gustafson, and SIUC plant biologist Dan Nickrent did a study of restored prairie sites in Illinois. That research supported the idea that using locally collected grass seeds, rather than seeds from other regions, is beneficial. "Where the seeds came from made a huge difference in how they grew," Gibson says.

But using native seed collected locally may not be a realistic option for many restorations, Baer says. "It took us months to collect a small amount of local native seeds, with low germination rates. Maybe the diversity of the

◀ **Restored prairie at Morton Arboretum, near Chicago.** ***Photo © Steve Geer, iStockphoto.com.***
▶ **Ryan Campbell gathering native seeds at the Konza Prairie Long-Term Ecological Restoration site in Kansas.** ***Photo by Sara Baer.***

From top: Seeding one of the experimental plots at the Konza site; the plots are covered with burlap until the seeds start to germinate; plants are harvested during the first growing season for biomass measurements. ***Photos by Sara Baer.***

mixture you put in is more important than the grass sources. For example, maybe if you put a cultivar in at a very low seeding rate [to compensate for its high productivity], you could establish a diverse prairie."

To test that idea, plots at Konza and Belleville will incorporate different proportions of cultivated seed in the total mix—from 4 percent to 97 percent—with the rest made up of equal numbers of non-grass species.

As the plants grow, the team will measure things like species cover at different times of the summer, soil nitrogen availability, and so forth. Master's student Allison Lambert will compare photosynthesis rates of the cultivars and non-cultivars. Master's student Lewis Reed will selectively remove grass species from various plots to test the theory that cultivars choke out other species because of their high growth rate.

Another master's student, Ryan Klopf, is studying root biomass. And Ryan Campbell, who collected most of the wild seeds for the project as an undergraduate, has stayed on as a master's student to study root colonization by fungi.

"When you go from prairie to cropland, you go from a fungal-dominated [soil] community to one dominated by bacteria," Baer explains. "Fungi are critical in restoring the aggregate structure of soil—a key measure of soil quality—that's lost in tilling."

Undergraduates in plant biology, zoology, and forestry also are an integral part of this large project, which runs the gamut from roots and leaves to the overall ecosystem. The team is studying the growth of individual plants and how that affects species biodiversity, but they're also looking at how biodiversity affects ecosystem-scale processes such as nutrient use and soil enrichment.

After just one growing season so far, Gibson says, "It appears already that cultivars are coming in quicker—establishing more and bigger plants. They've got a head start. The establishment of native seeds is not great so far."

Wild seeds may be getting shut out, he says, or they may simply take more than one year to germinate. Baer speculates that wild seeds "may be allocating more energy belowground at first. Cultivars, like crops, may allocate more aboveground." That would explain why they overtop other species.

What goes on in the soil, however, is more important in the long run to creating and sustaining a diverse prairie.

"In a prairie there's more biomass belowground than aboveground," Gibson says. "There's lots of activity belowground; it just hasn't been studied properly." Restoring a sustainable prairie depends on how well these perennial plants take root and rebuild soil organic matter and nutrients.

Baer holds a three-year, $286,000 fellowship from the Andrew W. Mellon Foundation—only one is awarded per year, to a promising junior researcher—to study long-term recovery of carbon, nitrogen, and microbial pools in the soil of restored prairie sites.

In four different areas, two in western Nebraska and two in northwestern Illinois, she's identified a number of small restored prairie sites ranging from two to 18 years old, along with patches of native prairie. These so-called "chronosequences" provide a timeline—a way to get a handle on long-term changes in soil quality. Baer will be able to compare sites across regions with climate differences (Illinois gets much more rain) and across soil types. Postdoctoral fellow Clinton Meyer is working with her on a total of 80 sites.

"We're hoping to expand this research to South Africa, where another prairie chronosequence has been identified," Baer says. "They have some native grassland left and have done some restorations, so we can look for global generalities."

Prairies are unquestionably good for the planet. They enrich the soil. They sustain a rich fauna. They build up and store large amounts of carbon—and the more carbon sequestered in the soil, the less carbon dioxide in the atmosphere to contribute to global warming.

But another reason for restoring prairies is, simply, to restore part of our heritage—to see for ourselves the same beauty that our forebears did.

For more information, contact Dr. Sara Baer, sgbaer@siu.edu, or Dr. David Gibson, dgibson@plant.siu.edu.

Wonderful World

▲ ***Rafflesia arnoldii*** **in full bloom in Sumatra, Indonesia. Photo by Jeremy Holden.**

Readers of *Perspectives* may recall seeing a photograph of a *Rafflesia* bloom similar to this one several issues ago, in an article on parasitic plants. *Rafflesia* species, which have no roots, leaves, or stems, grow as a fungus-like strand inside a host vine for years before eventually developing a bud on the exterior of the host. Their flowers are the world's largest and smelliest, reaching three feet in diameter, weighing up to 15 pounds, and packing an olfactory punch with a stench like that of rotting flesh.

The genetic lineage of *Rafflesia* has been a scientific mystery. But earlier this year, Harvard biologist Charles Davis and SIUC biologist Daniel Nickrent got national attention for publishing the answer to the puzzle in *Science* magazine. Using DNA sequencing, they determined that this genus is part of the family Euphorbiceae. Ironically, that family includes many species known for very small flowers, such as poinsettias (whose red bracts are not part of the flower) and castor bean plants (whose flowers have no petals).

Apart from the basic scientific knowledge the team gained, a better understanding of the genetic mechanisms underlying floral gigantism could help researchers in agriculture and horticulture, where there is much interest in growing bigger flowers, Nickrent says.

For more about Nickrent's research, visit **www.siu.edu/~perspect/05_fall/parasiticplants.html.**

—Tim Crosby

Research Development and Administration
Woody Hall C206 - Mail Code 4709
Southern Illinois University Carbondale
900 S. Normal St.
Carbondale, IL 62901

ADDRESS SERVICE REQUESTED

NON-PROFIT ORG.
U. S. Postage
PAID
Permit No. 15
Carbondale, IL

Southern Illinois University Carbondale
Visit us on the web at: www.siuc.edu

SOUTHERN 150