

# FUTURES

AGBIORESEARCH • MICHIGAN STATE UNIVERSITY  
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## MSU Global Water Initiative



*Making a splash in Michigan  
and beyond*

## MSU GLOBAL WATER INITIATIVE Making a splash in Michigan and beyond

Home to 20 percent of the world's fresh water, the Great Lakes region is awash with research opportunities for Michigan State University (MSU) scientists and researchers from around the world. With the 2012 launch of the MSU Global Water Initiative, the university is delving even deeper into water research and positioning itself as a leader in addressing one of this century's most important challenges — securing a safe and plentiful water supply. MSU AgBioResearch is a key player in the initiative's water research mix.

"The connections that AgBioResearch has across campus provide a tremendous advantage to leverage the existing research infrastructure to make sure that we take advantage of every opportunity to connect with research involving water," said Steve Pueppke, director of MSU AgBioResearch, associate vice president for research and graduate studies, and initiative leader. "Over the past five decades, MSU has built a strong research infrastructure rooted in food safety and agricultural development, and these link directly to key issues involving water."

In this issue of *Futures*, you can read about the some of the many ways that AgBioResearch scientists are contributing to this watershed effort.

Given world population growth and an increase in irrigated agriculture to meet food demand, it is critical that agriculture significantly improve its water use efficiency, and that a safe, clean water supply is available to grow crops and raise animals. AgBioResearch scientists are covering a variety of "waterfronts" to keep Michigan's production agriculture industry thriving.

From exploring ways to predict the effects of modern-day climatic influences and preventing pollution to better managing natural resources, advancing sustainable agriculture and protecting groundwater, AgBioResearch scientists are working across disciplines and geographic boundaries to develop technologies and practices




to ensure a plentiful supply of safe water.

In addition to being surrounded by fresh water, Michigan has numerous rivers, lakes and streams. This seeming abundance of water poses a problem in the water policy/management arena because it appears that there is plenty of water. To address this challenge, AgBioResearch scientists are pooling their knowledge and expertise to develop and implement effective water policy and management practices for the 21st century.

We hope you enjoy this issue of *Futures* on the significant advances being made in water research and hope that it helps you to understand a little more about AgBioResearch and the research it funds. If you have comments about this issue or would

like to subscribe (it's free!), send a note to *Futures* Editor, 446 W. Circle Dr., 109 Agriculture Hall, Michigan State University, East Lansing, MI 48824-1039, or send an e-mail to [osowskiv@msu.edu](mailto:osowskiv@msu.edu). You also can call 517-355-0123.

For the latest information about AgBioResearch news and events, you can subscribe to the free AgBioResearch e-newsletter. Sign up by visiting the AgBioResearch website at [www.agbio-research.msu.edu/news.htm](http://www.agbio-research.msu.edu/news.htm). You also can view this and past issues of *Futures* there by clicking on the "news & stories" link. 

VAL OSOWSKI



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SWIM  
AREA



MSU'S KNOWLEDGE AND EXPERTISE IN WATER RESEARCH WILL BRING FACULTY MEMBERS FROM MULTIPLE DISCIPLINES TOGETHER IN A WAY THAT ADDRESSES THE WATER PROBLEMS OF MODERN SOCIETY.

# Diving to new depths in water research

**E**SSENTIAL TO LIFE, WATER IS ARGUABLY THE MOST IMPORTANT NATURAL RESOURCE ON EARTH. Beyond that vital role, water evokes a strong emotional connection. That bond is perhaps no more robust than in Michigan, home to 20 percent of the world's fresh water<sup>1</sup>.

It's wading in the waves of Lake Michigan searching for Petoskey stones. It's casting a fly into the Au Sable River on the quest for a blue ribbon trout. It's leaping off the end of a dock into Houghton Lake on a hot summer day. It's pausing on a wooded trail to admire the beauty of Tahquamenon Falls. Whatever the association, water is an integral part of being a Michigander.

It is also uniquely meaningful to Michigan State University (MSU). With more than 40,000 square miles of fresh water within its borders and 3,177 miles of Great Lakes shoreline<sup>2</sup>, Michigan is a natural playground for water enthusiasts, home to a diverse array of fish and

other aquatic life, and a living laboratory for scientists. An inland lake is never more than 6 miles away, and one of the Great Lakes is just over an hour's drive from campus<sup>3</sup>. Such remarkable accessibility to fresh water has attracted leading researchers from around the world to MSU for the past century.

With the 2012 launch of the MSU Global Water Initiative, the university is delving even deeper into water research. MSU will add more than a dozen new scientists to the ranks of the 100-plus faculty members currently studying water. By pooling knowledge in chemistry, engineering, crop and soil sciences, microbiology and fisheries, the university will emerge as a leader in addressing one of the most important challenges of the 21st century — securing a safe and plentiful water supply.



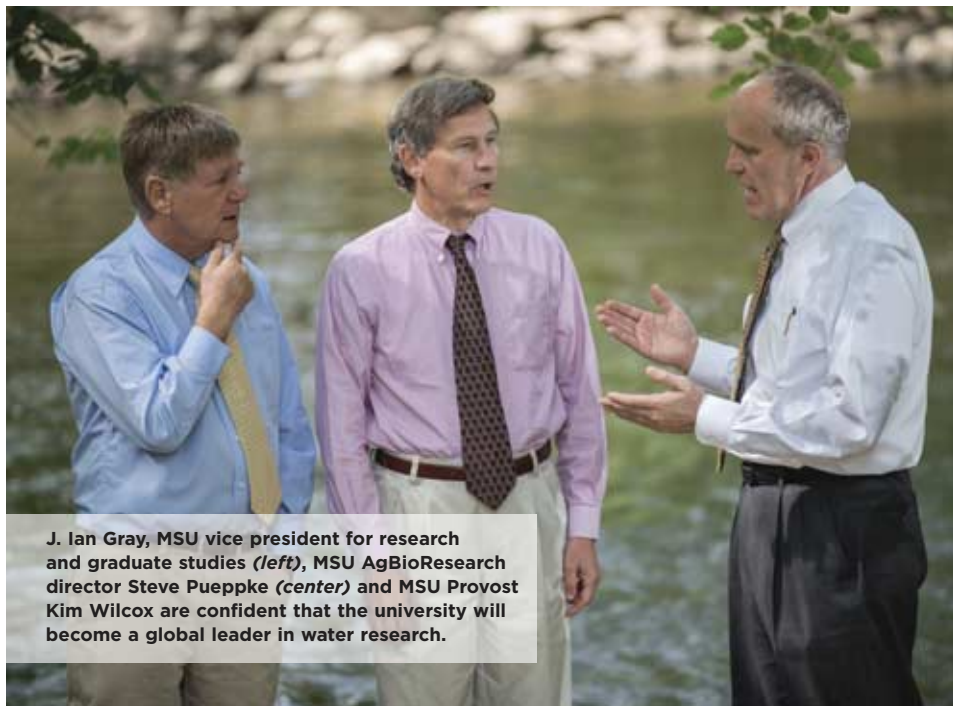
Nearly 97 percent of the world's water is salty or otherwise undrinkable. Another 2 percent is locked in ice caps and glaciers. That leaves just 1 percent for all of humanity's needs.

Source: Environmental Protection Agency



## State geography + university expertise = MSU Global Water Initiative

A native of Sault Ste. Marie, Mich., MSU Provost Kim Wilcox remembers one attribute he missed most when he moved out of state: the water.



J. Ian Gray, MSU vice president for research and graduate studies (*left*), MSU AgBioResearch director Steve Pueppke (*center*) and MSU Provost Kim Wilcox are confident that the university will become a global leader in water research.

“I could drive a few miles from my childhood home and see Lake Superior or Lake Huron,” said Wilcox, who also serves as vice president of academic affairs. “The water was always there. There’s something about that. It’s not just the large lakes but the streams and wetlands. Water shapes how we conduct business and how we design our roads. It’s a natural part of being from Michigan and from MSU.”

The MSU Global Water Initiative is being built, in large part, on the breadth and depth of water research already going on across the university.

“We have faculty who understand the biochemistry of effluent-soiled water,” Wilcox said. “We also have people in engineering who know how to use new membrane technology to clean water. We have people who understand the politics and policies around the ownership and movement of water. Weaving these pieces together represents a fantastic opportunity for MSU.”

J. Ian Gray, vice president for research and graduate

studies at MSU, believes that water will be the next game changer for the university.

“Water is related to everything we do,” he said. “Water quality affects global health, the future of the fishing industry, environmental sustainability and climate change. For many years, we have participated in the Great Lakes Sea Grant Network, building our knowledge about how human activities affect our inland lakes. And thanks to the work being done through MSU’s International Network of Coupled Human and Natural Systems [also known as CHANS-Net], we are finding sustainable solutions that benefit the environment and enable people to thrive. Water is key to that.”

## Investing in the future of H2O

To complement MSU’s existing capacity in water research, the university will hire 16 new faculty members to study various aspects of water, said Steve Pueppke, MSU AgBioResearch director and associate vice president for research and graduate studies, who is leading the water initiative.

“At a time when resources are tight, this investment represents an amazing commitment on behalf of the university in one single area,” Pueppke said. “These new positions are going to be indexed into our current faculty pool for water research. They will fill some holes in our current research capacity and they will serve to link research more closely to policy — something we very much want to do.”

The university has already gained international acclaim in water, thanks to scientists such as Joan Rose, an expert on health-related microbiology, who is working to prevent waterborne diseases; Jan Stevenson, who is working with the Environmental Protection Agency to develop national water assessment programs; Volodymyr Tarabara, who is developing new nanostructured membranes for use in water quality control; and Jinhua Zhao, who is examining the adoption of irrigation technologies and the role of water in adapting to climate change.

“Our new investments will make this group not only larger but stronger as they work together in the land-grant tradition,” Pueppke said. “It fits very well with our historical strengths and our aspiration to be world-class — to have a heightened status in what we do in water and to enhance what we can deliver.”



The total water supply of the world is 332.5 million cubic miles. A cubic mile of water equals more than 1 trillion gallons.

Source: United States Geological Survey



# “WATER QUALITY AFFECTS GLOBAL HEALTH, THE FUTURE OF THE FISHING INDUSTRY, ENVIRONMENTAL SUSTAINABILITY AND CLIMATE CHANGE.”

The initiative’s success will require sharing knowledge in fields from engineering to law and from agriculture to medicine. MSU — with at least one college in each of those areas — is eminently equipped to do that.

“There is also a tradition of having low barriers between our colleges and units, allowing us to move quickly on these types of collaborations,” Gray said. “Interdisciplinary projects are something we do very well. Our excellence in water research will bring faculty members from multiple disciplines together in a way that addresses the water problems of modern society.”

## An underappreciated resource takes center stage

An American resident uses about 100 gallons of water per day — twice the amount of his/her European counterpart. At the same time, more than 880 million people worldwide lack access to clean water. Disparities like these are just a few of the drivers behind the formation of the MSU water initiative.

“It’s interesting that water has been a little bit underappreciated in the past,” Pueppke said. “It’s something that’s always there and, in many cases, it’s free. Water hasn’t been viewed as something limited until just the past couple of years. It really affects everything we do here in Michigan and the global footprint we have.”

As society increasingly realizes the importance of water, some of the initiative’s next research objectives will be to examine situations in other parts of the world and to build new partnerships to address water-related challenges on a global scale.

“We will bring together local expertise with experts around the world,” Wilcox said. “China is dealing with water problems. Africa, especially in arid parts, is dealing with water problems. For us to effectively study the problems we have in the United States, we need to learn from people in other places as well. It will be about taking advantage of the attributes that few places in the world have — the breadth of our intellectual capacity, our international connections and our proximity to fresh water.”

MSU is not only ideally positioned in the heart of the Great Lakes state, but its researchers possess vast knowledge about the agricultural industry. Further, MSU scientists inherently understand the relationship between land and water — an understanding that is especially valuable in light of an increasing world population.



“It’s important for Michiganders to understand the very good position we’re in with respect to water,” Pueppke said. “We’re surrounded by water, and it affects everything we do. What we’re realizing is that if we’re wise — if we answer research questions and we convert that into wise policy decisions — we can be in better economic shape, serve as better stewards of the resources we have and, of course, do some wonderful things as a research university.”

The MSU water initiative is built on a philosophy of collaboration — going beyond the field, crossing boundaries, and developing procedures and techniques for the common good.

“In essence, the MSU Global Water Initiative is really borrowing the mantra of AgBioResearch, MSU’s 17 colleges and nearly 20 water-affiliated units (*see box on page 8*) to promote cross-university initiatives,” Gray said. “In the end, building on the strengths of water research at MSU is really a no-brainer.”

HOLLY WHETSTONE



The Great Lakes contain 6 quadrillion gallons of fresh water. Spread evenly across the continental United States, the Great Lakes would submerge the country under about 9.5 feet of water.

Source: Great Lakes Information Network



## WHERE ON THE WEB?

For more on MSU’s leadership role in water research, visit:

**Smart People Discover Water & That Could Kick-Start the Blue Revolution, [bit.ly/L1thjk](http://bit.ly/L1thjk)**

<sup>1</sup>Great Lakes Information Network, [www.great-lakes.net/lakes/ref/lakefact.html](http://www.great-lakes.net/lakes/ref/lakefact.html)

<sup>2</sup>State of Michigan, [http://www.netstate.com/states/intro/mi\\_intro.htm](http://www.netstate.com/states/intro/mi_intro.htm)

<sup>3</sup>State of Michigan, [http://www.netstate.com/states/intro/mi\\_intro.htm](http://www.netstate.com/states/intro/mi_intro.htm)

*Many programs and centers at MSU are conducting water research. The following is a list of the key organizations and their activities.*

≡ **Anaerobic Digestion Research and Education Center (ADREC)**

ADREC faculty and staff members comprehensively research, develop and evaluate technologies associated with integrated anaerobic digestion systems for small to medium-sized farms. Anaerobic digestion can protect human health and the environment from problems related to agricultural wastes and convert these wastes to resources that are used to produce electricity, heat or vehicle fuel.

<http://www.researchgroups.msu.edu/adrec>

≡ **Biogeochemistry Environmental Research Initiative (BERI)**

The BERI fosters, coordinates and enhances research activities in all aspects of biogeochemistry, which lies at the nexus of biology, geology and chemistry. An integrative science, biogeochemistry has emerged from the growing need to understand how living organisms interact with physical and chemical aspects of their environment.

<http://beri.espp.msu.edu/>

≡ **Center for Advancing Microbial Risk Assessment (CAMRA)**

CAMRA scientists develop resources to address microbial hazards associated with public health risks, including the spread of infectious disease and bioterrorism. Models, tools and information are designed to reduce the health impacts of biological agents of concern. Knowledge is shared through a national network of scientists and students.

<http://www.camra.msu.edu/>

≡ **Center for Global Change and Earth Observations**

Research activities at this center address the international aspects of social, land and climate systems in fostering interdisciplinary approaches for understanding global change by using both social and biophysical science tools. Faculty members, staff members and graduate students at the center are committed to applying their research and expertise to inform both public and private decision making on critical global environmental change issues.

<http://www.globalchange.msu.edu/>

≡ **Center for Integrative Toxicology (CIT)**

Activities at CIT build on recognized research strengths in determining the effects that pollutants have on human health and the environment. More than 50 faculty members distinguished in a wide range of scientific disciplines offer programs that provide an innovative and highly integrative environment for research, teaching and graduate education in toxicology.

<http://cit.msu.edu/>

≡ **Center for Microbial Ecology (CME)**

CME offerings include programs in research, graduate education, and industrial and educational outreach that are designed to create new knowledge, facilitate knowledge dissemination, help develop a well-trained microbial ecology workforce and increase scientific literacy among K-12 students.

<http://cme.msu.edu/>

≡ **Center for Water Sciences (CWS)**

The CWS mission is to advance research and knowledge for understanding, protecting and restoring water resources and their sustainable use by humans and ecosystems around the Great Lakes and the world. Interdisciplinary teams address issues including antibiotics in water and the development of microbial resistance, viral pathogens and waterborne disease, and valued attributes of aquatic ecosystems.

<http://www.cws.msu.edu/>

≡ **Environmental Science and Policy Program (ESPP)**

The ESPP builds and facilitates interdisciplinary, campuswide graduate education and environmental research. It also links research with national and global research priorities and connects areas of excellence at MSU with national and global efforts.

<http://www.espp.msu.edu/index.php>

≡ **Great Lakes Regional Integrated Sciences and Assessments Center (GLISA)**

The two overarching goals of GLISA are to contribute to the long-term sustainability of the region in the face of a changing climate and to improve the utility of scientific knowledge to decision making. GLISA is a collaborative effort between MSU, the University of Michigan and The Ohio State University, with funding from the National Oceanic and Atmospheric Administration.

<http://www.graham.umich.edu/about/>



### ≡ **Institute of Public Utilities (IPU)**

IPU activities support informed, effective and efficient regulation of the infrastructure — an intensive network of industries providing vital utility services such as electricity, natural gas, water and telecommunications.

<http://ipu.msu.edu/research/index.php>

### ≡ **Institute of Water Research (IWR)**

Faculty and staff members at the IWR address land and water resource issues through coordinated, multi-disciplinary efforts using advanced information and networking systems. The group works to strengthen MSU efforts in nontraditional education, outreach and interdisciplinary studies using advanced technology and partnerships with local, state, regional and federal organizations.

<http://www.iwr.msu.edu>

### ≡ **Kellogg Biological Station (KBS)**

Scientists, staff members and graduate students at KBS (one of 14 MSU AgBioResearch centers located across Michigan) develop research, education and outreach programs directed toward a comprehensive understanding of natural and managed ecosystems and the conservation of natural resources. Emphasis is placed on fundamental and applied research in ecology and sustainable agriculture.

<http://www.kbs.msu.edu/>

### ≡ **Long-term Ecological Research Program (LTER) at the Kellogg Biological Station**

This program is designed to examine the ecology of intensive field crop ecosystems. It's part of a national network of sites established by the National Science Foundation that supports research to improve understanding of ecological phenomena in both natural and managed ecosystems.

<http://lter.kbs.msu.edu/>

### ≡ **Land Policy Institute (LPI) —**

Research activities at LPI equip federal, state and local policy-makers with science-based tools and solutions that help build a better quality of life, strengthen the economy and protect the environment. The institute encourages collaboration among land use researchers, policy-makers and community organizations.

<http://www.landpolicy.msu.edu/>

### ≡ **Michigan Sea Grant**

This initiative supports research, outreach and education to enhance the sustainable use of Great Lakes resources to benefit the region's economy, environment and quality of life. It is part of the National Sea Grant College Program, a network of more than 30 university-based programs in coastal states administered through the National Oceanic and Atmospheric Administration.

<http://www.miseagrant.umich.edu/>

### ≡ **Midwest Invasive Species Information Network (MISIN)**

MISIN activities target early detection and rapid response programs for invasive species in the Midwest. MSU faculty and staff members, including several who have received international acclaim, conduct invasive species research, education and outreach programs.

<http://www.misin.msu.edu/>

### ≡ **MSU Watershed Action through Education and Research**

This group integrates research, teaching and outreach activities within the Red Cedar River watershed. Research seeks to determine the university's ecological footprint on the river enhance MSU's reputation in water research, teaching and outreach; develop a comprehensive watershed plan that includes practical management alternatives; and meet stormwater management objectives.

<http://www.msu-water.msu.edu/>

### ≡ **Remote Sensing & Global Information Systems Research and Outreach Services**

The mission of this program is to provide state-of-the-art remote sensing, global positioning system, geographic information science and cartographic services, including instruction and technology transfer and grant and contract work for on- and off-campus units.

<http://www.rsgis.msu.edu/>

### ≡ **Sustainable Michigan Endowed Project (SMEP)**

SMEP provides a venue for ongoing scholarship on the sustainability of Michigan as well as seed grants for state-level sustainability research. The project is designed to encourage long-term sustainability discourse with the goal of influencing the intellectual culture within MSU, particularly in the College of Agriculture and Natural Resources.

<http://www.smep.msu.edu>

# Cultivating novel approaches to water research for agriculture



MSU AgBioResearch geographer Sharon Zhong studies the moisture budget of the Great Lakes, with the ultimate goal of understanding climate changes in the region and its effects on production agriculture.



WATER IS ESSENTIAL FOR FOOD PRODUCTION.

Agriculture is the largest consumer of freshwater resources, currently accounting for about 70 percent of global water diversions<sup>1</sup>. Population growth and an increase in irrigated agriculture to meet food demand point to the need for agriculture to significantly improve its water use efficiency to remain sustainable and profitable. It is also critical that a safe, clean water supply is available to grow crops and raise animals, and that agricultural practices protect the environment and this precious, limited resource. To aid in its continued sustainability and competitiveness, Michigan State University (MSU) AgBioResearch scientists are covering a variety of “waterfronts” to keep Michigan’s production agriculture industry thriving.

### Gaining a new perspective on climate change for the Great Lakes region

The winter and spring of 2012 are good examples of the difficulties of predicting the climate in Michigan and the Great Lakes region. MSU AgBioResearch scientist Shiyuan (Sharon) Zhong knows that well. She is an atmospheric scientist whose research focuses on the effect of climate — specifically, the hydroclimate of the Great Lakes region.

“Our goal is to understand climate change and quantify the uncertainties associated with future climate projections, especially projections of the region’s water budget,” said Zhong, a professor in the MSU Department of Geography. “Climate impact studies rely on climate projections but, unfortunately, these projections are associated with a lot of uncertainties.”

The main source of uncertainty is the climate models themselves, which are the primary tools used for making projections of what the climate will look like, especially in the long term. Most climate projections have been based on output from global climate models. Although many of these studies show that changes will occur, the influences on a regional climate are quite different from influences on a global scale, Zhong said.

“The resolution of a typical global climate model is not high enough to accurately assess the Great Lakes,” she explained. “Some models don’t even register the Great Lakes. They don’t resolve them, so they can’t be used to make good projections. When talking about water or agriculture, you are looking at a specific site such as an orchard, and the model cannot get close.”

By using a technique called dynamic downscaling, Zhong and her research team have made progress downscaling global

model results using regional climate models to more accurately project changes specific to the Great Lakes region.

“There’s been a lot of attention paid to the skill of regional climate models for the western United States, but there hasn’t been a lot of work on the Great Lakes region,” Zhong said. “Our work is to fine-tune the model to better reflect conditions for this region and, more importantly, to quantify the uncertainties associated with them. If you want to get better projections for things such as hydrology and agriculture, you need an accurate regional projection.”

The models in general do better in the winter than in the summer in predicting both precipitation and temperature. Predictions of summertime precipitation are poor because it is often caused by local convections — transfers of heat from one place to another by the movement of fluids — that current climate models don’t resolve well.

“The model registers the spatial variability across the region fairly well, but for a specific location, the model is not that good,” Zhong said. “In general, the models are capable of capturing the spatial pattern and seasonal variation of temperature and precipitation, but we still have a long way to go before we’ll be able to predict climate for a specific area such as an orchard or a farmer’s field.”

Zhong believes that in five years or so, computer technology will make it possible to run regional climate models at this scale. But even then, she said, accurate rainfall predictions will still be a challenge because of the difficulty in simulating clouds and associated feedback processes in climate models.

Zhong added that collaboration is key to her research. For example, she is working with David Hyndman, professor of geological sciences, on a project that couples climate models with groundwater models to get better hydroclimate predictions and to simulate extreme wet and dry years. She is also working with climate researchers from the U.S. Department of Agriculture Forest Service to improve descriptions of forest canopy in climate models.

“We are not forecasters,” Zhong emphasized. “Our goal is to improve the climate models so that they become better tools for future climate projections at regional and local scales.”

In the meantime, Zhong wants people to be aware of the uncertainties of climate models.

“We need to better communicate what the models can and cannot do so that uncertainty can be accounted for when making climate adaptation decisions,” she said.



There is more fresh water in the atmosphere than in all of the rivers on the planet combined.

Source: Environmental Protection Agency



## “WE CAN NOW OBTAIN HUGE AMOUNTS OF DNA SEQUENCE FROM MICROBIAL COMMUNITIES, VIRTUALLY ALL OF WHICH IS NEW.”

### Small but mighty: Microbes tapped to address water quality challenges

Wherever there is water, there are microbes. Microbes include bacteria, viruses, fungi and protozoa, most of which can be seen only with microscopes. Of these, bacteria are the oldest living organisms, and no corner of the earth escapes their influence. They control every ecological process from the decay of dead plants and animals to the production of oxygen.

They are in the food we eat, the air we breathe and the water we drink.

“If you could weigh all of the microbes in the world, their weight would be equivalent to that of all the plant matter on Earth,” said MSU AgBioResearch scientist James Tiedje. “We can’t see them, but they are everywhere.”

There are lots of microbes in the soil, partly because soil always has water.

“There are about a billion microbes per gram of soil, and they convert carbon, nitrogen and phosphorus to elemental forms,” said Tiedje, a university distinguished professor of crop and soil sciences and of microbiology, and director of the National Science Foundation Center for Microbial Ecology (CME) at MSU. “In production agriculture, that means mineralizing nitrogen and phosphorus so that they are available for plants. For microbes to be active, there has to be sufficient water to carry out these processes. At the same time, microbes are metabolizing waste materials such as manures and plant residues and releasing the nutrients from them for plants. If there are no plants, the nutrients are available to leach into groundwater or run off into streams.”

In most cases, microbes are just part of the normal biological experience and are not harmful. In fact, most are helpful, such as those that cycle nutrients. One problematic group, and a focus of Tiedje’s current research, is one that carries antibiotic resistance. Antibiotics are humanity’s key defense against disease-causing microbes.

“Antibiotic resistance has become a huge human problem because there are some extremely resistant strains of pathogens that are resistant to all known antibiotics,” Tiedje said. “The question is, what are we doing that exacerbates this problem? The widespread use of antibiotics in human medicine and in animal agriculture is a topic of concern because their use contributes to the spread of antibiotic resistance.”

Tiedje has worked on microbes and the problems associated

with them since the late 1970s. The center he directs has developed novel methods for microbial community analysis that have greatly expanded knowledge about complex microbial communities in soil.

“Microbes in soil are the greatest unknown biological diversity in the world,” he said. “This is largely because microbial history is very old — the evolutionary history of microbes began more than 3 billion years ago. During this time, microbes have adapted to all kinds of conditions and all kinds of different food sources. In that long evolutionary history, there is undiscovered genetic material that is potentially useful in biotechnology and for developing new pharmaceuticals.”

Tiedje’s current work with microbes is aided by the rapid development of new genomic technologies. His research focuses on the genomics of important microbial species and on the new science of metagenomics — the study of the genetic composition of communities of microbes instead of an individual microbe.

“We can now obtain huge amounts of DNA sequence from microbial communities, virtually all of which is new,” Tiedje said. “One feature we look for is any undiscovered strategies microbes may have to metabolize problem chemicals such as PCBs, dioxins and chlorinated solvents, the latter of which are significant groundwater pollutants. Gathering data to examine the behavior, evolution and functions of these microbes in water is fundamental to solving problems in water quality, in waste treatment, and in controlling diseases in plants and animals, including humans.”

### Conquering detection problems with water- and food-borne pathogens

MSU AgBioResearch scientists are exploring new frontiers in the detection of water-related diseases by developing sensors that can detect harmful pathogens in food and water before they cause widespread disease.

“From farm to table, there are numerous opportunities for food and water to become contaminated with pathogenic bacteria,” said Evangelyn Alocilja, a professor of biosystems and agricultural engineering.

To help address this issue, Alocilja has developed a nanostructured biosensor that promises speedy detection of deadly pathogens and toxins, especially in water. This hand-held device can be used in a farmer’s field to test, for example, for *Escherichia coli* (*E. coli*), a bacterium that is commonly found in the intestines of warm-blooded organisms. Most strains are



Almost half of Michigan is comprised of water and, except for Alaska, Michigan has more shoreline than any other state.

Source: Great Lakes Information Network





**MSU AgBioResearch scientist Jim Tiedje (left) uses molecular methods to understand microbial community structure and function. Here he discusses lab results with MSU microbiology and molecular genetics doctoral student James Kremer.**

harmless, but some, such as *E. coli* O157:H7, can cause serious food poisoning in humans and can be responsible for product recalls. The biosensor also can be used for the rapid detection of a broad range of other threats such as *Salmonella*, anthrax and tuberculosis.

Alocilja's idea for the biosensor originated more than 10 years ago when she attended a conference on biodefense where the concept of a biosensor was presented. She believed that she had the expertise to develop a sensor and was driven by a desire to save lives.

A continuous cycle occurs when an animal with *E. coli* leaves excrement on the soil. Rain sends the contaminated soil into surface water, including irrigation water and recreational lakes and rivers, or it is leached into groundwater. When crops come in contact with that water — especially fruits and vegetables that are grown close to the ground — they are contaminated. As crops move through processing and/or packaging, there are opportunities for further contamination.

"If a farmer can find out that the water being used on his crops contains, for example, *E. coli*, he can take action and stop the contamination," Alocilja said.

She points out that there are there costs involved not only in sending products to market but also in pulling contaminated products out of the marketplace.

"It can become a double jeopardy situation," Alocilja aid. "Many times, a recall caused by something such as *E. coli* can

bankrupt a company and threaten the whole industry. For example, an outbreak of *E. coli* in spinach in 2006 caused not only the company that was the source of the contamination to suffer, but the whole spinach industry suffered because no one wanted to eat spinach."

In related work, Tiedje, whose work with microbes is described earlier, is part of a team of researchers led by MSU civil engineering professor Syed Hashsham that has developed a device called Gene-Z. This device differs from Alocilja's biosensor in that it is made with pieces of DNA that match those from the target pathogen. If the pathogen is in the sample, its DNA binds to the complementary DNA in the sensor gives off a florescent signal.

"DNA testing can be sensitive, rapid and inexpensive," Tiedje explained. "It can detect various strains of bacteria and viruses as well as antibiotic resistance in the pathogens."

Tiedje and Alocilja agree that there is room for both types of sensors.

"It's critical that we have the necessary tools to address this challenge at every level," Tiedje said. "We will definitely need a 'detection train' as we become more sophisticated in our detection efforts."

"Every detection device has an important role to play in the fight against water-borne and food-borne diseases," Alocilja added.

Using Alocilja's biosensor involves putting a reagent in a



MSU AgBioResearch scientist Evangelyn Alcoilja is using nanotechnology to develop biosensors that detect infectious disease agents that threaten the food supply chain, public health and the environment.

sample of water. Then the sample is separated with a magnet. The magnetized product is reconstituted and put into a small biochip. This chip then goes into a handheld reader, which provides a final readout in about an hour. Each test costs about \$2, significantly less than currently available technology. A new biochip has to be used for each test.


To use the Gene-Z device, farmers and food and water quality inspectors would take a sample, extract the microbes or DNA, and transfer it to a microfluidic chip, which is inserted into the device. Used with an iPod Touch or Android-based tablet, Gene-Z can identify the pathogen, its genotype and its amount in 10 to 30 minutes and transmit the results to a central data center. To fully develop this approach, the sample processing step needs to be more efficient. That work is under way. Gene-Z is ready to be field tested, and the researchers are working with MSU Technologies, the office that manages technology transfer at MSU, to bring the product to market.

Alocilja's biosensor is now in the hands of a commercial company, nanoRETE, which is funded in part by MSU Technologies. Alocilja decided to take this major step

when a colleague said, "If you are doing this to save lives, you will never save lives if it stays in your lab." She also realized that putting the product in the commercial marketplace will validate its usefulness and point out its weaknesses so that improvements can be made.

"In the lab, everything is in a controlled environment," Alocilja said. "If we send it out as a commercial product, we can see exactly what is needed in the field and we can revise the design if necessary."

While one of her designs for a biosensor is well on its way to the marketplace, Alocilja knows there will always be new designs.

"We are looking for better performance, faster results and a less expensive device," she said. "It will be a lifetime quest." 

JANE L. DEPRIEST



Waterborne diseases cause about 1.8 million human deaths annually, and 88 percent of those deaths are attributable to unsafe water supply, sanitation and hygiene.

Source: World Health Organization



**WHERE ON THE WEB?**

For more information on the research initiatives listed in this article, visit:

- [www.msu.edu/~zhongs](http://www.msu.edu/~zhongs)
- [www.cme.msu.edu/tiedjelab](http://www.cme.msu.edu/tiedjelab)
- [www.egr.msu.edu/~alocilja](http://www.egr.msu.edu/~alocilja)

<sup>1</sup>International Water Management Institute, [bit.ly/Llql2N](http://bit.ly/Llql2N).pdf.



# Pursuing a plentiful supply of safe, clean water

FRESH WATER IS A PRECIOUS COMMODITY, PRIZED FOR ITS ABILITY TO SUSTAIN LIFE, QUENCH THIRST AND MAINTAIN HEALTH, AND ALSO BECAUSE OF ITS SCARCITY. Although 70 percent of the Earth's surface is covered by water, only 2.5 percent is fresh water, and, of that, less than 1 percent is easily accessible<sup>1</sup>. Worldwide, about one in eight people lacks access to clean water, and more than 3.5 million die each year from water-related disease<sup>2</sup>.

Statistics like these are difficult to comprehend in the United States, where the average household faucet flows at a rate of 2 gallons per minute. They're perhaps even more difficult to grasp in Michigan, a peninsula surrounded by what seems a limitless supply of fresh water. Nonetheless, the facts speak for themselves and serve as catalysts behind the newly launched MSU Global Water Initiative.

Scientists are working across disciplines and geographic boundaries to develop new technologies and identify practices to ensure a plentiful supply of safe water.

The solution isn't about one discovery — it's about many. It entails finding ways to better manage natural resources, prevent pollution, predict the effects of modern-day influences, advance sustainable agricultural production and protect groundwater. More importantly, it's about sharing the findings to benefit people around the globe.

## Looking at the big water picture

Limnologists have been collecting data on water bodies in the United States for more than a century. Although the information is usually applied locally to



MSU AgBioResearch scientist Pat Soranno, (left), Kendra Cheruvellil (center) and Pang-Ning Tan are working on the development of a comprehensive approach to understanding, conserving and managing freshwater lakes, streams and wetlands — landscape limnology.

individual lakes and then filed away, an MSU-led research project is under way to broaden the scope, analysis and shelf life of the data.

Patricia Soranno, a Michigan State University (MSU) AgBioResearch scientist, is spearheading a multistate endeavor to pool data on 8,000 lakes in 17 states gathered over the past three decades. The facts will be analyzed to improve the understanding of some basic environmental problems such as eutrophication (a process that causes a depletion of oxygen in water) and to better protect the quality of lake ecosystems.

“There’s a treasure of untapped information sitting in filing cabinets and computers, not being used,” said Soranno, an MSU associate professor of fisheries and wildlife. “By pulling together these separate data sets and studying large populations of lakes — traditionally studied as individual ecosystems — we hope to better predict how fresh waters are going to change, particularly in light of land use and climate change.”

The information is expected to help communities better manage the effects of such things as urban and suburban development, herbicide applications, fish stocking and regulations, and water policies.

“Although we think we’ve solved the water quality problem,

particularly in the Great Lakes, all you have to do is look at Lake Erie and see that the problem is creeping back,” Soranno said. “Maintaining water quality is still a challenge in the United States, and it’s a huge issue in developing countries. A lot of good progress has been made by intensively studying lakes one at a time. With this project, however, we’re using a broader perspective to see what can be learned by studying thousands of lakes in regions with different climate, land use and human influences.”

The data, provided by numerous agencies and organizations in each of the 17 states, is extensive. Pang-Ning Tan, MSU associate professor in computer science, is involved in designing the framework to store the data, expected to occupy about 1 terabyte (1 trillion bytes) of computer space. He will also analyze the information using innovative tools from computer science that are not typically used by freshwater scientists.

“My research area is data mining, which deals with the development of algorithms that can efficiently and effectively analyze this type of large-scale database,” Tan said. “This project, however, presents new challenges in data analysis, such as how we put together these data from various sources, or how we incorporate information from lakes that have been sampled once compared with lakes that have been routinely sampled for 30 years. Our project is trying to take advantage of all available information.”



Michigan has more than 11,000 inland lakes.

Source: Michigan Department of Natural Resources





## “IF THERE ARE TOO MANY NUTRIENTS, THE WATER CHANGES COLOR, AND NO ONE WANTS TO LIVE ON A GREEN LAKE.”

Kendra Spence Cheruvilil, MSU assistant professor in Lyman Briggs College and the Department of Fisheries and Wildlife, worked with Soranno to develop the underlying concepts for the project. She will apply her expertise in the study of lakes at the regional scale to the large dataset.

“Lake nutrients are one of the first things we’re examining,” Cheruvilil said. “People care about lake nutrients whether they realize it or not. For example, if there are too many nutrients, the water changes color, and no one wants to live or recreate on a green lake. In the future, we anticipate including other kinds of response variables such as biology to see how lakes respond to climate and land use change. That’s also something the public cares greatly about.”

The project unites researchers at MSU with colleagues from the University of Wisconsin, Iowa State, Penn State and the Great Lakes Environmental Lab.

“A team of multidisciplinary experts is key to the success of these types of projects,” Soranno said.

She added that the group has expanded the scope beyond Michigan to look at water quality on a continental scale.

“We’re tackling about a third of the continent — a 17-state region in the upper Midwest and northeastern United States — that contains many of the continent’s natural lakes,” Soranno explained. “We can’t conduct studies like this without a team of experts from a range of fields to study such complex questions as — ‘Will fresh waters in some regions be more sensitive to climate change than others?’ and ‘Does it depend on whether land use changes, too?’ We’re pretty sure that there are big regional differences in how fresh waters will respond to human impacts, but we currently do not have the tools to tell which will be the most sensitive. That’s one outcome that we hope to achieve in this project.”

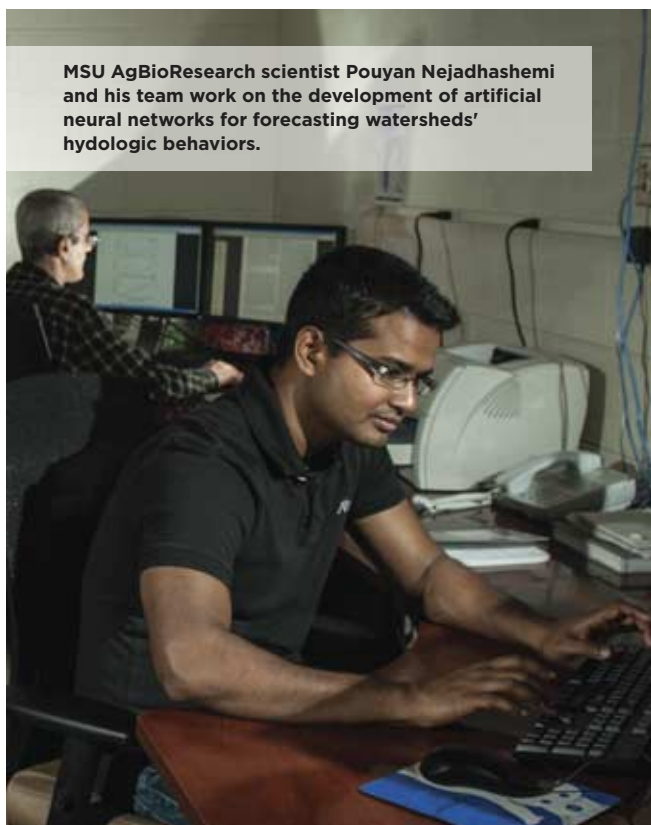
Soranno and Cheruvilil are known for studying fresh waters from a broad scale. They pioneered the concept of landscape limnology — a new approach of studying fresh waters by looking at all inland water bodies and how they interact with one another and with the landscape. Their latest research endeavor takes the concept of landscape limnology a few steps further.

“When we’re facing the challenge of climate change, there are going to be huge effects on ecosystems,” Soranno said. “Freshwater ecosystems provide a lot of important services to people, such as clean water for recreation, food crops and drinking water. We need diverse scientific approaches to tackle this important challenge. Our approach is not commonly taken, but we are confident that it will add to the knowledge base necessary to address critical issues for fresh waters.”



Biofuel production is estimated to be 3 percent of the irrigation use in the United States. Under current production conditions, it takes an average of roughly 2,500 liters of water to produce 1 liter of liquid biofuel — the same amount needed on average to produce food for one person for one day.

Source: World Water Assessment Programme



MSU AgBioResearch scientist Pouyan Nejadhashemi and his team work on the development of artificial neural networks for forecasting watersheds’ hydrologic behaviors.

### Auction concept prompts hundreds to implement pollution control practices

Little is known about the effects that modern-day issues such as climate change and bioenergy crop production will have on water. But AgBioResearch scientist A. Pouyan Nejadhashemi is working with a team of assistants to change that.

“We’re looking at numerous effects on water, including those from bioenergy production, climate change and adaptation in agricultural production,” said Nejadhashemi, assistant professor in the MSU departments of Biosystems and Agricultural Engineering and Crop and Soil Sciences. “Fortunately, I am collaborating with a large group of graduate students. Each of



MSU AgBioResearch scientist Wei Zhang studies the movement of water, solutes and fine particles such as microorganisms, abiotic colloids and emerging engineered nanomaterials in soil profile and groundwater.

them is working in areas that overlap while, at the same time, they have their own direction.”

One particular project is off to an impressive start. It utilizes the concept of an auction to encourage farmers to implement best management practices (BMPs) — techniques to reduce point- and nonpoint-source pollution. Agricultural

producers participate by submitting bids to supply the buyer (e.g., watershed group, state agency) with water quality improvements through BMP implementation. Winning bids are awarded to producers who provide the most water quality improvements for the least cost. The buyer can be a government entity or private firm that needs to achieve particular reduction in emissions. The auction allows bidders to indicate the amount of money they’re willing to accept to adopt a BMP.

So far, the process — only halfway through — has been well-received. More than 200 bids were received from agricultural producers in two small regions of Michigan — the River Raisin watershed in southeastern Michigan and the Pinnebog watershed in the Thumb region.

“Although there are many environmental and conservation programs that offer compensation through various federal

agencies, studies show that less than half of all agricultural producers are actually participating,” he said. “There are many reasons, ranging from too much government control to the low payments of the programs. But with the BMP auction, participation is increasing throughout the watersheds.”

Nejadhashemi is also looking at watershed studies to determine possible environmental implications of bioenergy crop production. Three studies cover the majority of agricultural regions of the Lower Peninsula, where nonpoint-source pollutant loadings (e.g., sediment, nutrients and agrochemicals) are a significant issue.

“If this is not the most comprehensive study [to focus on bioenergy crop production] of this type in the state, it is certainly one of the most comprehensive,” he said. “We worked with MSU Extension and the people who work with bioenergy crops and identified all of the crop rotations that can be used in the Michigan climate. We ran through thousands of scenarios, including studying the effect of sediment, phosphorous and various herbicides being applied on both humans and aquatic life.

“It’s safe to say that corn is one of the more intensive bioenergy crops and switchgrass is less intensive, but it is certainly not black and white,” Nejadhashemi added. “There isn’t just one solution. The location and rotation of crops can also be very valuable.”



Around 30 percent of the world’s supply of freshwater is stored underground in the form of groundwater.

Source: United Nations Environment Program



### **Taking the plunge: An optimum time for water research**

Perhaps no one on campus was more elated to hear about MSU's Global Water Initiative than newcomer Wei Zhang, who joined MSU as an AgBioResearch scientist and a crop and soil sciences assistant professor in early 2012 with a resume that includes extensive water research for the U.S. Environmental Protection Agency. Zhang said he is thrilled by the possibilities looming on the horizon.

"This is an extremely exciting time to be conducting water research at MSU," he said. "One thing I've observed already is that there are no boundaries between disciplines and colleges, which allows for some really exciting outcomes. I see a huge potential to do collaborative, interdisciplinary research."

In fact, Zhang has already discussed possible projects with various faculty members, including AgBioResearch plant pathologist Mary Hausbeck.

"We're talking about ways to collaborate on vegetable plant pathogen research," he said. "We need to better understand how these pathogens move in water and the environment. This will help growers increase product values and reduce their costs."

Promoting the protection of surface water and groundwater through sustainable agricultural production is a top priority for Zhang, who has studied water movement, solutes (nutrients, agrochemicals and environmental toxins) and fine particles such as microorganisms.

"My broad interest lies in looking at how we can better utilize our soil and water resources without compromising the beneficial use of future generations," he said. "My main focus is the movement of pollutants, nutrients and agrochemicals in the environment — primarily in the soil or subsurface soil."

The emerging field of nanotechnology — the science of manipulating materials on an atomic or molecular scale, especially to build microscopic devices — is also enticing to Zhang.

"There's going to be increased use of nanotechnology in agriculture and the food sectors, which is why we're trying to do more research in this area," he said. "For example, you can detect microbial passage in water using nanosensors. Ultimately, I'd like to help along the way as new technologies are developed to minimize the collective effect of these microorganisms on the environment and human health."

### **Using "one man's waste" to produce energy AND clean water**

A project in Central America is linking water and energy in an innovative way to help reduce agricultural pollution. It's a partnership between MSU and the University of Costa Rica



**For MSU AgBioResearch scientist Dawn Reinhold, plants are a crucial component of natural treatment systems that can be used to protect the environment and human health.**

that holds a great deal of promise for rural farm communities, said AgBioResearch scientist Dawn Reinhold.

"What we're striving for is economically, environmentally friendly, more sustainable ways to address some of the pollution issues associated with animal agriculture," said Reinhold, an assistant professor in the MSU Department of Biosystems and Agricultural Engineering. "With this project, we're using an anaerobic digester and following it with a filter system of a wetland with the belief that we can produce not only energy with the digester but also clean water."

The project, called Decentralized Clean Energy Production for Rural Latin America, launched last fall in Costa Rica, Nicaragua and Panama. Central America was chosen because it's a region where agriculture is the second leading industry and more than half the population — 19 million people — lives in rural areas, according to project organizers.

The project team, led by MSU Department of Biosystems and Agricultural Engineering assistant professor Wei Liao, will work over the next several years to develop an integrated



Repurposing treated municipal wastewater for irrigation could help protect aquatic ecosystems.

PHOTO: ISTOCKPHOTO/DENGUY

small-scale, self-sustained system for converting waste to clean energy, while producing value-added byproducts such as fertilizers for local farming applications and reclaiming water. The system works by leveraging solar power that is captured through a thermal collector. Animal manure, crop residues and food wastes go into the unit, generating heat and electricity. It also produces solid and liquid effluents that can be converted into fertilizer.

Another research focus for Reinhold is the understanding and engineering of plant-based ecosystems for the protection and treatment of water resources. She and members of her lab are examining the abilities of food crops to phytoaccumulate (a process by which a plant takes up chemicals) antimicrobials from biosolids (nutrient-rich organic materials resulting from the treatment of sewage sludge, often used as fertilizer) and wastewater used for irrigation in agricultural fields.

“Antimicrobial agents are used in soap and many other consumer products,” Reinhold explained. “Most of these products get washed down the drain and are not transformed in conventional wastewater treatment plants. Untransformed, these chemicals enter the environment through wastewater treatment effluent and biosolids. These agents adversely affect ecosystems and, at high concentrations or with continuous exposure, can potentially affect human health.”

To help address this problem, Reinhold and members of her lab first conducted vegetated soil column studies to look at biosolids application, which introduces antimicrobials to soil and water resources. The findings from these initial studies showed that pumpkin and zucchini reduced concentrations of antimicrobials in agricultural fields, and that the

consumption of these crops presents minimal risk to human health. More recently, she found that chili peppers, of all the crops examined, exhibit the highest capability of removing antimicrobials left in the soil after the application of biosolids.

Reinhold and her team are now investigating the relevance of bioaccumulation of antimicrobials from irrigation waters to human health risk and environmental fate.

“Repurposing treated municipal wastewater for irrigation could also help remedy the negative impact that antimicrobials have on aquatic ecosystems when the wastewater is discharged into surface waters,” she added.

Like most of her colleagues studying water, Reinhold is examining several aspects at once.

“There is no way to look at water as a completely separate entity when you talk about agricultural systems,” she said. “You may ask, ‘Why do you really need clean water to grow crops?’ The answer is that there might be human health implications. And when you start talking about treating the water, there are energy implications as well.”

### Teamwork matters

Regardless of discipline or approach, all of the researchers interviewed agree that collaboration is critical to the success of the overall water initiative.

“When you’re approaching a subject as big as water, the research must be done in teams,” Soranno said. “People with different expertise have to work together, put aside their egos and be accountable to the team and for the end results. We’re training our graduate students to be team members as well as leaders because I believe the future of environmental research to solve real-world problems, is this interdisciplinary collaborative approach.”

“If you look at only one variable or one indicator, you’re always going to be wrong,” Nejadhashemi added. “We’re always striving to take our research to the next level — bring it out of the lab and implement it in the real world. We look at the application and try to develop a scenario to address that possibility or practicality rather than doing research only for the sake of research.”

HOLLY WHETSTONE

### WHERE ON THE WEB?

For more information on the research initiatives listed in this article, visit:

<http://www.fw.msu.edu/~llrg/>.

<http://www.ecpamericas.org/initiatives/default.aspx?id=72>.



Energy production accounts for 1-2 percent of the world's water demand.

Source: World Water Assessment Programme



<sup>1</sup>Environmental Protection Agency, [http://www.epa.gov/watersense/docs/ws\\_supply508.pdf](http://www.epa.gov/watersense/docs/ws_supply508.pdf).

<sup>2</sup>Water.org, <http://water.org/water-crisis/water-facts/water/>.

# Navigating a new course

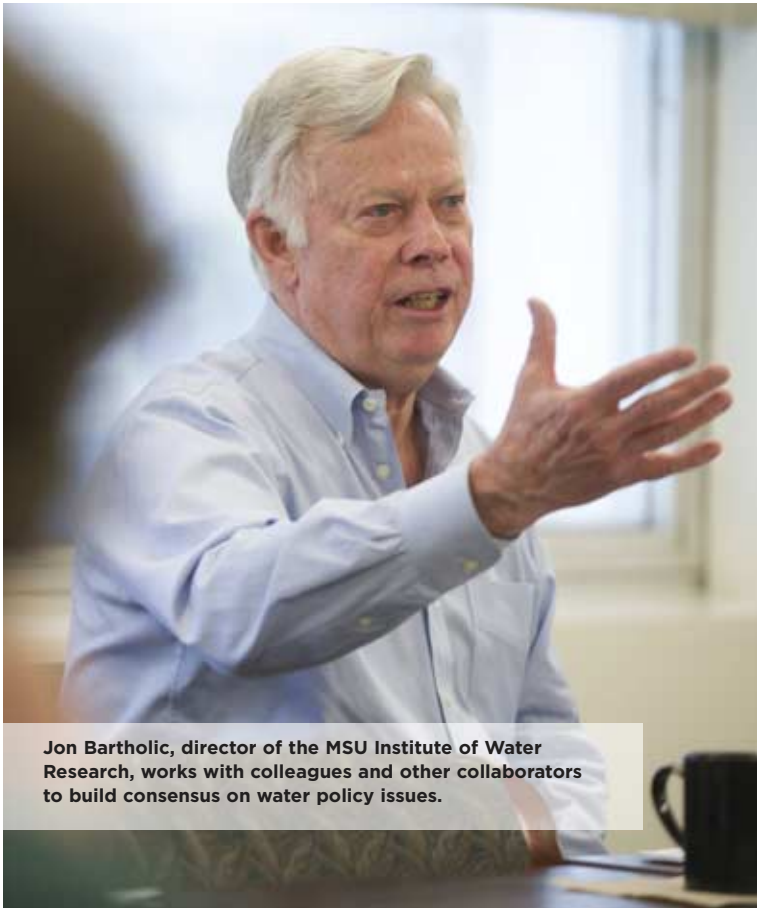
## for water resource policy and management

“W

TATER, WATER EVERYWHERE,” AS THE LINE IN SAMUEL TAYLOR COLERIDGE’S POEM GOES, IS ESPECIALLY TRUE FOR MICHIGAN. But unlike the poem, which goes on to say, “Nor any drop to drink,” there currently is sufficient water for Michigan residents and businesses to drink and use. The state is surrounded by fresh water in the Great Lakes and has

numerous rivers, streams and lakes. This seeming abundance of fresh water poses a problem in developing water policies and managing water resources because everyone thinks there is plenty of water.

“People look around and say, ‘There’s all this water,’” said Michigan State University (MSU) AgBioResearch policy



**Jon Bartholic, director of the MSU Institute of Water Research, works with colleagues and other collaborators to build consensus on water policy issues.**

economist Patricia Norris. “At the same time, we have people around the state trying to explain to residents why there isn’t enough water. We do have a lot of water, but it is not distributed evenly across the state.”

To address this challenge, Norris and other MSU AgBio-Research scientists are pooling their knowledge and expertise to develop and implement effective water policy and management practices for the 21st century.



Approximately 400 billion gallons of water are used in the United States per day.

Source: Environmental Protection Agency

### **New laws, changing conditions, influence overall policy**

Global trends and Michigan-specific issues are affecting the state’s water policy and management.

“We can’t talk about water policy unless we really understand the increase in world population,” said Jon Bartholic, director of the MSU Institute of Water Research. “By 2050, a third of the world population — 3 billion people — may not have a daily water supply. The bottom line is that the challenges are gigantic and Michigan is a key player in the changing water dynamics globally.”

Because the growing population means increasing demand for food, Michigan sales of agricultural products are increasing, especially in international markets, and that trend will continue.

“We have water not only to produce the food, but to process the products,” Bartholic said. “We are already experi-

encing the need for more food and an increase in irrigated acres. The number of registered wells for irrigation and industrial uses have expanded more rapidly in the past few years than at any other time in the state’s history. With \$6 to \$7 a bushel corn and \$10 to \$12 a bushel soybeans, irrigation is economically viable and helps assure supply year after year, which is so critical, whether it is providing seed corn or food stuffs.”

In addition to increases in population and the growth of agricultural production, water policy and management in Michigan are being influenced by the Great Lakes-St. Lawrence River Basin Water Resources Compact (often referred to as the Great Lakes Compact), which went into effect in December 2008. It is a legally binding agreement to regulate water use and reduce diversions of water in Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania and Wisconsin.

“Basically, the compact dictates that each state can manage its water resources so that residents can use the water economically and without any adverse effects on the natural ecosystem,” Bartholic said.

Michigan, however, is a riparian state, meaning that all landowners whose property is adjoining a body of water have the right to make reasonable use of that water. Reconciling the riparian water rights and the restrictions instituted to implement the compact has not been easy, Bartholic said.

The theoretical and applied perspective of this issue is the focus of much of Norris’s work.

“All water users have to figure out together how to share the water,” said Norris, who holds the MSU Guyer-SeEVERS chair in natural resource conservation and is an MSU Extension specialist. “I compare it to a bank account that has a minimum balance. The state is now divided into catchments based on surface water hydrology, and a minimum balance has been established for each catchment. You can imagine the tension between riparian doctrine that says landowners get to use water and the enforcement of a regulatory program that says you don’t get to pull any more out if you go below your minimum balance.”

Norris believes that building capacity for water management through a partnership between researchers, educators, resource users and regulators can help with this issue.

In signing the Great Lakes Compact, Michigan strengthened its water withdrawal law by requiring the registration of all new wells with a capacity of more than 70 gallons per minute. This includes all irrigation and industrial wells but not individual wells for homeowners because they are generally below this capacity.

One of the tools used to implement the new registration

## “IT IS DIFFICULT TO BUILD A SENSE OF URGENCY WHEN EVERYWHERE YOU LOOK, THERE IS WATER.”

requirement is the Water Withdrawal Assessment Tool (WWAT). The website for the WWAT was developed by the IWR in partnership with other state organizations. On the website, people can put in the location and capacity of a new well and its withdrawal effect is automatically calculated. The tool comes back with a “pass” or “no pass” determination. If there is no adverse resource impact, — “pass” — then the people registering the well can move ahead with it. If the well gets a “no pass,” the Michigan Department of Environmental Quality does a site-specific review.

“In practice, about 70 percent of those needing new wells have been getting a pass and move ahead with their wells,” Bartholic said. “However, the state is keeping track of what those withdrawals are in real time. This is a phenomenal system because rarely has anyone been able to look at human activities in real time simultaneous with the effects they have on the natural system.”

Despite its pluses, the withdrawal law has created controversy in some parts of the state, especially where irrigation of agricultural crops has become a necessity.

“Michigan is a supplemental irrigation state, but we have certain types of production activity that require intensive irrigation,” Norris said. “The two big water users in Southwest Michigan are seed corn and potato production. These two crops generally are grown under production contracts that require either a certain yield or a certain amount of water every week.”

These contracts create the potential for conflicts among water users in areas where the water use is high relative to the amount of water available given the minimum balance that must be maintained. In addition, not everyone agrees that registering wells and setting limits on how much can be withdrawn is the best way to manage the state’s water. And some water users question whether the state’s program accurately accounts for the true availability of water and the impacts of withdrawals.

“When the water use law was passed in 2008, it was envisioned that the program, and the data and models that support it, would be reviewed periodically to insure that decisions were made using the best information possible,” Norris said. “However, the

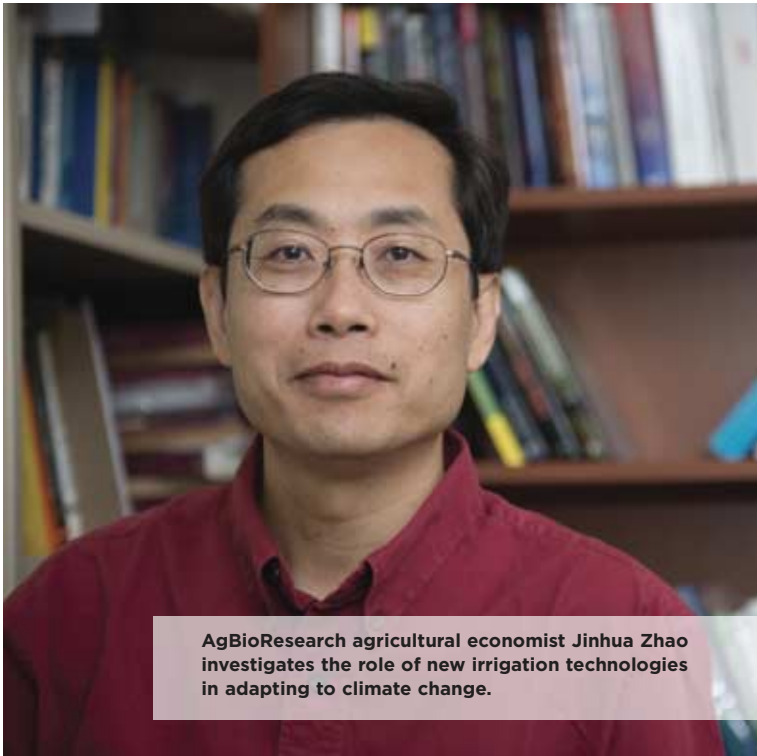
state does not have the resources to undertake this review. There used to be five people working on this program and now there are two.”

Effectiveness and accuracy of the program might benefit from input from diverse stakeholders. The water use law was guided by the Water Resource Conservation Advisory Council, which included representatives from many groups of stakeholders from around the state. The council has disbanded, but Norris sees an opportunity to bring back a similar council so that all stakeholders have a voice.

“The program can be improved with input on what is



**AgBioResearch policy economist Patricia Norris believes that there is a critical need for partnerships and increased education on water management and policy.**



**AgBioResearch agricultural economist Jinhua Zhao investigates the role of new irrigation technologies in adapting to climate change.**

working well and what needs to be changed,” she said. “People in the community know a lot about the resource that state officials and other water experts do not know. These sorts of collaborations can provide even better information.”

Climate change also has to be taken into account with water policy.

“We could reach a point in Michigan where irrigation is no longer supplemental,” Norris said. “We can expect that, in parts of the state where irrigation was never necessary, there is going to be a need.”

Norris and Bartholic agree that the demand for water will grow and that there is a critical need for partnerships and increased education.

“Partnerships are the only way to effectively improve the understanding and management of resources,” Bartholic said. “We need to see the big picture. If we understand the system, we can help guide Michigan’s water resource needs.”

Norris goes back to the crux of the problem.

“It is difficult to build a sense of urgency when everywhere you look, there is water. However, it seems prudent to build capacity now before there is an emergency or crisis,” she said.

**Adapting to new technologies in light of climate change**

AgBioResearch agricultural economist Jinhua Zhao investigates some of the issues that Norris and Bartholic are concerned about — most specifically, the role of new irrigation technologies that reduce the amount of water used on crops

and the role of water in adapting to climate change.

“The traditional way of thinking about this from an economic standpoint is that a farmer will adopt irrigation technology if the cost-to-benefit analysis makes sense,” said Zhao, a professor in the MSU Department of Economics and the Department of Agricultural, Food and Resource Economics, and director of the MSU Environmental Science and Policy Program.

“In the real world, we see that profitable, water-saving irrigation technologies are often not adopted, but after a couple of years of severe draught or when the farm changes hands, they are adopted.”

Zhao’s research is focused on explaining why that is the case and what the roles of information and information sources are in the farmer’s adoption decisions.

“Many times, adoption of technologies, especially the adoption of large-scale irrigation technologies, represents a risky investment to the farmer,” Zhao explained. “It requires a big dollar investment, and that investment is sunk if the technology does not work out or doesn’t perform well.”

One of Zhao’s current research project centers on the Ogallala aquifer in the High Plains region of the United States, which consists of Nebraska, Kansas, Oklahoma and Texas. The research team on this project looks at many aspects of adaptation to climate change, but Zhao looks specifically at irrigation technology adoption.

“In that region, irrigation is THE most important element in agriculture, and adoption is critical to adapting to future climate change,” Zhao said.

The information gained from the high plains project could be useful in Michigan, Zhao added.

“The major conceptual innovation in the model will enable us to take into consideration adaptation of technology for new crops in other regions,” he said. “Our plan is that, once the model is developed, we can expand or carry that model to other regions such as Michigan, where you may have different crops and practices to be adopted.”

Once the adoption model is in place in the high plains, the research team will study institutional changes and policy changes.

“When local governments or irrigation districts impose new restrictions or different pricing systems, these facts can be easily incorporated into the models, and we can evaluate what happens to farmers’ decisions,” Zhao explained. “You can basically predict the effects or impacts of policy changes on farmer behavior related to irrigation technology, water withdrawal and the crop types.”

Zhao’s work also looks at adaptation to climate change.

“Fundamentally, the international community, including



The Great Lakes, inland lakes and streams, and groundwater supply Michigan’s water. Total water use for Michigan from these sources is more than 4 trillion gallons annually.

Source: Michigan Department of Environmental Quality, 2006







AgBioResearch sociologist Stephen Gasteyer talks with Marcia McLaughlin, CEO of the Midwest Assistance Program, New Prague, Minn., during the 2012 annual conference of the American Water Works Association.

the United States, has been very slow in efforts to reduce the release of greenhouse gases — a process called mitigation,” he said. “Given that the international community is now faced with the prospect of a warming climate, what is the response? That’s the motivation for adaptation. We have to do something to change and adapt.”

Zhao’s research in this area includes the development of sophisticated models to predict the future of cropping patterns for U.S. agriculture.

“By looking at historical data, including land characteristics and weather data, we are trying to understand the factors that drive farmers to adopt a crop in a local region,” he explained. “Once we understand the features of the crops that determine farmers’ decisions, we can predict which crops are most suitable. In that model, however, the availability of irrigation water turns out to be critically important in determining what crops are grown.”

That high demand for irrigation water then will have to be matched with other factors, Zhao said.

“Will there be enough water available, including from groundwater, for irrigation, and can the water supply be matched with water demand in the same geographic locations?” Zhao asked. “Those will be the biggest questions with climate change.”

**Ownership of water resources a major factor in policy decisions**

People ultimately make policy, so AgBioResearch social scientist Stephen Gasteyer looks at the social organization behind water management.

“It’s important to look at how people organize around water, including all the institutions and social movements that drive the use of water resources,” said Gasteyer, an assistant professor in the MSU Department of Sociology.

One of the issues that Gasteyer researches is the ownership of water resources.

“I am interested in issues of water privatization and answering questions such as ‘What does that mean?’, ‘How is it implemented?’ and ‘Under what conditions does it create opportunities or problems?’” he said. “This also includes the mechanisms that are used to maintain water systems after they are put into place. In the United States, the water industry tells us that there is a real crisis with the systems that are in place to treat, deliver and filter water. What are the mechanisms to fund repairs over time?”

Recently Gasteyer’s research has been related to questions of access.



Irrigation increases yields of most crops by 100 to 400 percent, and irrigated agriculture currently contributes to 40 percent of the world’s food production.  
Source: Food and Agriculture Organization of the United Nations



“There are 2 million people in the United States who still do not have access to water and sanitation on a regular basis,” Gasteyer said. “There are communities where the infrastructure has deteriorated to the extent that it is not delivering safe water. Where do these people fit into the ownership models? What are the mechanisms that keep them from having access to water?”

Gasteyer believes that the water rates that Americans currently pay may not cover the costs to maintain, repair and upgrade water and wastewater infrastructure.

“We need to figure out how this discrepancy translates into a policy for raising water rates and, if we decide that raising water rates is a good idea, will people get hurt?” he said. “We need to determine if there are people disproportionately harmed by raises in water rates.”

In fact, Gasteyer’s recent research shows that racial minorities pay substantially more for basic water and sewer services than white people. The “structural inequality” is not necessarily a product of racism, Gasteyer said, but of whites fleeing urban areas and leaving minority residents to shoulder the cost of maintaining aging water and sewer infrastructures.

Gasteyer, who worked in Mali and the Palestinian territories before returning to the United States for his doctorate and his current position at MSU, also looks at water resources internationally. Two years ago, the United Nations General Assembly formally recognized the human right to water and sanitation. Gasteyer recently testified on this issue in Washington, D.C.,

before Catarina de Albuquerque, the UN-appointed “independent expert” on this issue.

“I am interested in following how this human right to water gets implemented on an international scale and how we deal with questions of access to water resources,” Gasteyer said. “Ultimately, I am interested in the connection between empowerment and capacity at the community level. To what extent are policymakers part of that matrix?”

As to the future, Gasteyer firmly believes that we need to get a better handle on the social justice of pricing.

“I believe water rates will increase in the United States. We need to understand who makes the decision for whom and empower people to make decisions that keep in mind the long-term sustainability of the system,” he said.

Ultimately, Gasteyer believes it is important to take a historical perspective.

“We need to take a look at how society has dealt with water over time and how governmental and non-governmental institutions that deal with water developed,” he said. “Whether in the high plains aquifer, the U.S. Great Lakes or Africa and the Middle East, you cannot understand how to make the future better if you don’t understand how the past got you to where you are.”

JANE L. DEPRIEST

#### WHERE ON THE WEB?

For more information on the research initiatives listed in this article, visit:

**Great Lakes Compact,**  
<http://www.cglg.org/projects/water/index.asp>.

**United Nations resolution on the right to water and sanitation,**  
<http://www.righttowater.info/>.

**Michigan’s Water Withdrawal Assessment tool,**  
[www.miwwat.org](http://www.miwwat.org).

**Michigan water withdrawal law,**  
<http://www.greatlakeslaw.org/blog/2008/07/michigans-innovative-new-water-withdrawal-law.html>.

**MSU Institute of Water Research,**  
[www.iwr.msu.edu/](http://www.iwr.msu.edu/).

**MSU Environmental Science and Policy Program,**  
[www.espp.msu.edu](http://www.espp.msu.edu).



At 1 drip per second, a faucet can leak 3,000 gallons per year.

Source: Environmental Protection Agency



<sup>1</sup>Environmental Protection Agency, [http://www.epa.gov/watersense/docs/ws\\_supply508.pdf](http://www.epa.gov/watersense/docs/ws_supply508.pdf).

<sup>2</sup>Water.org, <http://water.org/water-crisis/water-facts/water/>.

## MSU invention plays key role in award-winning product



A new forage boost product — containing a revolutionary microbial fertilizer developed by a team of Michigan State University (MSU) researchers including AgBioResearch scientist **C. A. Reddy** — has been selected as one of the top products of the year by *Popular Science* magazine.

Forage Boost from Bio Soil Enhancers, Inc., is the recipient of a 2012 “Best of What’s New” Grand Award. It earned top honors in the Green Technology category from the magazine for its positive environmental impact. A key ingredient in Forage Boost is SumaGrow, which was invented by Reddy, a professor in the MSU Department of Microbiology and Molecular Genetics, and Lalithakumari Janarthanam, a visiting microbiologist and plant pathologist.

SumaGrow is different from common fertilizers because it harnesses the power of non-genetically modified living microorganisms to improve the productivity of forages, hay crops, and a broad spectrum of grain and vegetable crops.

“SumaGrow reduces the need for chemical fertilizers by fixing atmospheric nitrogen, thereby reducing greenhouse gas emissions and lowering chemical pollution of soil and water,” Reddy said. “Benefits also include improved disease resistance and increased phosphate availability.”

*Popular Science* praised Forage Boost, projecting that it could possibly eliminate all other fertilizer use on the planet’s 8 billion acres of pasture grass. It also states that Forage Boost helps to replenish microbes in over-

farmed soil, increases productivity by locking in nitrogen in the soil, breaks down organic waste into useful nutrients and decreases surface water runoff by about half.

## AgBioResearch scientists land USDA grants to improve food safety

Three Michigan State University (MSU) AgBioResearch scientists landed grants totaling nearly \$3 million from the U.S. Department of Agriculture (USDA) for work to improve food safety.



The grants were publicized as part of USDA Deputy Secretary Kathleen Merrigan’s visit to MSU in December, during which she announced 17 grants totaling \$10.4 million from the USDA’s National Institute of Food and Agriculture to universities around the country.

The three AgBioResearch scientists receiving grant dollars are part of the recently created MSU Food Safety Group. This team comprises about 30 MSU researchers from more than 10 departments working with other universities around the world to improve food safety. The grant recipients are:

**Elliot Ryser**, professor of food science and human nutrition, who will use a \$1.8 million grant to explore ways to reduce contamination by *E. coli*, *Salmonella* and *Listeria* during the processing, packaging and retail distribution of fresh fruits and vegetables. Ryser will work with colleagues from MSU, the International Food Protection Training

Institute (Battle Creek), California Polytechnic State University, Rutgers University and Ohio State University to improve the microbial safety of cantaloupe, tomatoes and many other types of ready-to-eat, fresh-cut produce.

**Les Bourquin**, professor of food science and human nutrition, was awarded \$543,000 to develop food safety education and training programs for the food industry. Many food-borne illness outbreaks are caused by food-handling errors by employees. This project will introduce standardized, competency-based processes modeled after internationally accepted criteria to reduce human error. Bourquin will work with colleagues from MSU, Ohio State University and the University of Maryland Joint Institute for Food Safety and Applied Nutrition.

**Brad Marks**, professor of biosystems engineering, received nearly \$543,000 to improve pasteurization methods for low-moisture food products. *Salmonella* is known to be extremely resistant to lethal treatments on foods such as almonds, wheat flour and peanut butter. Marks will work with colleagues from Washington State University to give the food industry sound scientific data, knowledge and tools to ensure effectiveness of measures to prevent outbreaks.

“With millions of Americans contracting food-borne illnesses each year, USDA is committed to supporting research that improves the safety

of our nation’s food supply,” Merrigan said. “Ensuring the safety of food is a top priority for USDA, and we will continue to work with our public and private sector partners on developing solutions to decrease potential risks.”

## MSU researchers show how new viruses evolve and, in some cases, become deadly

Researchers at Michigan State University (MSU) have demonstrated how a new virus evolves and sheds light on how easy it can be for diseases to undergo dangerous mutations.

The scientists showed for the first time how the virus Lambda evolved to find a new way to attack host cells, an innovation that took only four mutations to accomplish. This virus infects bacteria — in particular, the common *E. coli* bacterium. Lambda isn’t dangerous to humans, but this research demonstrated how viruses evolve complex and potentially deadly new traits, said Justin Meyer, MSU graduate student, who co-authored a paper with **Richard Lenski**, MSU AgBioResearch scientist and MSU Hannah distinguished professor of microbiology and molecular genetics. The paper appeared in a recent issue of *Science*.

“The viruses and bacteria reproduce so quickly that we can watch evolution in action,” Lenski said. “We can even study evolutionary changes that require several mutations and involve the interaction between different species.”

Meyer and his colleagues’ ability



to duplicate the results of their research — conducted at BEACON, MSU’s National Science Foundation Center for the Study of Evolution in Action — implied that adaptation by natural selection, or survival of the fittest, had an important role in the viruses’ evolution.

When the genomes of the adapted virus were sequenced, they always had four mutations in common. The viruses that didn’t evolve the new way of entering cells had some of the four mutations but never all four together, said Meyer, who holds the Barnett Rosenberg Fellowship in the MSU College of Natural Science.

“In other words, natural selection promoted the viruses’ evolution because the mutations helped them use both their old and new attacks,” Meyer said. “The finding raises questions of whether the five bird flu mutations may also have multiple functions, and could they evolve naturally?”

Additional authors of the paper are Devin Dobias, former MSU undergraduate (now a graduate student at Washington University in St. Louis); Ryan Quick, MSU undergraduate; Jeff Barrick, a former Lenski lab researcher now on the faculty at the University of Texas; and Joshua Weitz, on the faculty at Georgia Tech.

## Study first of its kind to look at the collateral effects of in-feed antibiotic use in farm animals

Antibiotics in pig feed increased the number of antibiotic-resistant genes in gastrointestinal microbes in pigs, according to a study conducted by Michigan State University (MSU) and the U.S. Department of Agriculture (USDA) Agricultural Research Service (ARS).

Published in the *Proceedings of the National Academy of Sciences*, the comprehensive study, co-authored by MSU AgBioResearch scientist **James Tiedje**, focused on understanding the effects of conventional in-feed antibiotics use on U.S. farms.



For decades, many producers of pigs, chickens and other farm animals have used antibiotics not only to protect their livestock from disease but also to boost growth rates and enhance feed efficiency (a measure of how well animals convert feed into weight gains).

“Scientists don’t know precisely how antibiotics enhance growth rates and feed efficiency, but they are concerned that on-farm use of these medications may contribute to the development of strains of microbes resistant to conventional antibiotics, strains that are potentially harmful to humans and animals,” said Tiedje, an MSU university distinguished professor of microbiology and molecular genetics and crop and soil sciences.

“The growth of antibiotic resistance in pathogens is a huge challenge for society around the world,” Tiedje said. “Studies to understand what contributes to the spread and what interventions can help control the problem are vital.”

According to the USDA, this study is the first of its kind to look at the collateral impacts of in-feed antibiotic use in farm animals using a comprehensive approach to detect shifts in the function and the makeup or membership of the microbial community in the model animal’s gastrointestinal tract.

## Bringing passito to America

Michigan State University (MSU) AgBioResearch scientist **Paolo Sabbatini** is working with vintners to introduce passito, an age-old Italian

wine, to the United States.

Passito, traced to 800 B.C. in Italy, is also known as straw wine. The grapes for passito are typically hand-picked and allowed to dry on cellar racks or, more traditionally, on mats of straw.

Many industry experts believe that ice wine — dessert wine pressed from frozen grapes at the peak of ripeness that can sell for around \$90 per bottle — could be the signature wine for the northern United States. Passito, however, could be just as distinct but also a lower risk option for wine producers, said Sabbatini, an MSU viticulturist and a native Italian.



“No one is making passito commercially in America, and this old Italian technique can be pivotal in cool/cold-climate viticulture,” Sabbatini said. “It can save unripe grapes from being wasted in a challenging year as well as produce a high-quality, high-value product distinctive to the northern United States.”

It isn’t necessary to harvest grapes used for passito during a perfectly timed freeze, so this age-old process can become a reliable source of income for the industry, he added. These grapes are dehydrated safely indoors and are pressed once they meet the chemical specifications of the winemaker.

“The percentage of market share for dessert wines is growing,” Sabbatini said. “In the northern United States, producers could capitalize on the growing market and look forward to having passito every year.”

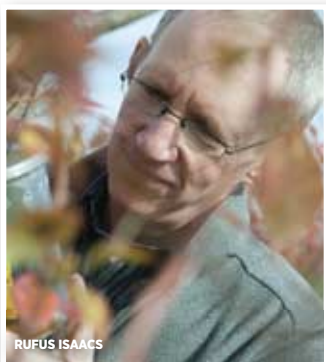
## AgBioResearch scientist heads response team to help Michigan growers manage spotted wing drosophila

Spotted wing drosophila (SWD), an exotic vinegar fly of East Asian origin, was first found in southwestern Michigan in late fall 2010. In the western United States, it has already infested numerous fruit crops and caused economic losses to growers.

Unlike the native vinegar fly, which is more of an annoyance than a problem, SWD (*Drosophila suzukii*) is able to lay eggs in ripe fruit still on the plant, rather than in just overripe or rotting fruit. Populations of SWD can build quickly because there can be multiple generations per year and female flies (which live 20 to 30 days) can lay hundreds of eggs during their life spans. Michigan growers are prepared for this new pest because of the actions of the SWD Response Team, headed by MSU AgBioResearch scientist **Rufus Isaacs**.

“In the fall of 2009, I attended a workshop in Oregon presented by research and Extension entomologists who talked about the pest, describing how bad it was for them to deal with,” said Isaacs, a small fruit entomologist. “From their presentations, it was clear that much of the eastern United States was at risk, and although Michigan’s cold winters might limit the pest, our summer climate and its host range looked appropriate enough to be concerned.”

Isaacs discussed what he’d learned about SWD with fellow MSU fruit entomologists and Extension specialists, highlighting the need for immediate attention. They decided to form the SWD Response Team and get stakeholders — including the Michigan Department of Agriculture and Rural Development (MDARD), MSU Extension, industry representatives and others — involved. This group got together to decide how and where to monitor for SWD in 2010.



RUFUS ISAACS

“SWD was found in 13 of the counties monitored for the pest in 2010,” Isaacs said. “It was a warm fall season, which accounted for the finds so late in the year because SWD activity is predicated on the weather. But there was no economic impact on fruit.”

Once SWD was found, the SWD Response Team put out the word through the newly created SWD website — <http://www.ipm.msu.edu/SWD.htm> — and informational materials for Michigan growers, and presented SWD information at grower meetings during the winter.

In 2011, the survey was widened, and, as of early December, SWD had been found in nine more Michigan counties.

“I’m optimistic,” Isaacs said. “Last year, we were facing a pest that we didn’t know much about. This year, growers have been learning more about it and now know that it is another pest they will need to add to their IPM [integrated pest management] programs. There are pesticides that can be used to control it in the short term, and we will be exploring alternative control tactics. We now have a strategy to manage SWD that will improve as we learn more.”

## MSU AgBioResearch scientist to oversee creation of Michigan tourism plan

Michigan’s tourism industry is generating a new strategic plan to guide its activities during the next five years, and a Michigan State University (MSU) AgBioResearch scientist is leading the effort.

**Sarah Nicholls**, associate professor in the departments of Community, Agriculture, Recreation and Resource Studies (CARRS) and Geography, will oversee the preparation of the new planning document in collaboration with the state’s official tourism promotion agency, Travel Michigan, and the governor-appointed Travel Commission.

“The 2012–2017 Michigan Tourism Strategic Plan will chart a course for the development of Michigan’s tourism industry over the coming five years,” Nicholls said. “Upon evaluation of the previous plan [2007-2011], we will work to develop a vision for the industry and then identify the more specific goals, objectives and strategies needed to move the industry toward its vision state.”



SARAH NICHOLLS

## Plant scientists find mechanism that gives plants ‘balance’

When a plant goes into defense mode to protect itself against harsh weather or disease, that’s good for the plant but bad for the farmer growing the plant. Bad because, when a plant acts to defend itself, it turns off its growth mechanism.

MSU AgBioResearch scientist **Sheng Yang He** is part of an international collaboration that has figured out how plants can make the “decision” between growth and defense, a finding that could help them strike a balance that keeps them safe from harm while continuing to grow.

Writing in the Proceedings of the



SHENG YANG HE

National Academy of Sciences, He, an MSU professor of plant biology, and his team found that the two hormones that control growth (called gibberellins) and defense (known as jasmonates) literally come together in a crisis to determine the plant’s response.

“What we’ve discovered is that some key components of growth and defense programs physically interact with each other,” He said. “Communication between the two is how plants coordinate the two situations. We now know where one of the elusive molecular links is between growth and defense.”

This is important because now that scientists know that this happens, they can work to figure out how to “uncouple” the two, He added.

“Perhaps at some point we can genetically or chemically engineer the plants so they don’t talk to each other that much,” he said. “This way we may be able to increase yield and defense at the same time.”

## Busy queen bees maintain genetic diversity, health of their colonies

By mating with nearly 100 males, queen bees on isolated islands avoid inbreeding and keep colonies healthy.

These findings, published in a recent issue of PLoS ONE, focused on giant honeybee colonies on Hainan Island, off the coast of China. Because these bees have long been separated from their continental cousins, it was thought that the island bees would be prime candidates for inbreeding and have very different genes, said MSU AgBioResearch scientist **Zachary Huang**.

“We believed that the island bees

would show evidence of the founder effect — random genetic changes in an isolated population — on a unique sex determination gene from the mainland bees,” said Huang, an associate professor in the MSU Department of Entomology. “At first we were surprised when we couldn’t document this effect. Looking at it further, I asked myself, ‘Why didn’t I think of this before?’”

When compared with bees, humans have a rather simplistic sex-determination process. In females,



the two sex-determination chromosomes are the same, and in males the two chromosomes are different. With bees, however, the combinations of complementary sex determination genes, or CSDs, determine the sex and the societal role of the bees.

One particular gene can have alleles — the “flavor” of genes. In humans, they dictate hair and eye color. In bees, though, they are responsible for creating females (worker bees), fertile males (that mate with the queen) or infertile males (diploid males which serve no purpose).

The “Eureka” moment came once Huang estimated the bees’ mating habits and the potential of CSD allele combinations. That’s when he understood why he couldn’t confirm the founder effect.

“Keeping the CSD mix diverse is one of the keys to maintaining a healthy hive,” Huang said.

## Journal shines spotlight on long-term ecological research



For more than 20 years, Michigan State University has been a part of the Long-term Ecological Research program (LTER), a National Science Foundation-funded project to conduct research on ecological issues that can last decades and span huge geographical areas.

In celebration of the LTER program, which has been in existence for nearly 30 years, six new papers relating to the importance of such long-term research were recently published in the scientific journal *BioScience*. MSU AgBioResearch scientists **Phil Robertson** and **Doug Landis** are among LTER researchers with articles published in the journal. There are more than 26 sites throughout the world, including the KBS LTER site at the MSU W. K. Kellogg biological Station near Kalamazoo.

Robertson, who has led the KBS LTER for those 20-plus years, is the lead author of the first article in the *BioScience* series. His piece notes the success of the program in documenting and understanding environmental changes that are difficult to detect in short-term studies.

“As we move into an era where human decisions affect even the most remote ecosystems, we need more than ever to understand how decisions cause ecological change, both planned and inadvertent,” said Robertson, a university distinguished professor of crop and soil sciences. “Many of these changes take a long time to play out, and LTER helps us to understand their underlying origins and effects.”

Unlike most grant-funded research that spans a few years, LTER studies are often sustained over decades, documenting gradual changes and sudden surprises that often cannot be revealed by short-term studies.

“Long-term field experiments are critical for discovering the causes and consequences of environmental change,” said Landis, a professor in the MSU Department of Entomology. “Even in managed ecosystems such as Michigan field crops, we can miss the boat without a long-term perspective.”

### MSU study: food and agriculture contributions to Michigan economy top \$90 billion

Michigan’s food and agriculture business sector has emerged from the recession with flying colors. An updated Michigan State University (MSU) study on the impact of the food and agriculture supply chain shows that the industry contributes an estimated \$91.4 billion to Michigan’s economy. That’s an increase of nearly 50 percent between 2004 and 2010.

**Chris Peterson**, director of the MSU Product Center, announced the findings from “The Economic Impact of Michigan’s Food and Agriculture System” during a Michigan Agriculture and Rural Development Commission meeting April 11 in Lansing. The study is based predominantly on 2010 data—the latest available.

Though the largest dollar growth came from the wholesale and retail distribution portion of the supply chain, the largest percentage of

growth came from farming. The farming line encompasses food, energy, horticultural crops, animal production and turf production.

“The impact of Michigan’s farms and the commodities they produce is 12 percent of the overall total, and their economic contribution has nearly doubled from less than \$7 billion to more than \$13 billion,” said Peterson, an MSU AgBioResearch scientist. “You’d be hard-pressed to find another business sector that has pulled through the recession with those kinds of numbers in just six years.”

Peterson attributes the growth to a substantial increase in the value of food and agricultural products throughout the world.

“The global population increase and the dramatic expansion of the middle class worldwide means that more people are consuming more food and, at the same time, that pushes the food price higher,” he explained.

According to the report, Michigan has more than 73,000 full-time farmers and farm workers. That’s 12 percent of the 618,000 direct jobs in Michigan’s food and agriculture business sector. Food and agriculture account for 22 percent of all jobs in Michigan when direct, indirect and induced jobs are considered.

### Eat healthy — your kids are watching

If lower income mothers want kids with healthy diets, it’s best to adopt healthy eating habits themselves and encourage their children to eat good foods rather than use force, rewards or punishments, said a Michigan State University (MSU) study.

The study, which appears in a recent issue of the *American Journal of Clinical Nutrition*, is one of a few that focuses on the eating habits of low-income families. The results demonstrate that the mothers who led by example and persuaded — rather than ordered — their kids to eat their vegetables had kids with healthier diets, said MSU AgBioResearch



scientist Sharon Hoerr.

“Mothers should stop forcing or restricting their kids’ eating,” said Hoerr, a professor of food science and human nutrition. “They’d be better off providing a healthy food environment, adopting balanced eating habits themselves and covertly controlling their children’s diet quality by bringing healthier food into the house.”

Overtly restricting certain foods from a child when others are eating them at mealtimes can lead to unhealthy eating, she added.

Additional parental tips include maintaining regular meal- and snack-times, offering smaller portions of healthy foods and allowing the children to decide how much they will eat.

In continuing this research, Hoerr hopes to develop home-based and interactive educational materials for parents who want to encourage healthful eating.

### New AgBioResearch faculty members

AgBioResearch is pleased to welcome five new faculty members.

**Robert B. Abramovitch**, assistant professor in the Department of Microbiology and Molecular Genetics, became affiliated with Michigan State University and AgBioResearch in January. His research focuses on utilizing genetic, genomic and biochemical approaches to characterize new genes and proteins that enable pathogens to survive and reproduce within host cells. He works primarily with *Mycobacterium tuberculosis* (*M. tuberculosis*), which causes tuberculosis, a leading cause of death in humans by an infectious disease. Abramovitch is initiating research to

## Research IN THE NEWS

study *Mycobacterium bovis* (*M. bovis*), which causes tuberculosis in animals and humans. *M. bovis* is endemic in certain Michigan deer populations and poses a threat to both agriculture and public health. Abramovitch's lab will undertake comparative studies of *M. tuberculosis* and *M. bovis* genetics, biochemistry and host-pathogen interactions with the ultimate goal of developing improved diagnostic tools and new vaccines.



ROBERT A. ABRAMOVITCH

Before coming to MSU, Abramovitch was a postdoctoral fellow at the Cornell University College of Veterinary Medicine from 2006 to 2011. He received his doctorate in plant pathology from Cornell University in 2006 and his bachelor's degree in microbiology from the University of British Columbia in 2000.

**Andrew Dillon**, assistant professor in the Department of Agricultural, Food and Resource Economics, became affiliated with Michigan State University and AgBioResearch in January. He is a development economist with research interests in agriculture, health and nutrition, education and labor decisions made by agricultural households, and the role of social networks in adoption decisions. Dillon is currently involved in randomized evaluations of projects in Burkina Faso, El Salvador, Ghana, Mali and Nigeria.

Before coming to MSU, Dillon was a research fellow at the International Food Policy Research Institute from 2008 to 2011. Dillon received both his



ANDREW DILLON

doctorate and master's degree in applied economics and management from Cornell University in 2008 and 2007, respectively. He received his bachelor's degree in economics and political and social thought from the University of Virginia in 1999.

**Cheryl Murphy**, assistant professor in the Department of Fisheries and Wildlife and Lyman Briggs College, became affiliated with MSU AgBioResearch in January. Her research focuses on how information translates across different organizational scales. Using fish as a model, she



CHERYL MURPHY

synthesizes information collected on individuals and uses it to answer questions at a higher organizational level. Specifically, she examines how an individual's physiological processes translate to behavioral changes and ecologically relevant endpoints; how short-term phenotypic changes in life history traits influence long-term genetic change; and how anthropogenic influences such as contaminants affect these relationships and fish populations or communities.

Before coming to MSU in 2008, Murphy was a postdoctoral fellow in the Department of Ecology and Evolutionary Biology at the University of Toronto. She received her doctorate in ecological and physiological modeling and ecotoxicology at Louisiana State University in the Department of Oceanography and Coastal Sciences in 2006, her master's degree in physiology and cell biology from the Department of Biology at the University of Alberta in 1998, and her honors bachelor's degree in marine biology from Dalhousie University in 1993.

**Lenis Saweda Liverpool-Tasie**, assistant professor of agriculture and food resource economics, joined Michigan State University and became affiliated with AgBioResearch in January. Her research focuses on differential effects of policies and poverty reduction strategies on farmer behavior and welfare. Saweda's work includes investigating the differential effects of social networks on technology adoption by and bargaining power of households and developing strategies to improve efficient fertilizer access and use in developing countries. In previous research, she used asset poverty measures to better understand the dynamics of rural poverty and its effect on the behavior of farmers.



LENIS SAWEDA LIVERPOOL-TASIE

Before coming to MSU, Saweda was a postdoctoral fellow at the International Food Policy Research Institute from 2009 to 2012. She received her doctorate in agriculture and consumer economics from the University of Illinois, Urbana-Champaign, in 2009. Saweda also received

a master's degree in urban and regional planning and a master's degree in third world development support — both from the University of Iowa — in 2004, and a bachelor's degree in economics from the Uni-



WEI ZHANG

versity of Jos, Nigeria, in 2000.

**Wei Zhang**, assistant professor in the Department of Crop and Soil Sciences and the Environmental Science and Policy Program, joined Michigan State University and became affiliated with AgBioResearch in January. His research focuses on soil and water quality and sustainability, with emphasis on the movement of water, solutes (e.g., nutrients, agrochemicals and environmental toxins), and fine particles such as microorganisms, abiotic colloids and engineered nanomaterials in natural and engineered systems, particularly in unsaturated soils. The overarching goal of Zhang's research is to promote protection of soil and water resources and sustainable agricultural production through the understanding of fundamental transport processes and scientifically sound management practices.

Before coming to MSU, Zhang held a prestigious National Research Council research associateship hosted by the U.S. Environmental Protection Agency. He received his doctorate in environmental engineering from Cornell University in 2010, his master's degree in biosystems engineering from Oklahoma State University in 2006 and his bachelor's degree in environmental chemistry from Nanjing University in 2000. 🌱

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