grow

Wisconsin's Magazine for the Life Sciences • Fall 2014

food systems • health • bioenergy • environment • climate • communities

Meet the Scourge

Scientists and communities join forces to contain the emerald ash borer

College of Agricultural & Life Sciences
UNIVERSITY OF WISCONSIN-MADISON

THE ICEMAN COMETH • MAKING SCIENCE ED RELEVANT • HOW FISH WENT ELECTRIC

Volume 8, Issue 1 • Fall 2014

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Wisconsin's Magazine for the Life Sciences

Morning comes to Arlington: Photographer Sevie Kenyon BS'80 MS'06 offers a bird's-eye view of the Arlington Agricultural Research Station.

Dean Kate VandenBosch

A Home for Signature Student Experiences

A dean's loss is our students' gain—and I couldn't be more pleased about it.

I'm referring to the beautiful Queen Anne home—in the middle of what is now Allen Centennial Gardens—that was built in 1896 to serve as the residence of the dean of CALS. Apparently it was part of an incentive package to keep our first dean, William Henry, from being lured away to Stanford or Cornell.

Deans Harry Russell and Chris Christensen lived there during their tenures, followed by Dean E.B. Fred, who stayed on in "Lake Dormer," as it was called, even after he had become UW president (and in fact, even after he retired). Fred was the last dean to reside there. The building was added to the National Register of Historic Places in 1984 and over the years has housed various administrative offices, none of them involving direct use by and for our students.

Until now. As you may know, CALS is home to nearly 40 student organizations representing the many interests, passions and professional aspirations one might expect from a college spanning 24 majors. Clubs are extraordinarily important in many students' lives. They not only serve as the hub of social activities but also allow students to do the kind of hands-on work that synthesizes what they've learned from many different fields of knowledge in the classroom.

> "It's an amazing gift to our students, and one that will certainly help CALS grow the future."

But up to now, the space students have had for their clubs—for meetings, for storage, for office equipment—has been very much catch-as-catch-can.

Students are squeezed for space for other enriching, future-directed activities as well. For example, CALS Career Services—the folks who offer students assistance in finding internships and jobs, including holding mock interviews and "etiquette" dinners—do not have dedicated space for those activities, nor are there adequate, modern facilities allowing corporate recruiters to conduct interviews with CALS students on campus.

Our popular Study Abroad programs, offering students unparalleled opportunities to participate in learning, research and community service all around the world, are run in spaces that are inadequate for their high demand. And alumni groups wishing to interact with students—to offer presentations, help with projects or simply get to know them better—have no space in which to center their activities.

Now we can only say: Thank you, Dean Henry! And thanks to the thoughtful leaders in CALS and the greater campus community who recognize how important all of these "beyond classroom" experiences are to the quality of education we offer our students. Renovations have begun, and in 2016 we plan to open the former CALS Dean's Residence as a home to a rich array of student experiences—including clubs, Career Services and Study Abroad—that help make CALS *CALS.* It's an amazing gift to our students, and one that will certainly help CALS grow the future.

For more on the building's history, see "Agricultural Dean's House," http://go.wisc.edu/deanshouse

To contribute to the building renovation fund, please visit http://supportuw.org/giveto/calsdeanshouse

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Volume 8, Issue 1
Fall 2014

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Hello, Sweet-tart!

Ice cream and cranberries make the perfect couple

Two big players in Wisconsin's food world are now an item. They were introduced at a CALS anniversary party earlier this year and are now sought-after for all the best campus events. We're talking about Happy Cranniversary, the harmonious blend of vanilla ice cream and cranberry that the Babcock Hall dairy plant created in honor of CALS' 125th anniversary.

A lot of people helped arrange this marriage. The name and basic idea came from Allison Dungan, an outreach specialist in the CALS soil science department who submitted the winning entry in a "name the anniversary ice cream" contest that drew 434 contenders. Concocting the flavor was the job of Bill Klein, manager of the Babcock dairy plant, and research intern Sandy Hughes.

Klein knows a thing or two about inventing ice cream flavors—he's developed dozens of great ones—but in this case he decided to get some help with the key ingredient. He turned to Marcy Berlyn, co-owner of Rubi Reds, a firm in Wisconsin Rapids that has found ways to incorporate cranberries into pretty much every food group, from trail mix, honey, vinegar and mustard to bratwurst, cheese, wine, vodka and many more.

"Rubi Reds sent us a total of 10 to 15 different ingredient samples to evaluate," says Klein. "We tested syrups in the basic ice cream mix until we found the intensity and type we were after. We then hand-mixed different variegates into the ice cream and evaluated for flavor and viscosity."

The final product has three cranberry ingredients: a syrup for flavor, a thicker, sauce-like "variegate" to form cranberry swirls, and sweetened cranberries.

Happy Cranniversary is a perfect union, mingling sweet and smooth with tart and chewy. It's been a big seller in the Babcock Dairy Store and at both UW student unions—and of course it's been a hit in cranberry country. Rubi Reds has sold it by the scoop at outdoor events and by the carton at its retail store.

Photo by Sevie Kenyon BS'80 MS'06

Dairy science junior Lindsey Hellenbrand dishes up some Happy Cranniversary at Babcock.

"We've made multiple runs to Madison to restock," Berlyn says. "It's a very popular product. We all love it."

—Bob Mitchell BS'76

The Shocking Truth

Scientists have learned how electric fish got their jolt

Photo by Jason Gallant/Michigan State University

For the first time, scientists have sequenced the genome of the electric eel. Their findings shed light on how fish with electric organs evolved to produce electricity outside of their bodies.

It is well known that a certain kind of fish swims the world's waters protected, as it were, by its very own stun gun.

Unknown, until now, is how electric fish evolved such a defense. A team of researchers led by CALS biochemistry professor Michael Sussman has established the genetic basis for the electric organ, an anatomical feature found only in fish. It evolved independently half a dozen times in environments ranging from the flooded forests of the Amazon to murky marine environments.

"These fish have converted a muscle to an electric organ," says UW Biotechnology Center director Sussman, who began this research almost a decade ago. The study, recently published in the journal *Science*, provides evidence to support the idea that the six electric fish lineages used essentially the same genes and developmental and cellular pathways to make the electric organ, which fish use to communicate with mates, navigate, stun prey, and as a shocking defense. The jolt from an electric organ can be several times more powerful than the current from a standard household electrical outlet.

Worldwide, there are hundreds of electric fish in six broad lineages. Their taxonomic diversity is so great that Darwin himself cited electric fishes as critical examples of convergent evolution, where unrelated animals independently evolve similar traits to adapt to a particular environment or ecological niche.

The new work includes the first draft assembly of the complete genome of the South American electric eel. "A six-foot eel is a top predator in the water and is in essence a frog with a built-in five-and-a-half-foot cattle prod," says Sussman. "Since all of the visceral organs are near the face, the remaining 90 percent of the fish is almost all electric organ."

Electric fish have long fascinated humans. The ancient Egyptians used the torpedo, an electric marine ray, in an early form of electrotherapy to treat epilepsy. Much of what Benjamin Franklin and other pioneering scientists learned about electricity came from studies of electric fish. In Victorian times, parties were organized where guests would form a chain to experience the shock of an electric fish.

All muscle cells have electrical potential. Simple contraction of a muscle will release a small amount of voltage. But at least 100 million years ago some fish began to amplify that potential by evolving from muscle cells another type of cell called an electrocyte—larger cells, organized in sequence and capable of generating much higher voltages than those used to make muscles work.

The "in-series alignment" of the electrocytes and the unique polarity of each cell allows for the "summation of voltages, much like batteries stacked in series in a flashlight," says Sussman.

In addition to sequencing and assembling DNA from the electric eel genome, the team produced protein sequences from the cells of the electric organs and skeletal muscles of three other electric fish lineages using RNA sequencing and analysis.

"I consider exotic organisms such as the electric fish to be one of nature's wonders and an important gift to humanity," says Sussman. "Our study demonstrates nature's creative powers and its parsimony, using the same genetic and developmental tools to invent an adaptive trait time and again in widely disparate environments."

And the findings may be useful to humans. "By learning how nature does this, we may be able to

Photos courtesy of Lindsay Traeger/Sussman Lab

(Left) **CALS genetics graduate student Lindsay Traeger (center, shown here with graduate students from the University of Louisiana) spent time this past summer gathering electric fish in Peru. They located the fish by using an amplifier that converts the fish's electric impulses into audio.**

manipulate the process with muscle in other organisms and, in the near future, perhaps use the tools of synthetic biology to create electrocytes for generating electrical power in bionic devices within the human body or for uses we have not thought of yet," says Sussman.

Sussman's collaborators include Harold Zakon of the University of Texas at Austin and Manoj Samanta of the Systemix Institute in Redmond, Washington. The study was funded by the National Science Foundation, the W. M. Keck Foundation and the National Institutes of Health.

—Terry Devitt

(Below) **Sequencing the electric eel genome is helping biochemistry professor Michael Sussman and his team better understand the development of other electric fish, such as the black ghost knifefish.**

New Life for a Grand Old Tree

Photo by Rebecca Bock

The Goff Family invites you to sit on a branch of their family tree in Allen Centennial Gardens. The Goffs were on campus this summer to present the Department of Horticulture with a spectacular bench crafted from a fallen portion of a historic larch named after their forebear, Emmett S. Goff, the UW's first professor of horticulture and one of CALS' original faculty members. The wood had been salvaged when the world famous geotropic Goff Larch lost a major limb during a winter storm in 2007.

With the Goffs' generous financial support, Madison artist Aaron Laux built the bench, using the living portion of the tree as inspiration for the design. The bench was unveiled at the Department of Horticulture's annual garden party, which was also a celebration of the department's 125th anniversary, held in Allen Centennial Gardens, where the surviving portion of the Goff Larch still grows.

Of Pests and Pathogens

Insects play a role in the spread of food-borne pathogens on crops

Imagine you're standing in a sun-drenched field full of lettuce plants. There's a gentle breeze and a smattering of tiny insects flitting about. It's a pleasant scene, right?

Now let's say one corner of the plot is contaminated with the deadly human food-borne pathogen *Salmonella enterica*, due to dirty irrigation water.

Could the insects, which hop from leaf to leaf feeding on plant sugars, play a role in spreading the contamination further afield?

"As insects feed and wander around on contaminated plant surfaces, it's possible that they pick up *Salmonella*, so we decided to ask if they are playing a role in food safety," says Jeri Barak, a CALS professor of plant pathology.

Photo by Sevie Kenyon BS'80 MS'06

Team *Salmonella*: Plant pathologist Jeri Barak, entomologist Russell Groves (standing) and doctoral student Jose Pablo Soto-Arias study how insects spread pathogens on food crops.

Photo by Kenneth Frost

Close-up of an aster leafhopper, one of the insects shown to be able to excrete *Salmonella*.

It's an important question. Salmonellosis is one of the leading causes of acute bacterial gastroenteritis in the United States, responsible for an estimated 1.4 million illnesses, 15,000 hospitalizations and 400 deaths annually. In recent years, there have been more salmonellosis illnesses linked to fresh produce than to animal products. Yet very little is understood about produce-associated outbreaks, including basic information about how human pathogens survive and spread on plants.

To test whether plant-eating insects play a role, Barak teamed up with CALS entomology professor Russell Groves to design experiments assessing the ability of two common crop insect pests—the aster leafhopper and the green peach aphid—to pick up and spread *Salmonella*.

"Because we work with human pathogens in my lab, we never get to do research outside, so it was important to have someone like Russ Groves on board," notes Barak. "He's a UW–Extension entomologist, so he has a lot of experience in the field, and he pushed us to be as practical as possible."

In one set of experiments, insects were given a piece of *Salmonella*-contaminated leaf material to munch on for 24 hours. In another, they spent the day drinking *Salmonella*-laced sugar water through a protective barrier that prevented physical contact between *Salmonella* and insect. In both setups, the insects were then transferred into a series of clean environments over the next 48 hours to see if—and how long—the contamination lasted.

In both cases, the insects readily picked up *Salmonella*, and once contaminated, most stayed contaminated.

Those that ate tainted leaves became contaminated inside and out, harboring *Salmonella* in their guts as well as on their feet and antennae, and when they were transferred to clean tubes, they spread the bacteria to fresh leaf material.

For insects that drank the *Salmonella*-laced sugar water, the bacteria got into their guts—and also found a way out.

"They excreted the *Salmonella* through honeydew—that's a nice word for insect poop. Even after 48 hours, they were still pooping it out," says Barak.

Honeydew, they also found, serves as a nutrient-rich fertilizer that helps *Salmonella* grow on plant surfaces that would otherwise be inhospitable.

On the practical side, notes Barak, farmers can now add these insects to the list of risk factors they consider when making crop management decisions.

"Now when a raw-produce grower looks out and it's been a bad year for insect infestation, it might signal to them that they may have a higher food safety risk," she says.

—Nicole Miller MS'06

A Groundbreaking Gut Check

Twenty years of reaching into rumens pays off

Photo by Sevie Kenyon BS'80 MS'06

CALS dairy science professor David Combs has developed a forage fiber test to identify the best feeds for cows—and milk production.

You might expect that the most important breakthrough in feeding dairy cattle in years would rate a snazzy name. Instead, you get "total tract neutral detergent fiber digestibility"—TTNDFD for short.

"Yes, I know. That's a terrible name. But unless someone comes up with something better it's TTNDFD," says CALS dairy nutrition scientist David Combs.

No matter. For an idea this good, a clever name isn't needed.

The discovery of TTNDFD, a new forage test, lays to rest a mystery that's perplexed researchers and dairy farmers since scientific forage analysis began 40 years ago: Why cows would wolf down one finely tuned dairy ration but turn up their noses at another that, on paper, was identical?

"We couldn't put a finger on it," Combs says. "You'd get your forage analysis, balance the ration, and everything seemed fine. But one time the cows would eat everything up, the next time you'd get a high rate of refusal."

That mystery cost money. When cows eat to capacity, they produce milk to capacity, and milk sold off the farm is what pays the bills. "It wasn't so much good forage, bad forage. Those things we can detect. It was those times when everything seems fine and the cows would not eat as much as expected or not produce as well as before," Combs says.

Cows are professional eaters and highly discerning about what gets served. They'll eat a lot of different things but will eat a great deal more of the things they like best. What the Combs team figured out—through research that involved 20 years of reaching into the 30-gallon vats known as cow rumens—was that how much cows gobbled up and turned into milk was influenced by the rate of fiber digestion. Developing a test to account for it ushered in a new feeding system that offers several advantages.

For one, the new forage fiber test lets farmers see the differences in the feeds they have on hand. For another, it helps them grow and buy the types of feeds most favored by cows. For yet another, plant breeders can use the test to create the type of crops cows want the most. And most important, the test can help milk producers make more money.

"How fiber is digested can easily make five to six pounds per day difference in milk production in a dairy cow," Combs says.

There could also be some positive ripple effects. As people applied the test to all kinds of forage, they discovered that grass is something of a magic missing ingredient in the daily dairy diet. The right kind of grass is really good for cows, and the test can help farmers select the right grasses to grow.

Reintroducing grass to dairy diets on a large scale could be great for the landscape. Grass soaks up carbon and nutrients, holds soil in place, covers otherwise bare ground during the winter, and can help absorb manure applications.

The test also opens opportunities for entrepreneurs. When Rock River Labs in Watertown hired John Goeser BS'04 MS'06 PhD'08, who'd earned a doctorate under Combs, it became the first lab in the world to offer this new analysis to the dairy community.

"It's started a little slow. But it went from no tests to 5,000 tests in a season," Combs says. Now Combs uses a large spreadsheet to review the data being generated by thousands of TTNDFD tests performed by Rock River. More labs are looking into offering TTNDFD results as part of a forage analysis package.

—Sevie Kenyon BS'80 MS'06

classAct

Desire Smith
City Farmer

Photo by Joan Fischer

"Born and raised in a food desert in inner-city Milwaukee, I never thought I'd be standing in front of you today," Desire Smith told a packed house on campus last spring. "The closest connection to agriculture I could make was to travel to the nearest Walmart to buy produce."

Smith, a senior majoring in community and environmental sociology, was the only undergraduate among several speakers—including CALS Dean Kate VandenBosch—to address a meeting of the new Institute for Urban Agriculture and Nutrition (IUAN), a multi-organizational partnership seeking to grow the urban food economy.

Smith became interested in agriculture as a student at Milwaukee's Vincent High School, where her biology teacher took her class on visits to the school's greenhouse. "I was intrigued by the beauty," she says, and soon got an after-school job there.

"But the more familiar I became with agriculture, the more confused I felt about what I, coming from an urban background, could possibly offer the field," she recalls. "Was agriculture even an appropriate concern for me to have?"

She wants the path to agriculture to be clearer for other young people of her background and has focused on that goal. She serves as an intern with the Community and Regional Food Systems project, a multiyear effort headed by CALS soil science professor Stephen Ventura to analyze and strengthen food systems in a number of cities.

And this past summer she created and coordinated urban agriculture-focused sessions for some 40 high school students enrolled in PEOPLE, a program that brings socioeconomically diverse young people to campus each summer. Smith herself is a PEOPLE alumna.

After graduating, Smith plans to get hands-on farm experience through World Wide Opportunities on Organic Farms, a nonprofit that links volunteers with farmers. And after that she's planning on graduate studies with a focus on urban agriculture.

She has her role model: Monica White, a professor in the Department of Community and Environmental Sociology. White has been an inspiring mentor to Smith.

"I look up to Monica White. I always tell her, 'I want to be like you,'" Smith says with a laugh.

—Joan Fischer

OPEN FOR BUSINESS this fall, a new undergraduate Certificate in Business Management for Agricultural and Life Sciences, offered by the Department of Agricultural and Applied Economics in partnership with the Department of Life Sciences Communication. It is open only to students who are earning a CALS degree.

ELECTED a Fellow of the American Poultry Science Association, **Mark Cook**, a professor of animal sciences, for professional distinction and his contributions to the field (which include more than 30 U.S. patents and several start-up companies based on his research). Being named a Fellow is one of the highest honors an association member can receive.

SELECTED for a Shaw Award ($200,000), **Aaron Hoskins**, a professor of biochemistry who studies the cellular machines that interpret the information found in DNA and put it in a form that can be used by the cell. The competitive award will enable Hoskins to pursue "high-risk, high-reward" projects vital to understanding how cellular machines are built.

RECIPIENTS of Alfred Toepfer Faculty Fellow Awards: **Julie Dawson** (horticulture), **Laura Hernandez** (dairy science) and **Garret Suen** (bacteriology). The award recognizes promising assistant professors in the early stages of their careers whose research benefits agricultural activities.

SELECTED to receive Elton D. and Carrie R. Aberle Faculty Fellow Awards: **Francisco Arriaga** (soil science) and **Jeffrey Endelman** (horticulture). Established by the former CALS dean and his wife, the award is designed to recognize and reward promising young faculty within CALS.

HONORED by the American Society of Landscape Architects, **William Tishler**, a professor emeritus of landscape architecture, with this year's Jot D. Carpenter Teaching Medal. The award recognizes significant and sustained excellence in landscape architecture education.

Number Crunching

Photo by Matt Stasiak

6 INCHES OF HAIL and more than three inches of rain pounded down on lower Door County on July 14, shredding crops in a 1.5-by-2-mile swath at the Peninsular Agricultural Research Station near Sturgeon Bay. "If I took all the hailstorms I've seen in my life and put them into one storm, that's what we had," superintendent Matt Stasiak told the *Wisconsin State Journal*. With the exception of some potato plants in greenhouses, "Everything at the research station is a loss," he said.

Five things everyone should know about . . .

Milkweed

By Evelyn Howell

1 | **It is the stuff of life for monarch butterflies.** Monarchs lay their eggs on milkweed, and milkweed leaves serve as nearly the sole food of monarch caterpillars. But many species benefit from the bounty of milkweed. Milkweed flowers produce nectar that other kinds of butterflies, honey bees, native bees and other pollinators enjoy. Hummingbirds line their nests with floss from milkweed seed pods.

2 | **It's both medicine and poison.** Milkweeds—there are more than 100 species—belong to the genus Asclepias, named after the Greek god of medicine and healing. Milkweeds have been used in medicine for thousands of years because their tissue contains cardiac glycosides, which increase the heart rate and in a purified form are useful in treating such conditions as cardiac arrhythmia and congestive heart failure. As a crude extract, cardiac glycosides are toxic and have been used as poison. Monarch larvae retain the toxins they consume in milkweed leaves and as butterflies remain toxic to predators.

3 | **Its presence is dwindling, along with the monarchs.** The first decade of this century saw a 58 percent decline in milkweeds in the Midwest, according to a 2012 study—a time when we've also seen a whopping 81 percent decrease in monarch production. Factors often cited for milkweed's decline include loss of habitat as grasslands and conservation reserves have been converted to farmland for corn and soybeans as well as increased use of herbicides on those crops.

4 | **There's a growing movement to bring it back.** Researchers at CALS and elsewhere have noted an increase in biodiversity, pollination and other ecosystem services that come from establishing or maintaining a mix of perennial native plants near cropland—and milkweed, they say, should be part of it. Vigorous efforts are taking place throughout the Midwest to plant large areas of milkweed along the monarchs' migration path to Mexico, where they spend the winter.

5 | **Milkweed will enliven and beautify your garden—but keep your gloves on when handling.** The toxins that protect the monarch can harm humans. Make sure the sap doesn't get into your eyes, and if it does, seek medical attention as it can cause significant damage. While not all milkweeds are equally toxic and some kinds can be eaten, great care must be taken when selecting and preparing it.

Evelyn Howell is a professor of landscape architecture.

COSTA RICA

New trail in paradise

This past January a group of CALS students found themselves bushwhacking through a dense mountain forest in Costa Rica, crossing paths with monkeys, colorful birds, snakes and strange-looking frogs along the way.

But no worries: They weren't lost.

CALS students blaze a trail for the Cloud Forest School in Costa Rica.

Photo courtesy of Sam Dennis

As part of a service-learning course offered by the Department of Landscape Architecture, they were scouting out a new hiking trail for the Cloud Forest School, a bilingual, environmentally focused K–11 school located just outside the majestic, fog-shrouded cloud forest reserves of Monteverde and Santa Elena. The reserves are among the most biologically diverse places on Earth, serving as home to more than 2,500 plant species, 400 kinds of birds, more than 200 species of mammals, reptiles and amphibians—and thousands of insects.

"We hiked through the most wild parts of the mountain to collect GPS points of potential new trails," says Lyn Kim, a landscape architecture senior who spent two weeks in Costa Rica as part of the Cloud Forest Studio course, as it's called.

CALS students helped plan, map and build a five-kilometer trail through the school's extensive grounds, which include both pristine and previously harvested cloud forest. The path, which includes resting points of special ecological interest, was designed for Cloud Forest School field trips as well as for the school's annual fundraiser run. Creating it, however, was just one piece of a much larger effort.

"The long-term goal is to help develop some kind of meaningful forest restoration plan for the property," says landscape architecture professor Sam Dennis, who co-leads the course along with department chair and professor John Harrington.

"We also want to help support the school's environmental education efforts so their students can go on to jobs in the local ecotourism industry," he adds.

Dennis and Harrington made a five-year commitment to the school and so far have led two groups of CALS students to conduct work there. In addition to building the trail, students have also started developing classroom curriculum materials, nature guides for the property and interpretive trail signage.

The trips expose CALS students to landscape architecture's vocational variety. "People tend to think of landscape architecture as putting plants onto landscapes, but that's very little of what we actually do," explains Harrington. The course gives students a taste of environmental restoration work, community development work, and the creation of outdoor educational spaces with community input.

Kim, for one, was thrilled with her experience last January, and not just because she got to see an active volcano and zipline down the side of a mountain on her day off.

"At school we always design on trace paper and in the computer, but we never get to see our designs built," she notes. "During our trail-building project, we got to see our work come to life."

—Nicole Miller MS'06

KAZAKHSTAN

Dam monitoring protects water supply

Unpredictable flooding and droughts, which scientists predict will intensify with climate change, elevate the importance of dams for managing and storing water, even in places that normally receive adequate rainfall. Maintaining the world's existing dams helps ensure that farmers will have the water they need to feed the planet's burgeoning population.

To aid that effort, graduate students Charles Chang and Andrew Schreiber, both in agricultural and applied economics (AAE), have created software that can quickly and inexpensively determine a dam's structural integrity using their algorithm and data from easily installed fiber-optic sensors, such as those already in use at the Koksarai Dam in Kazakhstan.

"Our system gives water managers a more cost-effective way to monitor the overall integrity of dams than any other technology," says Chang. He is collaborating with a team of engineers who developed the sensors, led by Professor Ki-Tae Chang at South Korea's Kumoh National University of Technology. The sensors, which measure water seepage through a dam, provide real-time data the researchers are using to locate areas of erosion that could eventually undermine the dam's capacity.

"We're targeting dams in developing countries, most of which are used as reservoirs for agriculture. Many of them have no solid core and are easily moved by high water pressure, or they are older dams that need maintenance," says Chang. "We can give water managers the information they need to decide whether repairs are required."

Up to now, notes Schreiber, "Earth dam monitoring has required considerable amounts of capital and labor, leaving poorer communities at a loss."

Chang and Schreiber drew on the expertise of an interdisciplinary team to create their product. The team includes civil engineering professor Chung R. Song of the University of Mississippi and Jesse Holzer, a UW computer science graduate student. AAE professors Tom Rutherford and Corbett Grainger serve as project advisors.

"Some models of dam sustainability measure the effects of sedimentation in the reservoir, but our project goes farther by looking at the erosion factor," says Chang. "For example, if Kazakhstan were to experience less rainfall due to climate change in the coming years, we would want to maintain a higher reservoir level in the dam for future agricultural use. But we also know that higher water levels can trigger more erosion."

As economists, Chang and Schreiber want to help governments predict how much they need to invest in a dam to increase its capacity. And because different climate change scenarios can affect both sedimentation and erosion—the main causes of dam failure—the team will model the returns to investment in dam maintenance or abandonment. "What is the benefit to society to have that dam reinforced or allowed to collapse?" Chang asks.

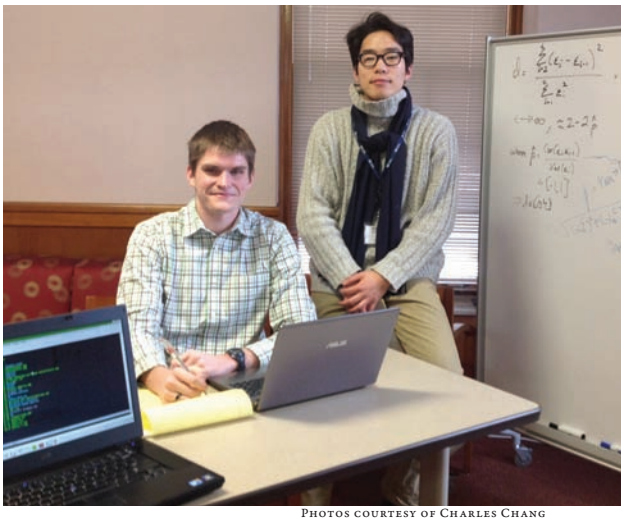
After implementing erosion detection algorithms for earth structures in Korea and Kazakhstan, Chang and Schreiber now collaborate with pH Global, a start-up venture that creates inference algorithms for a variety of geotechnical public amenities, such as tunnels and dikes.

"A fifth of the world's population lives in water-scarce regions, and most dams lack monitoring capability," says Chang. "With our algorithm and sensors, water managers can minimize costs by using less hardware and more software."

The students may have a viable commercial product on their hands. It has drawn some attention in South Korea and France, Chang says, and several contracts for using it are already in place.

—Barbara Forrest

AAE graduate students Andrew Schreiber and Charles Chang (below) have created software that can determine the structural integrity of dams such as the Koksarai Dam in Kazakhstan (left). Their product is attracting buyers around the world.



Photos courtesy of Charles Chang

Keeping Track of Wolf Deaths

Illegal killing seems to be rising, says wildlife ecology professor **Tim Van Deelen**

Interview and photo by Sevie Kenyon BS'80 MS'06

TIM VAN DEELEN, a CALS professor of wildlife ecology, specializes in the management of large mammals, including population estimation and dynamics, hunting, interaction of deer life history and chronic wasting disease—and, not least, the growth of Wisconsin's wolf population and its effects on white-tailed deer.

As this year's wolf hunt season opens in Wisconsin, we talked with him about a hidden and disturbing topic: illegal killing, which Van Deelen says may have increased in recent years. Much of the data on this subject, he says, comes from work by his former doctoral student Jennifer Stenglein MS'13 PhD'14, who is now a wildlife researcher with the Wisconsin Department of Natural Resources.

Can you give us an idea of how wolves die?

As we know from radio collaring data, wolves die for a variety of reasons. Wolves in Wisconsin have relatively high mortality rates, and that probably has to do with the fact that they're living on a landscape that's much more highly impacted by humans than, say, northern Canada or Alaska. We have higher levels of wolves getting hit by cars, especially as they begin encroaching parts of central and southern Wisconsin where we have higher road densities.

Wolves are also territorial, so on the margins of their pack territories or where there are territorial disputes between packs, wolves will kill each other.

Wolves die of disease. We've had deaths due to parvovirus and mange. Wolves sometimes starve to death if they can't get enough prey or if they're old or injured and otherwise inefficient as hunters.

There's also a fair amount of unexplained mortalities that we have from radio tracking data.

Can you elaborate on that?

We have radio-collared wolves that outlive the radio collars—that is, they outlive the battery that powers the collar—so you have a record that starts when the animal is radio-collared and ends when you stop getting signals. Understanding mortality rates at the population level requires you to make some decisions about how you're going to treat those animals once the record stops.

Research that my graduate student has been doing suggests that a fair number of those animals are dying.

Do you suspect illegal killing?

Well, the problem with illegal killing is you don't observe it. You can't point to something and say, "That wolf died from illegal killing," but you need extra mortality in the system once you explain everything else in order to reconcile the mortality rates that we're seeing with the reproductive rates that we get from the pup counts and the growth rate that we see from the annual population counts.

So there's a missing gap in the data of why some animals disappear.

Right. The basic population dynamics equation is very simple. It says that the number of animals born minus the number of animals dying is the net addition or subtraction from the population. If we have a population that we can count every year like we do with wolves—we count them every winter—then we can mathematically fit an equation to that growth using things like observed deaths and estimated reproduction.

When we can't get that to reconcile, then we need some additional deaths that are unobserved to make the growth rate that we see agree with the mortality and the reproductive rates that we're measuring.

The suspicion is that many or some of those unobserved deaths are due to illegal killing. Because from our radio tracking data we do have good estimates on the relative amounts of deaths that are due to other things, like being killed by other wolves or dying of disease or being hit on the road.

What would prompt illegal killing?

Human dimensions research done at the Nelson Institute suggests that people living in wolf range have a sense of frustration that many people think traces back to this on-again, off-again listing of wolves under the Endangered Species Act.

We went through a period where the wolves would be de-listed, or there would be movement toward de-listing, and then somebody would step in, the courts would intervene, and the wolves would become listed again.

There's good human dimensions research in wildlife that says that attitudes toward wildlife tend to degrade when people feel like they have no options for dealing with the problems that those wild animals are causing.

When wolves are put "off limits" because of the Endangered Species Act, then people who are experiencing problems with wolves, real or imagined—their attitudes toward wolf conservation begin to degrade.

That aligns with some of the research that's been done on this campus suggesting, among other things, that

Wildlife ecologist Tim Van Deelen demonstrates installation of a trail camera used to capture images of wolves and other creatures in the wild.

people who are interviewed in the north say they'd be more willing to illegally kill a wolf if the opportunity presented itself. More people are saying that now than in the early 2000s. That time period aligns with the growing frustration people have experienced over de-listing.

How many unexplained wolf deaths are there?

About 20 to 30 per year, in our best estimate. That's been from the period 1980 to 2013, where we fit the models. There's evidence that it's been increasing recently. By "recently," I mean within the past five or 10 years.

Can you please elaborate?

During the early part of the growth phase of wolves in Wisconsin (1996–2002) the wolf population averaged about 200 wolves during midwinter counts. We estimated that about 43 of these would die during the year, and unobserved deaths were likely not needed to reconcile observed population growth. During the latter part of the growth phase (2003–2012), Wisconsin's wolves averaged about 600 wolves, and about 138 of these would be expected to die during the year. However, you would also need another 24 dead wolves to reconcile the rate of population growth observed. These 24 would include a mix of natural and human-caused subtractions, including an unknown level of illegal killing. The change from 1996–2002 to 2003–2012 suggests that illegal killing may have increased.

What kinds of conflicts do people have with wolves in Wisconsin?

Probably the most important right now are conflicts with livestock producers. We have a handful of areas in Wisconsin that are hot spots where there's been sort of long-term chronic depredation by wolves on livestock.

That's a real problem—and fortunately in Wisconsin, the Department of Natural Resources has a partnership with USDA Wildlife Services. They have professional USDA trappers who can go in, verify whether a calf or a cow was killed by wolves, and then help the landowners either by excluding the wolves from the territory or by trapping and euthanizing the wolves that are causing problems. They're very professional, they're very good at what they do, and they're very successful.

Another problem in Wisconsin is wolves depredating hounds. These are mostly hounds used for hunting bears and smaller carnivores. If you're running hounds late in the summer, that's when the wolves are provisioning their pups at rendezvous sites.

The wolves probably interpret that incursion as an invading pack, so they would attack and kill those hounds. That happens, that's an issue to deal with. DNR has been proactive with trying to identify those areas where depredations have occurred and might be more likely, and warn people to avoid those areas with their hounds if at all possible.

There's a lot of talk about wolves having impacts on deer in the north. In some places, that's probably a reality. In some places it might be more perception than reality. At a statewide scale using the harvest statistics, we just haven't seen a real impact of wolves, but that's sort of a coarse-filter approach.

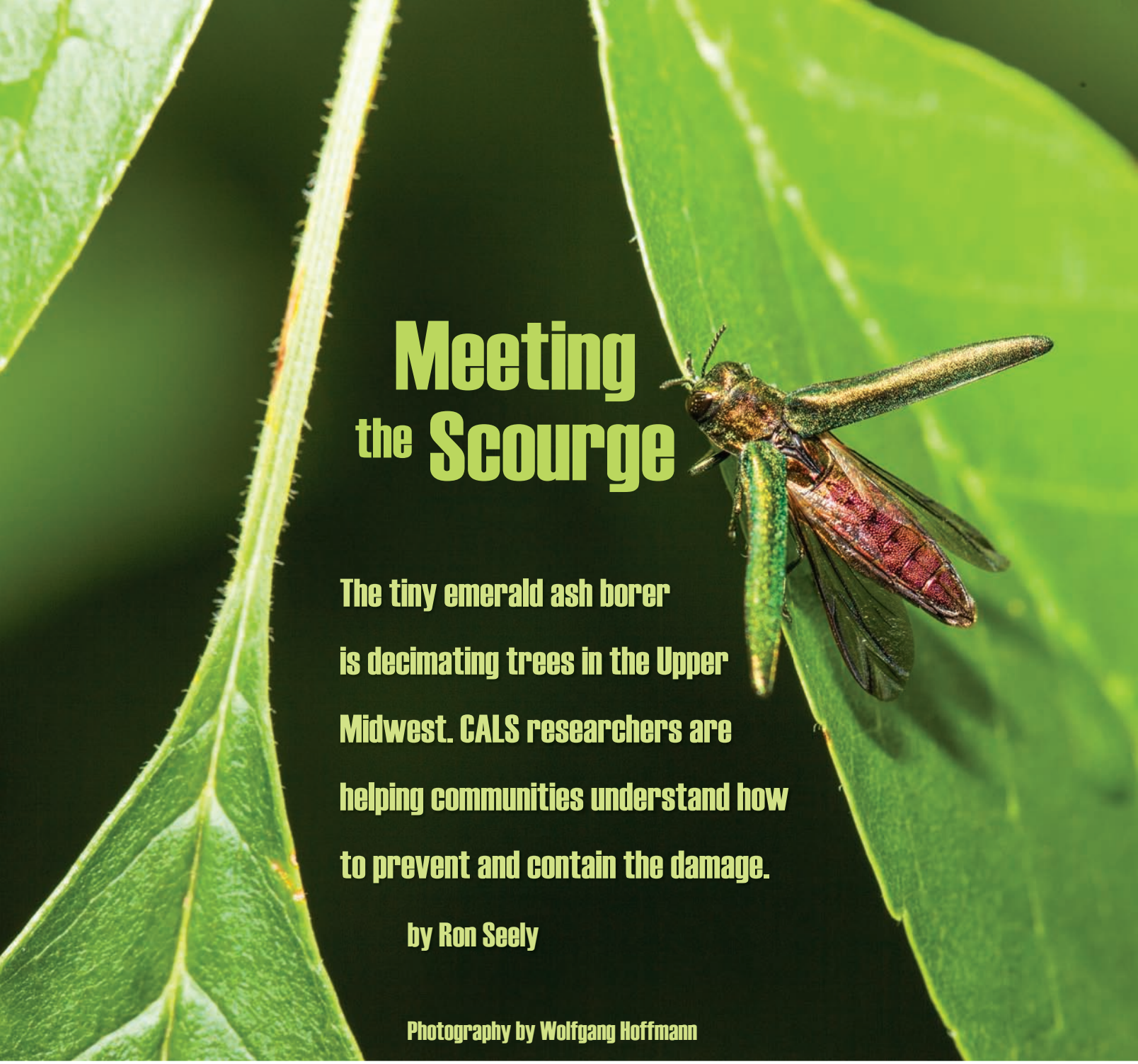
We have two deer research projects going, one in eastern farmland and one in the northwest. We actually don't find a whole lot of wolf predation on adult deer, which would be the mechanism by which wolves would have the most impact on the deer herd. Still, if you're the unlucky individual whose hunting spot happens to be sitting right on top of a wolf rendezvous zone, you might not be seeing very many deer.

What would you like to see done with wolf management going forward?

One of the unique things about wolf management in Wisconsin is that we're managing this population now at a pretty high exploitation rate—meaning that we've got heavy harvest seasons. Those are designed explicitly to reduce the wolf population.

Harvest management theory would suggest that there's some danger of long-term instability. I think the most important thing that managers of Wisconsin's wolf population need to do is keep putting efforts into monitoring the wolf population—tracking population trends, tracking the extent to which wolves live on the landscape. Those are the measurements you can use to identify some sort of instability and then be able to deal with it.

To be fair to the managers, they know that, they're working on that. We're collaborating with them to come up with more cost-effective ways to get the sort of information they need to track population trends.



Meeting the Scourge

The tiny emerald ash borer is decimating trees in the Upper Midwest. CALS researchers are helping communities understand how to prevent and contain the damage.

by Ron Seely

Photography by Wolfgang Hoffmann

IT IS AN INSECT LITTLE BIGGER THAN A GRAIN OF RICE. But the invasive emerald ash borer may as well be Godzilla for all the chaos it has brought to the Upper Midwest's forested landscapes.

The borer has already laid ruin to the ash that dominated urban and lowland forests in Michigan, where it first turned up near Detroit in 2002, likely a hitchhiker on wooden shipping pallets from China. And in dozens of Wisconsin villages and cities, street terraces are marked by the stumps of ash trees already removed because of infestation.

The Wisconsin Department of Natural Resources says the borer has killed more than 50 million ash trees and is now found in a dozen states, including more than 30 counties in Wisconsin. Though it is not a threat to human health, the ash borer's inevitable spread is likely to dramatically change the face of both urban and state and national public forests. The insect has already cost Wisconsin communities millions of dollars as they prepare for its assault and as they begin to remove and treat infested and threatened trees.

And it has proven a massive challenge to researchers—including entomologists at CALS—as they bring science to bear on understanding and slowing the march of the tiny, tree-killing insect and reducing its impact where it is established.

CALS entomologist Chris Williamson, who has studied the insect since 2003, says the word "cataclysmic" is not too strong to describe the eventual devastation that will be wrought by the emerald ash borer.

"The emerald ash borer means the demise of ash trees in North America," says Williamson, who is also a UW–Extension specialist.

His colleague, CALS entomologist Ken Raffa, has researched and introduced parasitic wasps as potential predators that might help at least slow the insect's steady march across the continent. But Raffa also said there is little doubt that such efforts are mostly holding actions against a foe that cannot be stopped.

"The genie is out of the bottle," Raffa says.

Even so, in the face of what seems to be nothing but bad news, research at CALS and elsewhere has provided weapons that are proving effective at slowing the insect, giving communities time to plan and homeowners the ability to treat and possibly save treasured trees with insecticides.

In fact, Williamson, surveying a stand of ash trees he has treated and studied at Warner Park on Madison's North Side, says he actually gets irked when someone says there's nothing that can be done to save an ash tree. He has spent long hours in the field, testing various insecticides. And he has found that treating an ash tree early enough and repeating that treatment every couple of years can save even large, prized trees that homeowners want to protect. Insecticides such as emamectin benzoate, marketed under the brand name "TREE-age," have also given urban foresters an effective tool to slow the loss of ash and temper the impact on a community's cooling leaf canopy.

Treatment has also been found to be less expensive than was originally anticipated. Experts with Arborjet, a company that has worked with a number of communities on treatment, says that an injection treatment, in which the insecticide is shot into the tree through holes bored in the bark, costs on average $50 to $60 every two years for municipalities. The cost is more for individual homeowners, according to Arborjet, but still cheaper than removal and replacement.

Research by Williamson and others has shown that when it comes to protecting an ash from the voracious borer, action must be taken.

"If you have an ash tree you want to preserve and you don't treat it, it will die," says Williamson.

Rebecca Lane, the city forester of Oak Creek, shows the looping trails the emerald ash borer gnashes through ash wood.

WHAT MAKES the emerald ash borer, also known as EAB, such an effective killer?

First, it is an invasive species. As such, it arrived on our shores to find it had won the insect lottery—millions of acres of tasty ash, no natural enemies poised to make a dent in its growing populations, and ash trees with no natural defense against the feeding larvae.

Added to this deadly mix of traits, according to Williamson, is the insect's near invisibility at the early stages of infestation. The flying insect is only about an eighth of an inch wide, he says, and it lays its eggs high in a tree's upper branches. The larvae emerge within a month, bore through the tree's bark and begin feeding on the soft wood beneath, creating a crazy map of looping trails.

All of this—from the infestation by flying adults high in the tree to the burrowing by larvae beneath the bark—is nearly impossible to spot, Williamson says. The only way to detect an infestation is through a laborious process of peeling away the outer bark of a tree and looking for the telltale trails left by the gnashing larvae. Unfortunately, by the time such evidence is found, it is too late to save the tree.

This cloak of invisibility, Williamson says, has made the borer a particularly deadly foe. Entomologists have estimated that, based on the extent of the damage to ash stands in Michigan, the borer had been dining on trees for nearly a decade before its presence was discovered, notes Williamson.

In the interim, the larvae were fatally damaging the ash trees' inner tissues, or cambium, the layers of the tree that carry food down to the roots and water and nutrients up to the leaves.

"It's like me going to your house without you knowing it and destroying your plumbing," says Williamson.

Williamson notes that if the tree's cambium is significantly damaged as a result of the feeding larvae, treatment is likely futile. "They've destroyed the conductive tissues," he says.

While Williamson has focused on the study of insecticides, Raffa has worked to find predators that might help slow the borer.

Researchers with the U.S. Department of Agriculture studying the insect in 2003 in its native China haunts found parasitic wasps that feed on the ash borer larvae, Raffa notes. Scientists narrowed their focus to three species that they concluded might be effective and would not attack native insects. Eight states released these parasitic stingless wasps between 2007 and 2010, and in 2011 Raffa, researchers from his laboratory, and members of state agencies cooperatively released specimens of the three species at Wisconsin's Riveredge Nature Center, near Newburg.

Raffa felled four infested trees in 2013, sectioned the logs and searched for wasps. He found that one species had survived and thrived.

"We knew they had established a population," says Raffa. "There's no doubt they were killing ash borers because that's all they feed on."

Now more of the wasps are being released by DNR pest specialists. But Raffa warns that, with the rapid spread of the ash borer, it is too late to hope that the wasps will have an immediate impact. Rather, Raffa says, the wasps may multiply and provide control after this initial, destructive wave of ash borer activity. Once the ash borer destroys much of its food source, the wasps may have a better shot at keeping their numbers in check.

"Their numbers are inadequate to affect this first big wave," Raffa says. "I'm hoping the wasps will be there to kick EAB when it's down."

Raffa adds that other researchers, including scientists at Ohio State University, are searching for and studying ash trees that survive the first ash borer attacks. Such trees may offer hope because of a natural resistance that, once understood, could be bred into a new borer-resistant strain of ash.

(Top) **The bare branches of infested trees.** ***(Bottom)*** **CALS /UW–Extension entomologist Chris Williamson has been studying the emerald ash borer for a dozen years—and works with communities around the state to address and alleviate the damage.**

The problem, both Williamson and Raffa say, is that such science takes time. "And time is not our friend here," notes Williamson.

Most effective in the short term at slowing the spread are DNR rules aimed at preventing the movement of firewood around the state. Raffa says the insect does not travel far on its own, and that the insect spread through the state is due mostly to its hitching rides on firewood.

A federal and state quarantine on counties where the ash borer is present requires tree nurseries and the wood industry to take precautions that prevent the spread of the borer in nursery stock or logs (see map on page 20). General public restrictions for bringing firewood onto state properties are posted at http://datcpservices.wisconsin.gov/eab/.

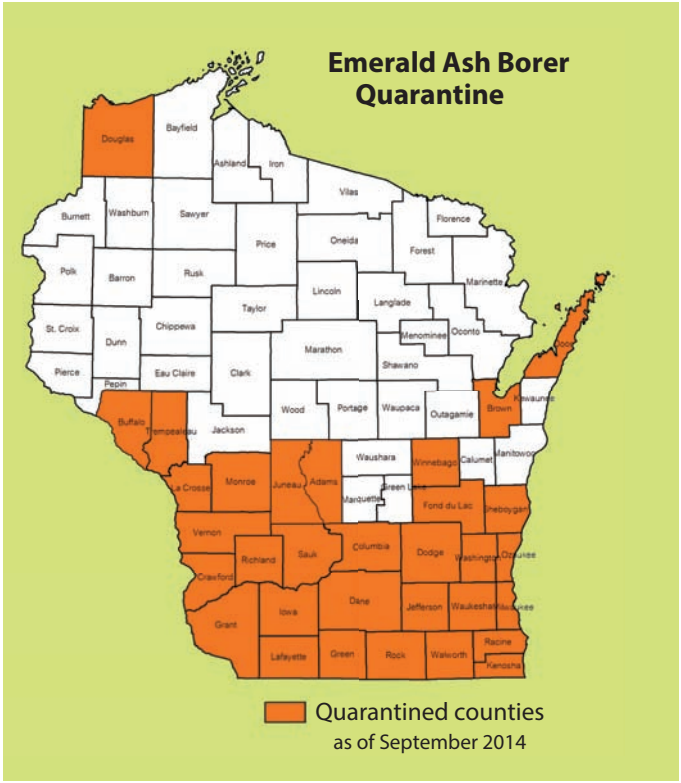
AT STAKE ARE extensive stands of ash that most communities planted in the wake of another tree calamity—Dutch elm disease. Often cited as being similar in impact to the emerald ash borer's spread, Dutch elm disease first appeared in the late 1920s and moved steadily across the continent through the 1970s. Caused by a fungus and spread by bark beetles, the disease killed 77 million of the much-beloved American elms between 1930 and 1989. Lost in that disaster were the beautiful urban tree stands that graced so many city and village streets, creating cathedral-like arches of shade.

In the wake of that loss, urban foresters planted millions of green and white ash trees. They grew fast, adapted well to urban growing conditions and resisted droughts. Madison's streets, for example, are lined with ash. The city's forestry department estimated that 21,700 of its publicly owned trees are ash. Thousands more are found in parks and on private property. Milwaukee has more than 30,000 ash trees lining its streets.

Statewide, Wisconsin has more than 770 million ash trees, according to the DNR's forestry division. That's 7 percent of the total tree population, and they dominate lowland forests. In the state's urban areas, according to the agency, 20 percent of street trees are ash.

Wisconsin ecological pioneer Aldo Leopold observed that disturbing one part of an ecosystem often has powerful and far-removed consequences. So it is with the loss of the state's ash trees, according to forestry experts. The loss of a large percentage of a community's tree canopy can lead to everything from more flooding to increased energy bills for homeowners, according to Marla Eddy, Madison's city forester.

In a 2004 study of urban trees in Minneapolis, researchers with the U.S.



Map courtesy of Wisconsin Department of Agriculture, Trade and Consumer Protection

Forest Service found that the benefits of landscape trees dramatically exceed the costs of planting and care over their lifetime. Each year, the study found, 100 shade trees catch about 216,200 gallons of rainwater and remove 37 tons of carbon dioxide as well as 259 pounds of other pollutants.

The researchers calculated that one well-placed large tree provides an average savings of $31 in home energy costs each year. And trees add value to a home, according to the study, which found that each large front yard tree adds 1 percent to the sales price of a house. Big trees can add 10 percent to property value.

So losing such a large percentage of the tree canopy in a community is about more than just appearances. That's why Milwaukee has chosen to treat as many as 28,000 of its 33,000 trees—to slow the loss of ash and keep as much of the canopy in place as possible as infested trees are removed.

In communities that were hit early by emerald ash borer, saving trees has been more difficult. In Oak Creek, just outside Milwaukee, EAB was discovered in November 2009, making it ground zero for the borer's assault on Wisconsin. In the absence of tested pesticides at the time, the city started an ambitious removal and replacement program aimed at getting new trees up as soon as possible, according to Rebecca Lane, Oak Creek's urban forester.

In fact, Lane, in anticipation of the insect's arrival, had already been taking steps to protect the canopy. "When we heard about EAB, I almost immediately stopped planting ash trees," Lane recalls. Of the city's 10,000 street trees, 1,500 were ash. Of these, 750 have been removed and 750 are under treatment. "As treatments became deemed dependable, we began to use insecticides for long- and short-term ash treatments," notes Lane.

Other communities, too, have been able to take advantage of insecticides that have proven effective, thanks to the work of Williamson and other researchers.

Madison is treating all healthy street trees 10 inches in diameter or larger, and anticipates saving as many as 60 percent of its street ash tree population, according to city forester Eddy.

"We have to think long-term," says Karl van Lith, organizational development and training officer for the city of Madison. "We're thinking about the tree canopy for the next generation."

WHILE RESEARCHERS have provided some help for urban forests, the more dense stands of ash in county, state and national forests will be much harder to save, according to Andrea Diss-Torrance, a plant pest and disease specialist with the Wisconsin Department of Natural Resources. The chemical treatments used in urban forests require application to individual trees, which is impossible when you're talking about entire forests.

Williamson says some research has looked at the effectiveness of aerial spraying a specific strain of *Bacillus thuringiensis,* similar to a bacterial strain used to control gypsy moth caterpillars. The pathogen is sprayed over the canopy and kills flying adults.

The practice remains limited, Williamson says, and comes with its own set of problems, not the least of which is the potential environmental impact of widespread spraying, as opposed to the controlled treatment of individual trees.

The bottom line is that saving extensive stands of ash trees in Wisconsin's public forests is going to be very difficult, acknowledges Diss-Torrance. "Our forests are going to be greatly changed," she says.

Diss-Torrance confirms that, just as the loss of urban ash trees will have environmental impacts, the death of thousands of forest trees is likely to cause damaging changes to the state's forest ecosystems.

Of special concern are lowland forests, such as black ash swamps. Research has already shown that the loss of black ash in these wetland areas can result in a rise in water levels because the trees are no longer there to soak up the water. That change, in turn, results in the growth of problem species such as reed canary grass, which muscles out other plants and so changes the wetland that it is no longer able to support its native cohort of plants and creatures, from amphibians to insects.

"You end up with very different communities," Diss-Torrance says.

The loss of black ash would be keenly felt by several of Wisconsin's Native American tribes, which have traditionally used the supple wood of the ash to make baskets for storing food.

"These baskets have always been a symbol of home and abundance," Diss-Torrance says. "They're central to the

Photo by Sevie Kenyon BS'80 MS'06

An urban forester injects insecticide to save an ash tree in Madison. Early intervention and repeated treatment can save even large trees, notes CALS/UW–Extension entomologist Chris Williamson.

harvest and to Native tradition."

In southern Wisconsin, green ash is prominent among the trees that line lakes, rivers and wetlands.

"We have a lot of lakes and a lot of wetland areas," Diss-Torrance notes. "And they're all dominated by green ash. Those trees help stabilize banks. What happens when they fall into the water?"

So the stakes are high as the battle continues against this tiny foe.

Williamson is spending less time on borer-related research but continues to spread the word about the use of insecticides—and he still spends a lot of time consulting with communities as they battle the insect.

In fact, Williamson says, with considerable misinformation circulating, the job of educating the public about the insect has been an important task of CALS scientists. He figures that between 2003 and 2013, he gave nearly 170 talks about the emerald ash borer.

One important lesson to come from the ash borer, Williamson says, is the need to diversify an urban forest's population. It's a lesson that should have been learned after the spread of Dutch elm disease, he notes. Now the rule of thumb is that no single species should represent 10 percent or more of a community's total tree inventory.

Both Eddy, the city forester in Madison, and Lane, her counterpart in Oak Creek, say creating that diversity in their plantings is a priority in the wake of the emerald ash borer.

Both also say that the disastrous spread of the insect has given them new insight into the touching connections between people and the natural world, especially their attachment to the beauty and solace of trees.

"That human factor is so much larger than I thought when I first started doing this," says Lane. "I thought of this as mostly a technical career."

But around Yahara Place Park, on Madison's near East Side, neighbors have seen ash trees beginning to fall and have decided to mobilize to protect what trees they can, according to Paul Nichols, one of the neighborhood organizers.

He and others went door to door collecting money to pay for treatment of healthy ash trees in the park alongside Lake Monona. Storms have recently roared through and destroyed a number of towering cottonwoods. So the remaining ash trees—about 22—took on added significance. Nichols and others took advantage of the city's "Adopt-a-Park Tree" program—which allows residents to pay for treatment of treasured park trees—to make sure that the ash got treated.

Why make such an effort? Nichols, strolling the park on a pleasant summer morning, pointed to the stumps of the removed trees and recalled the beauty of the big trees and their arched branches—old friends that were once visible from the front window of his home.

Nichols and others say they miss the trees and understand they may not be around when the ash that are saved grow to maturity. But, he adds, they know that others will someday know and appreciate the view of the blue lake framed between stately trunks, or the pleasure of sitting beneath a shady canopy on a lazy summer afternoon.

"What we're really talking about," Nichols says, "is doing something for the generations to come."

To the Ends of

Decades of field research at both poles have given soil scientist James Bockheim a front-row seat on climate change.

By Adam Hinterthuer

James Bockheim (left) in Antarctica with former graduate student Adam Beilke MS'11. They are drilling a shallow borehole in which to install instruments for measuring temperatures of "active layer" soil, which thaws and freezes.

the Earth

Photo Courtesy of James Bockheim

In April 2011, James Bockheim led a small team of researchers to a rocky spit of land called Cierva Point, a habitat protected by the Antarctic Treaty as a "site of special scientific interest." Home to breeding colonies of bird species like Gentoo penguins, as well as a remarkably verdant cover of maritime plants, Cierva Point is also one of the most rapidly warming places on Earth.

Bockheim and his crew were beginning another field season on the Antarctic Peninsula, the long finger of rock and ice that snakes past Palmer Station, the United States' northernmost Antarctic research station, and curls out in the Southern Ocean (see map, page 25). They'd been deposited onshore, along with their gear, by the *Laurence M. Gould*, a research vessel that wouldn't return until late May. As the ship sailed back into the frigid sea, Bockheim turned his attention not to penguins or polar grasses, but to the ground beneath his feet.

Every year there was more and more of that ground as glaciers drained into the Southern Ocean, revealing soils and bedrock that had been covered in ice for millennia. Bockheim wanted to know what was going on underneath the

Photo courtesy of James Bockheim

newly exposed surface and had brought along a soil and bedrock coring tool, a device that looks like a cartoonishly oversized power drill, to get to the bottom of it.

His crew fitted the drill with its two-meter-long impact hammer bit. Graduate student Kelly Wilhelm pointed the drill at the ground and pulled the trigger.

It wouldn't be the first time that Antarctica caught Bockheim by surprise.

Bockheim, a CALS professor of soil science, has spent his career studying polar and alpine soils. From field sites north of the Arctic Circle to mountain passes in the Andes and the dry valleys of Antarctica, Bockheim has worked to classify and understand how soils are formed in the Earth's coldest climates.

Bockheim first set foot on Antarctic soil in 1969 as a Ph.D. candidate at the University of Washington. Although his dissertation was on alpine soils in the Cascades, his advising professor had a project in Antarctica and invited him to come along.

"And that was it," Bockheim recalls. "It just got in my blood." Startled by the "peace, solitude and stark beauty," he knew he would have to return.

Six years after that first trip, Bockheim got his chance. He had recently accepted a position at the University of Wisconsin–Madison when a call came in asking if he'd like to join a glacial geologist from the University of Maine on a multiyear research project in Antarctica's dry valleys. Bockheim's reply was succinct: "Absolutely."

Over the next 12 years,

Bockheim returned to Antarctica each year for a two-month stint of digging out soil profiles, collecting samples and boring holes into the continent's surface, especially in the largest ice-free region of Antarctica, the McMurdo Dry Valleys.

It was during this time that Antarctica presented Bockheim with its first riddle. The dry valleys are a "polar desert," a system that rarely gets above freezing and, even when it does, contains precious little water.

As in other places with permafrost—soils that stay at or below freezing for two or more years at a time—soils there are primarily formed by cryoturbation. Also called "frost churning," cryoturbation is a process by which what scant ice there is freezes and then thaws year after year, breaking up bedrock, working surface particles down into the ground and bringing buried particles up. Such mixing is never a quick process, but in the dry valleys of Antarctica it occurs at an especially glacial pace.

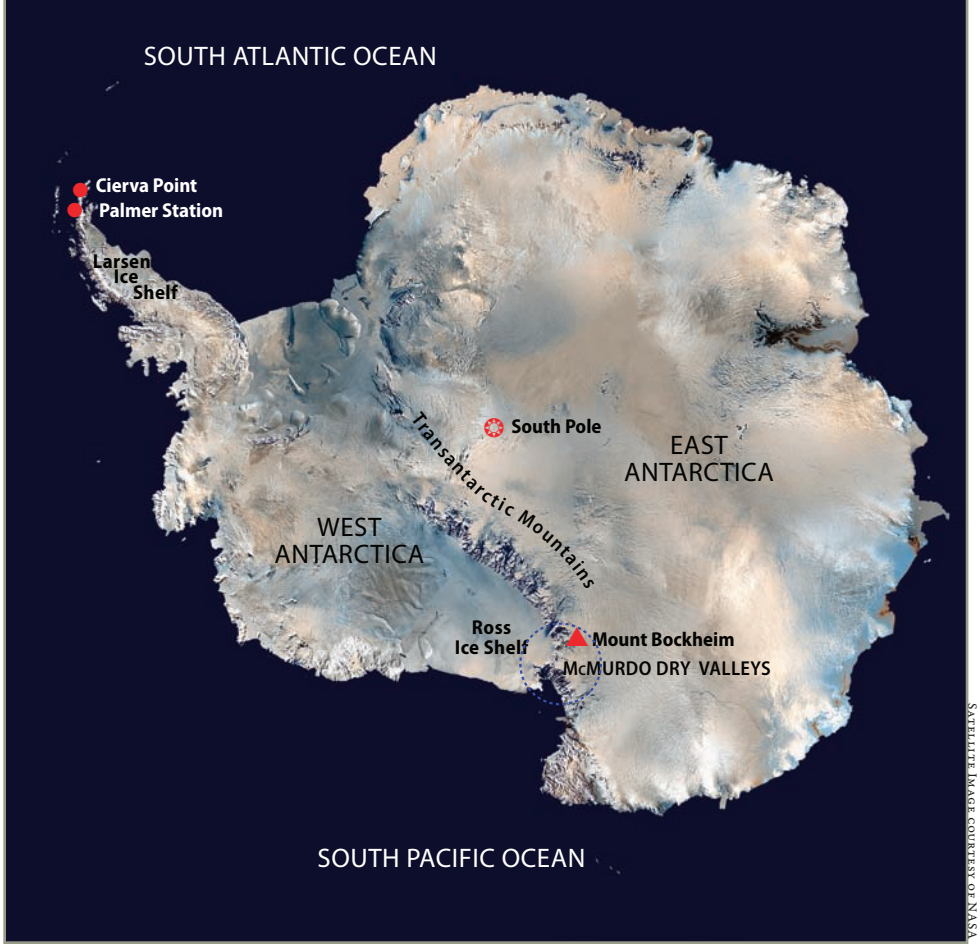
The resulting material didn't exactly fit what Bockheim knew to be the generally accepted definition of soil. While the weathered substrate had been eroded and deposited in layers over millions of years, it often looked more like a combination of loose pea gravel and sand. What's more, only lichen and mosses were found growing in it, not the "higher plants" usually considered a prerequisite for soil status.

But to Bockheim, that requirement was a relic of soil taxonomy's tendency to classify soils based on what human uses they could sustain, like crop production or road building. In Antarctica, such endeavors were a moot point.

In a 1982 paper published in the journal *Geoderma*, Bockheim made his first mention of these polar soils in the scientific literature. The journal's editor, anticipating pushback from other soil

(Left) **Researchers use a drill with a two-meter hammer bit to reach permafrost in Antarctica.**

(Right) **Map of Antarctica including Cierva Point and the McMurdo Dry Valleys. The McMurdo Dry Valleys include Mount Bockheim, an 8,935-foot peak named in James Bockheim's honor.**



SATELLITE IMAGE COURTESY OF NASA

scientists, urged him to first define the word "soil" for his readers. Bockheim produced a definition similar to the existing one, with one small change—"higher plants" were nowhere to be found. It was the opening salvo in a scientific debate that would simmer for more than a decade.

By 1987, after 12 uninterrupted years of spending field seasons in Antarctica, Bockheim decided he needed a break. He was tired of leaving his wife and five young daughters back in Madison for two months at a time and wanted to stay closer to home. While the move shifted his focus to the forest soils of northern Wisconsin, Bockheim continued to publish papers on his research on Antarctic soils.

Then, in 1992, the Soil Conservation Service (now the Natural Resources Conservation Service) took note of Bockheim's argument that the existing classification system didn't do polar soils justice. He was asked to lead a committee discussing the need for a new order of soil. The result, after a few years of lively debate, was the addition of Gelisols, or "permanently frozen soils," to the USDA catalog of soil types.

"These soils were far away, poorly researched, and people thought they might be insignificant because we couldn't grow anything on them," says Bockheim's colleague, CALS soil science professor Alfred Hartemink. "But with time came knowledge, and it was recognized that this is a large part of the world, and soils were being classified there incorrectly."

The soil classification system had been set at 10 distinct orders of soil for so long, Hartemink says, that the change "was a bit like adding another month to the year. But Jim was able to build that body of knowledge, consolidate it and pull it off. That was an immense deal."

It was an impressive first half of a career. In fact, it would be an impressive list of accomplishments for any scientist's entire career.

But Bockheim isn't just any scientist. He has spent 20 tours of scientific duty in Antarctica, 19 field seasons in the Arctic Circle and several in alpine ecosystems across the world's mountain ranges. He recently returned from a two-month trip to South America, where he'd received a Fulbright grant to teach classes on Antarctic soils in Chile and a special invitation to teach a similar class in Brazil. During that visit he took a side trip to the Andes, where one of his graduate students deployed tiny temperature probes, called thermistors, into the frigid soils.

Even in more domestic climes—say, the stairwells of King Hall, home of the Department of Soil Science on the UW–Madison campus—Bockheim bounds down the stairs from his office to his lab. "Fit college students sometimes have a hard time keeping up with him in the field," says Kelly Wilhelm, who has spent two field seasons with Bockheim in the Antarctic.

That energy carries over into the more cerebral part of his profession. Bockheim has authored 170 scientific articles, and his work is cited by other scientists at a rate almost unheard of in soil science circles.

"Jim wrote three books in two years," notes Hartemink. "Who does that? Most scientists write one every five, maybe 10 years. I can't think of anyone else who could do that."

The books—*Soil Geography of the U.S.A., Cryopedology* and *The Soils of Antarctica,* the latter two coming from the publishing house Springer within the next year—promise to serve as definitive works in the field.

So it's not just fit college students who can't keep up. Bockheim is considered by many to be one of the top cryopedologists—scientists who study frozen soils—in the world.

Ironically, after all of his painstaking work describing how polar soils had come into their ancient, frozen state and, quite literally, putting them on the map, many of the Gelisols Bockheim had worked to have reclassified began changing—their defining characteristics melting away.

"We're literally losing these soils," says Hartemink. "There are soils disappearing just like there are species disappearing."

Photo by Carsten Müller

(Left) **James Bockheim and former graduate student Jenny Kao-Kniffin examine a core of permafrost they've just pulled from the Arctic Circle in Barrow, Alaska. The core contains layers of organic materials and minerals, the result of cryoturbation, or "frost churning."**

(Right) **Life in Antarctica includes fields of mosses, fur seals and Adelie penguins.**

Photos courtesy of James Bockheim

The question now is: What happens when the world's "permanently frozen" soils begin to thaw?

Bockheim first began asking that question nearly 20 years ago, when he again received an offer he couldn't refuse. This time, however, it was an invitation to study the opposite pole.

In 1995, after several years focused on his growing family and the soils of Wisconsin, Bockheim returned to polar soils, assuming command of a project focused on permafrost 320 miles north of the Arctic Circle, near Barrow, Alaska. Knowing where different soil types were located and how they'd gotten there, Bockheim knew, was the first step in trying to predict what they'd do as they warmed.

Understanding the fate of permafrost in a warmer world may be one of the most crucial pieces of the climate change puzzle. For millennia, the hard layer of frozen soil has contained vast amounts of carbon and methane, which contribute to greenhouse gas levels when they are released into the atmosphere. As Earth warms, so does this soil, pushing the permafrost line deeper and freeing up more and more soil to release carbon and methane via processes like erosion or microbial activity.

In 2004, the New Zealand Antarctic program was starting a mapping project and wanted Bockheim's expertise to help add Antarctic soils to their efforts. Bockheim jumped at the chance to reconnect with the continent he'd first fallen for, but Antarctica surprised him again. The place he returned to looked nothing like the one he remembered.

Handheld GPS devices didn't exist during Bockheim's first foray into Antarctic fieldwork in the 1970s. Scientists instead relied on landmarks like mountain peaks, glaciers or snowbanks to lead them back to their annual field sites. Bockheim's team relied on snowbanks that dotted the dry valley landscape, set down in distant, less arid eras. Using aerial photographs and topographic maps, the team could work out roughly where each site was located.

But 30 years after those pictures had guided him, they'd been rendered obsolete by more than updated technology. "I had taken a picture of snowbanks from the helicopter in 1975," Bockheim recalls, "and it's just by chance that, when I went back in 2004, I took a picture from the exact same spot in the air. But the snowbanks were gone."

Of course Bockheim wasn't caught completely off guard by these developments. Like any scientist studying the poles, he knew that temperatures over the last four decades had been rising. In fact, at Antarctica's Palmer Station, the mean annual air temperature was up three and a half degrees Celsius. In winter, the mean temperature during that span had risen nearly 10 degrees Celsius, or 18 degrees Fahrenheit.

Even so, the magnitude of the observed changes was startling.

"There was water everywhere," Bockheim remembers. "I've got a whole shelf of field books and I take notes on things like the weather and conditions. In December it would always still be extremely cold."

During his first 12 years working in Antarctica, he says, "there was always a stream in one of the valleys and maybe some smaller lateral streams that would run in the warmest time of the year, from mid-December to mid-January. But when we went back in 2004, it was so warm that there was just water everywhere, even on the high mountain slopes. There were wet patches of snowmelt coming down the slopes."

Where areas on the Antarctic Peninsula had once thawed for two months of the year, they were now above freezing for up to five months. That warmth and the water had rejuvenated processes like the pattern of ground freeze from cryoturbation, Bockheim recalls. There was highly developed soil becoming exposed.

The only thing that was as he had left it 17 years prior was Bockheim's own energy and enthusiasm for Antarctic fieldwork.

Malcolm McLeod, now a soil scientist with the New Zealand–based institute Landcare Research, spent three field seasons on the project mapping Antarctic soils with Bockheim. Bockheim soon became McLeod's doctoral advisor. "Because of his wealth of Antarctic experience, he was able to focus on the important bits of the soils puzzle that told a story," McLeod recalls. "He worshipped data, and he had this line—'Soils never lie.'"

During their project, that mantra led Bockheim to make what McLeod



calls "big advances" in scientists' understanding of how Antarctic soils form. Antarctic glaciers are "cold glaciers," meaning they don't melt. They advance when large chunks break off the leading edge, and they retreat by ablation, or evaporating straight from their frozen state into the cold, dry air. As a result, the Antarctic landscape has none of the usual telltale signs glaciers leave behind to provide a history of the region's geology. Bockheim showed that soils could tell the story.

Bockheim's wealth of experience also carried over into field camp. "His breakfast bacon and hash browns couldn't be beat," says McLeod. "I also remember his 'hot towel' dispensed airline-style each morning by dipping a paper towel into a billy of hot water."

Nearing the two-decade mark of fieldwork in the Antarctic, Bockheim had become both an accomplished scientist and a veteran polar explorer. But after so many years in the polar desert, his mind began to wander to greener pastures.

"I'd done all my work in Antarctica in the dry valleys in the interior mountains, and I kept hearing that the peninsula was quite a different environment," Bockheim says. "On the peninsula, it's a whole different world. You have rain, whereas, historically, no one has ever experienced rain in the dry valleys. That rain causes accelerated soil formation and there are plants, a lot of lichens and mosses, but also there are two higher plants, one a grass and the other a member of the pink flower family."

What would this greener landscape mean? Was Antarctic soil seeing an increase in the "active," or unfrozen, layer of soil? Was the permafrost being pushed deeper below ground? Bockheim knew that the peninsula would be the best place to study how the warming he was witnessing was impacting Antarctica.

"So I wrote a proposal and decided to strike out on my own rather than being under someone else's research priorities," he says. That proposal led Bockheim to Cierva Point with a gigantic power drill in 2011. It was the reason Kelly Wilhelm was bent over the soil driving a two-meter-long bit into the ground. And it was the beginning of addressing yet another Antarctic riddle.

"We are trying to be one cog in looking at how climate change is affecting the Antarctic Peninsula," says Wilhelm. "There are people looking at air temperature and changes in weather patterns. Other people are looking at how far south the vascular plants grow, or migration patterns of seals and penguins. But permafrost—on the peninsula, at least—has pretty much been one of the last things to be examined."

When Bockheim headed to the Antarctic Peninsula, the only prior information his team had to go on was a soil survey conducted in the 1960s during April, the warmest month of Antarctica's short summer. On that survey, researchers dug 40 centimeters into the soil, or less than half a meter, before hitting hard permafrost.

Bockheim's team knew that the permafrost would now be deeper, as surface soils warmed with the surrounding air temperatures. They had prepared for the change by bringing drill bits that would bore into the soil more than four times deeper than the last known permafrost.

It wasn't enough.

"Not one of our holes hit permafrost," Wilhelm recalls. What's more, the temperature at the bottom of every hole was well above freezing, suggesting that the permafrost was located several meters beyond the reach of their drill.

If soils never lie, what is the unexpectedly warm peninsula trying to say?

"That is the grand unsolved question," Bockheim says. "Based on the latitude, we expected the active layer to be thinner," which would have meant a much shallower permafrost table. Bockheim says that the distribution of sea ice and westerly flows of air and seawater may play a role, but—so far—they can't explain it.

"It's what we're writing papers on right now," says Wilhelm. "People don't even know about this. It's a pretty new thing."

Whatever the answer, one fact is undeniable. The seasonal thaw, or "active" layer of polar soils, is increasing. That means that more and more soil near the Earth's poles is being grown over with plants, worked over by microbes and eroded by wind and rains. In the Arctic, this activity will undoubtedly lead to the release of carbon and methane, making it a huge source of those greenhouse gases.

In the Antarctic, though, the picture is still fuzzy and may in fact produce an effect that is, well, the polar opposite. The plants beginning to carpet Antarctic soils could end up pulling carbon dioxide out of the atmosphere instead of adding to the problem like the Arctic's melting permafrost.

"In the Antarctic, with its increased land mass, increased plant cover and, presumably, increased photosynthesis, one could easily argue that it could become a sink for atmospheric carbon," says Bockheim. And, in fact, that's exactly what Bockheim thinks will occur—at least temporarily.

Beyond that, the man who wrote the book on Antarctic soils is content to wait and see. The soils don't lie, but they may yet have one more surprise in store.

Connecting Our **WAYS** *of* **KNOWING**

Photo by Hedi Baxter Lauffer

A CALS PARTNERSHIP ENGAGES **NATIVE AMERICAN KIDS** IN **SCIENCE** BY INTEGRATING **INDIGENOUS KNOWLEDGE** INTO **TEACHING** AND **LEARNING**

BY JOAN FISCHER

Illustrations by Anthony Gauthier

IN ANY OTHER CLASSROOM, mention of planting "Three Sisters" might cause confusion. But in Becky Nutt's science class at Oneida Nation High School, located on a tribal reservation in northern Wisconsin, most students know that the Three Sisters are corn, beans and squash, crops that in Native American tradition are planted together in a single mound.

Guided by Nutt, their questions focus on photosynthesis, the process by which plants like the Three Sisters convert sunlight into the energy they need to grow and produce oxygen. The lesson culminates with each student pretending to be an atom of a particular element in that process—oxygen, carbon or hydrogen—and "form bonds" by holding hands or throwing an arm around a classmate's shoulders. It's a fun lesson that resonates, judging by both the enthusiastic participation and the thoughtful entries each student writes afterward in a logbook.

The students know the lesson as part of a "pilot curriculum from UW–Madison," as Nutt tells them—perhaps the easiest way to explain POSOH (poh-SOH), which is both the Menominee word for "hello" and an acronym for "Place-based Opportunities for Sustainable Outcomes and High Hopes." The program is being developed in partnership with both Oneida and Menominee communities.

But what POSOH really represents is a new way of teaching science. Funded by a $4.7 million grant awarded by the U.S. Department of Agriculture in 2011, the program has the mission of helping prepare Native American students for bioenergy- and sustainability-related studies and careers. POSOH aims to achieve that by offering science education that is both place-based and culturally relevant, attributes that have been shown to improve learning.

"We're hoping to help make science relevant to young people," says CALS biochemistry professor and POSOH project director Rick Amasino. "Bioenergy and sustainability offer an entrée into broader science education."

For Native American students, sustainability is an obvious fit for science discussion, Amasino notes. The Native American concept of thinking in "seven generations"—how the natural resource management decisions we make today could affect people far into the future—has sustainability at its foundation, and most Native American traditions reflect that value. The Three Sisters, for example, offer a way to discuss not only photosynthesis but also indigenous contributions to our knowledge of agronomy, including how mixed crops support long-term soil health and animal habitat.

Photo by Hedi Baxter Lauffer

An innovative program like POSOH is needed because current teaching methods are not proving effective with Native American students. Native American students score lower in reading and math than their white counterparts in elementary and high school, and only a low percentage have ACT scores that indicate college readiness, according to "The State of Education for Native Students," a 2013 report by The Education Trust. Other studies show higher dropout rates and unemployment among Native Americans—and, specifically, that Native Americans are vastly underrepresented in STEM fields as students, teachers and professionals.

Verna Fowler, president of the College of Menominee Nation, sees POSOH as offering a crucial connection. Her tribal community college, along with CESA 8, the state public education authority that includes the Menominee Indian School District, has been a key partner in developing and piloting POSOH. Other leading partners include Michigan State University and, within UW–Madison, the Great Lakes Bioenergy Research Center.

"POSOH takes you into science in the natural world and helps you relate your concepts and understanding so that you understand science is all around you," says Fowler. "Sometimes that's what we miss in our classrooms. A lot of students are afraid of science classes. They don't realize what a scientific world they're living in."

IN DEVELOPING POSOH

materials, Amasino serves as the go-to guy for verifying the science. "The main thing I do is work with everyone to keep the science accurate," he says.

Curriculum development and other POSOH activities are led by CALS researcher and POSOH co-director Hedi Baxter Lauffer, who has a rich background in K–12 science education. In a previous project she worked with California state universities in developing a multiyear math and science education program with diverse ethnic communities in the Los Angeles Unified School District. Alongside her work with POSOH, Lauffer directs the Wisconsin Fast Plants Program, which operates worldwide.

From the start Lauffer saw POSOH as a trailblazing effort. "We wanted to create a model for how a culturally responsive science curriculum can emerge from the community it is serving," she says. "There's nothing else like it."

Lauffer knew her group was on to something during early curriculum design sessions with local educators, Native American community elders and students, particularly when she participated in a talking circle with seventh- and eighth-graders from the Menominee Indian School District. The kids were asked a simple question: "How do you take care of the forest—and how does the forest take care of you?"

"They had all kinds of stories about the plants and animals that live there," says Lauffer. "They were saying things like, 'I take my nephew into the forest and teach him to pick up his trash. He needs to know that it's a beautiful place to play.' It was clear that their connection to nature was strong—and that's an opportunity for making science learning relevant and valuable."

Initial steps for curriculum development included building key institutional partnerships and forming teams for curriculum design that brought in a wide range of Native American voices. Team members include scientists, assessment professionals, and teachers of science, education and Native American culture, some of whom are field-testing the materials.

The group is creating curricula for grades seven through nine. Seventh grade is complete, comprised of a fat lesson book and accompanying DVD with graphics and other enrichment materials. The other grades will be completed by the end of 2015, the project's final year.

Other POSOH activities include after-school science clubs facilitated by undergraduate interns who also

(Left) **Middle-schoolers from the Menominee Indian School District look at bones they found in the forest (and on pages 28 and 32, examine forest plants and insects). With them is POSOH team member Jerilyn Grignon, a Menominee elder and a professor at the College of Menominee Nation.**

(Below) **POSOH team members on the CALS campus. Lower step: Project co-director Hedi Baxter Lauffer. Upper step, left to right: Linda Orie, Justin Gauthier and intern McKaylee Duquain.**

Photo by Joan Fischer

serve as informal mentors. This work is conducted in partnership with the Sustainable Development Institute at the College of Menominee Nation under the direction of Kate Flick BS'06, who studied community and environmental sociology at CALS and now serves as POSOH's education coordinator.

Thumbing through the seventh-grade lesson book, it is immediately clear that cultural relevance is placed front and center. A typical textbook might pay tribute to cultural relevance with sidebars while the main text carries on with "science as usual." With POSOH materials, cultural relevance is embedded in the meat of the text.

The seventh-grade curriculum, for example, is called "Netaenawemakanak" —Menominee for "All My Relatives"— and its six units focus on various scientific aspects of the Menominee Forest, such as organisms, microhabitats and ecological interactions. Students learn how such terms as evidence, protocol and conceptual models are used in science and, as a final lesson, how to formulate their own stewardship action plan based on what they've learned.

And it's not just what the students learn, but how they learn it. POSOH incorporates forms of teaching and learning that are rooted in Native American culture, such as:

- Storytelling—Scientific concepts are imparted through stories involving the everyday lives of young Native American protagonists as well as figures from Native American legends and folktales.
- Perspective-taking—Students are invited to look at ecosystems from the viewpoint of animals, plants and other natural resources.
- "Careful noticing"—Students use all their senses when getting to know an environment, paying close attention to what is and is not present. In an exercise in the forest, for example, students are asked not only what they see, smell and hear, but also, "How do the woods make you feel?"

"These are age-old practices in indigenous pedagogy, but they aren't widely seen as such. They're so fundamental that I think they're often overlooked," says Linda Orie, an enrolled member of the Oneida tribe who taught middle-school science at the Menominee Tribal School. She now works on the POSOH curriculum team.

Orie considers POSOH a huge eye-opener for students. "It's probably one of the first times they've seen anything in science class that has anything to do with Native Americans or Native American contributions to science and forestry," she says. "Especially for a Menominee, that's really important because most of them live on the reservation and a lot of their parents are employed through the lumber mill."

"So they live and breathe the forest, but they don't often get that instruction in the classroom," Orie continues. "It was a huge gaping hole in the curriculum when I started teaching at the tribal school."

By drawing upon indigenous ways of teaching and learning, POSOH helps bridge a gap between how students experience nature and how knowledge about it is imparted in the classroom. POSOH team member Robin Kimmerer, for example, says that as a professor of forest biology and as a Native American, she's had to work hard to reconcile two distinct perspectives.

"In science we are asked to objectify the world, to view it in a strictly material, intellectual way," says Kimmerer, who earned her doctorate in botany at UW–Madison and now teaches at the State University of New York. "In indigenous ways of knowing, we're reminded that we can understand the world intellectually, physically, emotionally and spiritually—and that we can't really

Photo by Hedi Baxter Lauffer

claim to understand something unless we engage all four elements," she says.

POSOH team member Justin Gauthier, an enrolled Menominee who as a teenager attended a Native American boarding school, has come to think of science as another language for indigenous ways of knowing nature. In science, he says, "They're using numbers, they're using experimentation. It's just different language."

That recognition helped science feel more approachable to him.

"I used to perceive science as being outside of my experience. It was meant for scientists to do in a lab in a white coat. When I started thinking about how it tied into the ways that I was thinking, I felt that it had always been a part of my life and I had just never given it much credence," he says.

Gauthier, a returning adult student, is earning his bachelor's degree in English at UW–Madison and plans to teach in a tribal college after earning an MFA in creative writing. He serves POSOH as a curriculum writer. Gauthier suggested naming the seventh-grade curriculum Netaenawemakanak ("All My Relatives") because it is often uttered as a kind of one-word prayer when entering and leaving the sweat lodge. To him, among other things, the word expresses Native American regard for nature.

POSOH is not only helping fill a gap in science education. Project intern McKaylee Duquain, a junior majoring in forest science, notes that POSOH is filling a gap in cultural knowledge among young Native Americans as well. As an enrolled Menominee who attended tribal schools, Duquain confesses to not knowing what the Three Sisters were until late in high school—and she learned about it on her own.

"It wasn't even offered when I was a student," she says. "I'm not the most traditional person out there—I try to practice the traditional ways, but you can only do so much in this day and age. I feel like having that knowledge incorporated into your everyday learning life in school would definitely cement it in more."

THE PROGRAM'S MOST enthusiastic ambassadors are the teachers and students who have been using it. So far the POSOH curriculum has been taught in 25 Wisconsin classrooms with the participation of some 135 students. Another 140 students have worked with POSOH materials in other settings, such as outreach programs conducted by undergraduate interns and the project's high school club, called the Sustainability Leadership Cohort.

"I love that the POSOH curriculum brings science to a local level," says Dan Albrent, a science teacher at De Pere's Ashwaubenon High School, where he's been piloting POSOH materials for the past two years. "Students a lot of times wonder why we are even learning all these complex things in science and just want a reason. POSOH does a nice job of bringing in real-life situations and issues that are literally close to home. And never in the curriculum are students sitting and listening to a lecture. They are actively talking and working with real data and real situations to solve problems."

To him, POSOH represents the future of science education. "I truly believe this is how science should be taught," Albrent says. "At the moment there is no better alternative for helping our kids realize the importance of learning science for our communities."

Becky Nutt, of Oneida Nation High School, is just as convinced. She appreciates the program's emphasis on reading and writing, which is not a given in science class—but important, she notes, in both communicating science and demonstrating understanding.

"Most important from my view is the integration of Native American culture into the materials," says Nutt. "If, through these materials, we can foster better relationships between our Native students and their communities and other individuals and their communities, then we are on the right track."

POSOH team member Linda Orie is taking a break from the classroom while earning her master's degree in curriculum and instruction at UW–Madison—but she plans to return to teaching in tribal schools and sees POSOH as a life-changing tool to bring with her.

"My career goal is to transform Indian education because it is stuck in

Photo by Reynaldo Morales

Teachers at a POSOH workshop learn to plant corn, beans and squash in "Three Sisters" mounds, in keeping with Native American tradition.

this terrible rut," Orie says. "Working in the tribal school I saw a lot of opportunity for growth. It was heartbreaking to see so much potential and not have colleagues that saw the same. And not seeing as many Native American teachers as there could be or should be in the schools. The kids need the best curriculum and the best teachers, and they're not getting that right now. I want to be part of the change."

That Orie, as an Oneida, backs the program so strongly speaks to perhaps the program's greatest indicator of success—the acceptance it has earned in Native communities.

"We've been presenting POSOH to different schools, to different areas, to our boards of education and so on, and they're very enthused about it—extremely enthused, I must say," says College of Menominee Nation president Verna Fowler.

That enthusiasm is no accident, but the result of the program being developed within and in partnership with Native communities. Patty Loew, who is a professor of life sciences communication at CALS and an enrolled member of the Bad River Band of Lake Superior Ojibwe, just happened to be on hand during a POSOH presentation on the Menominee Reservation and was heartened by what she saw.

"I've been in a lot of situations where UW people try to engage with community members and it's like pulling teeth for reasons that vary, but often come down to a basic mistrust of researchers," Loew says. In those encounters, she says, "People are either being polite or they'll have their arms folded and are just quietly listening or maybe hiding their resentment."

"That was not the case on this day," Loew says. "People were really engaged, they were discussing, they had ideas, it was emotional. It was clear to me that the community's handprints were all over this project. They not only were hosting the research, they had shaped it, they were contributing to it, they were using the materials in their classrooms, they had a lot of pride in it. And I was really impressed."

POSOH team member Justin Gauthier also knew about the mistrust firsthand—and saw it melt away.

"Historically in Indian Country there's been this sort of stigma toward outside groups coming into the community, studying groups of people, taking data out of that community—and nary shall the two meet again," Gauthier says. "But I really like and respect the way that the POSOH process is set up because, while the leadership team is made up of people from within and without that community, the ideas—the voices at the table—are respected and integrated into the process. I feel like when we finish the project the curriculum and the relationships we've built are going to remain strong."

"And that could be the big takeaway for me from this project," Gauthier says. "Communities have the right to be wary of people coming in and studying them. But when you have a project like this, where the end result is meant to be a gift for that community, then you really see the beauty of cultures blossom and open up."

That could be the big takeaway for Amasino and Lauffer as well. They and their team conceived of POSOH as an experiment in developing culturally integrated science curricula in a way that could be applied in various settings around the country.

"Our overarching mission is to build a transformational model for place-based collaborations dedicated to preparing all learners, especially those who are underrepresented in science and science education," says Lauffer. "These community-based processes are what the project will share more broadly as it draws to a close. We plan to pass on lessons from POSOH to many other communities who can then build on our work and continue improving science teaching and learning."

Learn more about the program at:
posohproject.org

in the field


Roger Freeman


Paul Gepts


Brian Just


John Navazio

Roger Freeman PhD'82 Plant Breeding and Plant Genetics • Roger Freeman, based in Brooks, Oregon, is the senior carrot breeder for Bayer Crop Science Vegetable Seeds. Since he began breeding carrots in 1982, Freeman has developed more than 50 carrot hybrids that have been used in the production of several billion dollars' worth of commercial carrot crops. In addition to developing new carrot varieties for the North American market, Freeman has developed hybrids for international markets around the world, including Europe, China and South America. "Food production is a common global language," says Freeman regarding his efforts. Freeman cherishes his time at CALS for the opportunity it gave him to learn about plant breeding and work alongside several esteemed faculty and staff members. In his free time he enjoys outdoor nature activities and especially spending time with family.

Paul Gepts PhD'84 Plant Breeding and Plant Genetics • As a professor of plant sciences at the University of California, Davis, Paul Gepts focuses his research and teaching on plant breeding. His bean breeding program serves as a platform for researching such topics as crop evolution and domestication. Gepts is interested in the transition from hunting and gathering to agriculture, and the effects of that transition on biodiversity. CALS' Plant Breeding and Plant Genetics program was Gepts' first choice for graduate studies, he says, noting that he was attracted to both the faculty and the broad spectrum of disciplines available for study. Teaching and research take up most of his time, but Gepts has applied his interest in plants to his personal life as well. His family has recently converted the lawn of their home, which once served as grounds for their son's soccer training, into a flower garden that's attracting many local pollinators.

Emily Haga BS'08 Horticulture, MS'11 Plant Breeding and Plant Genetics • Based in Waterville, Maine, Emily Haga is a plant breeder for Johnny's Selected Seeds. Her work entails developing new varieties of tomatoes and lettuce to support the needs of small-scale farmers who participate primarily in local markets. The opportunity to apply her passion for food, farming and science to develop solutions for problems faced by local farmers has been most satisfying to Haga. As an undergraduate at CALS, Haga participated in two independent research projects—one concerning plant flowering times, the other an evaluation of pepper germplasm for adaptation to Wisconsin's short growing season—that gave her hands-on experience in her intended field. As a master's student, Haga conducted a multiyear field study on early blight resistance in potatoes. Haga's time at CALS exposed her to a wide range of disciplines within the field and provided her with skills that she draws on each day as a member of the seed industry, she says.

Brian Just PhD'04 Plant Breeding and Plant Genetics • Brian Just is a sweet pepper breeder for Monsanto. His work, based in Felda, Florida, aims at developing new varieties of sweet peppers with improved yield, quality and disease resistance. Much of his time is spent in fields and greenhouses observing the development of different varieties of peppers, as well as conducting lab tests to analyze those varieties. Just's career has called for him to work in different markets around the world—and being a good plant breeder, he says, requires not only knowledge and experience but also strong cultural competence and compassion for diverse needs. Just maintains strong collaborative relationships with fellow Plant Breeding and Plant Genetics alumni. Outside of work, he enjoys spending time with his family and is eager to learn to fish the waters of southwestern Florida.

Jason Lilly MS'98, PhD'00 Plant Breeding and Plant Genetics • Jason Lilly serves as vice president of corporate development at the Neogen Corporation, a food security company in Lansing, Michigan, where he has worked for nearly a decade. Lilly is responsible for the company's mergers and acquisitions as well as identification of new technology platforms for the agrigenomic and diagnostics businesses. Lilly's knowledge of agriculture and genetics, and the laboratory experiences he gained at CALS have been vital to his ability to successfully oversee the company's identification and integration of new technologies and potential acquisition targets. Lilly credits his success in acquisitions to the broad knowledge base he developed at CALS. He also values the opportunities he had to learn how to troubleshoot complex problems, develop solid communication skills with other students and faculty, and be

Alumni from Plant Breeding and Plant Genetics

—By Claudia Roen

Emily Haga | Jason Lilly | David Mies | Flor Rodriguez | Mark Sorrells

About *In the Field*

These alumni represent the depth and breadth of alumni accomplishments. Selections are made by *Grow* staff and are intended to reflect a sample of alumni stories. It is not a ranking or a comprehensive list. To read more about CALS alumni, go to www.cals.wisc.edu/alumni/

Know a CALS grad whose work should be highlighted in *Grow*? E-mail us at: grow@cals.wisc.edu

part of diverse teams—experiences that have helped him in both the academic and corporate worlds. Lilly and his wife, Dana Tatman MS'00, enjoy classic cars, gardening, and spending time hiking and rafting at national parks.

David Mies PhD'78 Plant Breeding and Plant Genetics • David Mies recently retired from a 35-year career with Syngenta. Throughout his time there, Mies' knowledge as a plant breeder and geneticist was instrumental to projects that included global corn breeding efforts, control of European corn borers through transgenic processes, and the development of Syngenta's corn breeding program in China. Mies fondly remembers opportunities to collaborate with Chinese scientists. Interviewing, hiring, training and empowering prospective members of the Syngenta Corn Breeding Program offered Mies not only the opportunity to learn "passable" Mandarin, he says, but also the chance to foster international professional relationships. Mies is still very much involved in international agriculture as a plant breeding consultant. Mies' time at CALS instilled in him an ability to think outside the box as well as the value of continuing education, which he notes is mandatory to staying relevant within the field. In his free time Mies says he enjoys "creating things and fixing things that are broken."

John Navazio MS'94 PhD'94 Plant Breeding and Plant Genetics • John Navazio is a senior scientist with the nonprofit Organic Seed Alliance, which seeks to promote the ethical development of genetic research within the seed industry. He's also an Extension specialist with Washington State University. Both positions entail training farmers and students in organic seed production and in participatory, on-farm plant breeding. Navazio works in partnership with farmers and students to develop crop varieties that have been adapted to resist environmental stresses. His work also aims to improve vegetable crop varieties in terms of nutrition, texture, and heat and drought resistance. In his spare time Navazio plays guitar for The Pheromones, a rock band that plays local barn dances and organic farming conferences.

Flor Rodriguez PhD'08 Plant Breeding and Plant Genetics • Prior to beginning her doctoral program, Flor Rodriguez served as a research assistant for the International Potato Center (Spanish acronym: CIP) based in her native Peru. After receiving her degree, she moved to Chile to work at the Instituto de Investigaciones Agropecuarias (INIA–Chile). As a potato molecular breeder, she was responsible for implementing molecular marker-assisted selection for resistance to potato pests and diseases as well as for nutritional and health-promoting components. Later she returned to CIP as an international scientist. In that position she supports CIP's mission to improve food security and community well-being, primarily by working with impoverished farmers in developing countries. Her work involves assessing and improving the genetic diversity of eight Andean roots and tubers, in addition to potatoes and sweet potatoes, using molecular tools to increase the quantity and quality of crops and yields. CIP's efforts include research to combat vitamin A deficiency by introducing orange-fleshed sweet potatoes to communities that would otherwise continue to consume mainly white sweet potatoes. These varieties grow quickly and prolifically under most agroecological conditions—and they taste good to children, who are most vulnerable to malnutrition.

Mark Sorrells PhD'77 Plant Breeding and Plant Genetics • Mark Sorrells serves as a professor and chair of the Department of Plant Breeding and Genetics at Cornell University. As a teacher, researcher and Extension educator, Sorrells seeks to improve the nutritional quality of grains, including wheat. Sorrells has released or co-released more than a dozen grain varieties, including barley, wheat and oat, for the northeastern region of the United States. As a CALS student Sorrells developed a depth of knowledge of breeding methods under the direction of corn breeder John Lonnquist, whose training provided a strong foundation for the work Sorrells continues today. Although his work keeps him very busy, Sorrells enjoys gardening and participating in triathlons.

Catch up with …

Lucas Joppa BS'04 Wildlife Ecology

LUCAS JOPPA grew up in northern Wisconsin 30 miles from the nearest stoplight, without a TV or computer. He spent his free time in the woods and became "hugely interested" in how various wild species interacted. So it's a lot easier to imagine him having a career devoted to wildlife conservation than to developing digital gadgets for Microsoft. In fact, Joppa does both. After going on to earn a Ph.D. at Duke University and a stint in the Peace Corps in Malawi, Joppa moved to Cambridge, England, with Microsoft's Computational Ecology and Environmental Sciences Group. For the past five years he's focused on developing technologies, programs and models to support global conservation efforts—work he's continuing from a new location this fall with a move to corporate headquarters in Redmond, Washington.

• Did you come to UW–Madison with an eye toward a career in conservation?

No. That was my passion, but it never occurred to me that your real job could be the thing you're most inspired by. Then I took [wildlife ecology professor] Stan Temple's Extinction of Species course. Seeing this guy who was so passionate, so fascinated by what he was talking about, I thought, "He's talking about exactly what I'm interested in." It was Stan who suggested that I major in wildlife ecology.

• How did that prepare you for what you're doing now?

What the forest and wildlife ecology department did so well was combine the theory and academic side of conservation biology—the statistics and computer programming—with a very hands-on applied approach. I found afterward that that's pretty rare. I find I'm often the only person in the room with an understanding of both the natural history and the statistics and computing needed to understand the overall system.

• Give us an example of the kind of projects you're involved in.

One thing we're doing is developing an extremely cheap, lightweight, reprogrammable tracking device for animals. We want to let as many people track as many animals as possible. Since conservation is a niche market, tracking devices are produced in small quantities, so they end up being pretty expensive. The organizations that most need these devices are least able to afford them. We want to change that. We're trying to build devices that are cheap and beefy enough to hold up in the wild and are easy for people to repurpose for their own needs.

• What advice do you have for today's wildlife students?

If you do what you're passionate about doing, the skills and the job will come. It's hard to be the best at something if you're not passionate about it because there's always somebody who cares more and will work harder. They don't mind taking the hard classes or putting in the time—not because they have to, but because they're fascinated. That kind of passion—waking up every day wanting to go to work—that's rare. But everybody I know with that attitude is hugely successful.

—Bob Mitchell BS'76

Givers

In honor of CALS' 125th anniversary, a look at how alumni and friends help keep the college strong

"It's the Right Thing to Do"


Bob and Angela Tramburg

ONE OF OUR COLLEGE'S MOST loyal supporters is not a CALS alumnus.

Bob Tramburg holds a bachelor's degree in nuclear engineering and an MBA in finance, both from UW–Madison. But as president and CEO of Vita Plus, an employee-owned livestock nutrition company, he has a deep sense of CALS' value to Wisconsin agriculture.

"We look to CALS to provide us some of that green stock coming out of the educational system," Tramburg says, noting that Vita Plus hires a good many CALS grads. "And we also look to CALS for research that we can utilize in our products."

Tramburg's own leap from nuclear engineering to agriculture is not very surprising when one considers his background.

"I sort of had it in my blood. I grew up in a family that owned part of a feed mill. My grandfather owned it originally," he says. "And that feed mill was purchased by Vita Plus in the early '70s, right before I joined the company."

Moreover, Tramburg's stepfather, Lyle Hill, was one of the founders of Vita Plus. "After I got my master's degree he made an offer for me to go to work at Vita Plus, which I accepted, and I came to understand the relationship that Vita Plus has with CALS," Tramburg says.

As an individual donor, Tramburg generously gives to the CALS Annual Fund as well as to Wisconsin Rural Youth Scholarships and the Aberle Faculty Fellow Fund. And each year his company offers the Vita Plus Dairy Nutrition and Management Fellowship, providing financial support to a graduate student in dairy science.

"People who are educated at CALS are really our future," Tramburg says, noting that they will affect the company's ability to serve customers in coming years and decades.

This year Vita Plus was also one of the first companies to sign on as a corporate sponsor for events and programs marking CALS' 125th anniversary.

As generous as Tramburg is to CALS, he and his wife, Angela—a graduate of the School of Nursing—also support a number of other UW programs and activities, most notably The Grandparents' Network, a Waisman Center–based support and resource group for families whose members have disabilities. The Tramburgs became involved when one of their grandchildren was diagnosed as being on the autism spectrum.

For Tramburg, giving generously is not merely a responsibility.

"It's more than that. It's just the right thing to do," Tramburg says. "You have some success and you want to share it with organizations that have provided something to you or your family or your business—and that's the relationship that Vita Plus has with CALS, that's the relationship that I have with the University of Wisconsin in total. One of my hopes is that whatever my wife and I do—whether it's for CALS, whether it's for the business school or the nursing school—will help maintain that level of excellence at the University of Wisconsin. That's our goal."

—Joan Fischer

You can give to the CALS Annual Fund at **supportuw.org/giveto/cals**

nextSteps

SHOP FOR THE HOLIDAYS ON CAMPUS—These quality goods benefit CALS student clubs and organizations as well as teaching and research.

Thanksgiving Turkey Sale Turkeys range from 11 to 26 pounds and will be available for pick-up **November 24–25**. Orders/questions should be sent to **uwpoultryscienceclub@gmail.com** by **November 7** (but order early as supply may run out). Proceeds benefit the Poultry Science Club.

Christmas Tree Sale The 41st annual UW Forestry Club Christmas Tree Sale takes place **December 5–7** in the UW Stock Pavilion. Tree species include Fraser fir, balsam fir and white pine as well as Fraser fir wreaths. Proceeds support student educational opportunities within the Department of Forest and Wildlife Ecology. Come early—trees are often sold out by Saturday. Cash or checks accepted. More info at **http://go.wisc.edu/xmastree**.

Hams and Prime Rib Sale: Bucky's Butchery, located in the Meat Science and Muscle Lab building (1805 Linden Drive), starts taking orders for Christmas hams and prime rib right after Thanksgiving. Orders must be placed by **December 1**. More information at **http://go.wisc.edu/meatsale**.

CATCH US UP NORTH—CALS researchers feature prominently in the **"Science on Tap Minocqua"** lecture series, which takes place at the Minocqua Brewing Company. The November 5 presentation features CALS **Dean Kate VandenBosch** talking about the Wisconsin Idea. Other recent CALS speakers include life sciences communication professor **Robin Shepard** on the science of beer, and wildlife biologist **Ron Eckstein BS'71 MS'75** on the recovery of bald eagles in Wisconsin. All talks are available online at: **http://www.scienceontapminocqua.org/past-events.html**

MARK YOUR CALENDARS for the Wisconsin Agricultural Outlook Forum on **Wednesday, January 21, 2015,** at the Memorial Union. The event is held by CALS and UW–Extension. More information available soon at **news.cals.wisc.edu**.

For more information, go to: ***www.grow.cals.wisc.edu***

UWMadisonCALS

Celebrating 125 years

College of Agricultural & Life Sciences

UNIVERSITY OF WISCONSIN–MADISON

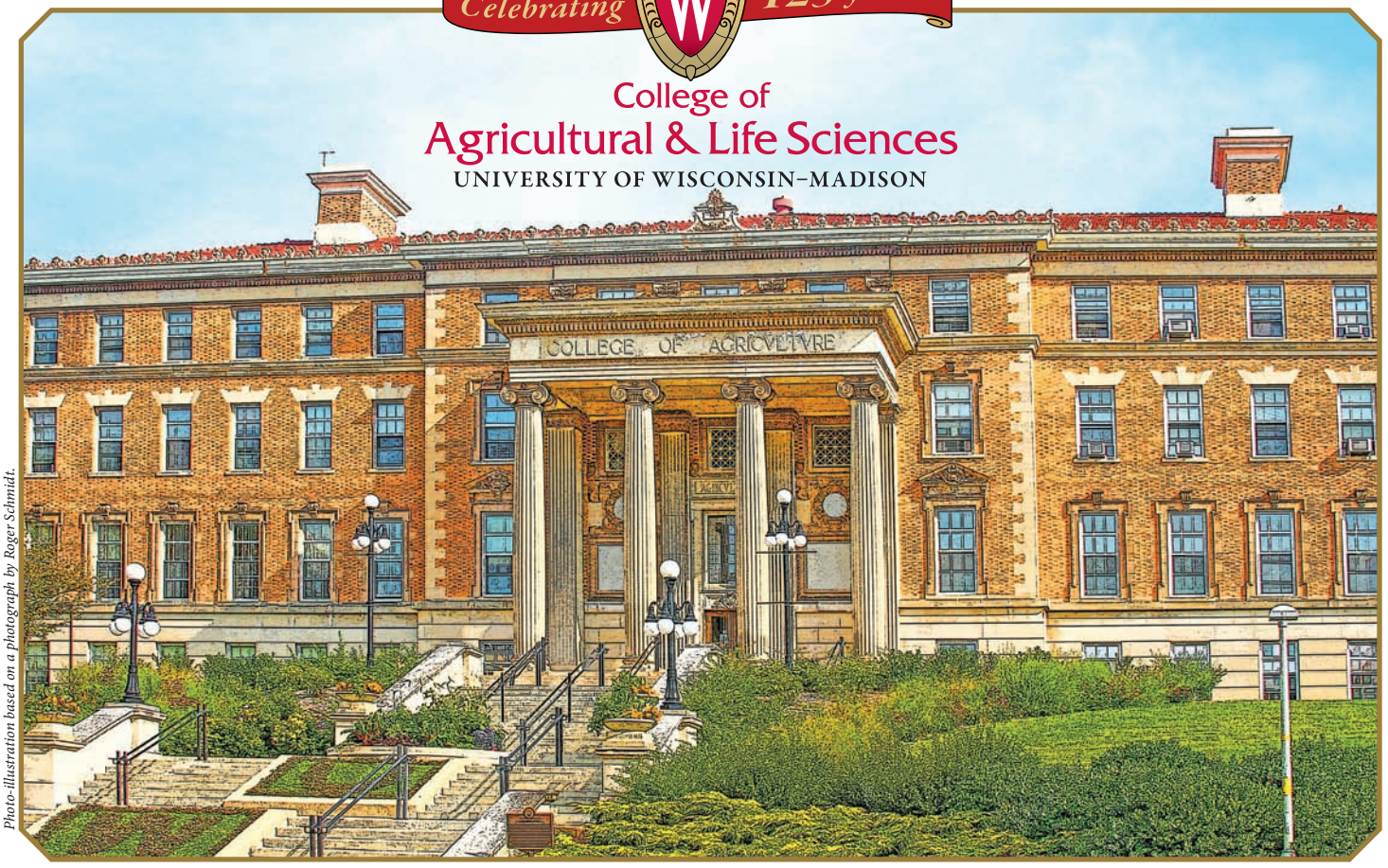


Photo-illustration based on a photograph by Roger Schmidt.

Thank you for helping us grow our future

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VITA PLUS

2014 is the college's quasquicentennial, so we have spent a lot of time looking back, but always with an eye toward the next 125 years. Our generous 125th anniversary sponsors have helped us honor and celebrate the past as we move forward with new initiatives, programs and projects that stay true to our mission of teaching, research and outreach.

THANK YOU AND ON, WISCONSIN!

Take the Final Exam!

This Edition: The CALS History Tour

A special Final Exam in honor of the college's 125th anniversary (Open Book)

The answers to these questions may be found on the historical plaques dotting the CALS campus. We've created an online tour of these memorials at http://go.wisc.edu/calsplaques

Fill out your answers online. Ace our quiz and we'll enter you in a drawing for a gift box of Babcock Hall cheese. Go to www.cals.wisc.edu/grow/ for more details.

1. Vitamin A was first discovered by biochemist Elmer V. McCollum in which of the following foods?

a) Carrots
b) Eggs
c) Butterfat
d) Spinach
e) a and c

2. The principles of modern agricultural and applied economics were influenced greatly by the scholars Henry C. Taylor and Benjamin H. Hibbard. Which of the following were among their priorities for Wisconsin's commitment to agriculture?

a) Public interest in private land
b) The role of family-operated farms
c) Resource policy
d) a and c
e) all of the above

3. Which of the following crops was the first bred to be resistant to a particular disease?

a) Beans
b) Cabbage
c) Squash
d) Corn
e) Potatoes

4. The discovery of "immune tolerance" has been vital to studies of organ transplantation, cancer and autoimmune diseases. Which of the following fueled further research into this field?

a) The development of "knock-out" mice for embryonic research
b) The study of the development of identical human twins
c) The study of blood cell types in non-identical cattle twins
d) The development of antibiotics from molds

5. Collaboration between a bacteriologist, a botanist and two biochemists was responsible for which of the following discoveries?

a) Producing a strain of alfalfa that is resistant to Wisconsin's freezing temperatures
b) Development of the first test for the butterfat content of milk
c) Synthesis of warfarin, an anti-clotting agent
d) Development of a genetically modified strain of mold for the mass production of penicillin
e) Discovery of the importance of micronutrients in diets

LAST ISSUE: Answers were 1: B, 2: C, 3: D, 4: A, 5: E. Congratulations to Melissa Brooks BS'99, who was randomly selected from 24 people who correctly answered all questions. She wins a Babcock Hall cheese box.

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"POSOH" means "hello"—

and a new way of teaching science that integrates Native American knowledge into learning materials and activities. Read more about it starting on page 28. The seventh-grade curriculum guide features a cover illustration, shown here, by Native American artist Anthony Gauthier.