

# FUTURES

Michigan State University • AgBioResearch

## Bombarded with conflicting information about food and health?

Most of us are. Please pull up a chair to Our Table where we will listen and engage in meaningful conversations about food and its impact on our health. Together, we will strive to provide the necessary tools to make better-informed decisions.



Michigan State University will serve as your trusted partner in conversations about food and where it comes from, including its impact on our health and the planet.

[FOOD.MSU.EDU](http://FOOD.MSU.EDU)



# FUTURES

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Who will talk about food  
in meaningful ways?

**Spartans Will.**

## Pull up a chair to Our Table!

Food is a common denominator across all walks of life. It can also be quite polarizing. Some of us have plenty of food to eat; others go to bed hungry. Some live in communities where good food is around every corner; others are born and raised in places where fresh food is hard to come by.

This issue of the magazine is devoted to food. A while back, Michigan State University (MSU) President Lou Anna K. Simon asked the College of Agriculture and Natural Resources to work toward raising awareness of the breadth and depth of the work the university is doing in the areas of food and health. I had the good fortune of having part of that task land on my plate.

Looking across campus, we were astonished at the various areas of expertise – from techniques to produce more food in sustainable ways to guiding food policy and regulation.

One example is the Center for Global Food Systems Innovation's "The Food Fix." This blog has been extremely inspirational in this process. David Poulson, senior associate director of the MSU Knight Center for Environmental Journalism, has a keen knack for unearthing great stories and sharing them in compelling and informative ways. You'd be remiss not to check out his blog at [msufoodfix.wordpress.com](http://msufoodfix.wordpress.com).

Storytelling prowess such as Poulson's got me thinking about all of the questions that people have on food and health and how all too often we turn to our smart phones and social networks for the answers. MSU is uniquely equipped to provide answers that are steeped in science yet easy to understand.

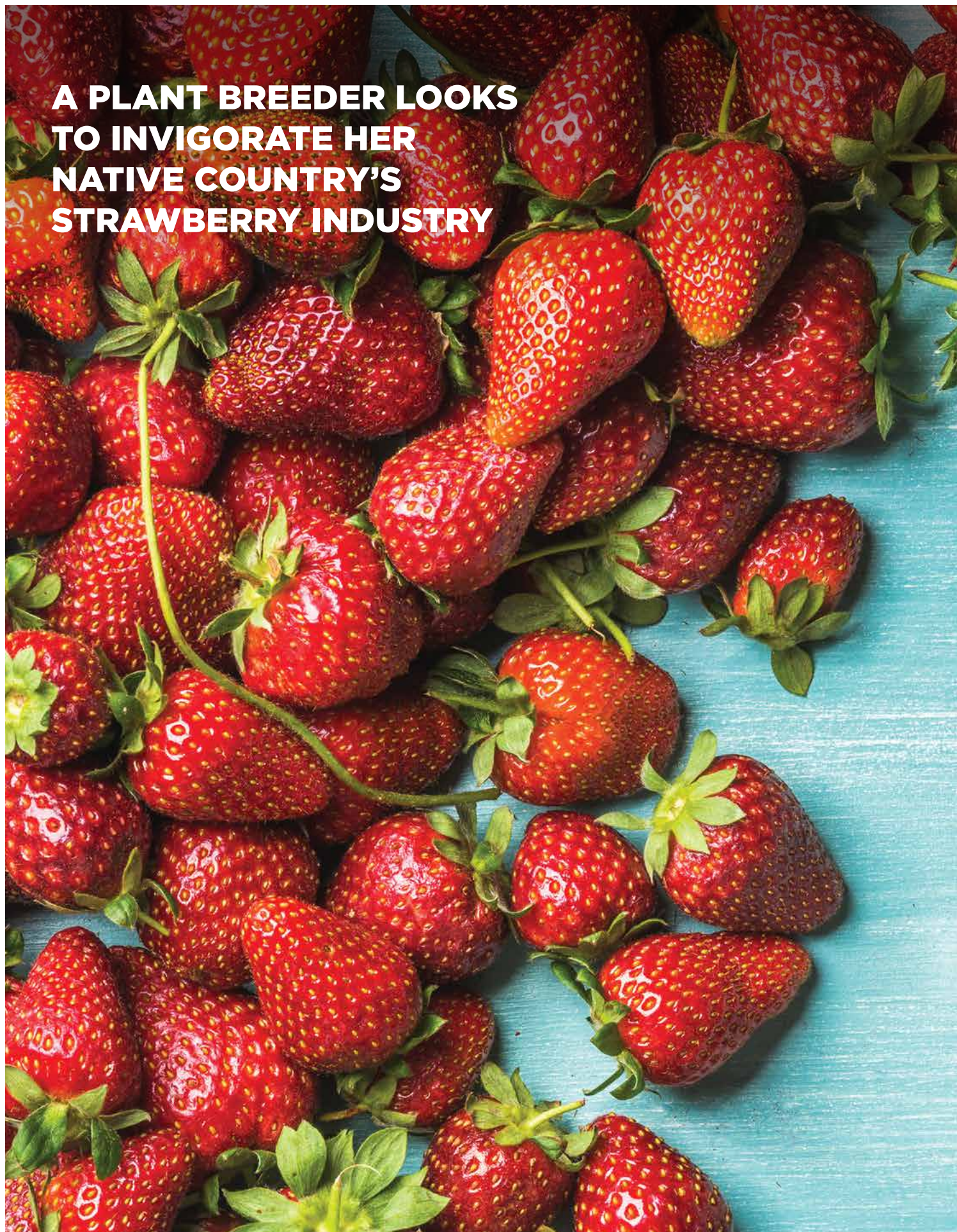
As this campaign began to take shape awhile back, I recalled a comment made to me when I started working at MSU. It came from someone with more than 40 years of human resources experience. He said when he reviewed job applicants that, all other things being equal, he'd choose an MSU grad over graduates of that other university across the state. His reasoning: "They're personable, relatable and easy to get along with." This comment helped formulate part of this new initiative – Spartans are people with whom you want to have dinner and share a meaningful conversation.

As a mother of twin 17-year-old boys, I hope this initiative inspires families to sit down together at dinner, cast aside their electronics and talk to one another. Engage in meaningful conversations on some of life's most important topics. There is a lot of misinformation out there. MSU can help sort through the clutter and provide the tools and information to make better informed decisions on the food and health choices you make for you and your family.

Please dig in and enjoy this issue!



Holly M. Whetstone



## A PLANT BREEDER LOOKS TO INVIGORATE HER NATIVE COUNTRY'S STRAWBERRY INDUSTRY

**CHOLANI WEEBADDE IS A PLANT BREEDER BY TRAINING. SHE'S ALSO AN EXPERT IN INTERNATIONAL AGRICULTURE. HER WORK WITH MICHIGAN STATE UNIVERSITY (MSU) TAKES HER AROUND THE WORLD, WHERE SHE FACILITATES THE DEVELOPMENT OF ORGANIZATIONAL RELATIONSHIPS THAT LEAD TO AGRICULTURAL IMPROVEMENTS. SHE ASPIRES TO INCREASE ACCESS TO NUTRITIOUS FOOD. BUT PERHAPS MOST IMPORTANTLY, WEEBADDE IS A PROUD SRI LANKAN.**

Her fondness for the country where she was born — a small island nation off the southeast coast of India — is what prompted her to begin a career in agriculture more than a decade ago. One instance in particular made her realize that she could bring together her skills in plant breeding and capacity building to give back to her native country.

While on a trip to Sri Lanka in 2006, Weebadde repeatedly heard from prominent agricultural and governmental leaders about a surging strawberry industry. During her childhood, she recalled seeing small plots of the fruit but nothing on

his protégés have ventured to MSU from all over the globe, Weebadde was the first from Sri Lanka.

Noticing the enthusiasm of his pupils, in particular Weebadde, Hancock suggested that international graduate students organize a recurring meeting to discuss agriculture in their home countries and how they wanted to improve it.

For several weeks, Weebadde listened to her peers express ambitions of influencing policy, breeding techniques, technology and more. She was inspired but didn't know how to channel her energy in the most efficient way. That's when Hancock brought in a guest to speak to the group about international agriculture.

"After the final student presented, Jim brought in Karim Maredia," Weebadde said. "I had seen Karim around campus before, but I didn't know who he was and I certainly didn't know the depth of MSU's international work. When I heard Karim speak, it solidified what I wanted to do after graduation."

Maredia is the director of the World Technology Access Program (WorldTAP) at MSU and a trailblazer in the fields of integrated pest management, biotechnology, biosafety and agricultural policy. He is currently leading a \$12 million project

# STRAWBERRIES IN SRI LANKA

BY CAMERON RUDOLPH,  
STAFF WRITER

a large scale. Intrigued, Weebadde visited a nearby market and purchased strawberries sold by a Sri Lankan company called Jagro.

"I thought there was definitely room for improvement," said Weebadde, an assistant professor in the College of Agriculture and Natural Resources. "I am spoiled because of my access to great varieties in the U.S., and I did my doctoral research on strawberries. I thought this was an area where we could lend some expertise and a new perspective."

When she returned to East Lansing, Weebadde relayed her experience to MSU plant breeder Jim Hancock, who is internationally acclaimed for developing many successful blueberry varieties.

"I told Jim that I thought the quality of strawberries wasn't where it could be," Weebadde said. "He looked at me and said, 'Well, why don't you do something about it?'"

### LEARNING THE ROPES

From 2000 to 2005, Weebadde was a fresh-faced doctoral student in Hancock's laboratory. Hancock — a professor emeritus in the MSU Department of Horticulture — has trained dozens of students over his more than 40-year career. Though

funded by the Bill and Melinda Gates Foundation to assist in the development of agricultural biotechnology in Africa.

"Karim is a builder," Hancock said. "He gets people from different sectors to work together in ways they hadn't considered. Knowing what Cholani was interested in, I knew she would be eager to talk with Karim about what he does and how he does it."

A few days after hearing him speak, Weebadde bumped into Maredia in the parking lot outside of the Plant and Soil Sciences Building on the MSU campus. She complimented his presentation, and the duo began chatting about international collaborations. By the time they made it from the parking lot into the building elevator, Maredia asked Weebadde if she wanted to work with him.

"I was so excited, and I ran to Jim to ask if it was OK," Weebadde said. "Jim was so supportive, and he gave me the freedom to continue pursuing my program in plant breeding while simultaneously establishing international contacts through Karim. It was amazing to have those two as mentors guiding me."

"Toward the end of my graduate program, Karim said something that really stuck with me. He told me that I could

do far more for Sri Lanka, or any other country, by being at MSU and utilizing those resources than I could by moving back home and working in the country. That has definitely proven to be true.”

Upon graduation, Weebadde earned a faculty position at MSU. Armed with her knowledge of breeding, genetics and international agriculture, she was ready to make an impact.

### CONNECTING THE DOTS

To build her network of contacts, Weebadde — who is now the plant breeder for international programs and associate director of WorldTAP — accompanied Maredia on various international trips. One journey in 2006 took her to Sri Lanka, where she met influential individuals in academia and government, including representatives of the Council for Agricultural Research Policy.

Both Maredia and Weebadde talked with the minister of agriculture, Hon. Chamal Rajapakse, and his advisors in parliament. The following year, the minister visited MSU to establish collaborations with Sri Lanka for capacity building, which are now conducted by Weebadde.

Meanwhile, Weebadde learned more about Jagro strawberries. After her tasting experience and at Hancock's urging, she pursued strategic partnership funding from the MSU Center for Global Connections. Once that was secured, Weebadde returned to Sri Lanka in December 2013 — this time with Hancock.



Cholani Weebadde, the associate director of the World Technology Access Program, is leading a project that brings new strawberry varieties to her home country of Sri Lanka.

A contact at the U.S. embassy introduced Weebadde to Jagath Fernando, the Jagro CEO. Although Weebadde was initially nervous to broach the subject of quality, the conversation was extremely positive.

“When we first visited Jagro, I expected to see a relatively small production area,” Weebadde said. “But Jim and I both remarked that this was a world-class operation. We saw and tasted some good strawberries, but those were for export. The berries that entered the local markets were not of great quality, so that’s where Jim came in.”

Along with his blueberry efforts, Hancock's strawberry breeding program dates back nearly 40 years to his beginnings at MSU in 1979. Back then, Hancock was working with wild germplasm in an effort to determine what may be horticulturally useful. He gradually combined that germplasm with

the established varieties of the time to create a diverse bank of genetic material.

Creating new varieties of strawberries — or any other crop, for that matter — is a painstaking practice. It involves many years of testing, picking the ideal traits from multiple parent plants to generate a cultivar that meets the needs of the grower. Some growers want day-neutral plants, meaning that they can continue to flower regardless of day length and exposure to sunlight. Others require cold-hardiness so that varieties can better withstand low temperatures, among a plethora of other characteristics.

Testing for Hancock's strawberries is mostly conducted in the temperate climate of Michigan, a stark contrast to the tropical Sri Lankan environment. But because most of Jagro's strawberries are grown in greenhouses, Hancock wasn't concerned. He suggested that the company grow some of his varieties to compare with its current products. If they perform well, Hancock and Weebadde discussed helping Jagro develop its own breeding program.

“We were really pleased when Jagro was receptive to our ideas,” Weebadde said. “They wanted to get moving on implementing Jim's varieties as quickly as possible, but there was a lot to figure out before that could happen.”

### A LONG PROCESS

The first step to getting plants to Sri Lanka was deciding which ones to send. Hancock and his lab technician Peter Callow have spent years in field trials with a host of varieties. Ultimately, they decided to send 17 advanced breeding lines to Sri Lanka.

Two of those 17 have been officially released as varieties and are on their way to commercialization. The first, known as Redstart, was intended for growing in the U.S. Midwest, Northeast and Pacific Northwest. It is a day-neutral variety that Hancock said has high marks for yield, color, firmness and flavor. The second, known as Wasatch, is to be grown in the same geographical regions but is stronger



Jim Hancock (left), one of the world's leading berry breeders, and his lab technician Peter Callow developed the strawberry varieties that were shipped to Sri Lanka. Hancock has also introduced several highly regarded blueberry varieties into the marketplace.

in its day neutrality than Redstart, fruiting longer in a Michigan trial.

The remaining 15 are what Hancock referred to as “elite selections,” some of which are good candidates for release as varieties.

During the selection process, Weebadde was in negotiations with Jagro. She told the company she would be willing to move forward with sharing the costs of testing and shipping the plants if Jagro let her participate in a research field trial. Weebadde wanted to see how varieties designed for a temperate climate perform in a tropical environment.

“This is a great scenario for us because we get research data, but we don't have any of the costs of maintaining the field or facilities,” Weebadde said. “If they decide to move forward, Jagro pays a royalty to MSU for the right to grow and sell the strawberries as well, so it's a win-win for the university.”

Though the benefits to MSU were vast, the team faced challenges in simply getting the strawberries to Sri Lanka. Callow was instrumental in completing this massive task, handling the day-to-day paperwork and shipping duties.

Callow first needed to obtain a material transfer agreement. It stipulates what the recipient will do with the shipment. In this case, the strawberry

varieties are patented by MSU, so Jagro will pay a royalty if the company decides to propagate and sell them.

Next Callow needed an import permit, which detailed the requirements set forth by Sri Lanka for the plants' entry into the country. This included thorough disease testing.

“Being an island nation, Sri Lanka has a ton of rules about what can and can't come into the country,” Callow said. “The disease testing alone took us almost a year to finalize. We had to send plant samples all over the U.S. The Michigan Department of Agriculture and Rural Development was a big help in connecting us with testing entities.”

Once disease testing was completed, the import permit stated that every plant must be free of soil. Callow and Weebadde spent several hours gently washing soil off of the roots and carefully packaging each plant.

“Obviously it's not good for the plants to remove all of the soil, so we did that as the last possible step before packing and shipping,” Callow said. “It was a nervous few days waiting for them to arrive.”

When the plants reached their destination safely in October 2016, Jagro employees sent Weebadde photos to ease her worries. Only a few of the 85 plants showed any signs of wear and tear.

### JUST THE BEGINNING

Weebadde receives pictures of the strawberries each month to monitor progress. A few of the varieties have started to develop small offshoots that can be clipped and used in propagating the plants. Weebadde will visit the facility this summer to identify the varieties that are performing best. With each visit to Sri Lanka, she is reminded of the advice from Hancock and Maredia.

“Jim told me to follow my heart, and that was really meaningful to me,” Weebadde said. “I've had two amazing mentors in Jim and Karim. I've always been treated as a colleague instead of a student. I wouldn't be here and in this position if not for their guidance, so I don't take for granted anything they've done for me.”

Hancock said it's rewarding to see a former student flourish, particularly in an area so personally meaningful.

“It's wonderful to have a former student do what Cholani is doing,” Hancock said. “To be able to continue working with her as a colleague is exciting. This project puts all the pieces together for her to make a significant contribution to Sri Lanka, in addition to the other work she's doing all over the world. She's following her passion, and as a teacher that makes me feel good.” ❖



# “LET’S TALK FOOD”

BY HOLLY WHETSTONE, EDITOR

## INSPIRING MEANINGFUL CONVERSATIONS IS THE CRUX OF A BRAND NEW MSU INITIATIVE

**“Communication is not something you add on to science, it is the essence of science.”**

– Alan Alda, actor and founder of the Alan Alda Center for Communicating Science

Food is the centerpiece of a new Michigan State University (MSU) public awareness campaign led by the College of Agriculture and Natural Resources (CANR). A major goal of “Food @ MSU. Our Table” is to provide knowledge so consumers can make better informed decisions about their food and their health, said Ronald Hendrick, dean of the CANR. The campaign is rooted in communication.

“As the value of science continues to be questioned in many political circles, we realize the need for MSU and other institutes of higher education to be more engaged with the public about how their research and work impacts important issues like food security, food safety and hunger,” Hendrick said.

A key component of the campaign will be a series of community roundtable discussions centered on specific food topics. Scientists, farmers, consumers, policymakers and others will be invited. They will join host and moderator Sheril Kirshenbaum, co-author of “Unscientific America: How Scientific Illiteracy Threatens Our Future.”

“With today’s technology and 24-7 news cycle, we’re constantly faced with conflicting messages about our food and health,” Kirshenbaum said. “As a mom of two young boys, I share the challenges of deciding what to put on the dinner table each evening. I look forward to hearing what concerns are top of mind and helping to lend advice in these important areas.”

The conversations will be filmed and shared online, possibly even aired on television.

Part of the initiative will also include national polling to help get a better understanding of people’s scientific understanding of food and where they’re



getting information. In doing research on the project, Kirshenbaum said she was surprised at how difficult it was to find.

“Just bring up GMOs and you realize there’s a lot of confusion and inconsistent information out there. It’s an example of a topic where both the public and policy lag far behind the science,” she said.

**“MSU KNOWS FOOD,”**  
HENDRICK SAID. “IT  
HARKENS BACK TO WHY  
THE UNIVERSITY WAS  
FOUNDED, AND WHERE WE  
ARE HEADED IN  
THE FUTURE.”

Hendrick said he hopes the campaign will inspire families to put down their technology, especially around the dinner table, and talk with one another.

“This isn’t about academics speaking scientific jargon, it’s about engaging in meaningful dialogue and providing practical, viable answers that are easy to comprehend,” Hendrick said.

Launched this spring, the initiative also includes a new website – food.msu.edu – and a Facebook presence. Both communication vehicles will spotlight stories and a question-and-answer blog, “Food for Thought.”

The initiative comes at a time when six out of nine consumers cite that their life issues of most concern are related to the food system, according to research conducted in 2016 by the Center for Food Integrity. That same research also revealed that 80 percent want to know more about where their food is produced but lack any direct connection to agriculture. More and more consumers are also crowdsourcing information – that is, accessing information from many sources, particularly non-expert websites and/or social media outlets.

“MSU knows food,” Hendrick said. “It harkens back to why the university was founded, and where we are headed in the future.” ❖



## Sheril Kirshenbaum: Host of the “Our Table” conversations that will take place starting this fall

Sheril Kirshenbaum is executive director of ScienceDebate, a nonprofit, nonpartisan initiative to restore science to its rightful place in politics. She works to enhance public understanding of science and improve communication between scientists, policymakers and the public.

She co-authored *Unscientific America: How Scientific Illiteracy Threatens Our Future* with Chris Mooney, chosen by Library Journal as one of the Best Sci-Tech Books of 2009 and named by President Obama’s science advisor John Holdren as a top recommended read. She is also the author of *The Science of Kissing*, which explores the science behind one of humanity’s fondest pastimes. In addition, she is director of The Energy Poll at The University of Texas at Austin and blogs at Scientific American.

Her writing appears in publications such as Bloomberg and CNN, frequently covering topics that bridge science and society from climate change to parenthood. Her work has also been published in scientific journals including *Science and Nature* and she is featured in the anthology *The Best American Science Writing 2010*.

Sheril has been a 2015 Presidential Leadership Scholar; a Marshall Memorial Fellow, a legislative NOAA Sea Grant Knauss Fellow in the U.S. Senate and a Next Generation Fellow through the Robert Strauss Center for International Security and Law. She speaks internationally about science communication and has appeared as a thought leader at events like TEDGlobal and Ciudad de las Ideas.

She holds graduate degrees in marine biology and policy. Previously, she was with the Webber Energy Group at UT Austin’s Center for International Energy and Environmental Policy and Duke University’s Nicholas Institute for Environmental Policy Solutions. Sheril has also been a visiting scholar with The Pimm Group, a fellow with the Center for Biodiversity and Conservation at the American Museum of Natural History and a Howard Hughes Research Fellow.

She lives in East Lansing, Michigan, with her husband David Lowry and sons. ❖

## SOME FOOD FACTS AND FIGURES

- **By 2050, the world population is expected to exceed 9 billion.** To feed a population that size, food production will need to increase by 70 to 100 percent. In response, Michigan State University has expanded its presence in key food-producing regions of the world, including the United States, Africa, Asia and Central America. Our scientists are tackling challenges posed by population growth, climate change and persistent malnutrition, especially among children and women.
- **In 2015 alone, MSU researchers received more than \$100 million in food-related grants.** This work is advancing sustainable agricultural practices and the livelihoods of farmers here in Michigan – the nation’s second most diverse agricultural state – and the world.
- **With three medical colleges and a rich agricultural history, MSU is uniquely positioned as the preeminent food, health and nutrition leader.** MSU has expertise in human, animal and plant health, along with researchers specializing in agricultural commodities from Angus beef to zucchini.
- **MSU is one of the key food research institutes involved with Feed the Future, an initiative led by the U.S. government to address global hunger and food security.** MSU is home to two Feed the Future Innovation Labs: one on food security policy and the other on grain legume research. Through efforts like these, we’re bringing disease- and insect-resistant beans to places where hungry people are in need.
- **MSU is the sole implementer of the Borlaug Higher Education for Agricultural Research and Development (BHEARD) program,** an effort under the U.S. Agency for International Development (USAID) to train agricultural scientists from developing countries to fight hunger and to strengthen the knowledge base. With \$33 million in total funding, MSU has 170 scholars from 11 developing countries pursuing master’s and doctoral degrees in both the United States and Africa.
- **The MSU Global Center for Food Systems Innovation, part of the USAID Higher Education Solutions Network involving seven American and foreign universities, is developing solutions to critical challenges affecting global food systems,** such as rapid urbanization, climate change, pressure on natural resources and skill gaps in the workforce. Because women make up 43 percent of agricultural labor worldwide, this initiative is largely focused on gender equity and women’s empowerment.
- **MSU has received more than \$47 million in support from the Gates Foundation’s Agricultural Development Initiative.** These efforts are providing millions of small farmers with the necessary tools they need to increase yields and build better lives for themselves and their families.
- **MSU Extension partners with the Michigan Department of Health and Human Services (MDHHS) to provide Supplemental Nutrition Assistance Program Education (SNAP-Ed),** a free nutrition education program to reduce hunger and food insecurity and promote healthy eating habits. Instructors teach youth, teens, adults and seniors how to make health a priority. Our goal is to increase the likelihood that those eligible for SNAP benefits will establish healthy eating habits and increase physical activity while staying within their limited food budget.
- **The MSU Center for the Health Impacts of Agriculture is addressing issues at the nexus of agriculture and health.** The World Health Organization estimates that unsafe food is linked to 2 million deaths per year, many of them children. Designing and implementing agricultural policies and practices is not just about producing more food in more sustainable ways – it’s also about taking into account plant, animal and human health.
- **MSU collaborates directly with more than 80-plus commodity groups in Michigan** to help address industry concerns and promote economic viability and sustainability. The state’s food and agriculture industry is valued at more than \$100 billion per year.
- **MSU operates more than a dozen outlying research facilities spanning the state** from Chatham in the Upper Peninsula to Benton Harbor in the southwest corner of the Lower Peninsula. These facilities provide places to conduct food research in the various soil types and diverse micro-climates of the Great Lakes region.
- **MSU Extension employs specialists in all 83 Michigan counties** to address concerns of and questions from local agricultural producers and others. These services are paramount to educating folks about recent research and discoveries.
- **The College of Agriculture and Natural Resources (CANR) is built on the land-grant foundation of combining education, research and outreach to prepare and train the next generation of agricultural producers.** The CANR offers 20 majors in 13 departments, most of which are related to food, energy and/or the environment. And enrollment is at a 40-year high.
- **MSU is the home of the Center for Research on Ingredient Safety (CRIS),** the only national center devoted to the study of the safety of ingredients in food and consumer products. CRIS is governed by representatives from industry, academia, the public sector and nongovernmental organizations, and focuses on state-of-the-art research, graduate education, and communication of easily understood and science-based information to consumers. ❖

# POTATO 2050:

Preparing for potato  
production in light of  
climate change

BY JAMES DAU, STAFF WRITER

Dave Douches, director of MSU's Potato Breeding and Genetics Program, examines potato plants in the greenhouse. By studying the performance of modern potato varieties under future climate projections, Douches can tailor his breeding program to ensure the continued productivity of the crop in a changing climate.



# THE YEAR 2050 WILL MARK AN IMPORTANT MILESTONE IN GLOBAL AGRICULTURE: THE WORLD POPULATION IS EXPECTED TO TOP 9 BILLION PEOPLE,

A ONE-THIRD INCREASE OVER THE CURRENT POPULATION. MUCH OF THIS GROWTH WILL TAKE PLACE IN LESS DEVELOPED, ALREADY FOOD-INSECURE REGIONS OF THE WORLD SUCH AS AFRICA. AND RISING LIFE EXPECTANCIES ARE EXACERBATING THE PROBLEM. TO MEET THE ESSENTIAL NEEDS OF A POPULATION THIS SIZE, GLOBAL FOOD PRODUCTION WILL NEED TO RISE BY AN ESTIMATED 70 PERCENT. AND CLIMATE RESEARCH INDICATES THAT MUCH OF THE WORLD WILL EXPERIENCE UNPRECEDENTED SHIFTS IN TEMPERATURE, PRECIPITATION AND HUMIDITY, AND INCREASINGLY EXTREME WEATHER BY 2050.

Fortunately, researchers from Michigan State University (MSU) are acting on these projections now to enable farmers around the world to produce food in an uncertain future.

## POTATOES FOR A CHANGING CLIMATE

When conducting research on plant biology and physiology for her Ph.D. at the University of Illinois, Urbana-Champaign, Courtney Leisner was able to study the effects of altered climate conditions on a variety of crops, such as corn and soybeans. In 2014, when she joined the lab of MSU AgBioResearch

plant biologist C. Robin Buell as a visiting research associate, she found new opportunities to pursue that interest.

“When I joined Robin’s lab, I was really interested in incorporating some kind of climate change work into our projects,” Leisner said. “When she told me about the possibility of a new potato project coming up, I saw an opportunity to tackle an issue that all of our growers are going to be wrestling with in the coming years.”

With funding from Project GREEN (Generating Research and Extension to meet Economic and

Environmental Needs, a collaboration between MSU, the Michigan Department of Agriculture and Rural Development and Michigan’s plant agriculture industries to fund plant agriculture research in the state), Leisner and Buell created a team with MSU AgBioResearch potato breeder Dave Douches and MSU climate scientist Julie Winkler. Their mission: to discover how potatoes would react to the climate of the future.

Using weather data recorded from 1980-2000 and climate change simulations from the North American Regional Climate Change Assessment Program, Winkler developed a suite of local climate change projections for Michigan between the years 2040 and 2070. This range was selected because the models would retain a high degree of accuracy, as an ensemble of climate simulations for the region was already available, and would give Douches enough time to begin developing entirely new potato cultivars.

Douches has been studying potatoes since joining MSU in 1988. As leader of the MSU Potato Breeding and Genetics Program and faculty coordinator at the MSU Montcalm Research Center, where the university has pioneered potato research for the past 50 years, Douches’ understanding of the importance and complexity of the tuber is pretty unrivaled. The development of new potato varieties to help Michigan growers face new challenges in the field is the cornerstone of his research.

“It takes between 10 and 15 years to create a new potato variety from start to



MSU plant biologist Robin Buell checks in on potato plants undergoing trials in a growth chamber. By altering the temperature and carbon dioxide levels in the chamber, the team is able to simulate various possible future climate conditions and study what changes in potato growth result.

finish, so we need to be proactive about identifying the challenges the future could bring,” said Douches, professor in the MSU Department of Plant, Soil and Microbial Sciences. “You can’t simply change your varieties year-to-year to react to last season’s issues – you have to look ahead as best you can.”

## NEW STRESSES FROM A NEW CLIMATE

The team turned to the latest high-tech tools. Using growth chambers, they grew multiple potato cultivars under the climate projections for Michigan’s potato region. They took careful physiological measurements of the plants, including the rate at which photosynthesis occurred and the level of gas exchange between the leaves and the atmosphere.

The potato plants were subjected to several experiments. In the first, potatoes were grown under a flat temperature increase of 2.7 degrees

Celsius above current field temperatures – the average temperature increase predicted for the climate of 2050.

The other two incorporated seasonal temperature changes: one in which temperatures in the growth chamber rose until they peaked during the potatoes’ bulking period, and the other in which the temperature peaked early in the season, when the plants were developing aboveground vegetation.

All of the experiments were treated with an increase in carbon dioxide levels, as well – with 563 parts per million compared with the approximately 400 ppm present in today’s atmosphere.

The temperature and photosynthetic period in each growth chamber were altered every two weeks to mimic changes throughout the season.

“We wanted to simulate what the plants would experience in the field,” Leisner said. “Not just in terms of the climate, but the entirety of the growing

season. It makes our findings that much more accurate to what farmers are going to see in reality.”

At the end of the growing season, the potatoes were harvested and final measurements taken of their color, biomass, weight and specific gravity – the estimate of dry matter, as opposed to water. All are significant factors in determining the market value of a potato crop.

While data analysis continues, the experiments have revealed that a changing climate will bring new stresses.

“Every time we did the experiment, you could tell within four to six weeks that the plants looked different,” Buell said. “While we’re not certain if the changes are caused by the higher temperatures, the higher carbon dioxide levels or both, it’s clear to me that something substantial is going on.”

Of the three iterations of the experiment, the team found that the





Courtney Leisner (right) and Robin Buell get ready to harvest potatoes. Leisner carefully monitored the potatoes in the growth chamber experiments, measuring their physiological responses to a changing climate.

climate conditions that saw temperatures peak during the bulking phase resulted in a significantly different harvest than the other two. Each individual tuber was slightly larger but showed a lower specific gravity, which reduces market value. Additionally, some potato cultivars produced fewer tubers than those under the control conditions.

The impact of climate change also varied greatly depending on the potato cultivar. Manistee, a cultivar released by Douches in 2013, proved significantly more resilient to the effects of climate change than the older varieties widely grown in Michigan – Atlantic and Snowden.

Though changes to the potato in the field would be highly significant, that is not where the journey ends. Most potatoes harvested in Michigan are ultimately moved into long-term storage, where they can be preserved for months and provide processors and retailers with product nearly year-round. Examining the impact of climate change on the potatoes' ability to retain their quality in storage was also of paramount concern.

"The tuber is still alive in storage, it's still respiring, and so you have to keep them under the right conditions so they don't start germinating and sprouting," Buell said. "That means keeping them dormant by keeping them cool."

Thanks to Michigan's relatively cool climate, current potato storage facilities do not experience significantly high costs to refrigerate during the five to six months of storage. Rising temperatures could mean change, however. The team is currently testing the storage viability of various cultivars under different climate projections, with Manistee, again, showing more resilience than others.

#### **BREEDING A MORE CLIMATE-PROOF POTATO**

As shown with the growth chamber experiments, the right potato varieties are key. Douches, armed with new data and the 30-year advance warning, is working to incorporate climate resiliency into the MSU potato breeding portfolio.

**FEW CROPS ARE AS IMPORTANT TO MICHIGAN AGRICULTURE AS THE POTATO, THE TOP VEGETABLE CROP IN THE STATE. MICHIGAN FARMERS HAVE DEDICATED APPROXIMATELY 50,000 ACRES TO POTATO PRODUCTION, WHICH, ALONG WITH PROCESSING AND MARKETING, GENERATES OVER \$1.24 BILLION ANNUALLY AND CONTRIBUTES MORE THAN 3,200 JOBS TO THE STATE'S WORKFORCE.**

– MICHIGAN POTATO INDUSTRY COMMISSION

"The climate models and the experiments we're doing here are telling us that we're going to see new stresses on potatoes, and that tells me, as a breeder, that we need to develop new varieties that can withstand that type of environment," Douches said. "And this will go beyond Michigan – it's going to affect all of the potato-growing states across the northern U.S., which together feed a lot of our country. If we can't figure this out, things are going to change in a really negative way."

Originating in the Andes Mountains of South America, potatoes are grown throughout the world, including regions with climates already close to Winkler's

projections for Michigan. Douches aims to look to the heat-tolerant cultivars grown in equatorial regions as a starting point, though even that brings challenges.

"Closer to the equator, they have a much shorter day length, which means those varieties are used to significantly less photosynthesis activity," Douches said. "So we can't directly take those varieties and plant them in Montcalm County. We can, however, study their germplasm and cross them with our current varieties to try to take advantage of their characteristics."

Rising temperatures and carbon dioxide levels also suggest that growers will see increases in pest and disease pressures, subjects of future experiments.

#### **BEYOND POTATOES**

The impact of climate change will extend to every aspect of agriculture in Michigan. In fact, in some respects, Michigan growers are already experiencing it.

MSU AgBioResearch plant pathologist George Sundin has been working with Michigan apple growers since he came to MSU in 2002.

"We know from the past 50 years that the date the apple trees bloom and when they break dormancy has been moving up," said Sundin, professor in the MSU Department of Plant, Soil and Microbial Sciences. "We were early again this year, and every time that happens we run the risk of frost damage."

Those same higher temperatures, along with wetter conditions, also stand to exacerbate the two major apple diseases – apple scab and fire blight. Together, these diseases already present significant challenges. In 2000, for example, a fire blight epidemic wiped out nearly 400,000 apple trees in southwestern Michigan and caused over \$42 million in losses. As periods with temperatures exceeding 70 degrees Fahrenheit during bloom have increased the past few years, incidences of fire blight outbreaks have risen.



Under an altered climate with higher average temperatures and carbon dioxide levels, Michigan potatoes could change in substantial ways. The team observed the plants grow fewer, larger tubers, as well as featuring higher moisture levels.

Breeding new apple cultivars takes many years. New varieties better adapted to a changing climate remain a distant prospect, Sundin said. Instead, he sees the adoption of a variety of cultural practices as the answer to fighting diseases – for example, providing information to growers on removing fire blight cankers and hastening the decomposition of dead leaves, in which the apple scab fungus overwinters, with fertilizers.

"Climate is an important issue that goes beyond sea levels and ice caps," Sundin said. "Most diseases are favored by warm, wet weather, and climate change is going to bring us more of both. It's critical for all of agriculture."

Michigan's cherry crops have also been hard hit by an already changing climate. Like apples, cherry trees have blossomed early because of warming weather, occasionally with devastating consequences. MSU AgBioResearch plant breeder Amy Iezzoni has seen the impact firsthand.

"Many growers in the state have already lost significantly to climate change," said Iezzoni, professor in the MSU Department of Horticulture. "In 2002, a spring frost wiped out all but

about 8 percent of the cherry crop. A lot of growers had no income from cherries that year. It was a horrific event that we thought would happen once in a lifetime. But then it happened again in 2012."

Iezzoni is breeding new cherry cultivars that bloom later in the spring, allowing them to miss most of the late frosts. But again, it takes time to develop new varieties. In the interim, Iezzoni recommends that growers seek out orchard sites with good air drainage, such as those near Lake Michigan, which affords a buffer against extreme weather conditions. She also advises using wind machines to raise the temperature around the cherry trees by mixing warmer air at the top of an inversion layer with colder air near the ground.

The new difficulties that climate change will bring and, in some cases, already has brought to Michigan agriculture underline the importance of such proactive research.

"Everything is affected by climate," Douches said. "We grow crops where we do because that's what the current climate dictates. While we can change where we grow them, we can also work to adapt them to new conditions, given enough time." ♦

# Bradley Marks: Killing bad bugs is what he does

**E**very year, approximately 48 million Americans become sick from food-borne illnesses, leading to 128,000 hospitalizations and 3,000 deaths, according to the Centers for Disease Control and Prevention. The most common culprits include bacteria such as Salmonella and Campylobacter, and viruses such as norovirus and hepatitis A. And they're all under the research eye of Bradley Marks.

"Our biggest goal is reducing food-borne illnesses," said Marks, professor and associate chairperson of the Michigan State University (MSU) Department of Biosystems and Agricultural Engineering. "Most of the food people buy is manufactured, and those systems – whether cooking, roasting, drying or toasting – need to be validated to ensure they're delivering a safe product. That's our sweet spot."

To accomplish this, Marks and longtime collaborator Elliot Ryser, professor in the MSU Department of Food Science and Human Nutrition, employ a unique blend of engineering tools and expertise on food-borne pathogens. Marks explains that, by focusing on improving the engineering aspects of the manufacturing process, their team is able to make novel contributions.

"Engineering has been a central strategy for me, careerwise," Marks said. "I'm often the unusual person in the room, and I've found that if you're the odd duck, you have a higher probability of coming up with something new and innovative for the project."

By drawing on expertise in heat and mass transfer, fluid dynamics and math modeling – knowledge sets uncommon in the world of food-borne pathogens – Marks's team has proven capable of addressing the design of food manufacturing systems as well as evaluating the safety of systems currently in use.

That distinct approach has led Marks and his team to many successes.

A primary foe of food processors today is the bacterium Salmonella. In the past few years, the pathogen has begun to appear in a wide range of common processed foods, including almonds, peanut butter, wheat flour and pistachios, where it is significantly more difficult to kill than in other potential hosts, such as chicken. Engineering methods to help food processors fight back have become Marks's major focus.

Recently, the team helped almond processors find new ways to validate their systems against Salmonella through the use of a nonpathogenic surrogate organism. The Almond Board of California, which represents the entirety of almond production in the United States, made a voluntary decision to require all almonds to have gone through a process to reduce the presence of Salmonella before they go to market.

No commercial manufacturer would ever test their equipment with actual Salmonella, so Marks's team helped validate a surrogate for them to use instead, an organism that mimics the properties of Salmonella without presenting any of the dangers. Their findings now constitute an important part of guidelines for the whole industry.

Marks's work against Salmonella did not stop with almonds. A nonpathogenic surrogate had already been developed for use in pistachios but had not been adapted to the high-volume demands of commercial-scale processes. Thanks to the work of Marks and his lab, that has now been accomplished through the use of a biosafety pilot plant at MSU, which allows researchers to test pathogens on real food and equipment at the pilot scale, thus bridging the gap between the lab and industry. Additionally, the team was able to show that, by raising humidity or soaking the pistachios in a brine prior to roasting them, processors can significantly increase the amount of Salmonella killed.

Marks is currently leading a \$4.7 million U.S. Department of Agriculture grant uniting experts from five other universities and the Food and Drug Administration to find ways to reduce Salmonella in low-moisture processing systems.

One of the most valuable aspects of his research program has been delivering solutions at a scale practical for commercial processors.

"One of the most seminal conversations I ever had was with the vice president of a food company," Marks recalled. "He told me that, while all the work we do in the lab is interesting and useful, it's a huge leap to go from that scale to processing 10,000 pounds of food an hour. The fact that we at MSU can approximate that commercial scale is a cornerstone of our work. It lets us talk to processors in terms they're familiar with and have confidence in."

At the end of the day, though, Marks draws his sense of accomplishment from knowing that his work helps keep food safe.

"We're doing something to prevent people from getting sick," Marks said. "If we can succeed at that, I know we've done some good. Killing bad bugs is what we do." ❖



**Name:** Bradley Marks

**Title:** Professor, associate chair, Department of Biosystems and Agricultural Engineering

**Joined MSU:** July 1999

**Education:** B.S., agricultural engineering, MSU, 1989; M.S. and Ph.D., agricultural engineering, Purdue University, 1992 and 1993, respectively

**Hometown:** Ida, Michigan

**Muse (person who has most influenced and/or inspired me):** Professionally, Fred Bakker-Arkema; I worked for him as an undergraduate. His expertise was in grain drying, storage and handling, and he did a lot of international work. When I first got into the field, I saw really advanced engineering being applied to make sure people had food to eat, and I remember thinking I could do all this math and science and it was really going to matter, it was helping food go where it was most needed.

**Favorite food:** Anything new. I like trying new foods, the adventure of it.

**Book I'd recommend:** The Checklist Manifesto. The author, surgeon Atul Gawande, shows how to apply the surgical checklist, the standard process for assuring that complex surgeries are carried out without mistake, to all kinds of activities. It shows the value of having even simple organized safeties for all kinds of fields, from airline safety to finance.

**On my bucket list:** Bicycle across America. The only trick is finding the four months to do it.

**Favorite vacation:** Family trip to the Canadian maritime provinces. My brother and I once biked Nova Scotia and Prince Edward Island, then my wife and I went back with our daughters years later.

**On a Saturday afternoon, you'll likely find me:** Either attending events with my daughters or doing gardening and yardwork.

**Best part of my job:** Making a difference in the lives of students – otherwise, why be a professor? I teach one class a semester, either an introductory freshman course or a junior required course, and I have taught several others at various times.

**If I wasn't a researcher, I'd be:** Probably an engineer in the food industry. But this is the best gig I could think of having.

**Something many people don't know about me:** I played tuba in the Spartan Marching Band, including a trip to the Rose Bowl.

**Words of advice for a young scientist:** Find your passion and work hard. I get a lot of students uncertain about the future, and I say if you aren't sure about this field, you need to find the one you are sure about.

**I went into this field because:** I enjoy the technical challenge, but I am impassioned about doing it in a way that makes a difference in people's lives. ❖



# SOME MSU food milestones



# The FPIC

## [ FOOD PROCESSING INNOVATION CENTER ]

**1855:** The Agricultural College of Michigan (now MSU) is founded.

**1862:** MSU becomes the pioneer land-grant university after President Lincoln signs the Morrill Act.

**1871:** William J. Beal joined the faculty and eventually went on to pioneer the development of hybrid corn, doubling the yield of plantings

**1890:** Robert C. Kedzie imports sugar beets from Germany and distributes them to farmers.

**1915:** Plant breeder F.A. Spragg releases the first navy bean variety, Robust.

**1928:** Plant scientist E.E. Down introduces hybridized barley (Spartan) to the Michigan grain industry.

**1929:** Dairy industry pioneer G. Malcom Trout linked the processes of pasteurization and homogenization, finding that homogenized milk needed pasteurization in order to have an appealing taste. He also developed new processes to make cheeses, yogurt and other products.

**1933:** Scientists develop flash pasteurization of apple juice, which becomes an industry standard.

**1940:** Horticulturist Stanley Johnston develops Red Haven peach, still one of the world's most widely grown varieties.

**1958:** Horticulturists Shigemi Honma and O. Heeckt hybridize snap and lima beans, transferring the early germination and early maturity from the snap bean to the lima bean.

**1974:** Bean breeder Wayne Adams and USDA-ARS plant pathologist Fred Saettler release Montcalm, the first halo-blight-resistant kidney bean, credited with revitalizing the industry.

**1979:** MSU wheat researchers increase wheat yields by 50 percent with the introduction of two white winter wheat varieties — Frankenmuth and Augusta.

**1985:** Food toxicologist James Pestka develops a process to screen for aflatoxin B-1, a poison produced by fungi that can contaminate spices, corn, small grains, cottonseed, peanuts and dairy.

**1994:** Alumnus Philip Rowe unveils the Goldfinger banana variety, resistant to the wilt diseases that devastated the industry in the 1980s and 1990s.

**2003:** Berry breeder James Hancock releases three of the most widely planted northern highbush blueberry varieties: Aurora, Draper and Liberty.

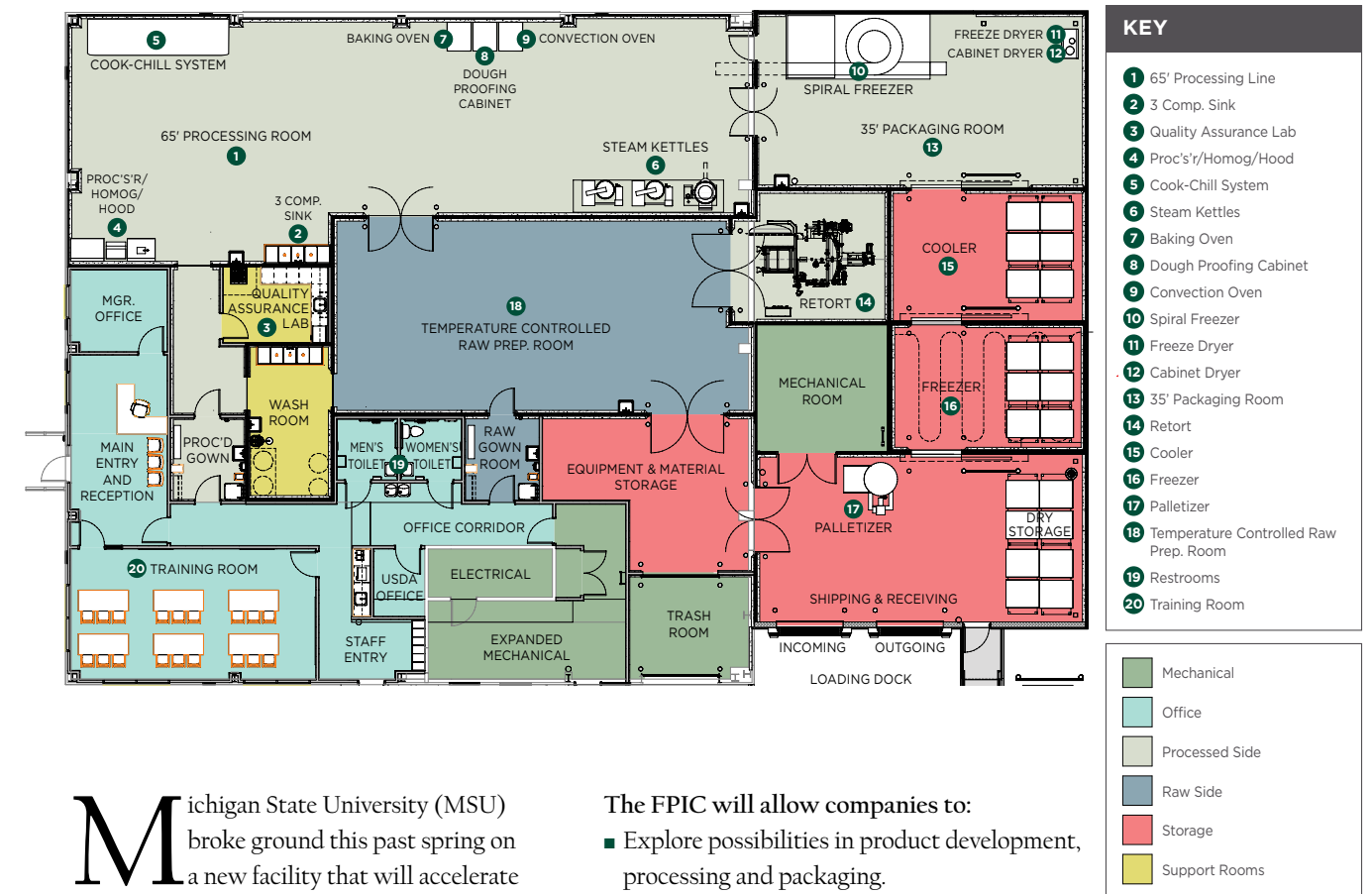
**2010:** MSU soybean breeder Dechun Wang develops aphid-resistant soybean germplasm called Spartan — the Soybean Aphid Shield.

**2013:** Potato breeder David Douches releases the Manistee potato variety. Manistee is an important chipping variety because of its ability to store until June, which assures processors of having a supply until the early summer crop is harvested in July.

**2015:** James Hancock releases Redstart and Wasatch strawberry varieties, bred for the Midwest and Pacific Northwest regions of the United States.

**2015:** Wheat breeder Eric Olson releases E6012, a soft white winter wheat variety that exhibits improved resistance to Fusarium head blight.

**2016:** Samurai, a dry bean variety, is released by long-tenured bean breeder James Kelly. He has released 47 dry bean varieties during his nearly four-decade career.



Michigan State University (MSU) broke ground this past spring on a new facility that will accelerate the development and creation of new food and agricultural products.

The Food Processing Innovation Center (FPIC) is a commercial-scale pilot plant where food industry processors can experiment and test new products and processing ideas. The 10,000-square-foot facility, located in Okemos, is fully compliant and regulated by the U.S. Department of Agriculture Food and Drug Administration. It is equipped with modern technology capable of producing full-scale, small to medium-sized production runs.

The FPIC will allow companies to:

- Explore possibilities in product development, processing and packaging.
- Visualize how to optimize processing and packaging lines to create products that people want.
- Collaborate with university faculty members and experts on products, research and development processes.
- Create connections and product solutions that build capital. ❖



Nathan Shaver has hand-crafted artisanal furniture for businesses throughout Michigan. He still makes time to create handmade storage units, pictured in foreground, for his children.



PHOTOS BY JEANADEE ALLEN

## CRAFTING OUR TABLE FROM FALLEN MSU CAMPUS TREES

BY JEANADEE ALLEN

Nathan Shaver hand-built his family's 10-person dining room table. His wife's family is spread across the state and their home is the midpoint. He said he wanted to create a space where the family can unite to celebrate food, each other and community.

His most recent project is working with the Michigan State University (MSU) Shadows Collection, within the Department of Forestry, to construct a one-of-a-kind table that will connect people across the globe. It is the centerpiece for "Our Table," a kickoff campaign to create engaging conversations on food and food's impact on health.

Shaver owns a Charlotte, Michigan-based woodworking studio. He regularly works with the MSU Shadows Collection, an initiative to repurpose fallen campus trees into works of art. His aesthetic is rustic modern. The imperfections in recycled materials inspire his designs.

"I was raised by my dad and my grandpa, and we would pound nails straight and reuse everything we could. It's some of the Depression-era thinking," he said. "This makes sense to me. I don't like to waste anything."

This ethic is evident in his studio. He salvaged the lights, cabinets and walls of his studio from various construction projects. For Shaver, creating a project for MSU is personal and mission-driven.

"I want 'Our Table' to reflect your values and my values as a carpenter and as a person," he said.

He said he's designing the table as simply as possible. It's being purpose-built to inspire clear communication.

"I want it to reflect our intentions, principles and ideas on speaking openly," he said. "It's a simple, solid, dependable table that conveys trust and thoughtfulness."

He hopes this table will unite people and facilitate honest conversations about food and health.

"People can make assumptions based on their life experiences, perspective or the information they've heard," he said. "I hope people sit around this table and have healthy conflict about these ideas, and it inspires them to have a positive impact on our situation."

The table is expected to be finished in July. Stay tuned to [food.msu.edu](http://food.msu.edu) to see the completed project. ❖



Natalie and Nathan Shaver said they purchased a home "within golf cart distance of family" because it was important to be close to his grandparents and parents. Pictured from left: Natalie, Whitaker, 1; June, 5; Ezra, 3; and Nathan Shaver.

# Feathered friends:

## HOW THE AMERICAN KESTREL AND FRUIT GROWERS ARE HELPING ONE ANOTHER

**H**igh atop a lone tree, a small, hawk-like bird with striking blue-gray, spotted plumage bobs its head and tail, then rockets into a field to strike its unsuspecting quarry.

The American kestrel, North America's smallest and most common bird of prey, can be found standing watch across the entire continent, from as far south as the Yucatan Peninsula to as far north as central Alaska. It is also common throughout much of Central and South America.

Across its extensive range, the diminutive raptor preys on a wide variety of small creatures, such as mice, voles, lizards and large insects such as grasshoppers and dragonflies, which it spots with its highly developed vision. This same superior sense of sight also allows them to intercept bats and small birds in midair. Not only has its varied diet staked out an important niche for the species in the food web – it also plays no small part in the birds' historic success at maintaining high populations.

Today, however, these high populations are significantly reduced. Since 1966, estimates based on data collected by the U.S. Geological Survey, the National Audubon Society and the Raptor Population Index, indicate that American kestrels have experienced an approximately 47 percent decline across North America. In Michigan, their numbers have been reduced by 28 to 43 percent, depending on the region.

Many causes have been proposed for this decline, from competition with larger birds of prey to disease or habitat loss through development, but none has yet gained enough empirical support to fully explain the phenomenon.

BY JAMES DAU, STAFF WRITER



Megan Shave, Ph.D. student in the MSU Department of Integrative Biology, holds an American kestrel in a Leelanau County cherry orchard. Shave coordinated efforts to set up kestrel nest boxes throughout the Leelanau Peninsula and monitor their inhabitants. The American kestrel is both the smallest and most common falcon in North America, having about the same weight as a blue jay or mourning dove. The tiny raptor feeds on a number of common orchard pests, including birds, insects and rodents.

### LOOKING INTO THE PROBLEM

The American kestrel is not without its allies, however. In 2011, a research team led by Michigan State University (MSU) integrative biologist Catherine Lindell received a four-year, approximately \$2 million grant from the U.S. Department of Agriculture (USDA) Specialty Crops Research Initiative (SCRI) to investigate the impact of and possible solutions to crop damage by bird pests.

Word reached the team that blueberry growers in the western United States had set up nest boxes for the American kestrel to attract them to their lands and take advantage of the birds' natural proclivity for hunting the insects, rodents and small birds that come to eat their crops.

"We thought it was something worth trying," Lindell recalled. "We knew through MSU Extension that the cherry growers in Leelanau County were having similar problems with pest birds in their orchards, so it created an

opportunity to test the technique in a region where it had the potential to really help people."

Growers in Leelanau County had a sporadic history of setting up nest boxes for kestrels, often placing them atop the very telephone poles the birds themselves choose as their perches. Lindell wanted to approach the technique in a more systematic way that also brought the kestrels into the orchards proper.

For Megan Shave, it was an opportunity to blend her interests in conservation and agriculture. Joining the project in 2012 as a graduate student, Shave oversaw the installation of 10 nest boxes in orchards throughout Leelanau County, adding to the eight that were installed in early 2012. Shortly thereafter, every box was occupied by a nesting kestrel pair.

"I came to Catherine's lab because I've always been interested in birds," Shave said. "I wanted to not only continue studying bird behavior and

population dynamics but also to look into how they relate to ecosystem services – how their presence could help human activity."

Determining the value that kestrels have for their human counterparts is critical for sustaining long-term interest in their conservation, Shave said. She and her team set up video cameras in each nest box to record what types of prey the birds brought back home. At the same time, the team measured populations of pest birds in orchards with occupied nest boxes and compared them with populations in nest box-free orchards.

The preliminary results are optimistic. In surveys of identical sweet cherry plots, Shave and her colleagues recorded an average of 3.7 pest birds when no nest boxes were present; in those with nest boxes, that number plummeted to only 0.69. Though sweet cherries are much more susceptible to pest bird activity than their tart cherry cousins, the same trend was borne out there: plots without nest boxes saw an

average of 1.33 pest birds; those with them reported an average of only 0.31. Shave attributes this not just to direct predation by kestrels but also to them having a deterrent effect.

“Kestrels are unlikely to eat all the birds in that area, but we found that just having an active kestrel box in an orchard serves as a warning to other birds in the area,” Shave said. “Kestrels and their young are very loud, and we think pests such as robins and starlings learn where raptors spend time and they avoid those spaces.”

Shave’s video cameras collected evidence that the kestrels were not only warding off pest birds but also preying on more terrestrial orchard pests.

Grasshoppers and other leaf-damaging insects were frequent entrees in kestrel meals, as were rodents such as meadow voles, which often damage the root systems of young trees as they burrow.

In the years since the project began, the team has put more boxes throughout Leelanau County to continued success: approximately 90 percent of the boxes remain occupied, and the local kestrel population has seen significant improvement as a result.

The original SCRI project expired in 2015, but the team’s efforts have continued under a new three-year, \$500,000 grant through the National Science Foundation’s Coupled Natural-Human Systems project.

“We’ve shown that when you put up nest boxes, more kestrels appear in the area,” Lindell said. “For example, last winter we put up five boxes along a route where there had been no kestrel sightings, and this season we’ve had reports of kestrels in the area.”

#### WORKING FOR GROWERS

Ensuring that nest boxes help growers as well as kestrels is central to the project, and something that Phil Howard, associate professor in the MSU Department of Community Sustainability, is actively studying. A member of the team since the project

began in 2011, Howard has focused on gauging the attitudes of consumers and growers alike with respect to kestrel conservation and ecosystem services.

“Depending on the crop, we found through surveys and focus groups that consumers were willing to pay 30 to 32 percent more for fruit from farms that practiced conservation through nest boxes,” Howard said. “Even if, in practice, it doesn’t quite garner that price premium, this shows there’s a lot of potential interest as consumers become more aware of nest box practices.”

With consumers interested, Howard and his graduate student, Chris Bardenhagen, who comes from a family of cherry growers in the Leelanau Peninsula, set out to work with growers, gauging their perspectives on the utility of nest boxes and their inhabitants for their orchards.

Through preliminary interviews with growers, Howard and Bardenhagen have identified a set of the 20 most significant factors – ranging from pest pressure to fruit quality to the cost of sprays and equipment – influencing grower decisions.

Bardenhagen’s task is to sit growers down with a 2-foot by 3-foot dry erase board with magnets representing each of the 20 factors. By having growers draw relationships between the factors – for example, higher fruit quality might be positively related to higher spray and equipment costs – Bardenhagen is able to gauge how growers perceive and consider the costs and benefits of orchard operations.

“Farmers do a lot of complex thinking when it comes to pest management,” Bardenhagen said. “They have numerous pests and diseases, different types of weather and combinations of conditions – it’s remarkably sophisticated. We’re helping them lay out their priorities in a visual manner, which gives us a better idea of what they’re most concerned about. And once they spend about five minutes on it, the farmers really enjoy the process.”

Howard hopes to use the information on how growers make complex decisions to inform a new online survey designed to deliver detailed information on kestrel nest boxes to growers and gauge their level of interest toward them as potential pest management solutions. That way, he says, the team can help connect growers with the resources they need to implement them.

Leelanau growers participating in the project are already reporting interest.

“We’ve gotten a lot of good feedback and cooperation from growers,” Shave said. “As we’ve expanded the project, new growers have been very interested and responsive about setting up boxes in their orchards. They tell me they often see kestrels flying over their property and believe the boxes are making a difference.”

Jim Nugent, president of the Michigan Tree Fruit Commission and owner of Sunblossom Orchards, a cherry orchard in Leelanau County, was an early adopter of kestrel nest boxes and has observed their benefits for many years.

“I’ve had a nesting pair of kestrels for many years now, and I just don’t have bird problems nearly as bad as I did before,” Nugent said. “I absolutely recommend them, especially for sweet cherry orchards. I always felt they were effective, but now, with the MSU study, we have data to back that up.”

#### MORE WORK AHEAD

The kestrel project is set to conclude in the summer of 2018, and though much has already been learned, Lindell, Shave, Howard, Bardenhagen and the rest of the team still have much more they hope to accomplish.

Chief among their remaining goals is finalizing the economic impact of using kestrels as a pest management tool. The team submitted their data to economists at the National Wildlife Research Center (NWRC), the research arm of the USDA Animal and Plant



**Upper left:** Catherine Lindell, Director of Graduate Studies; MSU Associate Professor of Integrative Biology

**Upper right:** An American kestrel

**Middle right:** Phil Howard, associate professor in the MSU Department of Community Sustainability, is working with Michigan farmers to assess whether kestrel nest boxes represent a potential solution to their pest management challenges.

**Below right:** Kestrel nest box

**Below left:** Lindell (left) and Shave open a kestrel nest box to inspect its contents. The nest boxes their team set up in Leelanau County showed a nearly 90 percent occupancy rate.

**Middle left:** Kestrel eggs



Health Inspection Service's Wildlife Services program. The NWRC's scientists focus on finding solutions to wildlife-caused damage across the spectrum of human activity, including agriculture.

In addition to measuring reductions in pest bird activity in orchards with active kestrel nest boxes, the team also estimated the volume of fruit removed from the orchards per minute by those birds.

"We were able to use that to figure out, when you have kestrels and thus fewer pest birds, how much fruit you could save with them in the field," Lindell explained. "We're in the process now of getting that data to our economist colleagues, who will translate that into actual financial savings."

While the economic data are analyzed, the team plans to continue testing nest box strategies by expanding into new crops and regions of the state. Last year, Lindell and Shave traveled to the blueberry farms of Van Buren and Allegan counties in southwestern Michigan, where they worked with growers to set up new nest boxes.

To date, these efforts have seen a slower increase in local kestrel populations than in Leelanau County, which Lindell and Shave attribute to a number of potential factors. These counties feature more heavily wooded terrain as opposed to the more open environs in which the kestrel prefers to hunt. Forestland favors the much more common eastern starling, which could be outcompeting the kestrel for the nest boxes. Van Buren and Allegan also do not have the same history of farmers using nest boxes that the team found in Leelanau County, which Lindell and Shave believe contributes to having a lower starting kestrel population in the region. Despite these challenges, the team is already seeing an approximately 33 percent occupancy rate.

"Kestrels are migratory birds, and Michigan is right on the border of their migratory area," Lindell said. "Looking at regions of the state that are farther



Catherine Lindell (right) and Megan Shave check on a kestrel nest box located in a cherry orchard on MSU's East Lansing campus. By monitoring nest boxes, the research team is able to determine what kestrels prey upon in an orchard.

south, closer to their year-round range, we might be able to make a larger impact in the long run."

#### CONSERVING BIRDS BY HELPING GROWERS

In 2012, the Peregrine Fund, a nonprofit organization working to improve the conservation of birds of prey around the world through research, launched the American Kestrel Partnership, a network of both professional and citizen scientists tasked with tracking and modeling kestrel populations around the entire Western Hemisphere. In so doing, the organization hopes to identify both the causes of kestrel decline and possible ways to reverse it.

As they explore the potential of kestrels as a pest management solution for fruit growers, Lindell's team members have submitted their data to the American

Kestrel Partnership to contribute to the conservation of the species.

"It's not just for scientists," Lindell noted. "Anyone interested in putting up a nest box can submit their data through an online tool."

For growers interested in setting up nest boxes, the team has learned a number of lessons for getting the most out of them.

Placing them in open areas away from encroaching woodland and spacing them half a mile from other boxes significantly increase the odds that kestrels will occupy them by reducing competition for shelter from forest-dwelling starlings and for hunting ground from other kestrels. When looking for the ideal location, it is also important to note that kestrels have been observed to thrive the most in mixed landscape environments, featuring both young and old orchards accompanied by pasture land. The team also cautions against the use of rodenticides during the time period when kestrels are active in the landscape because the poison can be transferred to the birds through their prey.

"I love the fact that these birds are already out there, doing things that are helpful to us," Lindell said. "If we can use nest boxes to better direct their activities and even enhance them, we can help them while they help us. We can help the birds, growers and, ultimately, consumers, all at the same time."

Being able to conserve a struggling species and help improve the operations of Michigan growers at the same time makes this a dream project for a scientist like Shave.

"Kestrels are beautiful, charismatic animals that people are immediately intrigued by and care about," Shave said. "This project has been a great example of how conservation and industry concerns don't have to be mutually exclusive. We've shown how both sides can become invested in the goals of the other. It's something that's worthwhile for everyone involved." ❖

## FROM THE OTHER GREAT LAKES: AROUND RWANDA'S COFFEE

LOCATED AT THE HEART OF AFRICA'S GREAT LAKES REGION JUST SOUTH OF THE EQUATOR, RWANDA HAS SOME OF THE WORLD'S MOST IDEAL GROWING CONDITIONS FOR COFFEE. IN FACT, COFFEE PRODUCTION HAS BEEN AT THE CORE OF FAMILY FARM LIVELIHOODS FOR GENERATIONS.

Today, coffee is the source of income for more than 355,000 households across the African country. The industry has seen an improvement in the quality of its wash processing system since 2001, which strengthened Rwanda's position as one of the best specialty coffee markets around the globe. The dry mills and export companies, both domestic and international, have similarly emerged during this period.

Though the added value from this transformation has benefited Rwanda's economy, those at the base — coffee growers — have benefited little. In fact, farmers are moving away from growing coffee.

A study conducted by the Feed the Future Innovation Lab for Food Security Policy (FSP) at Michigan State University examined the causes for decreasing numbers of coffee farmers in Rwanda. The results show that failing to include the farmers as full business partners has been the main reason for this decline over the past decades. Compensation for coffee growers is on average 24 percent below the revenues of other farmers in the region.

FSP findings show that the true cost of coffee production in Rwanda, including household and wage labor, inputs and equipment, is 177 RWF (22 cents) per kilogram, a figure well above the old reference used for establishing cherry floor prices of 80 RWF (10 cents) per kilogram. As a result, a large proportion of growers has unsustainably low margins or may even incur net losses, as was the case for over one-third of growers in 2015.

The study reveals that farmers would make more by working as agricultural wage laborers on other, more productive farms. Though taking good care of trees by pruning and weeding can increase yields, farmers have been neglecting and disinvesting in coffee trees because of poor compensation. This is particularly true of large-holder growers who can more easily change crops.

End-of-year premium payments provide some incentive to improve production, but only just over a quarter of coffee producers receive cash premiums. These are typically being paid by buyers for higher quality coffee and average about 8 percent. Even with such a small incentive, farms that receive premiums have an estimated 26 percent higher productivity than those that do not receive premiums. These findings demonstrate how sensitive farmers are to even small changes in remuneration and suggest possible policy changes to improve the equality of coffee growers. ❖



"A large proportion of growers has unsustainably low margins or may even incur net losses"

Photos: Ruth Ann Church, Rwanda, 2016  
Story: FSP African Great Lakes Coffee team



BROWN MARMORATED

# Stink bugs:

*Stemming the tide  
of an invasive pest*

IN 1998, RESIDENTS OF ALLENTOWN, PENNSYLVANIA, BEGAN TO NOTICE AN UNFAMILIAR INSECT LURKING IN THE SHADOWS OF THEIR HOMES AND GARDENS. THOUGH IT BORE A PASSING RESEMBLANCE TO A NUMBER OF STINK BUGS - WITH BROWN, MOTTLED COLORATION AND TRIANGULAR, SHIELD-SHAPED CARAPACE - THIS ONE HAD DISTINCTIVE DARK BANDS ON THE REAR OF ITS WINGS AND LIGHTER COLORED BANDS ON ITS ANTENNAE. ENTOMOLOGISTS NOW RECOGNIZE THIS AS THE BROWN MARMORATED STINK BUG - AN INVASIVE PEST NATIVE TO CHINA, JAPAN, TAIWAN AND THE KOREAN PENINSULA - WHICH POSES MAJOR THREATS TO CROPS AND INFESTS HOMES.



**Left**  
Paul Botch (right) and undergraduate Krista De Cooke examine samples in the federally certified BSL-2Ag quarantine/containment facility at Michigan State University.

**Right**  
Close up of a marmorated stink bug feeding on a carrot.

BY  
JAMES  
DAU,  
STAFF  
WRITER

Insects have ranked as one of the greatest challenges for farmers worldwide since the beginning of agriculture. Management methods have become increasingly sophisticated, including strategic insecticide sprays, natural predators and pest-resistant cultivars. At the same time, the pests have changed. In today's globalized economy, the threat of invasive pests, which local ecosystems have little natural ability to hold in check, is greater than ever.

## TRACKING THE INVASION

The brown marmorated stink bug probably arrived in the United States inadvertently as a stowaway in a shipping container that made landfall on the Atlantic coast. Entomologists estimate that this occurred several years prior to its first detection in 1998, and it has been slowly spreading west and north ever since. It's now been found in 43 states and four Canadian provinces.

In 2010, the stink bug was discovered in southwest Michigan's Berrien County, and as of last summer, it had spread to 59 counties spanning both peninsulas of the state. Julianna Wilson, tree fruit integrated pest management outreach specialist with the Michigan State University (MSU) Department of Entomology, has watched the spread of the stink bug in Michigan from the beginning.

"It's been a slow invader, creeping its way across the country since we first found it," said Wilson, co-author of the first brown marmorated stink bug management guide for Michigan growers. "They're good hitchhikers, so we have to keep an eye on where they pop up."

In 2015, Wilson sent a notice through MSU Extension asking that sightings of the invader in houses and offices be reported online. Sightings were entered at the Midwest Invasive Species Information Network (MISIN) website, a tool that collects user-submitted data on a wide variety of invasive species and displays it visually on a map. Since then, reports of the marmorated stink bug in the MISIN system have grown from just eight submissions in 2015 to more than 9,000.

The brown marmorated stink bug's coloration makes it difficult to identify, both because it renders it relatively similar to native stink bug species and it helps it blend into its surroundings.

"It's a really cryptic insect," Wilson said. "They're just a mottled brown that blends in almost perfectly with tree bark, and unless you get a close look at them, they look a lot like the kind of stink bugs that are supposed to be here."

To help apple and peach growers properly identify the pest, MSU Extension held a workshop in Grand Rapids, Michigan, early this summer. Experts were on hand to teach attendees about the distinctive characteristics of the bug.

With a grant from the U.S. Department of Agriculture (USDA) Specialty Crops Research Initiative (SCRI), Wilson and MSU AgBioResearch entomologist Larry Gut will use a statewide monitoring network to develop a biological model of the insect to better predict where and when it will become a problem for growers.

The SCRI project uses brown marmorated stink bug traps laced with pheromones, which attract the bugs to a sticky panel where they are collected. The traps are spread across orchards,

vineyards and vegetable plots at over 70 sites around Michigan. After making observations, the team will add data to that of similar teams across the nation to improve understanding of its behavior and distribution.

"In the short term, our monitoring work will help growers make decisions driven by scientific data," Wilson said. "In the long term, it will help us better understand how the insect operates and spreads around the country, and come up with more focused, specific solutions for managing it."

## DEFENDING FARMS

The greatest threat of the brown marmorated stink bug is damage to crops. Michigan, with 300 potential host plants for it to choose from, including approximately 100 crop and ornamental plants, is a significant attraction. In 2010 alone, the brown marmorated stink bug is estimated to have caused over \$37 million in damage to the apple industry across the mid-Atlantic, with some growers losing up to 60 percent of their crop.

Through a long, strawlike proboscis, the stink bug can penetrate the protective epidermal layer of even tough fruits such as apples and pears to feed on the juices inside. Though this causes nominal damage to the fruit, it creates entry points for bacteria, fungi and other insects, which cause the bulk of the damage much later.

"The damage from this pest often doesn't appear until three or four weeks after it feeds," Wilson said. "It can come and go and you wouldn't even know it was there until it was too late."

MSU AgBioResearch insect ecologist Ernest Delfosse,

professor emeritus in the MSU Department of Entomology, has spent the past five years developing methods to help Michigan farmers combat the brown marmorated stink bug.

"Since it targets such a wide range of crops, the brown marmorated stink bug affects a huge segment of agriculture in Michigan," Delfosse said. "Growers need to have tools to manage it, especially sustainable, long-term, low-input, low-cost methods."

Two management strategies are being developed to control brown marmorated stink bugs and protect crops. The first employs a series of traps with pheromone lures called ghost traps, which draw the pests away from crops and ensnare them in a net laced with insecticide. This effectively kills the bugs and has the potential to lower costs for farmers by reducing the need to spray insecticides directly on crops.

The shortcoming of this trap-and-kill strategy is that it fails to take proactive measures to reduce the overall population of the pest. Brown marmorated stink bugs venture into farm fields only during the day to feed - they retreat at night to the shelter of nearby tree canopies, where they also lay their eggs.

To strike the pest at its source, Delfosse and his lab have been exploring a second management option: biological control through natural predators.

"The population of brown marmorated stink bug is growing in Michigan, and we're on track for some major infestations," Delfosse said. "You can't spray all the trees in the forest, so you need something that attacks the eggs to really reduce their numbers."

To gather a better understanding of both the pest and its



**Upper left:**  
Close examination in federally certified BSL-2Ag quarantine/containment facility.

**Upper right:**  
MSU researcher Julianna Wilson checks a trap for the invasive pest, brown marmorated stink bug in a MSU fruit orchard.

**Middle right:**  
A brown marmorated stink bug

**Below: right**  
Larvae being observed in petri dish

**Below: left**  
Professor Emeritus Ernest “Del” Delfosse, Director of the department’s federally certified BSL-2Ag facility.

**Middle left:**  
Stink bugs on the tip of a carrot



potential weaknesses, scientists from the USDA traveled to eastern Asia, where they studied its life cycle to determine when it is most vulnerable and which natural predators attack at each stage. They discovered that a number of wasp species prey on the eggs of the insect. One of them, *Trissolcus japonicus* or the Samurai wasp, found throughout the brown marmorated stink bug’s native range, showed particular promise.

The Samurai wasp, a small, black insect measuring no more than 2 millimeters in length, is a parasitoid that reproduces exclusively by implanting its eggs in the eggs of brown marmorated stink bugs. Upon hatching, the wasp destroys its host. A female Samurai wasp carries 42 eggs, making her capable of wiping out entire stink bug egg masses.

Introducing new species always bring risks, so, to determine if the diminutive wasp would be effective at controlling brown marmorated stink bugs without causing additional damage to native ecosystems, Delfosse’s lab, through a grant from USDA’s Animal and Plant Health Inspection Service (APHIS), conducted host specificity testing.

The researchers exposed the eggs of brown marmorated stink bugs and 28 native stink bug species to the Samurai wasp under quarantine conditions to see whether the new wasps posed a threat to the native species.

“In classical biocontrol, like this, you want to reunite the pest with its key natural enemies,” Delfosse explained. “But you need to make sure you’re not introducing something that could become a new invasive pest in its own right.”

Ultimately, Delfosse’s team determined that the Samurai wasp posed too great a risk for a large-scale introduction into North America. They found that the wasp fed on 10 to 15 types of stink bugs, including the brown marmorated stink bug. The team prepared to move on to the next likeliest natural predator for testing.

Nature, however, apparently had other plans. As the team and their APHIS

colleagues were readying a new round of tests, reports came in from the USDA that Samurai wasps had appeared in fields in both the western and eastern United States. After genetic testing, USDA scientists determined they had not escaped the lab quarantines and had likely arrived in the same way their prey had years before, in shipping containers.

Delfosse’s lab has continued studying potential impacts in the wild through sentinel egg testing. This involves scientists depositing masses of stink bug eggs, both native and invasive, waiting until the wasps implant the eggs, then taking them back to the lab to see which species of wasps emerge. This will allow the team to track whether Samurai wasps have entered Michigan and whether native wasp species are now adapting to the presence of brown marmorated stink bugs.

“Since *Trissolcus japonicus* is already out there and moving, the only ethical thing to do is to evaluate it through more study,” Delfosse said. “We know from 150 years of classical biocontrol on everything from mites to weeds to mammals that sometimes environmental factors mediate the spread of natural predators, which can therefore mitigate the harm they might cause. We need to determine if that’s going to be the case. If it is, this has a very good chance of being a successful program.”

#### TROUBLE FOR HOMEOWNERS

Though the most concerning issue for Michigan is the danger to crops, the pest has also become a nuisance for homeowners around the state. In fact, homes are where the pest tends to appear first.

“A lot of the calls we get here at MSU are from homeowners,” Delfosse said. “Back east, where it’s been around a lot longer, we’ve seen as many as 20,000 individual bugs overwinter in a single house. People used snow shovels to get them out.”

**“IT WILL PROBABLY STILL BE A FEW YEARS BEFORE WE SEE THE NUMBERS THEY GET BACK EAST,” RUSSELL SAID. “BUT IT’S BETTER TO BE PREPARED NOW.”**

Most infestations fall well short of that mark, however. In the Lansing area, a house might have between a few dozen to a hundred stink bugs attempting to outlast the winter, but that number is expected to rise as the insect spreads.

Howard Russell, entomologist with MSU Diagnostic Services, points out that besieged homeowners already have multiple tactics at their disposal to expel these invaders.

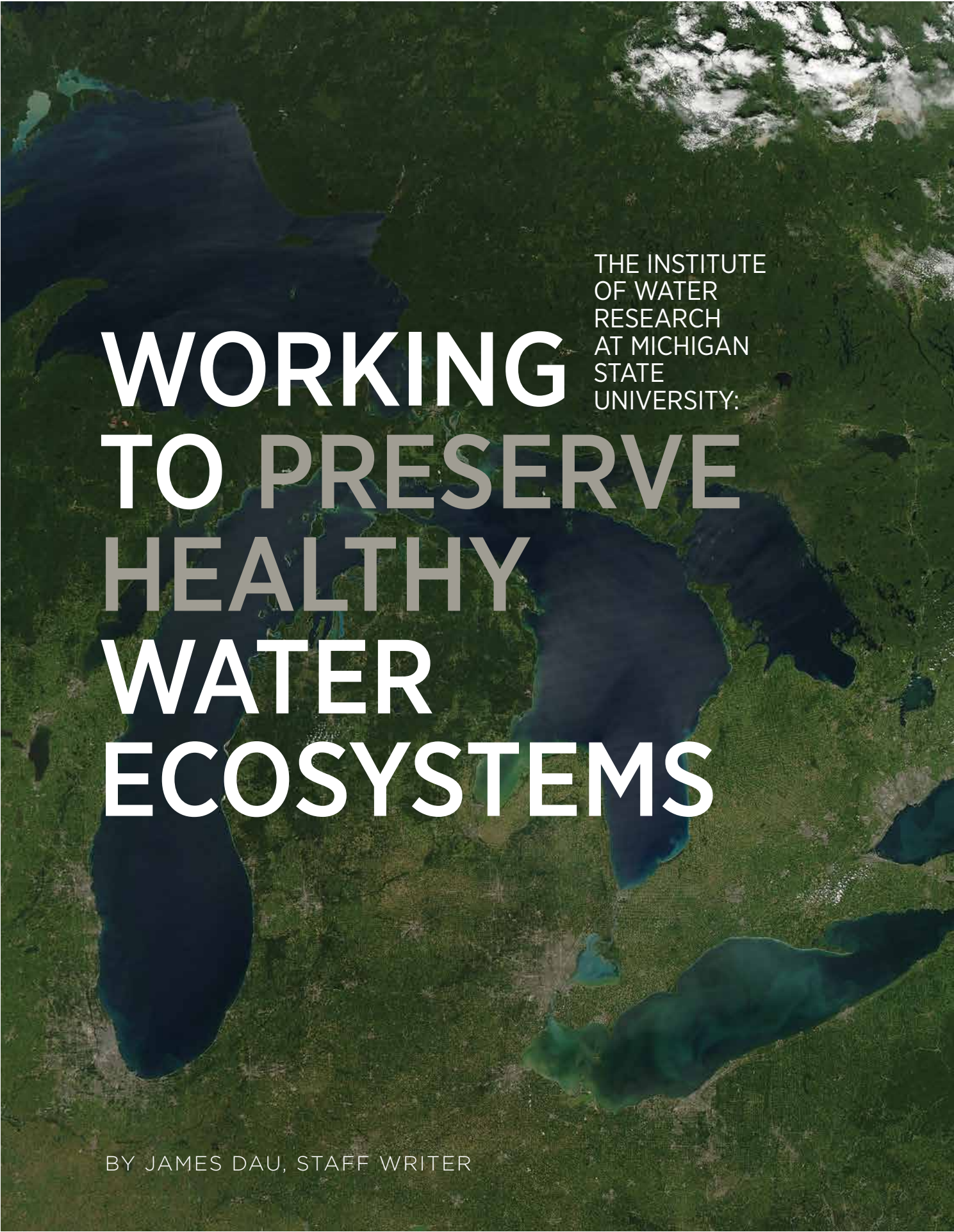
“Brown marmorated stink bugs generally seek shelter inside houses and other buildings in the fall,” Russell said. “While they aren’t known to bite people or pets or spread disease, they do produce a pungent odor that’s readily transferred.”

Though the insects can be removed by manual means, such as brooms or vacuums, Russell advocates taking more proactive measures to ensure long-term prevention.

Caulking or otherwise sealing cracks and other openings in the exterior of a building can be effective at reducing the number of entry avenues. This is significantly less effective in homes with vinyl siding, which is loosely attached to the walls so that it can expand and contract with temperature changes.

Applying insecticide sprays around the outside walls of homes in September and October, when the insects begin their inward migration, is another effective approach. And if all else fails, caulking indoors – around electrical outlets, ducts and ceiling lights – can at least confine the insects to the inside of the walls and keep them away from living spaces.

“It will probably still be a few years before we see the numbers they get back east,” Russell said. “But it’s better to be prepared now.” ❖



# WORKING TO PRESERVE HEALTHY WATER ECOSYSTEMS

THE INSTITUTE  
OF WATER  
RESEARCH  
AT MICHIGAN  
STATE  
UNIVERSITY:

BY JAMES DAU, STAFF WRITER

MICHIGAN, IN MANY WAYS, IS DEFINED BY WATER. THE STATE BOASTS 11,037 INLAND LAKES AND TENS OF THOUSANDS OF MILES OF RIVERS AND STREAMS, PROVIDING AT LEAST ONE BODY OF WATER EVERY 6 MILES. THEN THERE ARE THE GREAT LAKES, WHICH LITERALLY SHAPE THE STATE.

In addition to sustaining the state's lush natural ecosystems and residential communities, water is a critical source of irrigation for the more than 52,000 farms that call Michigan home. It also plays a central role in the state's \$18 billion outdoor recreation industry.

Fortunately, researchers with the Institute of Water Research (IWR) at Michigan State University (MSU) have devoted over a half century to protecting and ensuring the responsible use of Michigan waterways.

In 1964, President Lyndon B. Johnson signed the Water Resources Research Act, which authorized the establishment of an IWR in each state. It was mandated that the institutes solve problems and advance scientific knowledge about water resources across the country, as well as recruit and train more scientists in those areas.

Because of its land-grant mission, MSU was the natural home for Michigan's IWR, an effort supported by MSU AgBioResearch, MSU Extension and the U.S. Geological Survey (USGS).

When he joined the MSU Department of Community Sustainability (then the Department of Resource Development) in 1978, Jon Bartholic brought the skills in satellite imagery and water resource use he had gained while at the University of Florida. Initially tasked with setting up the center for remote sensing and geographic information systems (GIS), Bartholic was quickly named acting director of the IWR when the previous director left in 1981. Five years later, he became the director, and he has since guided the institute's efforts to ensure that Michigan's water resources remain both safe and useful.

"You need both healthy land and water resources for high-quality, sustainable food production," said Bartholic, professor in the MSU Department of Community Sustainability. "If we don't sustain them, we won't be able to optimize our capabilities to enhance the environment and the economy."

One of the key steps under Bartholic's leadership was to establish an advisory group to examine water resource issues with funding from the Great Lakes Protection Fund. The advisers allow the institute's work to be guided by a holistic understanding of the entire state.

Bartholic's early work with the remote sensing and GIS center led directly into what would become a new focus for the IWR. IWR scientists took statewide water quality data from digital databases and, using GIS software, overlaid it onto maps of the state. By laying the data out visually, the team was able



Jon Bartholic served as director of the Institute of Water Research at Michigan State University (MSU) for over three decades. By emphasizing the potential of cutting-edge information technology, Bartholic led the institute to develop tools that have helped Michigan's agricultural industries grow food safer and more efficiently.

to see water quality in the state change over time, particularly with respect to nitrate levels.

Nitrates – naturally occurring organic compounds found in air, water and soil – are made up primarily of nitrogen and oxygen. Though nitrates are harmless at natural levels, high nitrate concentrations in water present health risks, particularly for infants and pregnant women.

"We noticed nitrates, which aren't supposed to exceed 10 parts per million in a water sample, had been growing over time, especially in rural areas where people rely on wells for their water," Bartholic said. "Finding that pretty much set the stage for the next chapter."

#### **AN INFORMATION TECHNOLOGY APPROACH**

Elevated nitrate levels in well water often result from complications from the location and construction of wells, in addition to the presence of chemical fertilizers, septic systems, animal feedlots and industrial runoff, according to the Centers for Disease Control and Prevention.

Approximately 39 percent of Michigan's consumptive water – water that is not returned immediately to the environment – is used for agricultural irrigation, according to a 2015 Department of Environmental Quality (DEQ) report. Previously, ensuring that the wells capable of delivering such significant water quantities leave a minimal impact on the environment was a costly, time-consuming process that required extensive inspection and permitting.

To help water users, like farmers, place wells in locations that would limit risk factors and better preserve their water resources, IWR scientists, working in concert with the Michigan Department of Natural Resources (DNR), the DEQ and the USGS, developed the Water Assessment Tool. A web-based system, the Water Withdrawal Assessment Tool allows farmers to input data on their land and proposed well, such as distance to nearby streams, the depth of the soil to bedrock and the amount of water they aim to withdraw.

The program runs that data through a statistical model that estimates the impact of the well on the watershed, such as the amount of water it will withdraw or the risks to nearby rivers and streams, and on the basis of that calculation either begins the registration process or helps the user begin a more in-depth inspection process.

Jeremiah Asher, assistant director of the IWR, served as the lead technical developer of the tool.

“Putting down irrigation wells is a major investment, and this tool helps reduce the amount of permitting required for them,” said Asher, who also serves as IWR director of information and decision-support technologies. “It provides a quick screening mechanism that allows wells with minimum impact to go through quickly while beginning the inspection process for more challenging cases. It’s a way to be less onerous on water users while still managing our resources responsibly.”

The final version of the Water Withdrawal Assessment Tool went into use in 2009, and since then, it has served approximately 4,500 applicants. It remains unique in the Great Lakes region, and it allows farmers to apply for irrigation wells in minutes rather than over the course of days.

The Water Withdrawal Assessment Tool’s application of information technology, such as the GIS-derived landscape data upon which its statistical modeling is built, represents a significant



part of Bartholic’s guiding vision for the IWR.

“We’re in the information age now, and that allows us to find ways to better, more efficiently manage our resources,” Bartholic said. “These tools are powerful and can look at many different aspects of the landscape at once, and that lets us better manage water for food production into the future while maintaining the high-quality environment that’s so important to us in Michigan.”

### SERVING COMMUNITIES

Ensuring the long-term sustainability of Michigan’s water resources goes beyond the computer screen, however. For water conservation practices to be effective, they have to go beyond merely reducing pollution and preventing the overuse of water resources – they have to be practical for farmers. Few people have as detailed a knowledge of the landscape as the people who live on and actively work it, and cooperating with these local experts has become a crucial element of the IWR’s work.

Stephen Gasteyer, associate professor in the MSU Department of Sociology, worked closely with Bartholic and the IWR research team to understand how farmers view water conservation practices and help them make data-driven decisions.

“If you look at a map of pollution in a watershed map, you’ll see pollution isn’t evenly distributed,”

Gasteyer said. “Chemical runoff tends to be concentrated in very specific areas, and my efforts focus on identifying why these problem areas occur and ways we can help farmers reduce them.”

Though several government agencies and research groups were looking at various parts of this issue, Bartholic said none of them were approaching it holistically. With assistance from Gasteyer, Bartholic worked to change that.

After a year of discussions with Michigan farmers about water conservation, the IWR identified three issues:

- The majority of farmers are willing to make improvements to their landscape, including using best practices to reduce water withdrawal and chemical runoffs. Implementation, however, must make financial sense.
- A variety of best practices for water conservation are needed because the practice that works on one farm may not work on another mere miles away.
- More knowledge is needed on why a minority of farmers do not implement water conservation practices and ways to encourage them to do so.

In pursuit of these issues, Gasteyer and his team of graduate student researchers took to the field, visiting individual farms and holding community meetings to learn more about what practices were working. They wanted to know why some farmers were interested

in water conservation and why others were not. Their work focused on the River Raisin watershed in southeastern Michigan near the Ohio border, where the team had established contacts among both the agricultural and conservation communities.

“It’s all about communicating with farmers, one way or another,” Gasteyer said. “It’s about finding ways to build trust and understand one another, then finding ways you can both achieve your goals together.”

The team began their interviews in 2015 and will continue the project until 2018. Already, several trends have begun to emerge.

“It’s increasingly clear that farmers want to work with researchers to better their land, rather than have us or government agencies hand down edicts without a full understanding of their landscape,” Gasteyer said. “Most of them are really receptive and want to have an operation that’s as efficient and conservative as possible.”

### INTO THE FUTURE

This past spring, Bartholic retired after nearly 40 years at MSU. His work dramatically expanded the impact of the IWR on Michigan’s agricultural community, helping it continue to flourish while having new cutting-edge technology to better manage agricultural operations.

“Jon did a really amazing job looking at the big picture and challenging people to think differently about how we manage water,” Asher said. “He was always interested in technologies that could help people with agricultural production, with improving water quality, with bettering environmental health. He was also, as somebody to work with, a flexible and understanding person who helped you grow as a scientist.”

Darrell Donahue, professor and chairperson of the MSU Department of Biosystems and Agricultural Engineering, has now taken over as IWR director. Donahue hopes to continue to expand the scope of the IWR’s work, using the

technologies pioneered by Bartholic’s team to help even more people throughout the state.

“For the past 20 years, Jon’s team has done a fantastic job addressing water quality and runoff issues in agriculture,” Donahue said. “They developed great tools to help farmers and communities in both large and small watersheds, and they did it by talking with those communities and addressing their concerns directly. Now we have an opportunity to build that framework out.”

Donahue’s vision for the IWR is to expand its capabilities to address new water challenges in the state, such as the Flint water crisis and the water infrastructure issues that event brought to the forefront. Much of the water delivery infrastructure in Michigan and across the United States is between 50 and 100 years old, and the risk of new issues similar to those found in Flint continues to grow.

The IWR’s commitment to agriculture will remain unchanged, however.

“We already have the tools to help farmers improve their operations, and anything we can do to help them, we will,” Donahue said. “If we can help them deliver food in a more sustainable way, we’ll be helping fulfill the university’s land-grant mission.”

From Bartholic’s perspective, the work of the IWR has never been more important.

“As we see the world population going from seven billion to nine billion, we’re going to be putting more stress on our resources, especially water,” Bartholic said. “It’s critical that the institute and those like it around the country continue to bridge the gap between fundamental research and decision-making systems in order to provide practical solutions that help everyone.” ♦



Darrell Donahue succeeded Jon Bartholic as director of Institute of Water Research (IWR) at MSU this spring. Donahue sees the institute expanding from its strong foundation under Bartholic’s leadership to address Michigan’s water challenges in both agricultural and human health settings.



Jeremiah Asher serves as the director of information technology for the IWR at MSU. Asher spearheaded development of the Water Withdrawal Assessment Tool, an online resource that helps Michigan farmers improve their water resource use gauge the impact of new irrigation wells.



Stephen Gasteyer, associate professor in the MSU Department of Sociology, is helping ensure the work of IWR scientists aligns with the needs and concerns of Michigan farmers.

By Cameron Rudolph, Staff Writer

# A new frontier

**As agricultural technology advances, MSU researchers are examining progress through the lens of food safety**

**GROWING FOOD CROPS IS TOUGH. FROM CONSTANTLY FLUCTUATING TEMPERATURES AND WEATHER CONDITIONS TO INCREASINGLY DAMAGING PESTS AND PLANT DISEASES, THE ODDS ARE OFTEN STACKED AGAINST A PRODUCTIVE GROWING SEASON. ADD IN THE PRESSURE OF MEETING HEAVY MARKET DEMAND, AND YOU HAVE A RECIPE FOR ANXIETY.**

It's only natural that growers want to get out in front of these obstacles as much as possible, deploying the latest technology to ensure a profitable endeavor. And while farming is big business with big challenges, the key to greater effectiveness in the field may come from something only seen with a powerful microscope.

Nanotechnology has been a topic of conversation in the scientific sphere for decades, but only recently has it forayed into agriculture. It involves the manipulation of materials at the atomic and molecular levels to perform a desired task. Nanoparticles currently appear in cosmetics, clothing, paint and many other products for a variety of reasons, including their antimicrobial properties. The market value of nanotechnology products is expected to surpass \$4 trillion by 2018.

In agriculture, nanotechnology has been developed in the form of nanocapsules for application of both pesticides and fertilizers. Additionally, nanosensors monitor soil and plant health. Although not widespread in use

yet, agricultural nanotechnologies are on the cutting edge of innovation.

"This is really amazing technology that can be revolutionary for the agriculture industry," said Wei Zhang, an assistant professor in the Department of Plant, Soil and Microbial Sciences at Michigan State University (MSU). "But it doesn't come without questions or concerns. These are brand new technologies in some cases, and because they are becoming more pervasive, we need to learn more about them."

Zhang is leading an MSU research team studying engineered nanoparticles (ENPs) as an emerging environmental contaminant. As more products employ nanotechnology — particularly in agriculture — the concentration of ENPs released into the environment will increase. The researchers want to know what that means, especially for food safety.

## KEEPING FRESH PRODUCE SAFE

Zhang began studying nanotechnology during his postdoctoral research. A soil physicist, he focused on the movement of nanoparticles in soil and water environments. Upon arrival at the East Lansing campus, he soon became acquainted with the university's world-renowned plant science community.

"I got to know some of the leading minds in plant science, and I learned that they were interested in nanotechnology and its agricultural applications," Zhang said. "After some discussion, a group of us came to the conclusion that food safety would be important.

We want to understand how ENPs enter the environment and how they are taken in by the plants, but we also need to determine the human health consequences that may come from that."

Each of the team members assembled by Zhang is a highly respected researcher who brings knowledge in a different area: Sheng Yang He, an MSU University Distinguished Professor and plant pathologist; Hui Li, an associate professor and soil chemist; and Elliot Ryser, a professor and food safety expert. In 2013, they received funding from MSU Project GREEN (Generating Research and Extension to meet Economic and Environmental Needs). On the basis of preliminary research data from the first year, they applied for funding from the U.S. Department of Agriculture (USDA) National Institute of Food and Agriculture (NIFA). The Agriculture and Food Research Initiative's Foundational Program within NIFA cites food safety as one of its priorities.

Unsuccessful in obtaining grant funding in 2014 and 2015, the team kept working to strengthen the proposal. They sought further funding and were eventually awarded a grant from the Discretionary Funding Initiative through the MSU Office of the Vice President for Research and Graduate Studies.

"The seed funding from MSU was crucial to putting together the best possible proposal," Zhang said. "It was a rigorous application process, but in 2016 we finally secured USDA funding."

Nearly \$500,000 was awarded to the researchers for a three-year project that began in June 2017. The team is

*Determining the optimal washing conditions for fresh produce is vital to ensuring food safety. These tests take place in the lab of Elliot Ryser, a professor in the MSU Department of Food Science and Human Nutrition.*





MSU soil physicist Wei Zhang leads a team of researchers studying engineered nanoparticles as an emerging contaminant on fresh produce.

conducting tests in three phases on lettuce, tomato and spinach.

“Fresh produce is the best option for our project because it’s minimally processed prior to being consumed,” Zhang said. “Many people want as little processing as possible for fruits and vegetables, but with that would come a higher likelihood of ENPs remaining in the product if it’s treated in the field with nanopesticides.”

The first step is to test the sorption of ENPs by the plants under various scenarios, such as nanopesticide application or irrigation with ENP-containing water. Understanding the interaction between the plant and ENPs will give researchers clues for developing effective remediation strategies. Several projects investigating nanotechnology have delved into the uptake of ENPs through plant roots. Very few, however, have studied the role of stomata, the tiny pores in plant leaves that allow for respiration.

“The stomata can be quite large relative to ENPs,” Zhang said. “Stomata may be a few microns in diameter, whereas the nanoparticles may be just a couple hundred nanometers. Since 1,000

nanometers equals one micron, it’s not hard to see how the ENPs could enter through that pathway.”

In stage two, the team will evaluate how a series of different food processing washing conditions affect the ability of the plants to soak up ENPs. The outcomes may differ depending on the temperature or the type of sanitizer used.

Finally, after researchers pinpoint the optimum wash water composition, the produce will be cleaned in a processing line where the team will measure the removal of ENPs. This step will ideally allow the group to make food processing recommendations.

“We are in the stage of gathering information,” Zhang said. “Once we get a good idea as to the concentration of ENPs in the plants, we can begin to quantify the potential risks. But it’s important to understand the scale we’re talking about when we refer to nanotechnology. Just because something is present doesn’t mean it’s automatically harmful. That’s why we need to perform risk assessments. This technology has great potential, and it’s our duty to use it responsibly.”

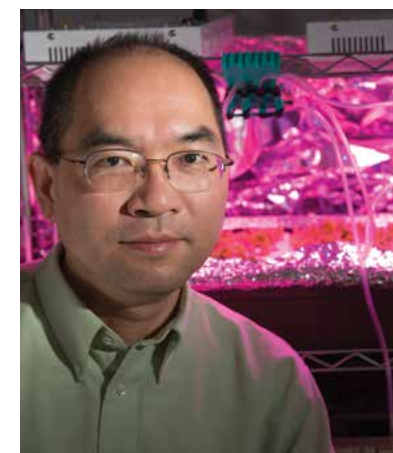
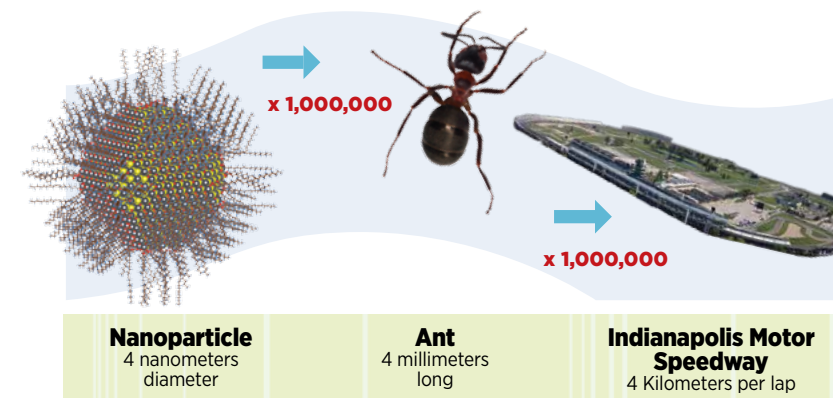
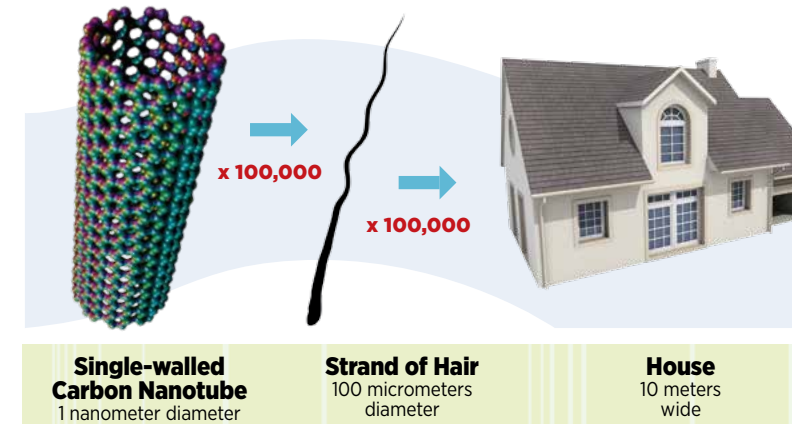
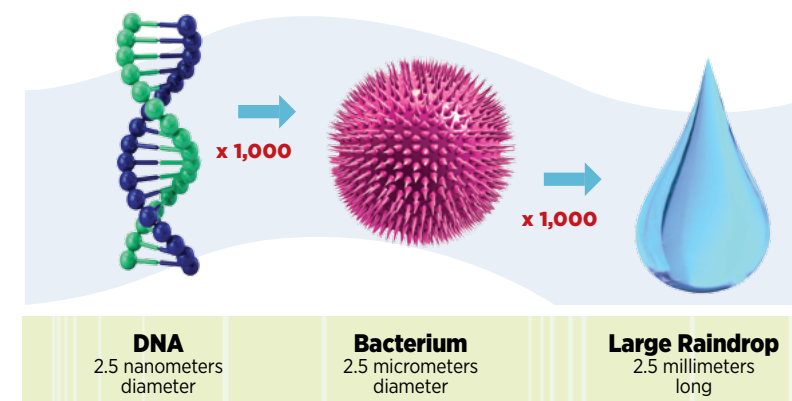
### LEVERAGING MSU’S TOXICOLOGY EXPERTISE

MSU is home to a plethora of accomplished food safety and toxicology researchers. To further capitalize on that, university leadership established the Center for Research on Ingredient Safety (CRIS) in 2014.

Michael Holsapple, the CRIS director, has held various positions within academia and the toxicology industry throughout his 30-plus year career.

“MSU is uniquely equipped to offer a powerful voice to the food safety conversation,” said Holsapple, who is also the endowed chair for CRIS. “CRIS can identify the most pressing issues associated with ingredient safety. Because CRIS operates as an independent academic center, we are committed to providing the public with a science-based, unbiased source for information to enable evidence-based decision making.”

CRIS is working in collaboration with more than 20 food, beverage and personal care product organizations, as well as the Grocery Manufacturers Association, on issues such as



MSU professor of Plant, Soil and Microbial Sciences, Hui Li.



Sheng Yang He, an MSU University Distinguished Professor and plant pathologist

nanotechnology and its impact on food safety. The focus of CRIS is founded in research, communications and training.

“Much more research is needed to determine the effect on human health of nanomaterials in food,” Holsapple said. “For any technology, we must ensure public safety and improve public discourse about the safe use of such materials in our food supply. That’s why communications is a vital aspect of CRIS. Through research and communications, we can provide insights about both the risks and the benefits of applying nanotechnology to agriculture.

“A good starting point is to recognize that there is already broad consensus that the total amount of pesticides sprayed on agricultural fields could be significantly reduced through the application of nanoparticles. However, while the size of nanoparticles can make them more efficient, it can also make them more unpredictable. We look forward to working with Dr. Zhang and colleagues to better understand the effects of ENPs on the environment and human health.”

Outside of nanotechnology, CRIS currently funds one research project in which three MSU scientists are studying the interaction of dietary fibers, gut bacteria and gastrointestinal health. The faculty members are Sudin Bhattacharya, an assistant professor in the Department of Biomedical Engineering, Pharmacology and Toxicology; Sarah Comstock, an assistant professor in the Department of Food Science and Human Nutrition; and Adam Moeser, an associate professor and the Matilda R. Wilson Endowed Chair in the Department of Large Animal Clinical Sciences. The project began in January 2017.

In addition, CRIS offers a graduate program for students in Environmental and Integrative Toxicological Sciences. This new educational focus area includes food and ingredient safety and takes advantage of several courses already available at MSU.

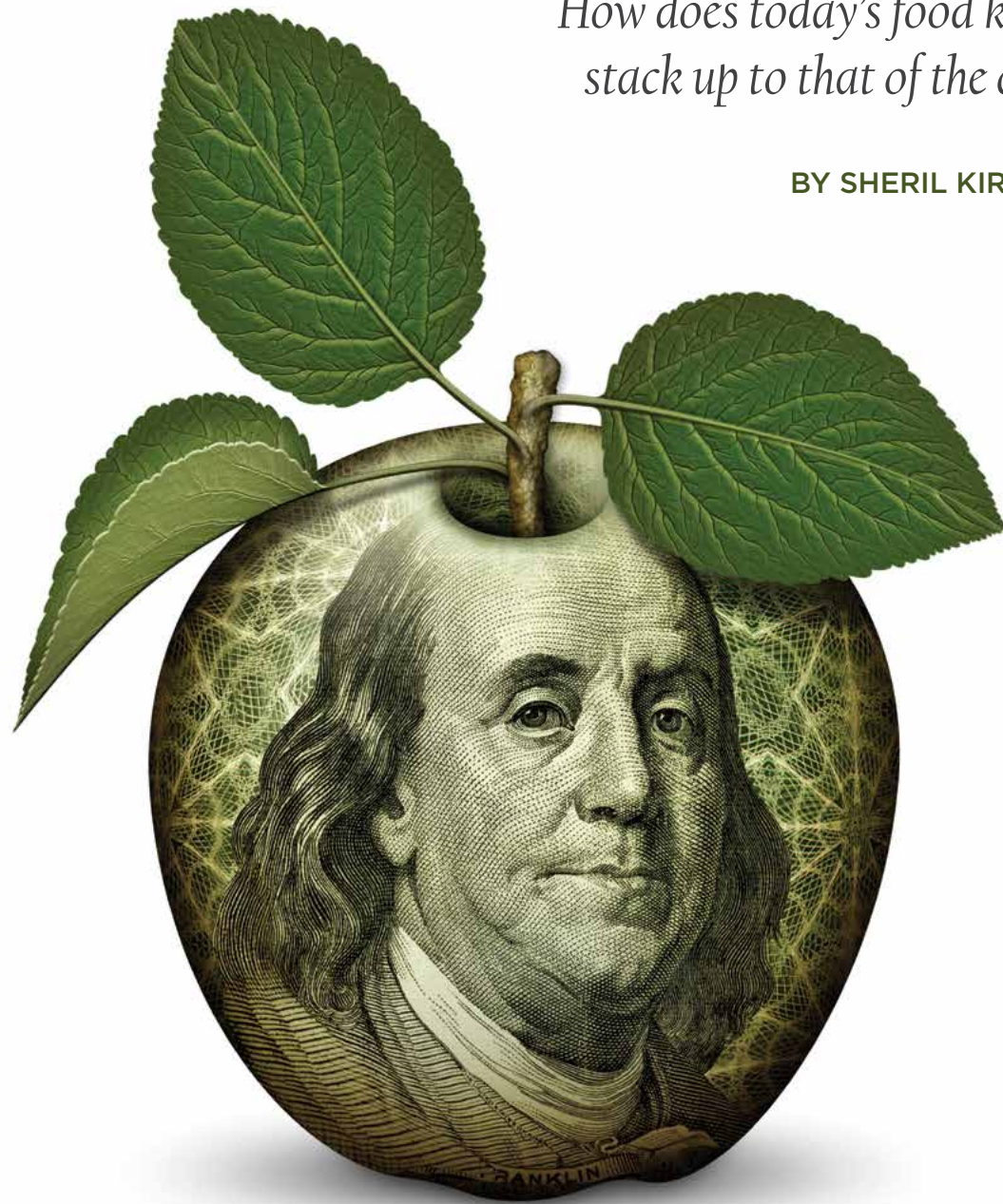
“A critical part of CRIS is training new scientists,” Holsapple said. “These students are the future of food safety and toxicology research. They will help to set the direction of the food industry and act as advocates for consumer safety and well-being. It’s an important task, and we think that MSU has the opportunity to be at the head of the table.”

For more information on CRIS, visit [cris.msu.edu](http://cris.msu.edu). ♦

# BENJAMIN FRANKLIN: AN ORIGINAL LOCAVORE

*How does today's food knowledge  
stack up to that of the colonists?*

BY SHERIL KIRSHENBAUM



**BENJAMIN FRANKLIN REALLY LOVED FOOD. HE ADVOCATED IN FAVOR OF AMERICAN PRODUCE AS A WAY TO LIMIT FOREIGN IMPORTS TO THE COLONIES. TAKING THINGS A STEP FURTHER, HE INSTRUCTED HIS WIFE, DEBORAH, TO SHIP BARRELS OF APPLES AND CRANBERRIES ALL THE WAY FROM HOME TO HIM IN EUROPE—NO SMALL TASK IN THE 1700s.**

For Franklin, food was inherently tied to patriotism and upon encountering negative opinions of the colonial cuisine in London, he took the time to compose a long treatise extolling the virtues of New World food. In my favorite line of the treatise, he praises Indian corn as “one of the most agreeable and wholesome grains in the world...a delicacy beyond expression.” His influence on international palates extended to France, where he helped to popularize potatoes – a potential solution to farming challenges – by inspiring a banquet at Les Invalides where tubers were served in every dish – dessert included. It worked so well that years later, the French extolled potatoes as a “revolutionary food.” While we celebrate Benjamin Franklin as a diplomat, inventor, scientist, musician and political theorist, he should also be recognized as America’s Founding Foodie.

Franklin did his best to understand food during his lifetime, but it was difficult to find reliable information about what to eat. He was keenly interested in where food came from, how it was prepared and the ways it could influence his health. He tried various diets, becoming a vegetarian for extended periods after reading as a teenager that this “promoted clearness of ideas and quickness of thought.” He also wrote down recipes in detail while offering advice such as “Squeamish stomachs cannot eat without pickles.” Lacking the Internet and modern medicine to guide them, colonists relied on word of mouth and cultural norms to dictate dietary preferences and habits.

Centuries later, we can sort through endless information about our food online. Cooking shows and competitions abound, and new tools and technologies provide opportunities to explore ingredients in ways even Franklin could not have imagined. A proliferation of news sources provides ongoing commentary on what we should eat and how we prepare it. Despite all of this, our 21st century understanding of food may not be much better than American colonists – we are arguably more confused than ever.

Advertisements and books bombard us with so many conflicting recommendations, misinformation and pseudoscience that it’s difficult to figure out whom to trust and where to find clear and accurate guidelines about how to eat. Diets blink in and out of fashion as our waistlines shrink and more often, expand to accommodate them.

In 2017, the American landscape is saturated with information, but it often lacks substance and credibility. The media alternatively celebrates and demonizes food staples such as butter, coffee and chocolate, flipping fast enough to give anyone paying attention whiplash. Celebrities regularly tout purported health benefits of sponsored products and eating plans, and our friends have become multi-level marketers on Facebook and Instagram, selling miracle shakes and supplements that claim to boost health and performance.

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AS FRANKLIN SMARTLY RECOMMENDED, BY  
INVESTING IN SHARED KNOWLEDGE – WE WILL  
BE ABLE TO PROMOTE A REAL CONVERSATION  
IN THE BEST INTEREST OF EVERYONE.

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And then there are labels. So many labels. From breakfast cereal to baby formula, labels tell us if a product is organic, artificially flavored, fair-trade, locally-sourced, free-range, genetically modified, farm-to-table, whole grain or gluten-free. Meanwhile the list of ingredients frequently reads more like a high school chemistry assignment than something we might recognize on a farm. On top of that, some of these terms have inconsistent meanings so it’s nearly impossible to parse what we need to know from the noise. By the time a consumer gets to the small print about allergens, he’s exhausted before he even opens the container.

That’s all prior to considering what’s best for our planet. As the global population continues to soar toward 9 billion by 2050, how will we increase food production to meet demand while decreasing the need for water and fertilizer in the face of a changing world? And with domestic energy challenges in mind, can we cut back on food waste? (We never consume nearly half of the food produced in the United States.) Identifying solutions feels like a lot to swallow.

But back to Benjamin Franklin. This connoisseur of fine cuisine and internationally recognized problem solver once wrote, “An investment in knowledge pays the best interest.”

In the case of what we eat, that means working to improve food literacy so each of us will be able to make more informed decisions. With that in mind, Michigan State University will bring all voices – scientists, farmers, industry experts, chefs and laypeople – to the same table to foster dialogue and mutual understanding. As Franklin smartly recommended, by investing in shared knowledge – we will be able to promote a real conversation in the best interest of everyone. ❖

# A continental contradiction:

## ADDRESSING THE DOUBLE BURDEN OF STUNTING AND OBESITY IN AFRICA

*Political unrest and economic instability have long plagued Africa, making the continent nearly synonymous with poverty. Today, Africa contains 75 percent of the world's poorest countries.*

According to the World Bank Group's latest data, more than 40 percent of people in sub-Saharan Africa live in extreme poverty, surviving on less than \$1.25 per day. For many, access to food is still uncertain, and UNICEF indicates that one in three stunted children worldwide reside on the continent. Poor nutrition can result not only in physical stunting but cognitive impairment as well.

The past two decades, however, have seen momentous change. Urban areas ballooned, and after a long stagnation or decline, per capita incomes finally began to rise. This resulted in some of the most rapidly

growing economies in the world. More stable governments and investment in the region point to progress, despite continued challenges for some.

David Tschirley, a professor in the Department of Agricultural, Food and Resource Economics (AFRE) at Michigan State University (MSU), is studying the economic changes taking place and how they are altering traditional African diets. This transformation has left those who have navigated their way up the economic ladder facing a seemingly unfathomable obstacle: obesity.

"When we think of Africa and food, we often think of people not consuming enough calories," Tschirley said. "Africa's double burden of malnutrition refers to the simultaneous struggle to ensure sufficient consumption for many while avoiding rapid growth in obesity and all the problems it brings, such as heart disease, diabetes and hypertension."

Tschirley explained that access to animal protein and processed foods has climbed dramatically as incomes have risen.

"There are still the major problems of malnutrition and food insecurity," Tschirley said. "But as many people acquire greater purchasing power,

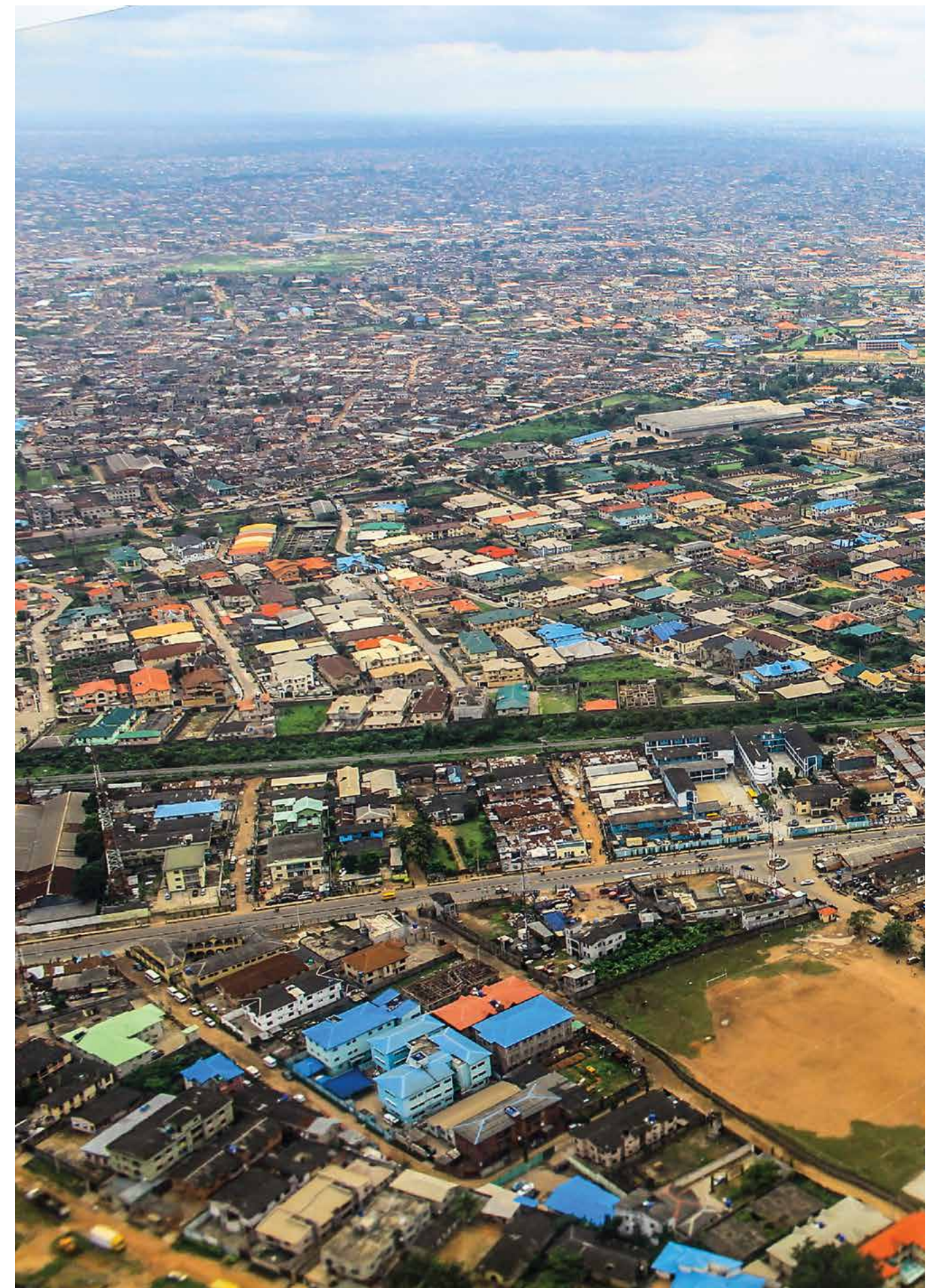
they are demanding food that is more processed, more packaged, more adapted to their lives. There are a plethora of elements at play, and that's one of the things we're looking at through our work."

### A CHANGING LANDSCAPE

For more than 30 years, researchers in the MSU Food Security Group within AFRE have been conducting field work in Africa. They are collecting and analyzing household expenditure data and monitoring the spending trends for families in countries such as Ethiopia, Malawi, Mozambique, Nigeria, Tanzania and several others.

Roughly five years ago, Tschirley began examining the changes in African diets with AFRE colleagues Thomas Reardon and Saweda Liverpool-Tasie. The research functions with support from the Feed the Future Innovation Lab for Food Security Policy (FSP) at MSU. The FSP lab is funded by the U.S. Agency for International Development and seeks to promote the growth of agrifood systems through policy influence in developing countries.

Tschirley and his team didn't initially approach the work from a nutrition angle. Instead, they focused on







how changing consumer behavior was creating opportunities and challenges in the supply chain.

“I think we’re taking an innovative approach to the situation, and MSU is really on the frontlines of dealing with this topic,” Tschirley said. “We’re approaching this from the perspective of asking questions. What do consumers want to eat? How do they want to obtain this food? What opportunities are these changes creating for local entrepreneurs, especially in food marketing and processing? The answers to these questions are important because this is what is shaping the agrifood industries in Africa.”

Tschirley emphasizes that Africa’s diet transformation is not occurring exclusively in cities, nor is it limited to middle- or upper-income people. He characterizes the evolution in three ways: Foods are becoming more purchased, perishable and processed.

Data gathered by the research team suggests that 50 percent of food in rural areas is now purchased, rather than grown for consumption by the consumer. Increasingly, what is purchased is not traditional grains such as corn and rice but processed foods such as maize meal, bread and even snack foods. This also includes perishable foods such as meat, dairy and fresh produce. In fact, 50 to 65 percent of all food in urban and rural locations is processed. When it comes to purchased food, that figure vaults to nearly 80 percent.

“Snack foods are now ubiquitous in African cities, and not just in supermarkets,” Tschirley said. “Whether locally made ‘corn puffs’ in markets of Lilongwe, Malawi, or potato chips being sold by young men patrolling the streets of Maputo, Mozambique, you find them everywhere now. I’ve observed these foods being purchased by low-income people as snacks for children. They are loaded with fats and salt. That tells me that these foods are really making inroads, and we need to make healthier options available and affordable.”

Though not all processed foods are bad, Tschirley is quick to point out that the nutritional aspects of these options need to be further inspected. Additionally he said that countries are currently ill-equipped to manage the market demands, not only from a policy perspective but also because of a lack of modern physical infrastructure.

“We think there are massive opportunities for agribusinesses to bridge the gap between supply and demand,” Tschirley said. “The question is whether it will be through foods being imported or whether local businesses can compete. Local businesses mean more food for more people — and more job opportunities. We need to work with people, businesses and governments to help foster an environment that offers healthy foods at a reasonable price for an evolving market.”

Food safety is also a mounting concern in the promotion of local businesses. Regulations need to be put in place to ensure that food is being produced using appropriate quality and safety standards. This will also build public trust in the agrifood system, Tschirley noted. But it is important that these regulations not be so burdensome that they force small businesses — which are largely run by individuals still considered poor — out of the market.

“Food quality and safety are critical, but governments are still primarily concerned about not having enough food throughout Africa,” Tschirley said. “They are still focusing most of their efforts on assuring sufficient production of staple foods such as corn, rice and cassava. But through some of our efforts, along with many others, awareness of these diet issues is growing.”

“Countries in Latin America have gone through this process already, and they have some of the highest obesity rates in the world today. We’re trying to work with our partners to get out in front of it in Africa and ideally help to avoid some of the pitfalls that historically come along with economic growth.” ❖



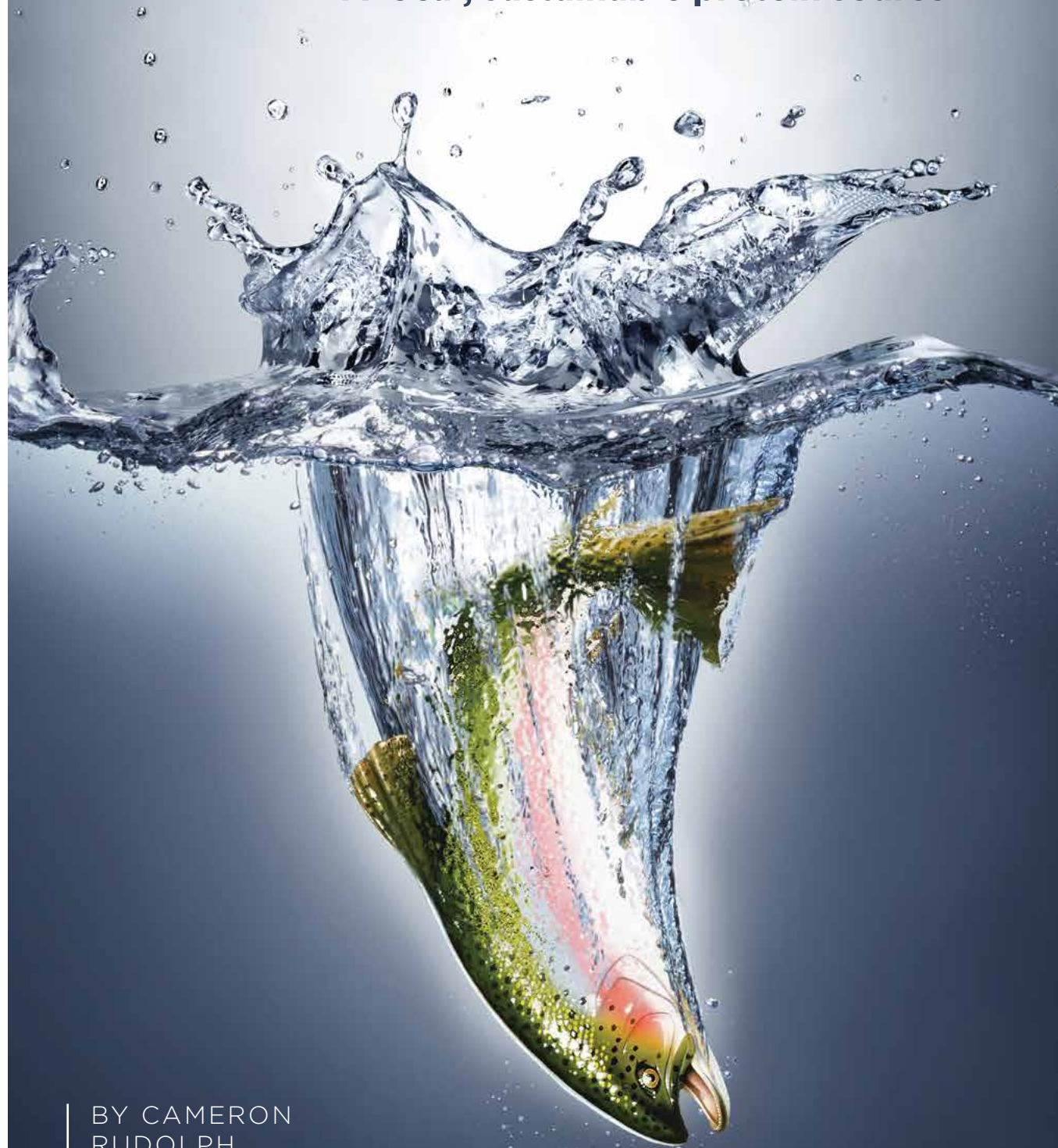
**Top:** David Tschirley, Bob Myers, Andrew Kizito (Ugandan national with PhD from MSU, now in Uganda), and a maize mill owner in Uganda  
**Middle and bottom:** Typical fast food street signage and store interior.



David Tschirley, a professor in the MSU Department of Agricultural, Food and Resources Economics, is examining the changing of African diets as a result of economic growth.

# Aquaculture:

A local, sustainable protein source



BY CAMERON  
RUDOLPH,  
STAFF WRITER

DESPITE ITS CLOSE PROXIMITY TO THE GREAT LAKES, WHICH CONTAIN MORE THAN 20 PERCENT OF THE WORLD'S SURFACE FRESH WATER, MICHIGAN IMPORTS 90 PERCENT OF ITS SEAFOOD.

In total, the United States has a nearly \$12 billion seafood trade deficit, according to the National Oceanic and Atmospheric Administration (NOAA). The only industry with a larger trade deficit is oil.

And much of that seafood comes from countries that lack rigorous regulatory systems and food safety standards.

To lessen U.S. dependence on foreign sources, the aquaculture industry is responding with an effort to expand around the country. But it has a long way to go to meet the swelling demand. Currently, only 5 to 7 percent of U.S.-consumed seafood is raised through American aquaculture.

Elliot Nelson, a Michigan State University (MSU) Extension and

Michigan Sea Grant educator in the eastern Upper Peninsula, views this as the perfect time to increase awareness of the impact that aquaculture could have on the state and the country.

"The world population is growing, and that is requiring us to produce more food," Nelson said. "Significant attention should be placed on identifying sustainable sources of healthy food, and aquaculture can be one of the answers. It's one of the more efficient agricultural processes for protein-based foods."

For example, NOAA data indicate that it takes 1.2 pounds of feed to yield 1 pound of salmon. This is significantly lower than the ratios for most animal proteins.

"Traditional wild fisheries are performing close to maximum capacity

and have been for decades," said Ronald Kinnunen, an MSU Extension and Michigan Sea Grant senior educator in the western Upper Peninsula. "If we want a more sustainable source of seafood, we will need to expand aquaculture. More than half of the seafood in the world is produced in aquaculture systems, but the U.S. is lagging behind in this regard."

With seafood demand at an all-time high, why hasn't the popularity of aquaculture skyrocketed, especially in Michigan? The answer lies in a convoluted, sometimes controversial, regulatory situation.

## WHAT IS AQUACULTURE?

Aquaculture refers to breeding, developing and harvesting both animals and plants in controlled systems that use fresh water or saltwater, depending on the aquatic species grown. Clams, mussels, oysters, salmon and shrimp constitute the bulk of U.S. aquaculture, but the industry is looking to expand into other species. Trout is a popular fish in Michigan operations.



Ron Kinnunen - senior educator through MSU Extension and Michigan Sea Grant



**Top:** Elliot Nelson - educator through MSU Extension and Michigan Sea Grant  
**Second:** Barbara Evans, a professor of biology at Lake Superior State University, speaks to a group of students. She is working with Nelson to provide educational opportunities around Michigan for young people to learn about aquaculture systems.  
**Bottom:** Student aquaponics system



Although there are multiple production methods, net-pen aquaculture — in which an underwater pen placed in an inland lake or coastal waters serves as home to a fish population raised for food purposes — has caused controversy in Michigan. This practice is common internationally and in some areas of the U.S.

The chief criticism is that net pens allow for an unfettered exchange of nutrients inside and outside of the pen. The amount of waste generated by the netted fish population, opponents argue, is unsafe for local ecosystems.

Angling groups have been particularly vocal in their resistance to net penning. They say it disrupts the environment for native populations in historically fertile fishing waterways.

Net-pen aquaculture is currently prohibited in Michigan, but producers are utilizing the technique on the Canadian side of Lake Huron.

“Fisheries and Oceans Canada has performed a five-year study on net-pen operations in Lake Huron, and the study found the risk to the environment to be low,” Kinnunen said. “We would like to conduct research in Michigan to test these findings, but it’s a complicated policy world right now with this topic. It’s also important to remember that there are other types of aquaculture that we can utilize currently.”

Other aquaculture options include recirculating, flow-through and aquaponics processes. Interested parties from around the state — including current and potential producers, students, teachers, and more — can attend workshops led by Kinnunen and Nelson.

At the K-12 level, Nelson has partnered with Lake Superior State University to educate students and teachers on various aquaculture approaches, particularly aquaponics. In these systems, fish are housed in a tank. The water from the tank is fed into a hydroponic setup, where plants absorb fish waste as nutrients. This purifies the water, which is then circulated back into the tank.

“Aquaponics is a great teaching tool to talk about topics such as the nitrogen cycle,” Nelson said. “Our school groups participate in an aquaculture competition, the Aquaculture Challenge. We had 10 groups this year. It gets kids interested in the science behind aquaculture, and although aquaponics operations can be complex, some of these kids might help us build useable models for implementing this technology on a large scale.”

Nelson is also collaborating with community colleges to develop curriculum for students who want to learn more about the technology and biology behind aquaculture. An internship program has been established that provides students with opportunities to work in aquaculture facilities and learn entrepreneurial skills to start their own operations.

Kinnunen created a Seafood Hazard Analysis Critical Control Point training program for the Great Lakes region. During these sessions, he instructs policy makers, industry professionals and other stakeholders on food safety hazards and how to mitigate them.

The U.S. Food and Drug Administration requires processors to keep tabs on aspects of food safety including sanitation, handling, storing and packaging. Those looking to enter aquaculture need a strong understanding of these mandates.

“Aquaculture is an industry with a tremendous amount of potential in Michigan,” Nelson said. “I usually talk to skeptical people about the amount of seafood being imported, and that wild fisheries are maxed out.

“We are being sensitive to environmental impact and continue to look at ways to improve our methodology. The bottom line is that if we want a safe supply of seafood that we know is sustainable and regulated, we need to learn more about the best ways to expand the industry here.” ❖



MONTMORENCY

# CHERRY recipes

## CHERRY PROTEIN BOWL

### DIRECTIONS

In a small, dry skillet over medium heat, toast the almonds and cashews until browned and fragrant, stirring often, about 3 to 5 minutes.

Mix the Greek yogurt with the maple syrup and vanilla extract.

Roughly chop the cherries and apricots.

Place the yogurt in a bowl, then sprinkle with all toppings (get creative!).

Recipe courtesy of Sonja Overhiser, [acouplecooks.com](http://acouplecooks.com)

*Photo reprinted with permission from the Cherry Marketing Institute'*

- PICTURED ON PREVIOUS PAGE

### SUMMARY

Total Time: 10 minutes

Prep: 10 minutes

Cook: N/A

Yield: 1 serving

Level: Intermediate

### INGREDIENTS

- 2 tablespoons slivered almonds
- 2 tablespoons cashew halves
- 1 cup Greek yogurt
- 1/2 to 1 tablespoon maple syrup or honey, to taste
- 1/2 teaspoon vanilla extract
- 2 to 3 tablespoons dried Montmorency tart cherries
- 2 to 3 dried apricots
- 2 tablespoons pepitas
- 1 teaspoon chia seeds
- 1 sprinkle of bee pollen, optional

## MONTMORENCY CHERRY PINEAPPLE SALSA

### DIRECTIONS

Mix all ingredients together in a medium bowl until well combined. Serve with tortilla chips or baby gem lettuce leaves.

Recipe courtesy of Emily Caruso, [JellyToastBlog.com](http://JellyToastBlog.com)

*Photo (opposite page) reprinted with permission from the Cherry Marketing Institute*

### SUMMARY

Total Time: 15 minutes + thawing time

Prep: 15 minutes

Cook: N/A

Yield: 3 cups

Level: Beginner

### INGREDIENTS

- 2 cups frozen Montmorency tart cherries, thawed and chopped
- 1 cup fresh pineapple, diced
- 1 jalapeno pepper, minced, seeds and ribs removed for less heat
- juice of one lime
- 1/3 cup cilantro, chopped
- salt to taste
- tortilla chips for serving
- baby gem lettuce leaves for serving



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## Facility Focus: The Trevor Nichols Research Center

6237 124th Avenue, Fennville, MI 49408  
Phone: 269-561-5040  
Established 1967. Size: 156 acres.

Situated just a few miles from the beautiful shores of Lake Michigan, Trevor Nichols Research Center primarily focuses on discovering new ways to keep fruit pest-free, while preserving the environment and ensuring economic viability for the state's fruit growers.

Research priorities include pesticide efficacy trials and effective delivery systems for crop protection materials, as well as controlling and monitoring native and invasive pests. Much attention has been devoted in recent years to the increased population of spotted wing drosophila, a small fly that has cost growers of soft-fleshed fruit millions since its emergence in Michigan in 2010.

“At Trevor Nichols Research Center, we strive to provide vital research and services to Michigan’s specialty crop industries that help preserve the highest standards of food safety and environmental quality,” said John Wise, the TNRC center coordinator. “We are actively delivering creative solutions to the pest management challenges of the 21st century.”

The center also supports Interregional Research Project No. 4 (IR-4), a U.S. Department of Agriculture (USDA) research initiative that began in 1963 in an effort to register pest control products for use on specialty crops. IR-4 is a collaboration among the USDA, researchers and growers — working with the Environmental Protection Agency.

**For more information on the TNRC, please visit [canr.msu.edu/tnrc](http://canr.msu.edu/tnrc).**

