# 2014 ANNUAL REPORT

AgBioResearch

MICHIGAN STATE UNIVERSITY

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MANAGING EDITOR'S NOTE: As we interviewed the scientists involved in the research projects presented in this report, they provided us with lengthy lists of colleagues, students, organizations and funders integral to their efforts. Including all of this information would easily double the length of the report, so we opted to limit project narratives to key research elements and the importance of the work in its respective field. We do, however, want to convey the interviewees' acknowledgments of the individuals and organizations with which they collaborate and their gratitude for the support they receive in doing their work.

## MESSAGE FROM THE DIRECTOR

Reflecting on a momentous 2014, confident that the excitement will continue

**Douglas D. Buhler**
**MSU AgBioResearch Director**
**CANR Senior Associate Dean of Research**

*It's truly a momentous time to be at Michigan State University (MSU). In 2014, there were many headline-grabbing events such as the visit by President Obama to sign the Farm Bill, a visit that included a private lab tour with research updates from three MSU AgBioResearch (ABR) scientists; the Rose Bowl win in Pasadena; and the construction start of the highly anticipated Facility for Rare Isotope Beams.*

*There were many milestones for ABR as well. Some of the highlights are included in this report, such as new findings about West Nile virus, discovering novel ways to address "big data" issues, easing child custody exchanges and keeping healthy foods affordable.*

*It's certainly been a busy year. In June, long-time ABR associate director John Baker left to become the College of Veterinary Medicine (CVM) dean. I thank John for his hard work and dedication to ABR over the past 10 years and look forward to working with him to strengthen the ABR-CVM connection. In John's absence, we were fortunate to be able to bring on George Smith from Animal Science as acting associate director and Mike Jones from Fisheries and Wildlife as assistant director. Both are ABR scientists who have years of experience in the animal agriculture and natural resources industries, respectively. (Learn more about George and Mike on the opposite page.)*

*We've been working closely with MSU Extension (MSUE) to reinvigorate our partnership with Extension faculty members, educators and specialists, especially at our outlying research centers throughout Michigan. One example of these efforts is at the Upper Peninsula Research and Extension Center in Chatham, where researchers and Extension specialists are collaborating to build an integrated food system and respond to the unique food, forage and soil challenges posed in this region of the state.*

*We're also looking at ways to upgrade our research centers to better meet the needs of the agriculture industry. One example is at the Clarksville Research Center, where a wind machine has been installed to more closely study techniques to protect fruit trees from frost damage. Researchers there have also made great strides in using a water mist method to delay spring bloom. With extreme weather oftentimes meaning the difference between having a crop and no crop at all, advancements like these are invaluable.*

*In March, we were extremely pleased to see apple, cherry, peach and plum growers across the state overwhelmingly pass a referendum to establish the Michigan Tree Fruit Commission. Assessments from this new state-administered program will go a long way to help meet the infrastructure needs of our fruit tree research centers and help our researchers remain competitive in the grant process.*

*Also in 2014, ABR joined MSUE and the College of Agriculture and Natural Resources to forge a new partnership with the Michigan animal agriculture industries. Over $630,000 in research endeavors have recently been funded to address key issues identified by the Michigan animal agriculture industries. More on that in 2015!*

*In July, I was honored to be appointed to the inaugural board of the Foundation for Food and Agriculture Research, which was established with a $200 million allocation within the Farm Bill. This national team is challenged with looking at key issues such as climate and water in a truly unique fashion. One of our goals is to match every dollar spent on research with external funds.*

*I look forward to continuing to lead ABR in the key research areas of food, energy and environment to benefit Michigan residents and people around the world. Our reach continues to broaden with endeavors that focus on issues from improving food safety to finding disease cures to challenges that affect each and every one of us.*

*Douglas D. Buhler*
*MSU AgBioResearch Director*

## NEW INTERIM ASSOCIATE AND ASSISTANT DIRECTORS

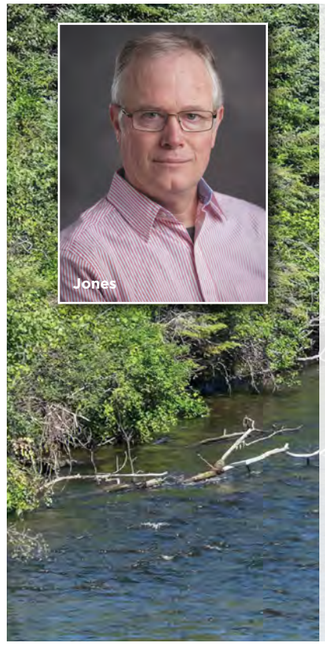

**George Smith**, Michigan State University (MSU) animal science professor and co-director of the MSU Reproductive and Developmental Sciences Program, began serving as acting associate director of MSU AgBioResearch (ABR) July 1.

In the part-time role, Smith provides leadership to ABR in the animal science research portfolio, oversight of the Office of Research Support, and the overall leadership and operation of the organization. Smith had previously served as a leadership intern under immediate past associate director John Baker, who left ABR to become dean of the MSU College of Veterinary Medicine in June.

In addition to his new responsibilities, Smith will continue his research, which focuses on the fundamental mechanisms that control ovarian function and contribute to egg (oocyte) quality in cattle as a biological model for reproduction in economically important agricultural species, as well as in human medicine.

Smith obtained his doctoral and master's degrees, both in physiology of reproduction, from the University of Missouri, and his bachelor of science in animal science from the University of Idaho. His research has been continuously funded by the U.S. Department of Agriculture (USDA) and the National Institutes of Health (NIH) since 1998.

To date, Smith has been the lead or co-lead on grants totaling over $9 million and published 101 peer-reviewed research articles and 16 invited reviews, and his research group has also filed two patents. He has also served on grant review panels for USDA, NIH, National Science Foundation and National Aeronautics and Space Administration competitive grant programs and on the editorial boards of several prominent reproductive biology and endocrinology journals.




**Michael Jones**, Michigan State University (MSU) fisheries and wildlife professor, was named assistant director of natural resources programs for MSU AgBioResearch (ABR) in late October. This is a new part-time position within the organization.

Jones, who served as chair of the Department of Fisheries and Wildlife from 2009 to July 2014 and acting chair in 2008-2009, is responsible for overseeing the ABR natural resources portfolio. He is working with departments to facilitate research productivity and collaborative opportunities across units.

Jones received his bachelors of science and Ph.D. degrees, both in zoology, from the University of British Columbia in 1977 and 1986, respectively. In 1997, he came to work at MSU, where he specializes in fish population dynamics and modeling, especially in the Great Lakes, and sea lamprey management. He is co-director of the MSU Quantitative Fisheries Center and is supported by the Great Lakes Fishery Commission through the Partnership for Ecosystem Research and Management (PERM), an agency-university collaboration that addresses significant ecosystem issues through research and outreach.

Jones, who was recently named the Peter A. Larkin Professor of Quantitative Fisheries at MSU, has been an ABR scientist for 17 years.

# SEEING CLEARLY:

## Fighting diabetic vision loss

ABOVE: Julia Busik, an MSU AgBioResearch physiologist, is hoping to bring an end to diabetic vision loss by restoring lipid concentrations in retinal tissue and the circulating angiogenic cells (CAC) in bone marrow to normal levels. *Photo: Harley Seeley*

OPPOSITE: CAC cells from the bone marrow (green) assist in the repair of retinal tissue (red). In patients with diabetes, these cells do not work efficiently, which allows retinal damage to build up over time. *Photo: Harshini Chakravarthy*

The World Health Organization estimates that nearly 350 million people, or approximately 5 percent of the global population, live with diabetes. It is the eighth leading cause of death, and by 2030, it is expected to jump to No. 7. People with diabetes are also at risk for developing a large number of health complications, such as kidney and heart disease, and vision loss. Approximately 29 percent of diabetic patients over the age of 40 will develop vision loss, or diabetic retinopathy. Michigan State University (MSU) AgBioResearch physiologist **Julia Busik** is working to bring that percentage down.

There is currently no way to prevent or cure diabetic retinopathy, although a number of options exist to help forestall its effects on a patient's vision.





"With the increase in the rate of the diabetes itself, we're seeing more patients develop the complications that come with it," said Busik, an associate professor in the MSU Department of Physiology. "Losing sight is not a laughing matter, and we're trying to find ways to cure it."

After four decades of research, scientists have yet to determine the exact cause of diabetic retinopathy. A metabolic condition, diabetes limits the body's ability to process sugar or glucose, leading to hyperglycemia. Researchers initially thought that this unhealthy increase in blood glucose was the sole cause of the retinal damage that leads to vision loss, but recent clinical trials have begun to reveal a different picture.

One of the effects of diabetes is a condition called dyslipidemia, in which blood has abnormal levels and composition of cholesterol, triglycerides and other fat compounds, collectively termed "lipids." An emerging trend in clinical trials is a link between dyslipidemia and retinopathy: as dyslipidemia worsens, the abnormal lipid composition exacerbates retinal damage. Busik is working to understand the correlation between the two conditions in the hopes of learning how to control and even prevent vision loss.

Most lipids in the body are produced in the liver, but Busik and her team found that some lipids are actually produced at higher rates and present in higher concentrations in the retina than in the liver and blood. These enzymes produce long-chain fatty acids such as docohexaeonic acid (DHA), which protects retinal tissue from inflammation. Busik's lab further discovered that, in diabetic animal models, fatty acid elongases are down-regulated by more than 40 percent. Accordingly, the level of DHA was reduced by up to 40 percent in the retina, removing the tissue's protection from inflammation. Busik demonstrated that diabetic retinopathy can be prevented through a diet high in fish oil, which contains high concentrations of DHA. This approach, however, is far from practical outside of laboratory studies.

"High fish oil diets are not what you want to use in clinical trials," Busik said. "If you take really high levels of fish oil, other issues, such as the prevention of proper immune system response, can develop. That's why we're trying to find the enzymes that directly improve omega-3 production."

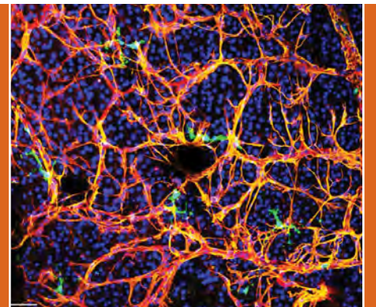
Busik's lab is now working on the regulation of the enzyme pathways that boost DHA production in retinal tissue so that treatments for diabetic retinopathy can be developed that return patients' DHA levels to normal. Such treatments would prevent retinal dyslipidemia and, consequently, vision loss.

Another cause of diabetic retinopathy is the failure of a special class of cells, called circulating angiogenic cells (CAC), or CD34+ cells in humans, from mobilizing from the bone marrow to repair damage to the retina. In patients with diabetes, these cells do not function as efficiently as they should, and that allows retinal damage to increase over time. Busik's lab has now begun to investigate the role of lipid imbalance in causing CAC deficiency.

"Our body, when its processes are working correctly, has wonderful potential for repair," Busik said. "It's similar to how you don't bleed to death from a cut on your finger. If the normal repair processes are intact, the body can heal damage to retinal vasculature. Normally, CACs are released from the bone marrow to assist with the microvascular repair process, but in diabetes, this release and function of CACs is impaired. Our challenge is to try to restore CAC release and repair back to normal."

There is currently no way to prevent or cure diabetic retinopathy, although a number of options exist to help forestall its effects on a patient's vision. By building an understanding of the mechanisms that drive diabetic vision loss, Busik hopes that new treatments will allow patients to sustain their vision longer, if not forever.

"Even though this is very basic research as we try to understand the mechanisms behind diabetic retinopathy, it's not just to help us understand this little structure for its own sake," Busik said. "What we're doing in the lab is very applicable — it can help people in the very near future."



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# RESPONDING TO INVASION:

## MSU shields fruit industry against tiny fly with big impacts

Michigan's fruit industry boasts more than 22,000 acres devoted to small fruit production; blueberries account for a whopping 20,900 of those. Valued at $118.5 million, the blueberry industry has helped Michigan gain a reputation as a top producer of one of the world's most popular fruits.

In 2010, researchers from Michigan State University (MSU) confirmed the presence of a pest that threatened the future of this industry: spotted wing drosophila (SWD). Since its arrival in the eastern United States, growers of most berry crops have spent millions of dollars on managing the invasive pest.

RIGHT: Rufus Isaacs, MSU professor of entomology, examines captured spotted wing drosophila in a blueberry field at Trevor Nichols Research Center. This invasive vinegar fly wreaks havoc in Michigan orchards by cutting into blueberries and other small fruits before they're harvested, leaving fruit damaged and difficult to sell.

OPPOSITE: Spotted wing drosophila caught on traps at Trevor Nichols Research Center.
*Photos: Kurt Stepnitz, MSU CABS*





**Rufus Isaacs**, MSU professor of entomology, has been leading a committed, grower-centered response to the threat of SWD in Michigan.

Native to Japan, this invasive vinegar fly was discovered in the United States in fall 2008 on California raspberries and strawberries. In 2009, SWD was reported in Oregon, Washington, Florida and British Columbia, Canada, before making its way to Michigan, Utah, North Carolina, South Carolina and Louisiana a year later. SWD is a pest of small fruits (e.g., blueberries, strawberries, raspberries and blackberries) and some tree fruits (cherries, mulberries and peaches).

"Spotted wing drosophila is a problem because the pest can cut its way into fruit while it's still intact on the bush or tree," Isaacs said. "This creates a scenario where live larvae could be inside the fruit at harvest time, compromising fruit quality. Additionally, growers have to spend a lot more money on controlling the pest. Combine those two factors, and this pest has quickly had major economic impact."

In partnership with several MSU AgBioResearch scientists and MSU Extension educators, Isaacs has developed an effective management program that equips Michigan growers with tools to help protect their fruit. Since 2010, he has made it a goal to understand which of the available control options are most effective to guide the recommendations that MSU makes to Michigan's fruit industry.

Isaacs explains that this has been a team effort. He credits Steven Vantimmeren, a research technician based at the Trevor Nichols Research Center (TNRC), and John Wise, TNRC director, as well as many undergraduate students for developing the research.

"We have developed methods for testing various insecticides and sprayers and, with help from Eric Hanson of the MSU Department of Horticulture, we've explored cultural controls — non-chemical ways to prevent SWD infestations," Isaacs explained. Examples of cultural controls include rapid picking, or removing fruit more frequently from the tree or bush; and netting, a physical method for limiting flies' access to the fruit.

Over the past four years, Isaacs and his colleagues have identified the most effective insecticides, first in a laboratory setting and then later in blueberry field tests at TNRC. Eventually, they partnered with local growers to confirm their findings.

"This allowed us to give growers combinations of programs and crop protectants they can use with confidence," Isaacs said. "These have been tested on growers' farms with success, enabling them to protect their crops and harvest marketable berries. From that perspective, I think we've been successful in the short term, but we also need to be thinking about what we can do in the long term to reduce the need for chemical controls."

Isaacs also worked with the MSU Fruit Team and the Integrated Pest Management (IPM) program to use MSU Extension's information delivery systems to quickly share vital information with growers across the state.

"Joy Landis quickly established a website from which we share IPM information and updates about this pest's behavior and presence in the state," he explained. "For the past three years, we've also held a series of hands-on workshops led by Carlos Garcia-Salazar that has brought together growers and consultants for presentations on the latest research and management techniques, as well as opportunities to take part in some hands-on demonstrations." These activities include building SWD traps, sampling fruit for larvae and identifying the pest on fruit.

Isaacs explained that, in his next phase of research, he would like to explore a range of biological controls — use of natural predators to suppress pests.

"There's a group in the U.S. that has gone to the native range of SWD to collect its natural enemies," he said. "Those insects are now being put through a very rigorous screening to see if there are any promising candidates that could be released in the U.S. to reduce SWD populations."

In addition to planning to explore biopesticides — pesticides that come from natural sources such as flowers, fungi, nematodes or viruses — he also expressed interest in determining the efficacy of targeting SWD controls early in the season. Isaacs speculates that there might be a way to kill the flies before they have a chance to reproduce and increase their numbers; doing so could reduce pest pressure during the growing season.

"We have gained some important insights about SWD over the past few years, as well as some results that have helped growers optimize their management of this pest," Isaacs concluded. "It's been so important to have the initial lines of defense that are being vigilant in an attempt to keep ahead of potential invaders. There's still a lot to do, but we're building on a good foundation of research and Extension efforts that are saving these tasty crops."

"Spotted wing drosphila is a problem because the pest can cut its way into fruit while it's still intact on the bush or tree." — Rufus Isaacs

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# GOOD EGG VERSUS BAD EGG:

## Understanding the makings of a high quality oocyte

ABOVE: MSU AgBioResearch animal scientist Keith Latham studies the early development of mammalian oocytes, or unfertilized eggs, and the early stages of embryo development. His genetic, genomic and molecular studies are coupled with microsurgical methods such as nuclear transfer, cloning, microinjection and cytoplasm transfer.

OPPOSITE: MSU Ph.D. candidate Puja Basu examines an oocyte under the microscope in the Latham laboratory. *Photos: Natasha Berryman, MSU ABR*

Women are born with about 2 million eggs in their ovaries. By age 30, about 90 percent of those eggs will be gone. By age 40, only about 3 percent remain.

Michigan State University (MSU) AgBioResearch scientist **Keith Latham** has spent the past two decades closely studying immature eggs — properly called oocytes — primarily in animals, but with findings often applicable to humans. He began his research lab more than two decades ago to study how life begins and, ultimately, to determine what makes a high quality egg.

Long fascinated with the concept of development, Latham recounts first realizing how similar, yet different his hands were from each other and the wonderment at how that happened. This early curiosity inspired Latham eventually to pursue undergraduate and doctoral degrees in biology, and a career devoted to the detailed molecular studies of oocytes, as well as embryos and stem cells in mammals. Much of his research has been conducted on mice.

"You're familiar with the saying 'the best place to begin a story is at the beginning' — that's exactly where my research is," said the MSU Department of Animal Science professor and adjunct professor of obstetrics. "Really, the beginning is inside the ovary in the formation of the egg. Though it may look simple from the outside, what's happening inside the unfertilized egg is extremely complex. It contains all the marching orders for developing the ability to transcribe DNA and to regulate DNA."

In August 2013, Latham moved his lab from Temple University School of Medicine to MSU. He and his team of lab technicians and graduate students focus on the underlying mechanisms that regulate the development of oocytes from pre-fertilization to uterus implantation. This includes the formation of spindles needed for segregating genetic material in the immature egg, and gene function and expression responsible for genome reprogramming. He also examines the mechanisms that maintain the cellular integrity and regulate messenger RNA in the oocyte and early embryo.

"We're looking at what makes a good egg," he said. "If your egg doesn't have these certain criteria, it will 'get late very early,' as we say. We study the egg, but we also have to look at the surrounding cells and the communication between the two. If you disrupt that dialogue, you will end up with a bad egg."

Latham and his colleagues have identified genes in mice that appear to be important to egg quality and discovered that oocytes may edit the paternal contribution to progeny characteristics. They are also studying environmental stressors on the early molecular development of mammal embryos and ties to conditions such as attention deficient disorder, Type 2 diabetes, obesity and asthma later in life.

"The topic of developmental origins of disease is one of the most exciting things to come up in biology in the past decade," he said. "It's the notion that things that happen to you, not only in the early embryo but in a developing egg, can have effects on health decades after birth. And that's not because our genes are any different — it's because our environment is."

Faced with some criticism over the years that studies on mice have little relevancy to human medicine, Latham turned to the Rhesus monkey embryo. In 2002, with funding from the National Institutes of Health, he created the Primate Embryo Gene Expression Resource (PREGER). This national resource, available to scientists, includes such services as a gene expression database, DNA libraries, online tools and training opportunities.

"I started PREGER with the idea that if I could take a single monkey embryo, which at the time cost $5,000, and convert it into a library of 15,000 gene expressions that could be shared with other scientists, that would be a big bang for the buck," he said. "It's continued to evolve to be a database resource because it makes sense to extract as much data as I can and really eliminate the need for others to get embryos for basic inquiries."

Through PREGER, researchers have been able to study the effects of the maternal diet and maternal binge alcohol consumption on oocyte quality and pregnancy outcomes in the monkey. Latham said these findings are relevant to human reproductive health and could enhance breeding productivity in farm animals.

In fact, Latham and his team are also using PREGER to examine the impact of assisted reproductive technologies on offspring growth characteristics.

"Assisted reproduction is a large and growing industry in both human clinical practice and in agriculturally important species," he said. "Understanding how oocyte manipulations may adversely affect outcomes is paramount to minimizing risks and maximizing success."

Latham is particularly excited about a new technology called CRISPR (clustered regularly interspaced short palindromic repeats), which allows for rapid and precise genome editing without the need for cellular cloning (with only a 1 to 2 percent success rate). Latham says this technology will lay the foundation for application of his work in agricultural species.

"Many lessons learned through the combination of mouse and monkey can be taken back to agriculture — markers of egg quality, embryo and oocyte quality, ways to intervene to make egg quality better," he said. "But I'm rather eager to make the transition from mouse and monkey and integrate farm animals into my work. It may mean that eventually the cow replaces the monkey for me. We'll have to see."

Though it may look simple from the outside, what's happening inside the unfertilized egg is extremely complex.

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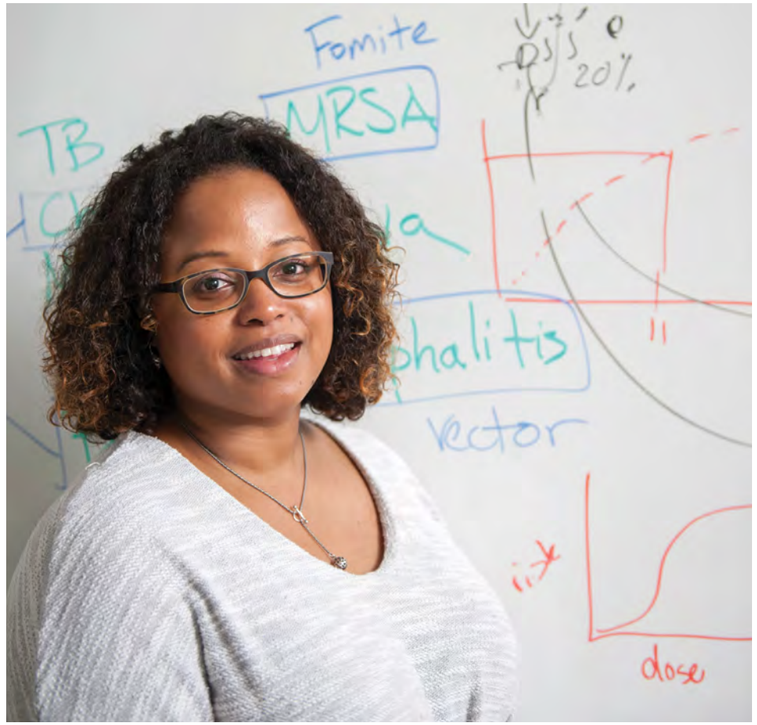
# RISKY BUSINESS:

## Training researchers to assess dangerous microbes

Even as the global population surpasses 7 billion, humans are vastly outnumbered by the trillions of microorganisms on the planet. Many are essential for everyday life, but large numbers of these invisible creatures present significant health risks. Michigan State University (MSU) AgBioResearch scientist **Jade Mitchell** has coordinated a program to train fellow scientists to assess microbial risks and to assemble plans to help keep people safe.




RIGHT: Jade Mitchell, MSU assistant professor of Biosystems and Agricultural Engineering, developed the Quantitative Microbial Risk Assessment (QMRA) III program to help researchers improve their ability to collaborate on projects that blend quantitative and social science approaches to help prevent microbial threats. *Photos: Kurt Stepnitz, MSU CABS*

FOOD & HEALTH

Mitchell, an assistant professor in the MSU Department of Biosystems and Agricultural Engineering (BAE), has developed a 10-day workshop to provide quantitative microbial risk assessment (QMRA) tools, models and training to university researchers around the nation. Her work is being funded by a nearly $1 million grant from the National Institutes of Health (NIH), the first grant of its kind begins for BAE. The program, which begins in August, is called the Quantitative Microbial Risk Assessment Interdisciplinary Instructional Institute (QMRA III). It will connect quantitative scientists such as engineers, with biologists and social scientists.

QMRA is a four-step process used to characterize the human health risk associated with exposure to various microorganisms. The information assesses the danger posed by pathogens and to develop appropriate plans in case of public exposure to infectious agents in all types of settings.

Although it's commonly used in mathematics and applied sciences such as engineering, QMRA draws on knowledge created by specialists from a range of disciplines, including biology and the social sciences. Training and expertise are not as common in these fundamental scientific fields as in the applied fields, however, and courses are not available at the graduate level in many academic departments. Mitchell said the training program will strive to fill those voids.

"It's important that we engage more with biologists and social scientists because their work is so important to risk assessment and the application of systems thinking to public health problems," Mitchell said. "Especially when it comes to defining and implementing management practices, which rely on how people respond to them."

QMRA III will help engineers and biologists take a systems approach to food and environmental issues.

"As we continue to integrate engineering with biology, and while taking a systems approach to issues of food and environment, this NIH grant will give the necessary boost in our efforts toward developing engineering systems for One Health," said Ajit Srivastava, BAE chairperson.

One Health is a collaborative, multidisciplinary movement to attain optimal health for people, animals and the environment.

Participants in QMRA III will learn the essentials of QMRA practice and apply their knowledge in cutting-edge, real-world case studies. Mitchell said this will help to develop new methods that can be used to tackle emerging issues in microbial risk management. Some of the case studies on emerging topics will be further explored after the program has concluded, developing into new research projects in their own right.

"One of the things I like best about this program is that it brings new research into the educational environment," Mitchell said. "Most recently we've looked at biosolids, such as manure, and viruses in drinking water. Those are both pretty hot topics right now, and we're at the forefront of training people for them. We're testing new methods and models, as well as developing the educational materials for these new issues."

One of the central features of QMRA III is QMRAwiki, a multilayered, interactive website that allows scientists to work together on individual projects regardless of geographical location. Participants will use the site's datasets, parameters, models and tools to conduct the risk assessment case studies during the program, but Mitchell said she sees utility far beyond the classroom.

"It's an opportunity to build on knowledge that's already been established," she said. "We're always adding new content, models and educational material to the site. It's a repository of data that is open to the entire QMRA community."

By providing QMRA researchers with a central hub of information, Mitchell looks to encourage the cross-disciplinary collaboration that lies at the heart of QMRA research.

"Risk assessment is always a team effort, so to best facilitate learning, this program had to be multidisciplinary," Mitchell said. "People are coming to this course to learn from the people who established this framework and are leaders in the field."

For more information, please visit **qmrawiki.msu.edu**. Registration information for QMRA III is available at **camra.msu.edu**. The deadline to register is March 31.

"Risk assessment is always a team effort, so to best facilitate learning, this program had to be multidisciplinary." — Jade Mitchell

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# PARADIGM SHIFTS:

## Re-envisioning agricultural landscapes to optimize ecosystem services

ABOVE: Doug Landis (right), MSU professor of entomology, has found that perennial grasslands provide a superior set of ecosystem services including increased greenhouse gas consumption, pest suppression, pollination and the conservation of grassland birds. Landis discusses pollinators with MSU graduate student Mitchell Lettow. *Photo: Kurt Stepnitz, MSU CABS*

OPPOSITE: Prairie grasses cannot only be converted to cellulosic biofuels, but also provide a new set of ecosystem services when they are incorporated into agricultural landscapes. *Photo: iStock*

In 2013, the United Nations released a report projecting that the global population will reach 9.6 billion by the year 2050. This increase of 2.4 billion people between now and then is already beginning to challenge the world's agricultural communities to provide adequate food, fuel and fiber while employing sustainable practices that conserve natural resources. The feat becomes more complex when coupled with the increasing demand to grow more bioenergy crops, combat biodiversity declines and regenerate the habitat of agriculturally important insects.

Within the system, users see a map of their neighborhood and can designate specific areas of their farms for potential conversion to bioenergy crops.





**Doug Landis**, Michigan State University (MSU) professor of entomology, is leading an interdisciplinary team of scientists in a multiyear investigation to explore the role of perennial bioenergy crops in supplying a host of services rising in demand.

"Ecologists developed the term 'ecosystem services' to account for the benefits that biodiversity provides to humans," said the MSU AgBioResearch scientist. "A variety of organisms and ecological processes provide ecosystem services on farmlands that are fundamental to crop production and society at large — soil formation, nutrient cycling, crop yields, water filtration, flood prevention, recreational opportunities, medicines, pollination and pest control are just a few examples."

Landis, with input from scientists from the Great Lakes Bioenergy Research Center (GLBRC), MSU AgBioResearch and MSU Extension, has determined that these services are enhanced when perennial bioenergy cropping systems are incorporated into agricultural landscapes.

He explained that much of the farmland in southern Michigan is used to grow corn, soybeans and/or wheat. Though those crops provide a set of ecosystem services, he said others such as switchgrass, mixed prairie grasses and flowering plants supply many new or improved services across multiple pieces of land.

"Mixed prairies, for example, support the breeding populations of several threatened grassland birds, provide stopover habitat as the birds migrate south in the fall, support flowers that promote reproduction of pollinators, and contain diverse plant communities that provide habitat for predatory insects and spiders that attack crop pests," he explained. "Moreover, some of these benefits spill over into adjacent crops, increasing biocontrol of aphids in soybeans and boosting pollination of fruits and vegetables."

Perennial crops provide an opportunity to alter and shape the landscape in a way that annual crops can't. So Landis and his GLBRC colleagues are also focusing on understanding the best ways to use perennial crops in agricultural systems. Past research enabled them to understand the important roles of perennial crops in agricultural landscapes. Now they're exploring efficient ways to build new landscapes in a way that provides the most benefit for the largest number of people.

This part of Landis' research has been used by groups that are creating computerized decision-support systems. Landis wants to equip communities with tools that will lead to informed decisions about the best way to incorporate bioenergy crops into landscapes. Because many ecosystem benefits accrue at the landscape scale — not the farm scale — it will be important for growers to coordinate their planning activities.

Linking geographic information systems with models that Landis helped develop is the basis of one such decision-support system. Within the system, users see a map of their neighborhood and can designate specific areas of their farms for potential conversion to bioenergy crops. Within a few seconds, the models display the projected influence on ecosystem services and economic returns. Users have found virtually manipulating landscape designs and seeing the potential results to be a powerful learning tool.

"I'm part of a larger consortium that conducts multistakeholder meetings that use these decision-support tools and bring together landowners, conservation groups, farm suppliers and all the people you might imagine who would need to be present to decide if bioenergy cropping makes sense for their local community," Landis said.

Currently, there isn't much incentive for farmers to coordinate their planning efforts. Most farmers act independently, but Landis envisions future agricultural policy that could provide a reward to farmers who coordinate their activities with others.

"If society wants to take advantage of larger ecosystem services, science-based polices are needed to inform the design of resilient agricultural landscapes," he concluded. "Our key finding is that the linkage between biodiversity and ecosystem services depends not only on the choice of bioenergy crop but also on its location relative to other habitats.

"In the past, agricultural landscapes developed by happenstance. Now we have the knowledge, the tools and the incentive to actually design these systems. This a real opportunity to ask the right questions and, hopefully, design better landscapes for the future."

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# WEATHER & CLIMATE:

## Managing two of the most uncontrollable factors in agriculture

BELOW LEFT: MSU AgBioResearch climatologist Jeff Andresen is a member of a research team utilizing three process-based crop simulation models to identify and examine the impacts of climate on corn production in the Midwest over the past century.

BELOW RIGHT: Andresen is also working with MSU AgBioResearch horticulturist James Flore and his graduate student Ishara Rijal (left) on a project that utilizes a fine mist of water to keep buds cool and delay bloom during an early spring warmup. *Photos: Kurt Stepnitz, MSU CABS*

In general, Michigan is becoming warmer (1 degree warmer on average in the past 120 years) and wetter (a 10 to 15 percent increase in precipitation over the same period). And the growing season has lengthened by about 1.5 weeks in the past 30 years, resulting overall in new challenges and opportunities for the state's agriculture industry.

State climatologist **Jeff Andresen** has worked directly with farmers to help manage and project the impact of weather and climate conditions on agricultural production systems since coming to Michigan State University (MSU) in 1991.

"If we had perfect [weather and climate] information about the future, we could help revolutionize the way farming is done. But of course, the reality is that we don't," said Andresen, professor of geography and Extension specialist. "The key is a better understanding of how weather and climate influence agriculture and the development of new techniques to make forecasts more reliable and useful. Ultimately, we hope to provide new scientific information that reduces weather-related risk."

Andresen is a member of a team of researchers who are utilizing three process-based crop simulation models to identify and examine the impacts of climate on corn production in the Midwest over the past century. The 12-state region accounts for more than 80 percent of U.S. corn production and 25 percent of global output. It is part of the Useful to Useable (U2U) Project, a U.S. Department of Agriculture National Institute of Food and Agriculture project seeking to improve the resilience and profitability of farming operations in the region amid climate variability and change.

In the work carried out at MSU, the process-based CERES (Crop Environment Resource Synthesis) -Maize crop model was used to simulate the impacts of weather and climate on corn production systems. Model validation was carried out with individual plot and county observations. The model was run with weather data for representative soils and cultivars from 1981 to 2012 to examine spatial and temporal yield variability within the region.

The researchers are also examining the influence of other crop models and spatial scales on regional yield estimation, as well as a yield gap analysis between observed and attainable yields. An additional study was carried out at 18 sites to examine historical trends from 1901 to 2012.

In general, Andresen said, the model estimates are in agreement with observed yields, especially in central sections of the region. He added that low precipitation and soil moisture stress were chief limitations to simulated crop yields during the past century. The study suggests that at least part of the observed yield increases in the region during recent decades have occurred as the result of wetter, less stressful growing season weather conditions.

"We're collaborating with Purdue, Nebraska, Iowa State and many other Midwestern land-grant universities," he said. "Primarily we're looking at variability in the current production setting and coming up with new information to help growers make more informed decisions related to seed selection, use of irrigation, field drainage tiling and variation in planting date to determine viable options to remove some of the uncertainty from the equation. We're also looking to assist researchers and the industry on the development of more efficient agricultural production technologies."

In another project, Andresen has teamed up with MSU horticulture professor **James Flore** to examine mist cooling to delay bloom and reduce the risk of frost damage in apples and cherries. Tree fruit in the Great Lakes region is especially vulnerable to cold damage in the spring after the trees break out of dormancy. Unfortunately, the number of spring freezes following initial fruit development in the region has increased in recent decades, Andresen said.

Conventional frost protection methods such as wind machines offer some protection, but they can be costly and are not effective against some types of freezes. Applying water with conventional sprinkler systems during the late stages of dormancy and early vegetative stages has been shown to reduce vulnerability to frost damage by cooling the plant tissue and delaying growth and development. Andresen emphasized, however, that the traditional technology requires large amounts of water, which leaches fertilizers and other nutrients from the soil, causes collateral tree damage from ice formation and carries increased risk of pathogens/diseases.

The MSU researchers are investigating the potential use of a new technology called solid set canopy delivery systems (SSCD) to delay the growth and development of tree fruit and reduce the risk of cold-related damage. Flore, who is leading the project, said SSCD is increasingly used in high-density orchards for application of fertilizer and other spray applications and could theoretically provide the water necessary for cooling with a tiny fraction of the rates used by a conventional sprinkler.

The experiments have been conducted at four orchard locations in Michigan's Lower Peninsula during the early portions of the 2013 and 2014 growing seasons.

"Thus far, the results are encouraging. SSCD mist applications during the two growing seasons delayed bloom of apple and cherry by five to 11 days on average relative to untreated blocks, and spring frost damage was found to be less for the treated blocks," Andresen said. "There was no apparent increase in disease or fruit set problems with the treated blocks. Finally, the amount of water needed for cooling with the new technology was far less than with conventional sprinkler systems."

The model was run with weather data for representative soils and cultivars from 1981 to 2012 to examine spatial and temporal yield variability within the region.

# CHANGING SCIENCE:

## Big data provides impressive potential for ecology research

ABOVE: MSU fisheries and wildlife scientists Pat Soranno (left) and Kendra Cheruvelil are working on the development of a comprehensive approach to understanding, conserving and managing freshwater lakes, streams, and wetlands — landscape limnology. They are at the forefront of a new field called macrosystems ecology, which uses big data to study ecosystems on a massive scale. *Photo: Kurt Stepnitz, MSU CABS*

As computer technologies advance and proliferate at an ever increasing rate, places around the nation and the world are becoming linked in ways never before possible. This new interconnectivity has changed ways of conducting business, government and social interaction, as well as science. Researchers now have access to datasets that span institutions, regions, nations and continents. Collectively termed "big data," these datasets open new levels of scientific analysis and help scientists answer a host of questions, including many about how large systems function and change.

One of the unexpected, yet essential developments of the research has been in pioneering ways to improve collaboration and cohesion between teams of scientists across multiple fields.





Michigan State University (MSU) AgBioResearch scientist **Patricia Soranno** has been leading efforts to apply this new big data frontier to her field of expertise — ecology.

"'Big data' is a hot term right now. It's generally defined as data so large that you cannot use the normal tools to analyze or manage it," Soranno said. "In ecology, we're used to dealing with smaller amounts of data, so as the amount of data increases, we have to develop new tools to use it."

Soranno, a Department of Fisheries and Wildlife professor, and her team are at the forefront of a new field called macrosystems ecology, which uses big data to study ecosystems on a massive scale. Soranno is among a group of researchers around the country who have developed some of the conceptual foundations for the field, recently recognized as an important research area by the National Science Foundation.

"It was amazing [to help develop the conceptual foundations of macrosystems ecology]," she said. "It was really fun to sit down and think of the gaps in the field of ecology and how an approach that takes a continental view of the natural world, harnessing the power of big data, could help fill them."

Specifically, Soranno and her team are looking at freshwater quality in the United States and the factors that influence it.

"For any big data project, you have to start with an important question — otherwise you just get lost in the data," Soranno explained. "We want to understand the problems and extent of water quality issues in the United States, and we also want to know what controls water quality in different regions."

Before the advent of big data, ecologists commonly studied single sites, such as a specific lake or river. Though that approach yielded incredible insight into one site, a big data approach provides the opportunity to apply the detailed knowledge to entire systems.

"By studying the full range of lakes, we're trying to understand their diversity and why some might be more prone to water quality issues than others," Soranno said. "We advocate that both kinds of studies are important. The single-site studies tell us a lot about how the various parts of the system work together; the broad-scale studies tell us how to extend those results to learn how groups of systems work together."

Bringing big data research into ecology will help researchers track the spread of invasive species such as zebra mussels and Asian carp across waterways and from one freshwater system to another. By studying lake systems as a population, researchers can also gain insight into their significance in larger issues such as climate change and the global carbon cycle.

Interdisciplinary collaboration is a critical element of any big data project, and nowhere is that more clear than in macrosystems ecology. To understand water quality issues across expansive areas, Soranno and her team needed to gather data not only on water chemistry but also on climate conditions, geology and land use change. Collecting such varied data requires a similarly diverse team of experts to properly manage and analyze it.

"In my view, I cannot imagine a big data project that is not interdisciplinary," Soranno said. "One thing that's great about being at MSU and with MSU AgBioResearch is that interdisciplinary science is valued. There have been no roadblocks to conducting our research this way, and I value that support."

One of the unexpected, yet essential developments of the research has been in pioneering ways to improve collaboration and cohesion between teams of scientists across multiple fields. Soranno and her team of 20 researchers have developed and applied teamwork models that help them act collectively rather than individually. With the team approach perhaps becoming the new norm in science, Soranno and her team serve as a fine example of the next generation of scientific inquiry.

"The media often represent science as a lone endeavor, but the team is crucial," Soranno said. "We found that this really is a different way of doing science than any of us were trained for, and it's been fascinating. It's an intellectually rich place to be."

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# LOOKING AT FORESTS:

## New light shed on importance of tree diversity

Michigan spans 36.3 million acres, and more than half of that is forestland. Michigan's state-owned forest system, managed by the Michigan Department of Natural Resources (DNR), is nearly 4 million acres — larger than any other state-owned system in the United States. In addition to the recreational, tourism and indirect economic benefits derived from this natural resource, Michigan's forests support more than 13,000 timber/wood product jobs and more than 2,200 companies.*

Michigan forests, however, have unique problems. Michigan State University (MSU) AgBioResearch forest ecologist **Mike Walters** studies factors that can have negative impacts on forests, especially

ABOVE: Michigan State University forest ecologist Mike Walters is conducting research to find ways to diversify Michigan northern hardwood forests.

RIGHT: This small tree has surpassed the 1-meter mark, a milestone achieved by avoiding consumption by deer and emerging through vegetation that often overwhelms many seedlings. *Photos: Evan Farinosi, MSU Dept. of Entomology*

the nearly 7 million acres of northern hardwood forests that thrive in Michigan, primarily in the Upper Peninsula (U.P.) and northern Lower Peninsula.

"The legacies of past forest harvesting practices and high deer populations have combined to contribute to low tree diversity and the perpetuation of just a few tree species that northern hardwood forests support, and some of these are undesirable for management," explained Walters, an associate professor in the MSU Department of Forestry.

Hardwood forests have been predominantly managed by a single tree selection system. Every 10 to 20 years, there are partial harvests of individual trees dispersed through the stand. This process creates small gaps in the overstory, the uppermost layer of the forest foliage forming the canopy. The assumption is that natural regeneration of species desirable for management will fill the tree voids.

Walters has found, however, that natural regeneration often does not occur. And when it does, he found that only a couple of species — oftentimes ones undesirable for management — regenerated.

"Northern hardwood forest can support 20-plus species, but now trees regenerating in these forests are dominated by sugar maples and some beech and ironwood," explained Walters, who has an appointment with Partnerships in Ecosystem Research and Management between MSU and the DNR. "Some species that were formerly abundant, such as hemlock, white pine, yellow birch and paper birch, have declined markedly."

Walters and his colleagues are identifying factors that reduce tree diversity and searching for practicable ways to restore it. By integrating information from a 1-million-acre natural experiment in the U.P. and a multistand, manipulative experiment in the northern Lower Peninsula, Walters has found that, for seedlings to become full-grown, they need to escape being eaten by deer and emerge through competing vegetation, such as raspberries and elderberries.

"Deer love tree seedlings, and it's no coincidence that tree regeneration is being dominated by ironwood and beech, because deer browse these species only when nothing else is available," he said.

A blend of tree species is ideal.

"A greater diversity ought to make the forests more resilient to disturbance. For example, currently 70 percent of the trees in the northern hardwood forests where I work are sugar maples. If the Asian long-horned beetle, which is already in parts of the U.S., comes to Michigan and attacks sugar maples, it could take out large portions of our forests," Walters said.

A more diverse mix of trees would also provide an economic buffer against changes in market demand. Increasing forest diversity is challenging, however, for several reasons:

- There have to be nearby adult trees of the species you want to increase to supply seeds, and some of the species needed to increase diversity are rare in the forests.
- The forest floor lacks a good substrate for seedlings to grow on. Because of forest management practices, few trees die, fall over and rot, and gentle logging practices expose little mineral soil surface, both of which make good substrates.
- The low light created by small forest harvest gaps allows only the seedlings of shade-tolerant species to thrive.
- Managing the deer populations in the forests is difficult — there are no readily available solutions to the problem of deer browsing seedlings.

In spite of these challenges, Walters and DNR and industry foresters with whom he works have some ideas, including changing the single tree selection harvesting method on sites where it is not working. They also recommend methods that provide for larger openings in the forest overstory, allowing for more light to reach seedlings.

"Scarifying" or exposing the mineral soil on the forest floor to allow the seedlings of smaller seeded species (e.g., birches) to grow is another recommendation. Walters said this could be done by promoting tree harvests in the summer, especially in areas where seeds of desirable species are available.

"The other thing is that seed is cheap," Walters said. "You could probably reforest all of Michigan with one big bag of paper birch seeds, so perhaps broadcasting seeds or planting seedlings will work on some sites. All of these are viable options."

**Source: Michigan Department of Natural Resources*

"The legacies of past forest harvesting practices and high deer populations have combined to contribute to low tree diversity and the perpetuation of just a few tree species..." — Mike Walters

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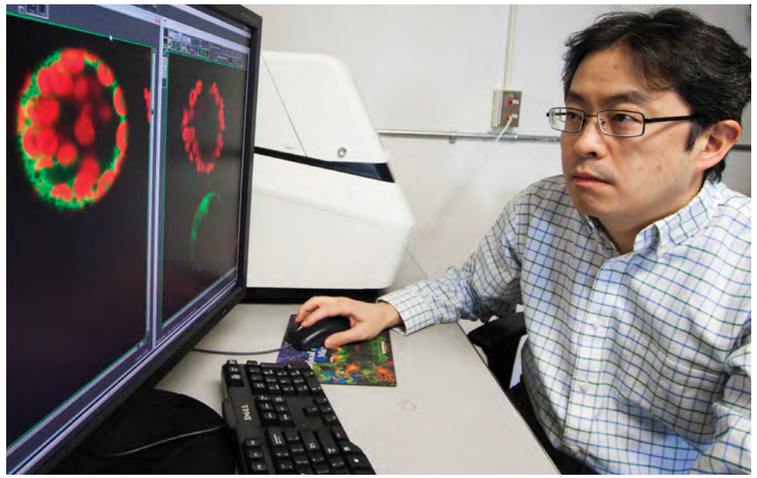
# CHANGING THE CYCLE:

## Deciphering the uptake and metabolism of sulfur in plants



ABOVE: Hideki Takahashi, MSU assistant professor of biochemistry, uses green fluorescent protein in *Arabidopsis* cells to observe the subcellular localization of a sulfur metabolite enzyme. Doing so enables him to identify the compartment in which the enzyme is expressed.

OPPOSITE: *Arabidopsis thaliana*, the model plant species that Takahashi uses to conduct sulfur metabolism research, matures in a growth chamber. *Photos: Natasha Berryman, MSU ABR*

A key component of crop nutrition involves assessing and enhancing soil health. According to the U.S. Department of Agriculture, in 2013, U.S. farmers spent more than $11.3 billion on fertilizers to boost soil fertility and to provide their land with lacking nutrients.

Many growers are burdened by the high cost of fertilizers and have concerns about their environmental impact. Often, nutrients that are not absorbed by crops leach into the surrounding water and soil systems, becoming a source of pollution that affects all components of that ecosystem.

**Hideki Takahashi,** Michigan State University (MSU) AgBioResearch biochemist, is uncovering insights into the uptake and metabolism of sulfur, an agriculturally important macronutrient. His long-term goal is to help plants be more efficient at sulfur uptake, thereby reducing farmers' reliance on certain fertilizers. This research will also enable scientists to find efficient and sustainable ways to utilize sulfur-containing metabolites that are essential to human and plant health.

"It's important to understand these processes and pathways because plant sulfur metabolism is an essential component of the sulfur cycle in nature; also, plants produce many useful sulfur-containing compounds," he said. "Some of these compounds are related to stress mitigation in plants; others can help humans become healthier."

Takahashi explained that all cells require sulfur to function optimally. Plants and animals employ sulfur as a nutrient to aid in the production of proteins, amino acids and enzymes, and to overcome disease and other stresses.

To help reduce fertilizer use in agricultural systems, Takahashi is exploring two ways to make plants more efficient at sulfur uptake. The first requires engineering sulfate transport systems in roots.

"If we increase the number of sulfate transporters in plant roots from one to 10, the plant will be able to take up 10 times more sulfate," he explained. "Or, if we can change the characteristics of that transporter to take up 10 times more molecules, then the plant will also take up more sulfate. This may sound basic, but it's very challenging to accomplish."

The second course he's exploring involves finding a way to increase the expression of genes responsible for producing sulfate transporters, which work to move sulfate across the cell membrane. In theory, it is possible to produce more sulfate transporters if the transcription factors responsible for initiating the expression of these transporters are overexpressed.

"However, plants are really smart and clever, so there should be a feedback mechanism that says, 'Oh — now there's too much sulfur; don't do this,'" he said. "If that happens, we'll have to find a way to override this response."

Takahashi's second research goal — to synthesize sulfur-containing metabolites that are useful for human health — also requires complex biochemical engineering.

"To achieve this, we need to manipulate sulfur metabolic pathways in the cell," he said. "We have to identify which enzymes are expressed in what cell compartments during sulfur metabolism. In the past 20 years, most of the discoveries that could be made about model plant species have been revealed. Because of that, we can focus on modifying specific pathways, processes and interesting enzymes to explore the effects of those actions."

The benefit of the sulfur-containing metabolites that he plans to synthesize depends on the plant being studied.

One genus of plants that he cites as an example is *Brassica*, a genus of plants in the mustard family that includes cabbage, cauliflower, broccoli, Brussels sprouts and oil-producing rapeseed canola. Brassicas are relatives of *Arabidopsis thaliana*, the model plant species that Takahashi uses in his research. Research indicates that sulfur-containing metabolites from plants in this family induce detoxification enzymes, stimulate the immune system, decrease the risk of cancers, and inhibit malignant transformation and carcinogenic mutations of cancer cells in humans.

To date, Takahashi and his team have made major progress in their research efforts to reach their goals.

Through genetic screenings of mutant *Arabidopsis*, Takahashi's team has identified a transcription factor that activates the expression of sulfate transporters in plants.

"This piece of information is very important because this gene is an activator," he explained. "So if we want to overexpress sulfate transporters, we can introduce this transcription factor into plants to see how sulfate transporters are overexpressed."

Using *Arabidopsis*, he has also cloned and characterized many sulfate transporters. His findings uncovered which sulfate transporters are expressed in specific cell types and membrane systems. He also identified several important transporters that are responsible for the uptake of sulfate in the epidermal layer of plant roots.

"Moving forward, my research will expand to see how these transporters and metabolic enzymes can change the balance of sulfur use in plant cells," he concluded. "My major interest is in the biochemistry of sulfur metabolism, but key scientific discoveries from this work have the potential to leverage the development of plants and compounds that will improve our quality of life in the long term."

Through genetic screenings of mutant *Arabidopsis*, Takahashi's team has identified a transcription factor that activates the expression of sulfate transporters in plants.

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# PUTTING SOIL TO WORK:

## Practical research yields major soil health improvements

Practiced on farms of the Middle East since at least 6,000 B.C., crop rotation is a key element of agriculture. Producers have long known that alternating crops in their fields, rather than growing the same crop year after year, improves their farms dramatically. Benefits range from rejuvenating soil nutrients to controlling pests and preventing soil erosion, all of which add up to improved yields and better, healthier crops. There is still more to learn about crop rotation, and Michigan State University (MSU) researchers at the Living Field Laboratory (LFL) are developing the next phase of knowledge about the ancient practice.

LFL was established in 1993 at the Kellogg Biological Station near Gull Lake under the direction of **Richard Harwood**, who was then the C.S. Mott Sustainable Agriculture Chair at MSU. The project was designed as a long-term study of the potential benefits of including cover crops in the rotation cycle of corn. The first crops were planted at the site in 1994 and crops planted there since have been diligently observed for the past 20 years. MSU AgBioResearch scientist **Sieg Snapp** took over LFL when Harwood retired in 2006.

BELOW: Richard Harwood began the Living Field Laboratory in 1993 to explore the benefits of crop rotation in corn.

RIGHT: Plots for the Living Field Laboratory at the Kellogg Biological Station.

OPPOSITE: MSU Department of Crop and Soil Sciences professor and ecologist with W.K. Kellogg Biological Station Sieg Snapp took over Living Field Laboratory upon Harwood's retirement in 2006.

"I think what makes this project so effective is that it's based on farmers' wisdom," Snapp said. "When I go through his legacy, all the material Dr. Harwood has given me, it's not just this one experiment — it's all these relationships with farmers. He took this to the farmers and sought their input, and that's kept our work very applicable to the industry."

The LFL compared various types of crop rotation and management. Harwood and Snapp's research teams compared the crops and soil of the LFL plots, profiling the soil three feet down and studying its biological composition and carbon levels. Though the data is still being analyzed, the benefits of crop rotation are apparent.

"Harwood was really at the forefront of this," Snapp said. "He realized there were all these hidden benefits of rotation that had been lost in the rush to grow large quantities of corn."

Crop rotation helps increase the amount of organic matter in the soil. This improves the soil's ability to filter and retain water, which allows it to remain productive during periods of drought. It also improves the soil's ability to release nitrogen efficiently, reducing reliance on fertilizers. Though some improvement can be made by adding large amounts of fertilizer such as dairy manure, the approach is rarely practical outside of academic experimentation.

"A lot of similar projects used a lot of manure to get big yield improvements, but we're trying to work on a more practical level," Snapp said. "As a researcher, you can afford tons of manure, but we tried to use amounts of materials that would be available to farmers."

The research showed that rotating crops and using reasonable levels of fertilizer could bring about beneficial changes in soil composition. Most improvements were not immediately apparent, however.

"A lot of the soil organic matter processes take at least five or 10 years to come to fruition," Snapp explained. "To see how much the soil can be improved, we needed long-term data."

After 20 years of study, their patience was rewarded. The researchers observed significant improvements in both the soil's organic matter and nitrogen efficiency, reaching a new peak level of productivity. Snapp determined that the experiment was over when the soil would not improve beyond that point. It had reached a new plateau but was now operating on a much healthier, more productive level than ever before.

"One of the big lessons we learned is that once you build your soil up, you can rely on that improvement," Snapp said. "A lot of times, when farmers build their soil up, they keep building it up. We found that you don't have to do that. More isn't always better, in this case."

The LFL is embedded in Michigan agriculture, but its results hold importance for farming around the world. Harwood's team published a document that synthesized their initial findings to help growers apply their knowledge in the field. Snapp actually first saw the document while working in Africa years before coming to MSU.

"I thought, if they're doing Extension so well in Michigan, I want to be there and be a part of that," she said. "Harwood took very complicated concepts and made them relevant and understandable to farmers — he synthesized it into a teachable form."

With field trials at the LFL complete, Snapp will synthesize the findings into an updated edition of that document, providing farmers around Michigan and the world with the latest tools to improve soil health. By keeping the focus on farmers' concerns, the long-term research at the LFL stands to have an even longer term impact on agriculture.

"We showed that using crop rotation and dairy manure, these very practical things, can make a significant improvement," Snapp said. "A lot of people do cover crop work, but MSU has distinguished itself by drawing practical lessons based on field science."

The research showed that rotating crops and using reasonable levels of fertilizer could bring about beneficial changes in soil composition.

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# STANDING WATCH:

## Protecting Michigan crops from dangerous pathogens

ABOVE: Mary Hausbeck, MSU plant pathologist and Extension specialist, examines flowers inside a greenhouse with her students. She is at the forefront of protecting Michigan vegetables and ornamental plants from a wide range of destructive pathogens. Photo: Kurt Stepnitz, MSU CABS

OPPOSITE: The underside of an impatiens leaf contaminated with downy mildew. Before the treatment protocol developed by Hausbeck's lab, this pathogen threatened to devastate Michigan impatiens production. *Photo: Blair Harlan*

With more than 112,000 acres across nearly 3,000 farms* dedicated to growing vegetables for fresh consumption and processing, Michigan ranks as one of the largest vegetable producers in the nation. It is the top producer of cucumbers for pickling and ranks in the top four for asparagus, squash, carrots, green beans and others. Vegetable production is a $255 million industry that helps feed the people of not only the state but the entire country.

This prosperity does not come without risk. Vegetable growers must contend with an increasing number of bacterial and fungal pathogens that threaten to contaminate their fields and destroy their crops. Michigan State University (MSU) AgBioResearch plant pathologist **Mary Hausbeck** is giving them the tools they need to safeguard the food supply.

"We're dealing with an influx of new pathogens, and it's up to us as field biologists to serve as the frontline defense for agricultural industries," said Hausbeck, a professor in the MSU Department of Plant, Soil and Microbial Sciences and an MSU Extension specialist.

Beginning in 2005, Michigan cucumber growers encountered a new threat — downy mildew, a fungus-like pathogen that causes a damaging blight on the vegetable foliage. The mildew cannot withstand the bitter cold of a Michigan winter, but is thought to be brought into the state from warmer southern regions such as Florida and Mexico. It can also overwinter in the climate-controlled environment of a greenhouse.

"In the grand scheme of things, it's a relatively new problem, but it's one we have to manage consistently every year," Hausbeck said. "We have to stay on top of it."

The management challenge recently intensified as Hausbeck's team observed that the mildew had developed resistance to several key fungicides used to control it. Her team is developing a management program that does not use many of the treatments previously relied upon.

"We've gained a better understanding of the pathogen itself, and we've developed early alert and control systems for growers that have worked quite well," Hausbeck said. "We're coming into 2015 with new challenges, but we're devoting a lot of our attention to solving them."

Confronting new challenges is nothing new for Hausbeck and her team. In 2010, a fungal leaf spot, called anthracnose, that had not been reported anywhere else on the planet, was detected in Michigan onion plants. Hausbeck's team developed a management program for the pathogen, and now anthracnose is no longer considered a serious threat.

"We feel we have things handled there," Hausbeck said.

Hausbeck's team is currently tackling another issue: leaf blight in onions, caused by the bacterium *Pantoea agglomerans*. It afflicted an estimated 35 percent of Michigan onions last year. First detected in 2011, this new pathogen is the target of intensive study by the scientists in Hausbeck's lab.

"A lot of our effort has been in surveying the Michigan onion industry to get a better understanding of this disease," Hausbeck said. "Once we understand it, we can develop mitigation strategies to protect our crops."

The mission of protecting crops does not stop once strategies are in place. About 15 years ago, Hausbeck developed and implemented a highly successful forecasting system to help growers manage foliar diseases in asparagus. This system assesses disease risk by using weather equipment to measure the amount of time that the asparagus leaves are wet and combines that information with the average temperature for that time period. Once the risk exceeds a certain threshold, the system triggers a fungicide spray. The result provides optimal disease protection while minimizing spray amounts. Hausbeck and her team are working to update the system to take into account the latest advancements such as new treatments and cultivars.

"Part of what we do is to make sure growers have the latest cutting-edge tools, and keeping these systems up-to-date is part of that," Hausbeck said. "It's a great example of an industry that has been really good about adopting new technologies."

Hausbeck has also been instrumental in revitalizing Michigan's impatiens industry from downy mildew (different from the mildew afflicting cucumbers). This new pathogen was capable of surviving through the winter in gardens, contaminating the soil and preventing impatiens from producing full flowers.

In response, Hausbeck, with support from industry leaders and Project GREEEN, developed a treatment protocol that could be applied in the greenhouse and protected the plants from the pathogen even after they were planted in consumer gardens. Applying a combination of fungicides during its early growth stages keeps the plant protected for nearly the entire season.

"This type of work is a crucial role filled by MSU as a land-grant university," Hausbeck said. "Without this aspect of the university, plant diseases could take a heavy toll on the state's economy."

**2012 Census of Agriculture*

"In the grand scheme of things, it's a relatively new problem, but it's one we have to manage consistently every year. We have to stay on top of it."

— Mary Hausbeck

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# DUAL-PURPOSE EMPHASIS:

## Program showcases advantages of farm animal research

RIGHT: Jim Ireland, MSU professor of animal science with a joint appointment in the Department of Physiology, focuses on understanding ovarian function to improve fertility in cattle, which may have applications for assisted reproductive technologies in women. He also works with various scientists, administrators at the USDA and NIH, and policymakers to enhance federal funding for farm animals as dual-purpose models for research in agriculture and biomedicine. *Photo: Natasha Berryman, MSU ABR*

In 2013, about one-third of the U.S. Department of Agriculture's (USDA) $155 billion budget was available for basic research in animal agriculture — an industry sector that contributes about half of the total U.S. agricultural receipts. Michigan State University (MSU) AgBioResearch animal scientist **Jim Ireland** believes that farm animals are an underutilized resource for basic research that could have applications to human health, in addition to animal agriculture.

"When I came to MSU in 1977, federal funding success for animal research was about 30 percent, or three out of every 10 grants submitted," said Ireland, MSU professor of animal science with a joint appointment in the Department of Physiology. "Now about five or six grants out of 100 proposals receive federal funding."

Some of the research areas that could be advanced by using farm animals as biomedical models:

- Obesity
- Diabetes
- Ovarian cancer
- Infectious diseases
- Nutrition
- Food safety
- Genomics
- Reproductive health

Ireland said he and his colleagues are thankful for the cooperation of NIH and USDA in helping make advancements in their dual-purpose project.



SECURE FOOD AND FIBER SYSTEMS

The reason, Ireland said, is that the high national debt makes it difficult for Congress to increase funding to support basic research. Ireland also points out that mice have become the predominant model for research, especially in projects sponsored by the National Institutes of Health (NIH).

"Mice are cheap, small and easy to use," Ireland explained. "What you learn in the mouse is good for basic research to test new ideas and concepts, but mice are so different from farm animals and humans that many times the results of the research do not apply."

He believes that farm animals make the best biomedical models because of their similarity in size, physiology, immune system and genetic makeup to humans.

About 10 years ago, Ireland and fellow MSU professors and MSU AgBioResearch animal scientists **George Smith** and **Jose Cibelli**, along with colleagues from other institutions, began trying to raise interest in increasing farm animal research funding. They worked with USDA and NIH representatives to organize workshops showcasing the advantages of farm animals as research models with benefits for both agriculture and biomedicine. One workshop led to the selection of several research focus areas that benefit agriculture and biomedicine.

"The agencies [USDA and NIH] recognize the importance of this dual-purpose, dual-benefit idea, and they have been funding four or five investigators since 2011. It's a small program, but 17 grants have been funded that would never have been funded before," Ireland said.

A project on cattle reproduction by Smith, acting associate director of MSU AgBioResearch, is the only MSU study to date to receive funding through this dual-purpose program.

In June 2014, Ireland made a presentation on the benefits of farm animals as dual-purpose research models at a National Coalition for Food and Agriculture Research seminar in Washington, D.C., where he met with Congressional staff members and other governmental agency representatives. He continues to work to promote the benefits of the dual-purpose research models that are supported by both NIH and USDA, and how they can produce results that solve complex problems.

Ultimately, Ireland hopes Congress will increase funding for farm animal research using dual-purpose models that explore infectious diseases, stem cells, reproduction and obesity. He believes the necessity for this type of research is becoming more crucial because of factors including new farming regulations, foreign competition, higher energy costs and increasing populations.

"These factors place a premium on all of animal agriculture to eliminate inefficiencies and get better weight gains, better health, better animal feeds and higher reproductive performance," Ireland said.

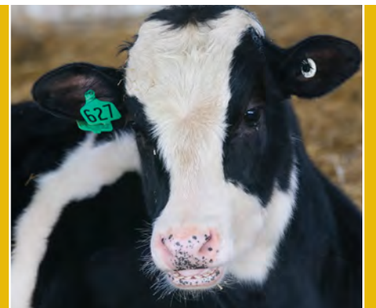
He believes farm animal research can be especially beneficial in learning what happens to women when they are pregnant and potential impacts on the health of their children.

"Whatever the mother, be it animal or human, is eating or whatever the mom is exposed to can have dramatic effects on the health of the offspring," Ireland explained. "Learning about this through farm animal research will change not only agriculture but human medicine as well."

Ireland said he and his colleagues are thankful for the cooperation of NIH and USDA in helping make advancements in the dual-purpose project. He is also appreciative of the scientists who took time to discuss their research with Congress, which ultimately will decide on funding.

"The politicians have to solve this problem," Ireland said. "They have to say that this dual-purpose program is a good idea and work on ways to fund it. I believe it is a unique way to bring human, veterinary and animal sciences together, and that it will help spawn interdisciplinary collaborations to resolve complex health problems in both humans and farm animals."

For more information on the advantages of domestic species as dual-purpose models, visit **adsbm.msu.edu**.

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# THE NEXT PHASE:

## Commercialization of biosensor technology

ABOVE: Michigan State University chemical engineering and materials science professor R. Mark Worden is using his expertise in oxidation-reduction reactions to accelerate commercialization of a versatile biosensor technology.

OPPOSITE: The researcher is looking to adapt his patented biosensor technology so it can be used in portable, low-cost, hand-held sensors similar to the personal glucose meters in this photograph used by diabetics to monitor blood glucose levels. *Photos: Courtesy MSU College of Engineering*

Millions of Americans with diabetes use a variety of meters to check their blood glucose levels and manage the disease. This concept is spurring Michigan State University (MSU) AgBioResearch scientist **R. Mark Worden** to commercialize a biosensor system that would have widespread applications in other venues, such as food processing facilities or clinical laboratories that assess high volume samples from many sources.

Worden, a professor in the MSU Department of Chemical Engineering and Materials Science (CHEMS), began working in oxidation-reduction reactions, also known as redox, in the late 1990s. These chemical reactions are important in a number of areas, including biofuel production. As the research progressed, Worden developed expertise in nanotechnology and biocatalysts, which are often used to perform chemical transformations on organic compounds.

Over the years, various stages of this project received funding from the National Science Foundation (NSF) and other organizations. In looking at various aspects of these reactions and trying to exploit their economic benefits, Worden developed a biosensor system that was recently patented by MSU.

Now Worden is collaborating on a new NSF project with **Paul Satoh**, MSU adjunct professor in engineering and food science and former vice president of research at Neogen, a Lansing-based company that develops and markets products dedicated to food and animal safety.

"This is a grant called 'Accelerating Innovation Research,' or AIR. It is not a grant for fundamental research but rather a grant to take previous NSF discoveries and move them toward commercial applications," Worden explained.

The new project is based on the same principle of conducting chemical reactions on electrodes that was used in past experiments. However, it focuses on translating research on nano-scale bioelectronics to fill the need for cost-effective biosensor systems that quickly, sensitively and accurately measure concentrations of important compounds.

"The amplified bioelectronics concept of the patented biosensor platform that we developed is important because it offers an unprecedented combination of performance properties, versatility and customizability," he said.

Worden points out that varying the architecture and recognition molecules in the sensing interface could lead to development of a broad range of commercially important biosensor systems. Applications include screening for therapeutic agents, measuring toxins and pathogens in food and environmental samples, point-of-care testing of biological samples and real-time on-site detection of chemical warfare agents.

Worden and Satoh hope to develop prototypes of three commercial biosensor systems: portable point-of-care meters, electrochemical multiwell plates and flow-injection analyzers.

"One of the features of the patented bioelectronics sensor platform that we have developed is a technique to amplify the signal and so increase sensitivity, which is an asset for customers using the finished product," Worden explained.

The patented biosensor was designed to measure an enzyme in humans that is affected by nerve gases. Worden is now striving to make it applicable to a wider range of enzymes and extending it to antibodies, which are used in detecting diseases and toxins and microorganisms in food.

Worden points out that linking the biosensor system to antibodies, proteins produced by the body in response to harmful substances, is useful in food safety applications. Other features of the patented bioelectronics sensor platform include multiple types of biological recognition molecules, compatibility with other commercial biosensor systems and disposable sensing units. These features make the new systems more user-friendly, convenient and cost-effective than competing technologies, he said.

"We are trying to develop electrochemical sensors that companies such as Neogen, which commercializes a variety of food safety test kits, might be interested in," Worden said.

Conductive Technologies, Inc. will lend technical expertise to the project, and MSU Technologies, the intellectual property unit of MSU, will help guide commercialization. CHEMS students will also be involved and will get innovation and technology-translation experience by participating in all aspects of the research. In addition, students from multiple engineering departments enrolled in the Multidisciplinary Bioprocessing Laboratory course that Worden developed with NSF funds will learn how to work effectively in multidisciplinary research teams.

Worden believes, however, that teaming up with Satoh is the key to success.

"Paul is a big asset for this project because he has worked in industry for many years and has expertise in commercial biosensor development, so he understands the business side of sensor technology," Worden said. "We believe that combination — my scientific expertise and his business knowledge — will make it possible to move to commercialization of the patented biosensor system."

These features make the new systems more user-friendly, convenient and cost-effective than competing technologies...

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# SPEEDING UP THE CLOCK:

## Accelerating fruit breeding through genetic technology

ABOVE: MSU AgBioResearch horticulturist Amy Iezzoni's extensive experience with plant breeding and the *Rosaceae* family made her a natural candidate to help lead RosBREED,a project to help breeders incorporate the latest genetic knowledge and tools on a family of flowering plants including apples and tart cherries.

OPPOSITE: Tart cherry samples at MSU's Clarksville Research Station. RosBREED's findings will help breeders produce new varieties of these and other fruits in the *Rosaceae* family. *Photos: Natasha Berryman, MSU ABR*

When shopping for fruit — whether at a supermarket, corner grocery store or farmers' market — consumers look for specific characteristics such as rich color and full shape. Producing varieties that display these hallmarks of healthy fruit is a slow process, however, often spanning decades. Breeding a new apple or cherry variety, for example, can take 15 to 25 years.

Michigan State University (MSU) plant geneticist **Amy Iezzoni** is working to speed up that clock by helping breeders take advantage of the wealth of fruit genetic knowledge that has emerged, particularly in the past decade. Her work has accelerated various fruit breeding programs across the country and allowed even the most stubborn traits to be improved.

In 2009, through a $7.2 million grant from the U.S. Department of Agriculture (USDA) National Institute of Food and Agriculture Specialty Crops Research Initiative (SCRI), Iezzoni began the RosBREED project to help breeders incorporate the latest genetic knowledge and tools on *Rosaceae*, a family of flowering plants including apples, peaches, sweet and tart cherries, raspberries, plums, pears and strawberries. Today, the project, led by Iezzoni and Washington State University plant geneticist Cameron Peace, has been refunded through SCRI for $10 million. A team of 35 scientists, including fellow MSU AgBioResearch scientists **James Hancock** and **William Shane**, from 14 universities and USDA agencies, along with international collaborators, are continuing their efforts to help fruit breeders produce the best and most competitive products possible.

"When we began our project, the genome sequences of peaches and diploid strawberries were becoming available, but no genetic knowledge was being used in breeding," said the MSU Department of Horticulture professor. "We had a huge chasm between what was known genetically and what was being used in application."

The team learned that they could frequently apply knowledge of a genetic factor in one fruit to the others with little adjustment because the fruits share common ancestry. For example, the genetic factor that controls the expression of red pigment is identical for apples, cherries and peaches.

"We, as researchers, decided to work together as a crop group because the fruits all belong to the same family," Iezzoni said. "We all had the same needs, and we could leverage that."

Under Iezzoni's direction, the RosBREED team developed genome scans that allow researchers to mark the most important genes in each crop. Through statistical analysis, they are then able to identify the variation in these major genes and uncover the alleles — the different possible expressions of a gene in an organism — that yield the most desirable characteristics, all before the production of any fruit.

Before the application of genetic technology made possible through RosBREED, fruit breeders were often limited to observing phenotypes — a fruit's physical characteristics — to make their breeding decisions. Though this worked, the process was time-consuming and inefficient because breeders had to wait for a plant to bear fruit to determine its effectiveness. Thanks to the technology pioneered by RosBREED scientists, however, breeders are able to know what kind of fruit a plant will produce before it even flowers.

"For example, when you see sweet cherries in the supermarket, some are black and others are yellow," Iezzoni explained. "If you want to release only black ones, you would cross two black sweet cherry plants. At harvest, however, a fourth of their cherries could have turned out yellow, and the producer would have wasted five years producing 25 percent extra cherries. With our genetic tests, we eliminate that risk for the grower."

Iezzoni's work was instrumental in releasing the popular Honeycrisp apple variety. Though it had appealing flavor, initially the fruits came in both red and green. Because the market at the time was not favorable to another green apple, RosBREED scientists were able to help producers breed the variety with a more marketable red skin.

"We wouldn't have known how that worked before, and even if we did, we wouldn't have been able to determine which plants would bear the undesirable phenotype before they fruited," Iezzoni said.

The work has allowed producers to create new varieties more quickly and less expensively than ever before, but the work is not finished. In the next phase, the researchers plan to tackle even bigger issues facing *Rosaceae*.

The RosBREED team will target significant fruit diseases such as fire blight, apple scab, powdery mildew, cherry leaf spot, bacterial spot, brown rot, *Armillaria* and blue mold, which together have caused producers to lose hundreds of thousands of trees and plants, as well as tons of fruit. By applying the genetic tools and knowledge developed over the past five years, the team will be able to reduce the crops' vulnerability and keep producers' livelihoods and the nation's food system more secure.

"There are virtually no apple, peach or cherry cultivars that are resistant to major diseases because breeding for these traits has been very slow," Iezzoni said. "Many times, we get disease resistance from cross-breeding with the plants' wild relatives. But those bear small fruit, and it takes a long time to get them back to a desirable size. Now that we have a better understanding, we should be able to speed up disease resistance breeding considerably."

The work has allowed producers to create new varieties of fruit more quickly and less expensively than ever before, but their work is not finished.

# BETTER WITH TIME:

## Improving wine grape production with innovative viticulture techniques

As the fourth largest grape-producing state in the United States, Michigan is home to more than 15,000 acres of vineyards that fuel a $790 million industry. The Michigan Grape and Wine Industry Council explains that a tremendous growth in sales and production of Michigan wineries has created demand for high-quality, Michigan-grown grapes that is challenging to meet. Growers must overcome cold winters and cool, wet summers, which take a severe toll on vines and encourage diseases that detract from producing the perfect bottle of wine.

**Paolo Sabbatini**, Michigan State University (MSU) associate professor of horticulture, is tackling this problem by developing viticulture techniques that alter grape cluster microclimates, thwart disease and improve fruit quality.

"At this time in history, there is a surplus of wine production," Sabbatini explained. "A new grape-growing region emerges in

RIGHT: Paolo Sabbatini, MSU professor of horticulture, examines the effects of winter weather on grapevines in northern Michigan. Michigan's harsh winters and short, wet, cool summers pose problems for the state's grape growers, but Sabbatini is committed to helping them overcome these barriers and find a place in the U.S. wine market.

OPPOSITE: Tight clusters of grapes hang on a vine at the MSU viticulture garden in East Lansing. *Photos: Kurt Stepnitz, MSU CABS*

Michigan grape growers and winemakers are under pressure to produce wines of the highest quality.





the world every year — every state in the United States now grows grapes and produces wine. No one saw that coming 20 years ago. As a result, people are looking for the best wines, and the market is responding by providing very competitive prices."

In short, Michigan grape growers and winemakers are under pressure to produce wines of the highest quality. Doing so enables them to earn an opportunity to compete in the larger U.S. market and, in the future, the global market.

Wine grapes thrive in temperate climates that boast warm, dry summers and mild winters. By way of photosynthesis, grapevines use the summer heat and sun to produce sugar and acid, develop color and accumulate heat for physiological ripening, which includes the development of color, skin and pulp texture, seed color and texture, tannins and other important flavor compounds.

Though the climate is considered temperate compared with those of other states in the Great Lakes region, Michigan's summers are often shorter and cooler than those in other similar regions of the world. This results in fewer opportunities for grapes to take advantage of the sun and warm, dry days. Each year, Michigan grape growers work in earnest to overcome this disadvantage, and with the help of Sabbatini and others, have done so successfully.

Sabbatini is helping them overcome a third climate-related struggle: preharvest rain.

"September and October mark the nearing of harvest time; growers have worked diligently to get and keep grapes on the vines so that they can develop the varietal characteristics needed to make great Rieslings, Pinot Noirs, Chardonnays and other wines," he said. "But it's very humid and wet in Michigan during these months — perfect conditions for fungi to cause cluster rot. This disease can completely destroy grape clusters in a matter of days or make potentially high-quality grapes an unmarketable product."

Sabbatini explained that growers currently have two options when seasonal rains come prior to harvest: leave the grapes on the vine and risk rot and rain damage, or pick them early and sacrifice quality and critical flavor compounds.

"Growers need a third option," he said. "Grape clusters are susceptible to rot at that point in the season because the grape varieties grown in Michigan have compact clusters with the berries touching one another. When it rains, water is trapped between the fruit and they're wet for many hours. Fungus then moves in and destroys the grape cuticles, resulting in rot."

The research question then becomes "How do we keep grape clusters on the vines during the wet, rainy period at the end of the season without losing them to rot?" His answer is to alter the cluster's microclimate by lowering cluster density.

Sabbatini reasoned that if he could reduce the number of flowers in a cluster, he could reduce the number of berries that would develop. This should work because the number of flowers a grapevine produces directly correlates to the number of berries a grape cluster will contain.

With the support of Project GREEEN, Sabbatini developed a vineyard management technique that involves removing the leaves around flower clusters at bloom time. Doing so temporarily eliminates the flowers' source of photosynthesis. The result is that the vines produce fewer flowers per cluster and, subsequently, less dense grape clusters.

"This works — not only does it give you less cluster rot, but it allows every berry in the cluster to be exposed to the sun," Sabbatini said. "Normally, the berries on the inside of the clusters don't get a lot of sun or heat, but now they can, which means that the fruit quality also improves. Our research shows that there was also less humidity and more heat in the clusters' microclimates."

To address concerns about possible decreased yields, Sabbatini plans to test various pruning techniques this winter with the goal of leaving more buds in the spring.

"If we're reducing the number of berries per cluster, then we need to increase the number of clusters per vine so that growers don't lose profits," he concluded. "Growers are hopeful about this approach — and I am, too. We have to get around the issue of cluster rot, and we have to improve fruit quality because there's nothing magical you can do. If the quality of the grapes is low, the quality of the wine will also be low.

"In comparison with much of the world, we are a very young region of wine producers, but we're overcoming problems every year, and we're giving consumers what they want — Michigan wine made from Michigan grapes."

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# REDESIGNING GENETIC TECHNOLOGY:

## Efforts aim to cut costs, improve accessibility

ABOVE: Juan Steibel, MSU associate professor of animal science, began studying SNP chip technology in 2008 when he attended a seminar on using it to study human populations. He soon realized its potential for pig breeding and has been working to make it applicable and cost-effective for breeders ever since.

OPPOSITE: The data yielded by the SNP chip allows breeders to better pair pigs for mating, producing better, stronger offspring in much less time. *Photos: Kurt Stepnitz, MSU CABS*

Worldwide, pork is the most widely consumed meat; in the United States, it ranks as the third most popular.* In Michigan alone, the pork industry is worth over $362 million, according to the 2012 U.S. Census of Agriculture. Throughout a 300-year history in North America, pork producers have continually worked to improve their ability to meet this high global demand through improved feeding, housing, health and conventional breeding methods.

First domesticated more than 10,000 years ago, pigs are receiving a breeding kick start thanks in part to research to develop low-cost tools to analyze the animals' genomes. New technology pioneered by Michigan State University (MSU) AgBioResearch geneticists **Juan Steibel, Ron Bates** and **Cathy Ernst** will allow breeders to better understand the genetics of their animals and increase the efficiency of their breeding programs.

For the past six years, Steibel — an associate professor in the MSU departments of Animal Science and Fisheries and Wildlife — and his collaborators have been developing a cost-effective tool to analyze specific elements, called single-nucleotide polymorphisms (SNPs), within a pig's genetic code. They insert a sample of genetic material, such as blood or hair, into the device, called a SNP chip. Probes then target each SNP with fluorescence technology. The probes glow different colors, denoting which SNPs are present, so the user can fully characterize an individual pig's entire genotype.

"It works a lot like something you'd see on a crime scene investigation [television] show," Steibel explained. "You have to be extremely careful with the sample to ensure DNA quality."

Applying the SNP chip to an entire population of pigs, such as a farm herd, enables breeders to predict the genetic value — the number of desirable traits — of the pigs and dramatically increase breeding efficiency.

"The SNP chip makes it much cheaper and easier for breeders and producers to do a genome analysis of their pigs," Steibel said. "They will be able to breed better, more productive pigs, and do it faster."

Most mammalian genomes contain between 5 million and 10 million SNPs. Many of them are redundant, however, carrying practically the same genetic information. This means that SNP chips need to target only a relative handful of SNPs to acquire the same level of information. The trick is finding the right ones.

Most SNP chips are high-density, meaning they target more than 50,000 SNPs to produce the full pig genome. Though effective, these devices are often too expensive for breeders to apply to large numbers of animals. This limits the size of the dataset and, therefore, its usefulness in creating a breeding strategy. Steibel hopes to change that by refining the technology and producing a low-density SNP chip that can yield the same quality of information at a significantly reduced cost.

"With the high-density chips, you can do a genotype for an individual pig, but for that to be useful on a commercial scale, it has to be done for thousands," Steibel said. "Using a low-density chip, we could more than double the number of pigs genotyped. The catch is to design a low-density chip that has minimal loss of information."

After years of extensive testing, Steibel's team discovered a series of 10,000 SNPs that predict the remaining 40,000.

"It was a simple concept but one that was computationally very demanding," Steibel explained. "Imagine a set of 50,000 SNPs, each one a two-letter combination, and applied to 10,000 pigs. You end up with a big matrix of data that we have to analyze and try to make sense of, looking for patterns of inheritance. We had to do this thousands of times to find which were the best SNPs to keep as predictors of the rest."

Making this technology widely available will improve the ability of American pork producers to take advantage of the latest developments in genomic breeding. By using the SNP chip to select the most promising young animals, industry producers will be able to accelerate the genetic progress of their herds and produce better quality animals in much less time.

"We'll start to see this in the next four or five years," Steibel said. "In the longer term, I think it will open the door to work on genetic traits that are currently difficult to improve, such as disease resistance and behavior."

The next phase of Steibel's work involves using the chip to predict the genetic value of pigs to be used in breeding by the National Swine Registry.

"The National Swine Registry doesn't produce the pigs we eat, but they produce some of the parents of the pigs we eat," Steibel said. "It's of the greatest importance to find quality animals there because their characteristics will be inherited by their progeny and, ultimately, affect what we eat down the line."

**Source: U.S. Department of Agriculture.*

The next phase of Steibel's work involves using the chip to predict the genetic value of pigs to be used in breeding by the National Swine Registry.

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# THE CHILD'S BEST INTEREST:

## Monitoring the presence of abuse in child custody exchanges


ABOVE: April Zeoli (left), MSU assistant professor of criminal justice, Cris M. Sullivan (right), MSU professor of ecological and community psychology, and Echo Rivera (not pictured), who recently earned a MSU doctorate in community psychology, investigated the strategies the courts and survivors of intimate partner abuse employ to thwart abuse during child custody exchanges. *Photo: Natasha Berryman, MSU ABR*

OPPOSITE: The American Psychological Association estimates that 3.3 million children witness violence against their mothers or female caregivers each year. *Photo: iStock.*

The Centers for Disease Control and Prevention (CDC) describes violence against women as a substantial public health problem in the United States. According to CDC data, nearly 5.3 million acts of violence occur against U.S. women 18 and older each year, resulting in approximately 2 million injuries and nearly 1,300 deaths. In most cases, these victims are harmed by an intimate partner.

Women in these situations are encouraged to separate from and have no contact with their abusers. This strategy, however, can be very difficult to follow, particularly when the victim and the abuser have children together. Victims who leave abusive partners are often forced, through child custody orders, to continue interactions with their former partners — and subsequently, face the possibility of further abuse.

Zeoli and her colleagues will focus on sharing their research findings and informing policy changes that prompt the assessment of court protocols.





**April M. Zeoli,** Michigan State University (MSU) assistant professor of criminal justice, has been examining child custody exchanges in which violence has occurred.

Intimate partner violence (IPV) is a pattern of behaviors used by one partner to control the other. Often, these behaviors include stalking, physical or sexual assault, and psychological or financial abuse. It occurs among current and former partners, heterosexual and same-sex partners, and people in all walks of life. Though both men and women are victims, research indicates that women make up the vast majority and sustain disproportionately more injuries and deaths than men.

Zeoli, along with co-investigators **Cris M. Sullivan**, MSU professor of ecological and community psychology, and **Echo Rivera**, who recently received her doctorate in community psychology from MSU, wanted to determine the strategies that victims and the courts have deployed to protect against abuse during child custody exchanges.

"It's important to know how courts are addressing domestic violence in child custody cases because it allows us to assess whether the interventions work to reduce violence," Zeoli explained. "From there, we can make informed policy recommendations. The goal is to identify practices that will keep victims and their children safe. Children are often also abused in these circumstances."

As part of a study, Zeoli and her colleagues recruited 40 mothers who self-identified as victims of domestic violence and intended to request a child custody order from family court. With support from the National Institute of Child Health and Human Development and the National Institute of Mental Health, Zeoli and her research team followed the progression of these court cases for 12 months, interviewing the women every four months.

"When we met, we talked in depth about their child custody cases and their interactions with their children's fathers," she said. "Specifically, we wanted to know if they experienced physical, financial or emotional abuse or stalking; we inquired about their mental health and well-being.

"We asked about their court progress and whether they had made any formal allegations in court against their partners, or if their partners had made any allegations against them. We also looked at the custody outcomes, including whether fathers exercised their court-granted rights to have contact with their children, and if that contact provided opportunities for abuse."

Zeoli found that the majority of mothers reported emotional and/or physical abuse during child exchanges, regardless of whether they were conducted in public or supervised by a non-professional (usually a family member of the father). During unsupervised exchanges, mothers described numerous acts of mistreatment that occurred, from destruction of property to threats and physical abuse. In the 29 unsupervised exchanges, seven women were physically injured and eight were threatened with death.

"When exchanges were unsupervised, mothers experienced the most abuse," Zeoli said. "We recorded instances of abuse in all of the domains we monitored: emotional abuse, physical abuse, physical abuse with injuries, stalking, threats of violence to the mother, death threats to the mother, and threats to others, including the children. It is important to note, however, that most of these types of abuse also occurred when exchanges were held in public and when members of the fathers' families supervised the exchanges.

"By virtue of being present, children witness abuse that occurs during these exchanges, and this can have harmful health consequences for them," she added. "Reducing children's exposure to violence can help them heal. However, when violence continues, even as their mothers try to gain safety, their attempts to heal are thwarted."

Zeoli said her findings suggest that child exchanges should have intervention when there's a history of domestic violence between parents. She recommends professional supervision by a professional third party or an exchange that removes the opportunity for contact between the parents altogether.

Next, Zeoli and her colleagues will focus on sharing their research findings and informing policy changes that prompt the assessment of court protocols.

"The family courts are very open to improving their processes. Not because they have bad processes, but because they're aware of the realities of domestic violence and the havoc it wreaks on families," Zeoli concluded. "They are committed to making improvements that protect the best interest and welfare of children, as well as survivors of abuse."

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# BITE BACK:

## Understanding West Nile virus in urban populations

Of the major events of 2014, not many earned the media coverage that the Ebola outbreak in Guinea, Sierra Leone and Liberia sparked. While many media outlets gave much attention to following the virus' movement throughout the world, the Centers for Disease Control and Prevention quietly reported on other infectious diseases also affecting people around the world. Polio, avian influenza, Middle East respiratory syndrome coronavirus, Chikungunya and enteroviruses caused thousands to become ill.

These infectious diseases, and several others, challenged health infrastructures, chipped away at public health budgets and claimed lives all over the world.

RIGHT: Ned Walker, MSU professor of entomology and microbiology and molecular genetics, in his laboratory, where he studies insect-vector disease, the ecology and epidemiology of vector-borne diseases and the means to control them. *Photo: Kurt Stepnitz, MSU CABS*

OPPOSITE: *Culex pipens*, the northern house mosquito, acts as the epidemic bridge between birds that carry West Nile virus and humans. *Photo: Courtesy of Ned Walker*



FAMILIES AND COMMUNITY VITALITY

**Edward "Ned" Walker,** Michigan State University (MSU) professor of microbiology and molecular genetics, is examining how emerging infections behave in time and space. He will use this information to further basic biology and to develop predictive models that guide community and public health responses to emerging diseases.

"Humanity seems to be facing a constant march of emerging infections," Walker said. "Some of these diseases arrive so quickly, and many of them create social issues in addition to health challenges. When these emerging infections arrive, my colleagues and I want to know where they set up, what will be high-risk years, and if it's possible to predict how they will behave."

Walker selected West Nile virus (WNV) to study. This virus, which is part of the *Flaviviridae* family, appeared in New York City in 1999 and very rapidly spread across the continental United States, reaching the West Coast by 2004. Even though it's not discussed in the media as often as it once was, Walker said that the disease still causes serious epidemics in the United States.

WNV is transmitted from birds to mosquitoes, which in turn pass the disease on to humans. Symptoms include fever, headache, body aches, skin rash and swollen lymph glands. Severe side effects can include stiff neck, sleepiness, disorientation, coma, tremors, convulsions and paralysis.

"This is a nasty virus, and it's costly to treat," Walker said. "Many people don't recover, but those who do often experience many long-term health problems. Unfortunately, the virus is doing well in eastern, urban portions of the United States."

Walker's research — which involves collaborators from MSU, the University of Illinois and the University of Wisconsin, and is supported by the National Science Foundation — focused on the metropolitan Chicago area as the primary study site and metropolitan Detroit as the secondary site.

The group first observed that WNV was only in certain locations — it was not widespread across metropolitan areas. They gathered data on the number and location of confirmed human cases of WNV and found that those locations correlated with areas where mosquito infections were also the highest. The group then categorized the urban landscapes by demography, density of houses and types of buildings.

When Walker combined all of this information, he could further delineate where, how and why the virus set up among human populations.

"The highest areas for human infection are what we call post-World War II neighborhoods," he explained. "The risk isn't as high in the inner city, and it's not as high in the newer suburbs — it's highest in those neighborhoods that fall right in between. In the Detroit area, this would be communities such as Dearborn Heights, Southfield, Westland, Livonia and Allen Park."

These communities share a set of common characteristics that encourage mosquito infestations: closely spaced houses on flat plains, lots of structures that encourage bird roosting (ranging from trees to bird feeders) and drainage catch basins along city streets.

"These WNV-carrying mosquitoes are the result of human activity," Walker noted. "One of their major larval habitats is street catch basins, put along residential streets to collect stormwater. At the bottom of these grates are sumps that gather the material that would normally clog pipes. Water and organic material accumulate in this space and make wonderful mosquito nurseries."

Another important observation was that the increases in mosquito infection rates correlate with increases in temperature and precipitation events.

Walker's team examined data across eight years and found that they could produce predictive models that take into account these two weather factors. They used degree-week as a simple measure of temperature; it accounts for the accumulation of heat above a specific base temperature on a weekly basis. This highlighted a pattern: the risk of contracting WNV was higher during years when the summers were warmer and drier.

"We're hopeful that our findings will guide public health decisions," Walker concluded. "They should guide messages from the media and help citizens understand the risks of disease during a given year. It should also provide a model for other diseases, either conceptually or as a model for approaching an emerging infection. So often we are reactionary when it comes to a disease outbreak. I hope this research, and more like it, will help us to become more anticipatory in the future."

"This is a nasty virus, and it's costly to treat. Many people don't recover, but those who do often experience many long-term health problems."

— Ned Walker

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# WHERE HAVE ALL THE FISH GONE?

## Studying walleye population changes in Michigan's inland waterways

ABOVE: Daniel Hayes, professor in the MSU Department of Fisheries and Wildlife, has lead a study of walleye population dynamics on the Inland Waterway in conjunction with the Michigan Department of Natural Resources (MDNR). *Photo: Kurt Stepnitz, MSU CABS*

OPPOSITE: MDNR scientists Emmett Sweeney (left) and Daniel Quinn examine a walleye before tagging it near the Cheboygan River in northern Lower Michigan. Tagging allows researchers to know where and when a fish was originally found, which gives them data on how far it has traveled when compared to where it was caught. *Photo: Courtesy of Seth Herbst*

Valued for their large size and excellent flavor, walleye rank as one of the most popular species of fish in Michigan. Measuring 15 to 24 inches and weighing 2 to 4 pounds, adults are also considered an important predator in the state's freshwater ecosystem.

In 2009, the Michigan Department of Natural Resources (MDNR) discovered that walleye in the Inland Waterway — a 45-mile long network of four lakes and multiple rivers spanning private, public and Native American tribal land in Cheboygan County — had greatly diminished since they were last surveyed in 1998. Returning the walleye population to a more sustainable level has become a priority because of their importance to commercial, sport and tribal fishing in the area. Now, through the efforts of Michigan State University (MSU) AgBioResearch fisheries scientist **Daniel Hayes** and his team, the MDNR and tribal fisheries managers are making more informed decisions to help the fish recover.

"Walleye are large, very mobile predators that often travel between aquatic environments," said Hayes, a professor in the MSU Department of Fisheries and Wildlife. "It's important, both as ecologists and fishery managers, to know where fish originate and where they travel. That tells us where they're living, getting their food and reproducing, as well as the threats that they face."

Learning about the movements of the fish was the first priority for Hayes and his team. Beginning in 2010, a succession of MSU graduate students worked alongside MDNR and tribal biologists to catch walleye in their spring spawning grounds. Each fish then had a metal tag inserted into its jaw that had a unique identifier code, along with information on where and when it was collected.

When local anglers and tribal fishermen caught the fish, they would turn the tags in to the MDNR. By looking at the distance between where a fish was caught and where it was tagged, researchers were able to determine the path and the environments the fish had passed through. Though most walleye are born in the rivers that feed the Inland Waterway, Hayes and his team found that over 80 percent of adults move into the lakes during the summer and travel widely throughout the entire system.

"Tagging tells us a lot about where fish go and how much they are harvested," Hayes explained. "Say we release 1,000 tagged fish in a season — if we get 500 tags back from fishermen, then we get a pretty solid picture of not only the percentage of the population caught but also of how far the fish travel within the waterway."

On the basis of stomach contents and tissue samples of the fish caught, Hayes and his team found that nutrition levels varied significantly depending on their travels.

"It's based around the idea that 'you are what you eat,'" Hayes said. "Fish feeding in different locations have different isotopes of nitrogen and carbon in their bodies, so what they eat can tell us a lot about where they've been."

No population study is complete, however, without future projections. Focusing on the streams feeding Mullett Lake, where the initial survey was taken, Hayes and his team used fine mesh nets to collect larval walleye from their hatching grounds. By studying environmental conditions such as food availability, Hayes was able to characterize the factors affecting mortality in young walleye.

During infancy, walleye are a far cry from the apex predator they become in adulthood. They measure about an inch in length and feed exclusively on microscopic organisms called zooplankton. Adult walleye lay thousands of eggs, but the vast majority of larvae die from lack of nutrition or fall prey to other aquatic species. Hayes discovered that a shortage of zooplankton in the Inland Waterway, escalated by invasive species such as zebra mussels that compete for the same resources, was limiting the population's growth.

"When you compare a juvenile walleye to an adult, it's almost like looking at two different organisms," Hayes said. "They don't eat the same things. They don't have the same predators. They're vastly different."

The tiny fish grow fast, reaching 1,000 times their original weight in the first year alone.

"That's like a human child growing an inch every day throughout the summer," he said.

Hayes and his students used a statistical technique called Bayesian analysis, a complex mathematical procedure that reduces uncertainty in a statistical model by comparing past and present datasets. The result was a dynamic overview of the factors affecting the growth of the walleye population in the Inland Waterway. With a more complete picture of their fishery in hand, both the MDNR and the tribes are now able to make better decisions about the use of their shared resource.

"This affects how we view the management of the entire system," Hayes said. "How we view fish stocking, harvest limits, the threat posed by invasive species. We have a far better understanding of how the fish live and the struggles they face, and we can more effectively manage them as a result."

Beyond resource management, the findings have helped nearby waterway residents develop a deeper appreciation of the lakes and rivers.

"As we've worked with citizens' groups in the area, we've encountered a number of people who may not be affected directly by the fishery but who still find value in the research," Hayes said. "We're helping them better understand the place they live. That's a social impact that you won't see on a graph or database."

On the basis of stomach contents and tissue samples of the fish caught, Hayes and his team found that nutrition levels varied significantly depending on their travels.

# ON THE DECLINE:

## Studying eastern massasauga rattlesnakes in Michigan

ABOVE: (From right) Henry Campa III, MSU AgBioResearch wildlife ecologist, and researchers Tara Harrison and Robyn Bailey perform an ultrasound on a female eastern massasauga rattlesnake to determine how many young she might be carrying. *Photo: Courtesy of Stephanie Zimmer*

OPPOSITE: An eastern massasauga rattlesnake coiled in its marshy grass home. Loss of habitat to development and innate mistrust of venomous snakes have led to the species being categorized as endangered or threatened in every part of its range except Michigan. *Photo: Courtesy of Ryan Webb*

From the common garter snake slithering through gardens to the elusive fox snake hailing from the pine forests of the Upper Peninsula, Michigan is home to 17 snake species. Only one, however, is venomous — the eastern massasauga rattlesnake. This particular snake is also the only one in Michigan to have a triangle-shaped head and a rattle on the tip of its tail.

Found in multiple isolated pockets throughout the Lower Peninsula and inhabiting a range from southern Ontario to Iowa, the snake occupies an important niche in the ecosystem. It feeds on a steady diet of amphibians, small mammals and other snakes, and in turn is prey for hawks, owls, cranes and some mammals. Those hoping to catch a glimpse of this snake, however, are in for a challenge. In addition to dwelling in damp, grassy wetlands and being characteristically shy by nature, the snake's population has begun to dwindle. As more and more wetlands are developed, the snake's habitat has been significantly reduced.

Although Michigan is now the only state where it is not listed as an endangered or threatened species, the eastern massasauga rattlesnake is fast becoming a rare sight here, too. Numbers in Michigan have fallen by about 33 percent from their historic levels, according to the U.S. Fisheries and Wildlife Service. Michigan State University (MSU) AgBioResearch wildlife ecologist **Henry Campa III** and MSU colleague **Gary Roloff** hope the species can begin its population recovery in Michigan.

"The massasauga is what we call a species of special concern," Campa said. "People are concerned for its population status, and the best way to help conserve it is to learn about it in places, like Michigan, where its numbers are relatively higher."

Campa and Roloff, both faculty members in the MSU Department of Fisheries and Wildlife, want to determine why the snake has been able to survive better in Michigan. Their team spends May through August wading through the marshlands and along the riverbanks of the southwestern Lower Peninsula in search of the elusive reptiles. Upon capture, the snakes are taken to the John Ball Zoo in Grand Rapids, where collaborating veterinarians implant each with a radio transmitter. After a couple days of recovery, the snakes are released back into the wild at their point of capture.

"Once they're back out there, we track them every day," Campa said. "By radio-telemetering the rattlesnakes, we can evaluate their survival and what habitat conditions they use, as well as develop standardized survey methods. We monitor as many as we can find and telemeter."

The researchers want to get a handle on not only current populations, but future ones as well. They use a portable ultrasound machine in the field to study pregnant females.

"The ultrasounds can not only tell us how many offspring there are but can also register their heartbeats and help us determine how many of them are viable," Campa explained. "Knowing the vital rates of the population is important because that tells us if the population is on track to stay viable over the next 50 years."

Using the radio transmitters, Campa and his team can track the snakes after they've given birth in early August. This helps to confirm the population projections.

Tracking the snakes enables Campa to determine the habitats in which they thrive. In a 2011 study published by Campa and his former graduate student Robyn Bailey, the researchers found that eastern massasauga rattlesnakes had better survivability at the Pierce Cedar Creek Institute, a 661-acre nature preserve near Hastings, than elsewhere in their range. The researchers believe this is due to large areas of open-canopy vegetation that lack significant human infrastructure.

Catching the snakes also affords the team the opportunity to collect valuable blood and tissue samples, which are used to investigate a relatively new threat to the species.

"There's growing interest in snake fungal disease," said Stephanie Shaffer, Campa's graduate student, who is researching the eastern massasauga rattlesnake for her doctoral degree. "It's potentially fatal to snakes, but not a lot is known about it. We're hoping the samples we take this season will help us determine its presence in Michigan."

By studying the snake in places that support larger populations of eastern massasauga rattlesnakes, Campa ultimately hopes to be able to gather knowledge that can be applied to places where the snakes are struggling.

"With respect to understanding the population's vital rates, our methods are applicable to the species' entire range," Shaffer said. "That's potentially very helpful for regions where the species is endangered."

The vitality of the eastern massasauga rattlesnake varies greatly throughout its geographic range. By building a clearer picture of the environment in which the species thrives, Campa and his team are helping researchers identify how to bring the species back from the brink of endangerment.

"There's a huge variability in their survival, depending on factors like habitat, temperature and human presence," Campa said. "We're trying to learn more about how those factors affect the species so we can manage for it as effectively as possible."

The researchers want to get a handle on not only current populations, but future ones as well.

AgBioResearch
agbioresearch.msu.edu

## MSU AgBioResearch CENTERS


For research center locations and contact information, visit **agbioresearch.msu.edu/centers**

## MSU AgBioResearch NEW FACULTY APPOINTMENTS IN 2014

**Jared Ali**, MSU Assistant Professor of Entomology, specializes in the behavior and chemical ecology of interactions between different levels of the food chain.

**Eva Almenar**, MSU Assistant Professor of Packaging, specializes in physicochemical, microbiological and sensorial changes in fresh produce during storage.

**Bruno Basso**, MSU Associate Professor of Geography, specializes in modeling agro-ecosystems and the spatial analysis of crop yield.

**M. Eric Benbow**, MSU Assistant Professor of Entomology, specializes in using ecological theory to explore interactions between entire microbial communities and individual insects and insect populations.

**Chen Chen**, MSU Assistant Professor of Animal Science, specializes in the genes and pathways influencing germ and stem cell self-renewal, differentiation and fertility.

**Joseph Herriges**, MSU Professor of Economics and Agricultural, Food and Resource Economics, specializes in environmental and natural resources economics and applied economics

**Cloé Garnache**, MSU Assistant Professor of Agricultural, Food and Resource Economics, specializes in natural resource economics and management, agri-environmental policies and institutions and bioeconomic modeling and dynamic optimization.

**Cheryl A. Kerfeld**, MSU Hannah Distinguished Professor of Biochemistry and Molecular Biology, specializes in bacterial microcompartments, carbon fixation and cyanobacterial photoprotection mechanisms.

**Wei Liao**, MSU Assistant Professor of Biosystems and Agricultural Engineering, specializes in anaerobic digestion systems, improving sugar and organic acid production in lignocellulosic materials such as straw, corn stover and wood residue.

**Jessica Miesel**, MSU Assistant Professor of Applied Forest Ecology and Management, specializes in fire ecology and management in temperate ecosystems.

**Nathan Moore**, MSU Assistant Professor of Geography, specializes in regional climate modeling, land cover and land use change and integrating models of human and natural systems, food security, remote sensing and water issues.

**Emilio F. Moran**, MSU Hannah Distinguished Professor of Global Change Science, Center for Systems Integration and Sustainability, specializes in social anthropology and studies tropical agriculture, social science, ecology, economics and earth observations from satellites.

**Matt Raven**, MSU Professor of Community Sustainability, Faculty Coordinator at Upper Peninsula Research and Extension Center, specializes in the diffusion and adoption of innovations in agriculture and community food systems and the connection between healthy soils, healthy food, healthy people and healthy communities.

**Diana Stuart**, MSU Assistant Professor of Sociology, specializes in social issues relating to agriculture and the environment.

**Lisa K. Tiemann**, MSU Assistant Professor of Soil Biology in Plant, Soil and Microbial Sciences, specializes in soil ecology and biogeochemistry

**Almudena Veiga-Lopez**, MSU Assistant Professor of Animal Science, member of the Developmental Programming Lab, which specializes in studying the fetal origins of adult reproductive and metabolic disorders

## MSU AgBioResearch 2014 PUBLICATIONS

### *Futures* Magazine

Published twice annually, *Futures* is a free, reader-friendly publication that provides an in-depth look at research that is applying science in practical, real-world ways that boost Michigan's economy, sustain the state's natural resources and enhance people's quality of life.

**SUBSCRIBE FOR FREE at:**
*agbioresearch.msu.edu*

**Spring/Summer 2014**
*Antibiotic Resistance: Seeking solutions in a time of growing concern*

The use of antibiotics is the single most important factor leading to antibiotic resistance around the world. This issue takes a look at some of the research happening at Michigan State University research in the areas of human and animal medicine, as well as plant sciences to help combat this very serious issue.


**Fall/Winter 2014** • *Lake Effect: Research in Michigan reaps great rewards*

In addition to being a sought-after vacation destination, Michigan is a prime locale for research. The state's unique topography is ideal for agricultural production. The lake effect, rolling hills and sandy soils make for some of the finest fruits and vegetables around. This issue highlights some of the Michigan State University AgBioResearch efforts underway in the Great Lakes State.

## Society of Plastics Engineers

Matuana

Michigan State University (MSU) School of Packaging associate professor and AgBioResearch scientist **Laurent Matuana** was elected a fellow of the Society of Plastics Engineers (SPE), the world's premier organization for plastics researchers and industry professionals.

Matuana is internatonally known for his work in blending biobased materials with plastics. His efforts to add value to underutilized wood species yielded an entirely new class of materials — wood-plastic composites — that has become widely used in the construction and automotive industries. His efforts have resulted in materials that are durable, easily fabricated, cost-effective and do not require expensive wood treatments using toxic chemicals. He holds five U.S. patents for wood-plastic composite technologies and has contributed to more than 80 studies on the subject.

The SPE is an international society providing technical information, educational and networking opportunities, and research support to professionals and academics from all areas of the plastics industry.

## MSU William J. Beal Outstanding Faculty Awards

Three Michigan State University (MSU) AgBioResearch faculty members from the College of Agriculture and Natural Resources (CANR) were honored for their outstanding contributions to education and research with the William J. Beal Outstanding Faculty Awards (formerly Distinguished Faculty Awards). They are:

Douches

**David Douches**, Department of Plant, Soil and Microbial Sciences, is the lead scientist of MSU's potato breeding and genetics project, directing a multidisciplinary program that integrates conventional breeding and cutting-edge biotechnological approaches to developing improved cultivars. To advance new breeding methodologies through genetic engineering and marker technologies, Douches's research has examined the genetic basis of insect and disease resistance traits as well as tuber quality. Under his leadership, 15 potato varieties have been released, many of which satisfy the industry's need for pest and disease resistance, particularly to the Colorado potato beetle, scab, late blight and the PVY virus.

**Mary Hausbeck**, Department of Plant, Soil and Microbial Sciences, has focused on the biology, management and epidemiology of diseases in vegetables and floriculture crops, where her ability to develop, implement and manage chemical strategies for growers in Michigan and around the world has successfully safeguarded numerous crops from disease outbreaks. When cucurbit downy mildew first invaded the important Michigan pickle industry, she quickly deployed people to evaluate fungicides for efficacy in combating this new disease. She also established scouting and reporting systems that allowed her to communicate disease threats and recommend protection procedures to growers in a timely manner. In 2011, her work provided the clear fungicide recommendations that are credited with protecting the state's $107 million cucumber/pickle crop.

Hausbeck

**Richard Horan**, Department of Agricultural, Food and Resource Economics, focuses on the understanding and management of coupled economic and environmental systems. Specifically, his work seeks to understand how human and environmental systems co-evolve, and how information about human–environment interactions can be used to construct public policies that correct market failures and move society toward more sustainable outcomes.  Along these lines, he has investigated a variety of topics relevant to Michigan, the United States and the world, including the management of agricultural non-point source pollution, species conservation and management, protecting the Great Lakes from invasive species, managing infectious diseases in wildlife-livestock systems, and how economic choices may have influenced hominid evolution.

Horan

## American Association for the Advancement of Science (AAAS)

Two Michigan State University (MSU) AgBioResearch scientists were named AAAS Fellows by the American Association for the Advancement of Science:

Benning

**Christoph Benning**, MSU professor of biochemistry and molecular biology, was honored for his distinguished contributions to the field of plant biochemistry, particularly the study of plant lipids and the enzymes and genes responsible for lipid biosynthesis.

Kroos

**Lee Kroos**, MSU professor of biochemistry and molecular biology, was selected for his seminal contributions to the understanding of developmental regulation in bacteria *Bacillus subtilis* and *Myxococcus xanthus*, and distinguished mentoring and service to the scientific community.

This national recognition is awarded to researchers for their efforts to advance science or its applications.

## Soil Science Society of America

Michigan State University (MSU) AgBioResearch scientist **Alexandra "Sasha" Kravchenko** was named a fellow of the Soil Science Society of America (SSSA), a professional organization for researchers, students, educators and professionals who are dedicated to advancing the field of soil science.

Kravchenko

Kravchenko, a professor in the MSU Department of Plant, Soil and Microbial Sciences, is the co-coordinator of the MSU Statistical Consulting Center in the College of Agriculture and Natural Resources. Her research focuses on understanding soil and plant spatial variability and factors driving it at scales ranging from agricultural landscapes to microaggregates. Kravchenko has taught statistical and geostatistical methods of data analysis to more than 800 students during her tenure at MSU.

The SSSA, founded in 1936, is a progressive, international scientific society that fosters the transfer of knowledge and practices to sustain global soils.

## American Phytopathological Society

Michigan State University (MSU) AgBioResearch scientist **Mary Hausbeck** was named a fellow of the American Phytopathological Society (APS), the nation's premier society of innovative plant pathology research.

Hausbeck, a professor and MSU Extension specialist in the Department of Plant, Soil and Microbial Sciences, is internationally recognized for her research and Extension efforts, which focus on furthering the biological understanding, management and epidemiology of vegetable, ginseng and greenhouse ornamental diseases. Throughout the course of her career, Hausbeck has secured more than $12 million in competitive funds, published more than 100 papers, and spoken at more than 350 outreach events in Michigan, neighboring states and countries abroad.

The APS is a diverse, global community of scientists that provides credible information related to plant health; advocates and participates in the exchange of knowledge with the public, policymakers and the larger scientific community; and promotes opportunities for scientific communication, career preparation and professional development for its participants.

## American Society for Horticultural Science

Michigan State University (MSU) AgBioResearch scientist **Wayne Loescher** was named a fellow of the American Society for Horticultural Science (ASHS), the world's premier professional society for horticultural science.

Loescher

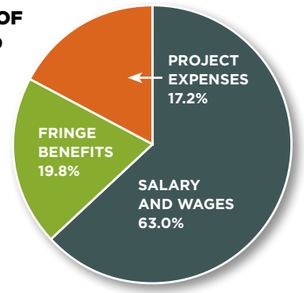
As a professor in the Department of Horticulture at MSU, Loescher has made major contributions to the understanding of carbohydrate metabolism in fruit trees and other horticultural species. His internationally recognized body of work has led him to be regarded as the premier U.S. scientist in this area.

His work also has contributed extensively to understanding abiotic stress resistance mechanisms. His studies, spanning diverse horticultural species and using a combination of horticultural, physiological, biochemical and molecular approaches, provide a strong bridge between fundamental and applied research. He has authored or co-authored more than 70 publications in plant science and horticultural journals, two of which were chosen as ASHS outstanding publications.

The ASHS is a network of national and international scientists whose research keeps fruit, nut, vegetable, turf and ornamental crop producers competitive as they raise sustainable crops.

# FINANCIAL REPORT — 7-1-2013 — 6-30-2014

**DISTRIBUTION OF APPROPRIATED FUNDS**




**INCOME:**

| | | |
|---|---|---|
| Federal Appropriation | | |
| Hatch | $ | 5,292,474 |
| McIntire-Stennis | $ | 317,246 |
| Hatch RRF | $ | 1,257,924 |
| Hatch Animal and Disease, Section 1433 | $ | 108,856 |
| Total Federal Appropriations | $ | 6,976,500 |
| State Appropriations | $ | 30,243,900 |
| Total Appropriations | $ | 37,220,400 |
| Grant – Federal, State and Private* | $ | 60,205,637 |
| **TOTAL INCOME** | $ | 97,426,037 |

**EXPENSES:**

| | | |
|---|---|---|
| Salaries | $ | 23,433,941 |
| Fringe Benefits | $ | 7,379,288 |
| Project Expenses | $ | 6,407,171 |
| Grants – Federal, State and Private* | $ | 60,205,637 |
| **TOTAL EXPENSES** | $ | 97,426,037 |

**PERSONNEL:**

*(Full-time equivalents funded from appropriated funds)*

| | |
|---|---|
| Research Staff | |
| Professors | 63.23 |
| Associate Professors | 31.19 |
| Assistant Professors | 15.32 |
| Research Associates and Specialists | 10.18 |
| **TOTAL RESEARCH STAFF**** | 119.92 |
| Support Staff | |
| Administrative Professionals | 45.00 |
| Supervisors | 23.45 |
| Clerical | 15.15 |
| Technicians | 3.25 |
| **TOTAL SUPPORT STAFF** | 86.85 |

**Grants are reported using most recent three-year average*

***Does not include department chairpersons and unit administrators*



# MSU AgBioResearch

## Director's Office:

*As of 1-7-2015*

**Douglas Buhler**, Director
CANR Senior Associate Dean for Research

**George Smith**
Acting Associate Director

**Michael Jones**
Assistant Director of Natural Resources Programs

**Carolyn Adams**
Research Support Coordinator

**Natasha Berryman**
Communications Manager

**Lori Bramble**
Research Support Coordinator

**James Dau**
Communications Coordinator

**Jackie DeSander**
Administrative Assistant

**Tonia DuMont**
Administrative Assistant

**Linda Haubert**
Projects Administrator

**Bill Humphrey**
Research Support Coordinator

**Mary Weinzweig**
Business and Finance Manager

**Holly Whetstone**
Senior Communications Manager

**Phone: 517.355.0123**
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## Affiliated Deans:

*As of 1-7-2015*

**Fred Poston**, Dean
College of Agriculture and Natural Resources

**Elizabeth Simmons**, Acting Dean
College of Arts & Letters

**Prabu David**, Dean
College of Communication Arts & Sciences

**Leo Kempel**, Dean
College of Engineering

**R. James Kirkpatrick**, Dean
College of Natural Science

**Marietta Baba**, Dean
College of Social Science

**John Baker**, Dean
College of Veterinary Medicine

## Unit Administrators:

(UNITS RECEIVING FUNDING)

*As of 1-7-2015*

**Lindon Robison**, Interim Chairperson
Agricultural, Food and Resource Economics

**Janice Swanson**, Chairperson
Animal Science

**Thomas Sharkey**, Chairperson
Biochemistry and Molecular Biology

**Ajit Srivastava**, Chairperson
Biosystems and Agricultural Engineering

**Martin Hawley**, Chairperson
Chemical Engineering and Material Science

**James Dearing**, Chairperson
Communication

**Michael Kaplowitz**, Chairperson
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**Mary Finn,** Director
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**F. William Ravlin**, Chairperson
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**James Kells**, Chairperson
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Pathobiology and Diagnostic Investigation

**C. Lee Cox**, Chairperson
Physiology

**Richard Triemer**, Chairperson
Plant Biology

**Michael Thomashow**, Director
Plant Research Laboratory (MSU-DOE)

**Steven Anderson**, Director
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**Raymond Jussaume**, Chairperson
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## MISSION STATEMENT:

*The mission of MSU AgBioResearch is to engage in innovative, leading-edge research that combines scientific expertise with practical experience to generate economic prosperity, sustain natural resources, and enhance the quality of life in Michigan, the nation and the world.*

*The mission, supported by more than 300 scientists working in agriculture, natural resources, engineering, social and natural sciences, human ecology and veterinary medicine, has enabled MSU AgBioResearch to be one of the most successful organizations of its kind in the country. This success is due to the efforts of outstanding researchers; close partnerships and collaborations with MSU Extension, seven MSU colleges, federal and state agencies, commodity groups and other key stakeholders; and exceptional legislative support.*