Michigan State University

AgBioResearch

2012 Annual Report

Michigan State University

AgBio**Research**

Leading innovation in food, natural resources and energy

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2012 Annual Report

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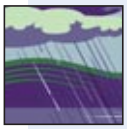

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MANAGING EDITOR'S NOTE: As we interviewed the scientists involved in the research projects presented in this report, they — to a person — provided us with lengthy lists of colleagues, students, organizations and funders integral to their efforts. Including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

MESSAGE FROM THE DIRECTOR

[A miracle every day]

STEVEN G. PUEPPKE

Lately I've been thinking about 21st century food systems and wondering how they will differ from those of our recent past. This is one of those mega issues that all of us in agriculture ought to ponder, but it often slips into the background as we go about our daily business of ensuring a safe, healthy food supply.

It's the cities that have me perplexed. I've been privileged to visit a number of them over the past year, digging deep to examine the successes and failures of today's food systems. We have all heard about the challenges of Detroit, whose citizens lack an adequate number of supermarkets and have limited food choices, even though Michigan and surrounding areas produce food in abundance. What irony.

But I've also ducked pineapples and squash flung by workers off trucks (yes, they really are flung). Those workers pile the fruits and vegetables onto handcarts and sort them into small lots for retailers in São Paulo, Brazil, the largest city in the southern hemisphere. Every day, more than 20 million people miraculously get fruits and vegetables, some of which—according to the signs I saw—are grown in the United States. One squash or one pineapple at a time, the fruits are flung until they reach the consumer.

As a Westerner, I've also nervously avoided eye contact with peasant farmers sitting on the ground among their wares in Hyderabad, India's famed rythu bazaars. Every morning, they tote their tomatoes, cauliflower, peppers and spices into these markets, pick up a loaner scale for weighing, sit down and hope for buyers. If they appear, producers return home with cash in their pockets. If they don't, the vegetables are dumped.

(continued on page 46)

(Left) **A market in São Paulo, Brazil, where every day more than 20 million people get fruits and vegetables, some of which are grown in the United States. Giant-size squash are displayed for sale.** ***(Right)*** **Pineapples are 'flung' from the back of a truck.**

AGBIORESEARCH FACULTY HONORS

Each year MSU AgBioResearch faculty members receive impressive awards and recognition and the fiscal year 2011-2012 was no exception. Here are some of the highlights:

Randolph (Randy) Beaudry, AgBioResearch horticulturist, was recognized as the 2012 Fruit Man of the Year by the Michigan Pomesters, an award not generally given to a researcher. Beaudry, a professor in the Department of Horticulture, was honored for his research with apples and his Extension outreach.

Doug Carmichael, manager of the MSU AgBioResearch Center in Lake City, Mich., received the 2011 Spartan Innovator award for designing and creating a cattle handling corral out of previously used materials. The award was given by the MSU Land Management Office.

Bruce Dale, an AgBioResearch engineer, made Biofuels Digest's list of the top 100 "People in Bioenergy" in 2012. The list was determined by votes from the readers of Biofuels Digest and the Digest's editorial board.

Dale, a professor in the MSU Department of Chemical Engineering and Materials Science, is recognized for, among other accomplishments, his pioneering work in cellulosic ethanol. Dale is using a $4.3 million grant from the U.S. Department of Energy to scale up his method of turning agricultural water and nonfood plants into materials easily processed into biofuel and chemicals.

James F. Hancock, AgBioResearch plant breeder, was the recipient of the 2011 American Pomological Society's Wilder Medal, which is conferred on individuals or organizations which have rendered outstanding service to horticulture in the broad area of pomology.

Hancock, a professor in the MSU Department of Horticulture, was recognized for his contributions as a researcher, plant breeder, author, teacher, advocate for international development and mentor to graduate students and junior faculty. He is recognized as a world authority in the evolution and ecology of crop species, especially strawberries and blueberries. Three blueberry varieties that Hancock developed – Aurora, Draper and Liberty – are the most widely planted blueberry varieties in the world.

Two AgBioResearch scientists were named 2012 fellows of the American Association for the Advancement of Science: **Sheng Yang He**, professor of plant biology, and **Gregg Howe**, professor of biochemistry and molecular biology.

He, a Howard Hughes Medical Institute and Gordon and Betty Moore Foundation investigator, focuses his research on molecular interactions between plants and pathogenic bacteria.

Howe's research aims to understand how plants respond to insect herbivory and other forms of wound stress. Howe uses experimental model systems to study the molecular evolution of chemical traits that shape plant-insect interactions.

Two MSU AgBioResearch scientists were among 10 MSU faculty members honored with 2012 Distinguished Faculty Awards, which recognize outstanding contributions to education and research.

Amy Iezzoni, professor in the Department of Horticulture, has distinguished herself as a researcher, plant breeder, teacher and mentor. She has dedicated her career to the study and improvement of cherries and is recognized internationally as the leading authority in cherry genetics and genomics.

Robert Last, professor in the Department of Biochemistry and Molecular Biology and the Department of Plant Biology, has built a world-class program in plant genomics and metabolism by implementing large-scale genomic and metabolomic approaches to advance discovery research on plant chloroplasts and secondary metabolism in plant trichomes.

Weiming Li, an AgBioResearch scientist and professor in the MSU Departments of Fisheries and Wildlife and Physiology, received the 2012 Distinguished Faculty Award from the MSU College of Agriculture and Natural Resources.

Li, an expert in fish biology, was recognized for his work on sea lamprey biology that has allowed for a better understanding of the invasive and highly destructive fish. Research from Li's laboratory identified a lamprey pheromone that not only provided a way of controlling this invasive species in the Great Lakes but also resulted in a patent.

Ajit K. Srivastava, professor and chair of the Department of Biosystems and Agricultural Engineering and an AgBioResearch scientist, was the recipient of the 2012 James R. and Karen A. Gilley Academic Leadership Award from the American Society of Agricultural and Biological Engineers (ASABE) in recognition of his exemplary and sustained academic leadership and for his outstanding contributions to teaching and research, as well as his dedicated service to ASABE.

food and health

Prevention, vigilance and ongoing research are key to ensuring that crops, animals and humans remain healthy and vital.

From conducting innovative research aimed at better protecting people from diseases such as cardiometabolic syndrome and diabetes to improving the availability of and access to fresh, safe and nutritious food, Michigan State University AgBioResearch scientists are hard at work providing Michigan growers and commodity groups with the critical information and resources they need to remain competitive in the global economy, and giving consumers knowledge that they can use to improve their health and well-being. The projects highlighted in this section provide a snapshot of the groundbreaking research being done in this priority area.

[**Exploring** the somewhat **obscure link** between **obesity and air pollution**]

PHOTO: COURTESY OF JACK HARKEMA

A study conducted by the Great Lakes Air Center for Integrated Environmental Research (GLACIER) at MSU involves extracting air directly from the atmosphere into mobile laboratory units. These modified semi-trucks are equipped with monitoring equipment to test for air pollutants.

More than one in three American adults has a condition known as cardiometabolic syndrome (CMS). It is a cluster of metabolic abnormalities such as high cholesterol, obesity, high blood pressure and high blood sugar that increases the risks of cardiovascular disease (CVD) and diabetes. Annually it costs billions in health care.

Jack Harkema, university distinguished professor in the Department of Pathobiology and Diagnostic Investigations in the MSU College of Veterinary Medicine and director of the Great Lakes Air Center for Integrated Environmental Research (GLACIER) at MSU, is investigating the link between the health effects of CMS and air pollution.

"We have a big problem now, not only in the U.S. but throughout the world, of overeating, obesity and poor diets. We believe that these may make people more susceptible to the adverse effects of air pollution and that air pollution may enhance facets of CMS," said the MSU AgBioResearch scientist. "GLACIER is trying to figure out if that's true and, if so, what multipollutants in the atmosphere are the most harmful."

GLACIER is one of four Clean Air Research Centers in the United States funded by the Environmental Protection Agency (EPA). Other centers are located at Harvard University, the University of Washington in Seattle and Emory University/ Georgia Institute of Technology in Atlanta.

Harkema realizes that a connection between CMS and air pollution can initially seem like a stretch.

"One question I frequently hear is, 'How can someone who suffers from CMS, which doesn't have anything directly to do with the lungs, be more inclined to the adverse effects of air pollutants?'" he said. "The best analogy is smoking. For the longest time, people didn't think smoking was bad. Then people started to believe it could cause chronic lung diseases such as emphysema. Then it was determined it could cause lung cancer and could contribute to other diseases outside of the respiratory system, such as breast cancer and heart disease."

Cigarette smoke, combined with specific predisposing conditions such as bad eating habits, can cause changes in the body apart from the lung and contribute to CMS. Harkema said he believes that, like CMS and smoking, air pollution can adversely affect multiple organ systems, including the heart, lung and liver, and even body fat.

Currently, he and his colleagues are examining whether the consumption of high-fructose products contributes to CMS and, ultimately, if a diet high in this sugar or a high-fat diet increases the risk of cardiopulmonary alterations from breathing polluted air.

"In the 1970s, high-fructose corn syrup was starting to be put in almost everything that needs sweetening, such as soft drinks,

> "The intersection of **two major health problems, obesity and air pollution,** is being investigated by many scientists. We're **on the forefront** and have a **great opportunity** working with some of the **world's best environmental scientists** to tackle this global problem." • JACK HARKEMA

beverages and ketchup. Today, it's pretty pervasive in our diets," he said. "When you look at a graph of obesity prevalence, that rise in obesity started at about the same time — in the 1970s."

Harkema has found that mice fed a high-fructose diet begin showing CMS symptoms after a few weeks. When those laboratory rodents are exposed to air pollutants, they develop a condition known as insulin resistance (IR), believed to be the underlying physiological cause of CMS, he said.

"With IR, the insulin is there in the body, but the cells cannot detect it, and they are unable to properly take up and utilize the glucose in the blood, leading to high blood sugar and other prediabetic conditions," he said. "In the case of our mice, air pollution — in combination with the high-fructose diet — seems to be causing an early rise in IR and other CMS facets."

Another GLACIER study involves extracting air directly from the atmosphere into mobile laboratories called AirCare1 and AirCare2. These modified semi-trucks are equipped with monitoring equipment to test for air pollutants.

"One airshed in southeastern Michigan that we're studying has a very high level of fine particles in the air," he said. "Kids with chronic diseases such as asthma and diabetes living in this community may breathe air polluted with these small airborne particles emitted from local industries and motor vehicles, and these inhaled particles may exacerbate health problems."

Harkema — recently appointed to the Clean Air Science Advisory Committee, a seven-member team of experts that makes recommendations to the EPA administrator — is pleased about the direction of the GLACIER research.

"This multidisciplinary group is really exploring something on the cutting edge because we don't know how diabetes and other cardiometabolic diseases are making people more susceptible to air pollution," he said. "The intersection of two major health problems, obesity and air pollution, is being investigated by many scientists. We're on the forefront and have a great opportunity working with some of the world's best environmental scientists to tackle this global problem." ●

More on the web at:
greatlakesairresearchcenter.org

[Setting the stage for children to eat healthier diets]

Childhood obesity rates in the United States have more than tripled in the past three decades. In 2008, more than one-third of children and adolescents were overweight or obese.*

Sharon Hoerr, MSU professor of food science and human nutrition, is examining ways that mothers can help their children learn to eat healthier diets. She is discovering that parents who adopt positive eating habits themselves and who encourage, rather than punish, their children see better results.

"Control can be very overt, such as 'Don't eat this, eat that,' 'Eat this or you won't get this,' or 'Eat this if you want ice cream,'" said the MSU AgBioResearch scientist. "That is negatively perceived by the child. Parents can exert a substantial amount of control covertly. This takes a little bit more energy, but findings suggest it is the best way to improve children's diet and in part, as a consequence, their weight as well."

Hoerr, who has spent 25 years on a local Head Start advisory committee, has developed a five-topic set of booklets called "Eat Healthy: Your Kids are Watching! A Parent's Guide to Raising a Healthy Eater." She worked with two child development specialists, several pediatric dietitians and a senior producer from the MSU College of Communication Arts and Sciences to create 24 short video segments to accompany the booklets. The segments feature actual parents with their children, not actors, talking about food in their homes.

The materials were tested with 20 parents in a clinical trial a year ago but didn't receive the desired response. Hoerr and the group went back to the drawing board to revamp the materials.

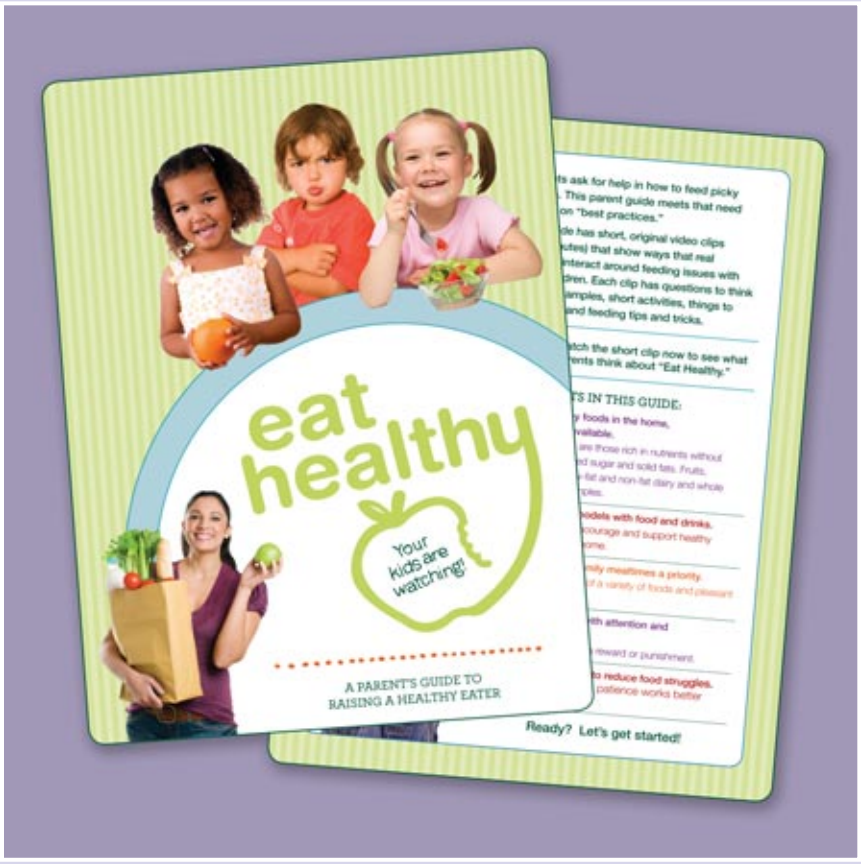
"The one finding that bothered us a lot was that while the parents liked the materials, about 40 percent didn't think they needed them," she said.

The amount of text (written at a third- to fifth-grade reading level) in the booklet was reduced and replaced with more

"Our studies show a **very high percentage of preschoolers who are overweight** — higher than the CDC rates. We're getting close to **40 percent overweight and obese children ages 3 to 5 in the immediate four-county region** [Ingham, Clinton, Livingston and Shiawassee]." • SHARON HOERR

bullet points, parent checklists, interactive activities with their children and graphics. The aim was to make the materials as interactive as possible. Hoerr said she is pleased with the response to the revised booklets and videos by a group of 30 parents this past summer.

PHOTO: COURTESY OF SHARON HOERR LAB



A five-topic set of booklets called "Eat Healthy: Your Kids are Watching! A Parent's Guide to Raising a Healthy Eater" has been developed by MSU professor of food science and human nutrition Sharon Hoerr with the assistance of child development specialists, pediatric dietitians and a producer from the MSU College of Communication Arts and Sciences.

"In a couple of the families, they even use the videos as rewards for good behavior," she said. "I was surprised by that at first, but when you think about it, these are 24 short clips of parents talking about feeding young children and show children that age. It makes sense that preschoolers would enjoy watching it. There are lots of kids their own age in their natural environments."

In collaboration with the Michigan Nutrition Network at the Michigan Fitness Foundation (MFF), Hoerr plans to determine how effective the guide is at changing children's eating habits. She will recruit 80 to 100 parents to use the materials in a quasi-experimental design over an eight-month period to see if eating habits change.

Finding ways to help children learn healthy eating is imperative, Hoerr said.

"Our studies show a very high percentage of preschoolers who are overweight — higher than the CDC rates," she said. "We're getting close to 40 percent overweight and obese children ages 3 to 5 in the immediate four-county region [Ingham, Clinton, Livingston and Shiawassee]."

In general, Hoerr said she encourages parents to continue introducing foods to picky eaters, up to as many as 15 times, because taste preferences change and mature with age.

"You can't acquire a taste for something if you don't taste it," she said. "The expectation has to be there. Even if young children spit it out, that's still tasting it. They should be rewarded and not punished for spitting it out."

Hoerr said parent feeding styles tend to fall into one of four main categories: authoritarian (controlling), authoritative (positive), indulgent and uninvolved. Early research has shown that children of middle-class Caucasian families with authoritative parents had the healthiest weights, but Hoerr said few studies have focused on lower income families, and the findings about feeding style have been inconsistent.

"The one uniform finding across all races and ethnicities and educational levels is that permissive parenting — indulgent and noninvolved — is terrible," she said. "Children of such parents have the worst quality diets, the most obesity and often psychosocial problems at school." ●

**Centers for Disease Control and Prevention.*

[Furthering **science** with the **help** of a **biochemical powerhouse**]

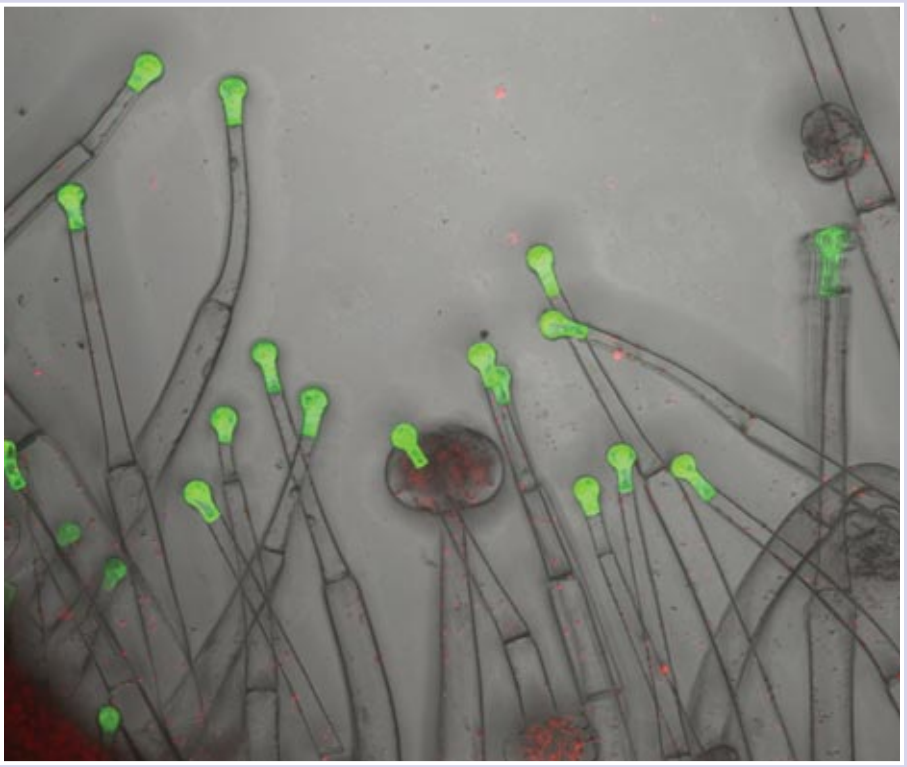


PHOTO: COURTESY OF TONY SCHILMILLER

Secretory and glandular trichomes — tiny, hairlike appendages on plants — play a critical role in plant protection against environmental threats. Many trichome-borne compounds also have commercial value as pharmaceuticals, fragrances, food additives and natural pesticides.

Throughout the entire plant kingdom, plants produce between 100,000 and 300,000 unique molecules — far more than the number produced in the animal kingdom. A recurring question among scientists is "Why?" Michigan State University (MSU) AgBioResearch scientist Robert Last and colleagues A. Daniel Jones and Cornelius Barry, also AgBioResearch scientists, are conducting collaborative research on secretory and glandular tomato trichomes (tiny, hairlike appendages on plants) in an attempt to shed some light on this question.

"Plants are master chemists," said Last, Barnett Rosenberg professor of biochemistry at MSU. "We want to know how and why plants make so many different molecules. Trichomes are perfect candidates for study because they're on the outside of plants — they're accessible and they produce really interesting chemicals."

Thought of as one of the first lines of a plant's defense, the trichome has become the focus of much study at MSU because of its ability to synthesize, store and secrete large amounts of secondary metabolites — chemicals produced by plants for which no role has yet been found in growth, photosynthesis, reproduction or other primary functions. Trichomes are found on approximately 30 percent of all vascular plant species. These hairs are thought to play a vital role in the protection of plants from environmental threats including herbivore attack; viral, fungal or bacterial infection; extreme temperatures; and overexposure to harmful ultraviolet rays. The chemicals found in the tips of some trichomes are used for pharmaceutical and culinary purposes.

Although these trichome roles have been identified and used by humans, Last and his colleagues were interested in having trichomes fill a different niche — the gateway to a greater understanding of essential biological processes. Specifically, because of their simple and highly accessible structures, trichomes are great for studying specialized metabolic pathways.

"Insights are coming out of this project that tell us more about how plants make small molecules," Last said. "This is new science that no one has seen before — we are able to see signs of the evolution of novel biosynthetic pathways. There will be some fundamental knowledge gained from studying biochemistry that is obviously under very strong evolutionary selection."

Last explained that others have studied a class of compounds called terpenes, which are made in many cells across the plant kingdom in presumably the same way. Research in this project revealed that tomato plants' trichomes make these compounds differently.

"This information is both exciting and eye-opening and it shifts our understanding of plant biochemistry as it deepens our understanding of evolution," Last said. "We've known how terpenes are made for decades, but now we know that tomato trichomes make them differently. We keep waiting for someone to publish a paper that shows another plant or cell that makes terpenes the same way as tomato trichomes do, but we haven't seen it yet. Why do they make these compounds this way? They can make them the same way trees do, but they don't. Maybe knowing this will help a smart chemist who's interested in solving a real-world problem approach it in a new way."

As more is learned about trichomes and the implications of these findings are explored, Last contends that these discoveries will lead to advancement and innovation in society. Many trichome-borne compounds already have commercial value as pharmaceuticals, fragrances, food additives and natural pesticides.

"These research findings have the potential to shape new

societal uses," Last said. "There are people who are interested in using trichomes as chemical-making factories because that's exactly what they are. For example, someone interested in trying to produce a novel chemical in a plant can take advantage of the unique features of trichomes; it also becomes easy to purify the chemical because the trichome is so easy to isolate — it can function as a tool.

"We don't know where the really important stuff is going to come from," Last added. "But I'm curiosity-driven. Opiates from poppies aren't made by plants because humans want to use them for medicinal purposes — they're made for other reasons, but we still benefit from it. We want to know why the plant makes them to begin with. Studying trichomes allows us to explore a greater genetic context, giving us an understanding that will lead to innovation." ●

> **"Plants are master chemists. We want to know how and why plants make so many different molecules. Trichomes are perfect candidates for study because . . . they're accessible and they produce really interesting chemicals."** ● ROBERT LAST

[**Understanding** the importance of **milk components** to **farm profitability**]

More than one-third of Midwest dairy farmers experience low milk fat production in their cows at any given moment.* This occurrence, known as milk fat depression, is particularly challenging because it diminishes returns for the farmer.

MSU AgBioResearch animal scientist Adam Lock is investigating dietary risk factors associated with milk fat depression and working to identify ways to increase milk fat yield.

"Nowadays farmers in the Midwest and in many parts of the country are paid within the federal milk marketing orders," said Lock, who was raised on a dairy farm in England. "Instead of being paid for how much fluid milk they ship, the main pricing is on the pounds of fat and protein that they're shipping off the farm. Even a slight change — let's say from 3.8 to 3.4 percent milk fat — can amount to a substantial financial loss."

Digestive processes occurring in the rumen — the first of the four parts of a cow's stomach — are of particular interest. Bacteria metabolize the unsaturated fatty acids from the feed into saturated fatty acids, a process called rumen biohydrogenation. This occurs through a series of steps that also results in the production of small amounts of unique fatty acids called biohydrogenation intermediates.

"In the last decade, there's been a big breakthrough in understanding the interrelationship between diet, rumen metabolism and milk synthesis in the mammary gland," said Lock, an assistant professor of animal science. "We understand that very subtle changes in the rumen environment can change how bacteria metabolize dietary unsaturated fat. Specifically, these changes can result in the production of biohydrogenation intermediates, which we've learned are very potent regulators of fat production in the mammary gland.

"We've just done some work where we were delivering specific fatty acids into the abomasum (the last part of the cow's stomach), completely bypassing the rumen, so we knew exactly what we were delivering. We think that perhaps these fatty acids might also inhibit fat synthesis."

Lock also recently surveyed corn silage samples in Michigan to try to better understand potential differences in the amounts and types of fatty acids in the major component of dairy cow diets.

"Presently we really do not have a good handle on whether this change is due to location, storage conditions, etc.," he said. "Changes such as these may have important ramifications with respect to rumen biohydrogenation."

Lock and fellow AgBioResearch animal scientist Mike Allen are also utilizing various in vitro techniques to mimic the rumen environment to improve their understanding of what causes changes in biohydrogenation processes and the formation of specific biohydrogenation intermediates. Specifically, they're looking at how different pH and starch levels and the types of fatty acids present in the rumen affect milk fat production.

They are also investigating whether milk fat and milk yield can be increased by supplementing the cows' diet with specific fatty acids. Saturated fatty acids are an option because they do not adversely affect the rumen bacteria. An initial study focuses on the effects of providing cows a dietary supplement of palmitic

PHOTO: COURTESY OF ADAM LOCK LAB

The occurrence of milk fat depression in cows dramatically diminishes returns for dairy farmers. Research being conducted by MSU animal scientist Adam Lock is examining ways to increase milk fat yield.

acid (C16:0). The preliminary findings show promise.

"We fed the cows a supplement that contained 85 percent palmitic acid," Lock said. "Results demonstrate that palmitic acid is able to increase milk fat concentration and yield, as well as the efficiency of feed conversion to milk. Further studies and on-farm testing are required to gauge responses across different types of diets and compare palmitic acid against other dietary fatty acids."

Discovering ways to improve milk production efficiencies will ultimately benefit the consumer.

"It's inefficient if there's a dietary issue that's making a dairy cow produce 3 percent milk fat instead of 4 percent," he said. "Those inefficiencies get passed down the line as higher prices in the grocery store."

> **"It's inefficient if there's a dietary issue that's making a dairy cow produce 3 percent milk fat instead of 4 percent. Those inefficiencies get passed down the line as higher prices in the grocery store."** • ADAM LOCK

In addition to working with animal nutritionists on a farm, Lock — who also has an MSU Extension appointment — educates about the human health implications.

"On the human health side in the next decade, I predict that we're really going to start challenging and countering this misconception about saturated fats and milk fat being negative for human health," he said. "For the past 60 years, there has been such negativity toward saturated fat in the human diet. And by association, that means milk fat."

Debate aside, the dairy industry no doubt plays an important economic role. In Michigan alone, in 2010, dairy generated $1.4 billion in cash receipts. It was the largest commodity group contribution within the state, outpacing the next closest — corn — by more than $300 million. ●

** Bailey, K.W., C.M. Jones and A.J. Heinrichs. 2005. Economic returns to Holstein and Jersey herds under multiple component pricing. J Dairy Sci. 88:2269-2280.*

More on the web at:
dairynutrition.msu.edu

[Piecing together the cause of diabetic vision loss]

With more than 25 million people in the United States diagnosed with diabetes and another 79 million considered prediabetic, understanding the puzzling "why" and "how" of this disease's complications has been the focus of much research.

Michigan State University (MSU) AgBioResearch scientist Susanne Mohr has been working to put the pieces together, synthesizing years of research to understand the link between inflammation and vascular changes associated with diabetic retinopathy — a common complication of diabetes that affects the eyes and can lead to blindness — and the cell mechanisms that trigger it.

"It's fascinating," said Mohr, MSU associate professor of physiology. "And the research is done with a purpose. There are so many people with diabetes, and retinopathy is a disease that

PHOTO: NATASHA BERRYMAN

MSU graduate student Kristen Entwistle *(left)* and lab manager Barbara Christian examine a tissue culture.

many diabetic patients develop. Though there has been a lot of research done on retinopathy, the understanding of the development and progression of the disease is incomplete, and views about the mechanisms underlying it are changing."

Diabetic retinopathy is the leading cause of new cases of blindness among Americans ages 20 to 74 according to the American Diabetes Association. It was long thought of as simply a vascular complication. Mohr's research is pointing to a different cause that could not only change the way retinopathy is conceptualized but also how it's treated.

"Diabetic retinopathy was previously considered a vascular disease," Mohr explained. "But now we think that the disease might originate in the neuroretinal part of the retina; the secondary outcome is the vascular event that we see clinically. We are looking at a specific cell type called Müller cells, special cells that have direct contact with blood vessels in the retina. We want to understand how high glucose levels induce inflammation in these cells, how this inflammation is maintained over a long period of time and what effect this chronic inflammation has on the entire retina."

Recent research by Mohr and her colleagues led to a significant discovery: the inflammation associated with retinopathy is the result of an autoinflammatory feedback cycle — high glucose levels cause cells to secrete an inflammatory mediator that circles back to the original cell, activating its own receptor and creating a self-sustaining inflammation cycle. Chronic inflammation leads to accelerated aging and the death of central cells. This new concept has been named "inflamm-aging."

In early research, Mohr identified two proteins that accumulate in the nuclei of Müller cells. One protein, siah-1 protein, is produced by the body when blood sugar levels are high. Mohr explained that siah-1 protein binds to a second protein, glyceraldehyde-3-phosphate dehydrogenase (GAPDH), enabling GAPDH to enter Müller cells' nuclei. When GAPDH accumulates in the nuclei, cells produce more inflammatory mediators, enhancing retinal inflammation and inhibiting proper maintenance of the telomere (a region of repetitive DNA at the end of a chromosome, which protects the end of the chromosome from destruction), which is necessary to prevent accelerated aging and cell death.

"If we can prevent the binding of the two proteins, we can stop GAPDH from entering the cell, creating a healthier environment for the retina tissue and preventing blindness altogether," Mohr said. "We're partnering with a bioengineer from Vanderbilt University who, under our direction, has synthesized a peptide that could prevent the binding between siah-1 and GAPDH.

"Diabetes is known to be a disease of accelerated aging," Mohr added. "We are testing whether inflamm-aging is applicable to diabetic retinopathy. We know that it's a very slow, chronic inflammatory process that feeds itself and then affects other cells, leading to their death, loss of function, hastened aging and the progression of the disease. Understanding this process and what can be done to stop it is what we will focus on moving forward."

Currently, there is no way to prevent diabetic retinopathy. The most patients can do is manage their diabetes under the instruction of their physician and regularly see an ophthalmologist as they remain vigilant of changes in their vision. Should Mohr's research continue to bridge the gap between what is known and what isn't, the implications for prevention and treatment would be profound.

> **"If we can prevent the binding of the two proteins [siah-1 and GAPDH], we can stop GAPDH from entering the cell, creating a healthier environment for the retina tissue and preventing blindness altogether."**
>
> • SUSANNE MOHR

"The dogma about the disease is changing," Mohr said. "And because it's changing, mechanisms of the disease can be looked at differently. All of this research is coming together — it's like a puzzle. We had these two puzzle systems and now we're starting to see how they might interlock. It's great." ●

environmental stewardship

and natural resources and policy

Developing economically and environmentally sound approaches to address environmental and natural resources challenges is increasingly important.

Practices, policies and science-based knowledge must constantly evolve to promote stewardship and sustainability in light of new opportunities for increased productivity, resource-saving technologies and enhanced quality of life. The projects featured in this section reflect some of the innovative work being done by Michigan State University AgBioResearch scientists in this area to help communities, natural resources managers, producers and policymakers at all levels make informed decisions and wise choices.

[**Envisioning** the future of **Michigan's environment** and **natural resources**]

PHOTO: MSU AGBIORESEARCH

Critical thinking on policies regarding natural resource conservation is being led by MSU AgBioResearch policy economist Patricia Norris and policy leaders throughout Michigan.

As human populations increase and habitats become more limited, increasing importance has been given to natural resources conservation globally and in Michigan. As more issues come to the forefront, there is an increased need for critical thinking on natural resource conservation policies. MSU AgBioResearch policy economist Patricia Norris and other policy leaders statewide are pooling their knowledge and expertise to inform the development and implementation of effective policies.

"Many of our state's environmental policies were designed to address problems that are well-defined, well-understood and fairly manageable, but we've solved — or at least done a pretty good job with — most of those kinds of issues," said Norris, the MSU Guyer-Seevers chair in natural resource conservation and an Extension specialist. "What we're left with are either problems that we've never figured out how to solve or new kinds of problems. The concern is that the tools developed for older challenges won't be appropriate for future ones. Further, state and federal budgets can no longer support programs based on older policies."

One program that is helping to guide critical conversations in Michigan is the Environmental and Natural Resources Governance Fellows Program. The fellows program is composed of 36 leaders from around the state. Participants met for a series of workshops to explore ways to update policies governing the management of the environment and natural resources in light of increasingly limited funding.

Norris has been a key force behind the fellows program along with Sandra Batie, retired professor of agricultural, food and resource economics and emeritus Elton R. Smith chair in food and agricultural policy. The group formed at the urging of the Michigan Environmental Advisory Council, which suggested that MSU and the Michigan Department of Environmental Quality partner in the initiative.

The fellows deliberated the context for changes in governance (the steering that undergirds the actions of government) and identified key assumptions about opportunities for and barriers to change. Now, many of the participants in the program are working — at both state and community levels — to engage citizens in policy discussions.

"A major role that MSU plays in this program is cultivating fellows who are then in a position to provide leadership," Norris said. "The objective was that we would hear from and provide resources for this small group of people, and, armed with this information, they would go out and expand the conversation. The most important part of the fellowship is that MSU is engaging the community by facilitating communication and then helping the knowledge spread."

The fellows acknowledge that, although the traditional approach to public responsibility for environmental and natural resource management will no longer be sufficient or appropriate, new policies will not develop overnight.

"The word 'trust' comes up over and over again — trust within a community, trust between a community and state government, trust between state agencies that have different areas of responsibility. Building trust among participants is important and will take time." • PATRICIA NORRIS

Another natural resource issue of increasing importance in Michigan is water rights. Water policy in Michigan is being influenced by the Great Lakes-St. Lawrence River Basin Water Resources Compact (often referred to as the Great Lakes Compact), a legal agreement to regulate water use and reduce diversions of water in the states surrounding the Great Lakes. Michigan, however, is a riparian rights state, meaning that all landowners whose property adjoins a body of water have the right to make reasonable use of that water. Reconciling riparian water rights and the restrictions instituted to implement the compact has not been easy. The theoretical and applied perspective of this issue is the focus of much of Norris's work.

"All water users have to figure out how to share the water," said Norris, who believes that building capacity for water management through a partnership between researchers, educators, resource users and regulators can help with this issue. One critical point is water for irrigation of agricultural crops.

"Michigan is a supplemental irrigation state, but we have some production activity that requires intensive irrigation," Norris pointed out. "We could reach a point where irrigation is no longer supplemental. In parts of the state where irrigation was never necessary, there may be a need in the near future."

In all areas of natural resource conservation, change will most likely be difficult because things have been done a certain way for a long time. One issue is trust.

"The word 'trust' comes up over and over again — trust within a community, trust between a community and state government, trust between state agencies that have different areas of responsibility," Norris said. "Building trust among participants is important and will take time." ●

[Monitoring the effects of biomass production on climate]

The Energy Independence and Security Act of 2007 mandates increased use of clean renewable fuels, often called biofuels. These are made from grassy and woody plants, food crops and other numerous sources.

MSU AgBioResearch scientist David Rothstein is studying how the conversion of marginal or abandoned agricultural lands in the northern parts of Michigan, Wisconsin and Minnesota can contribute to the increased use of biofuels.

His work with experimental willow and poplar forests is being done in collaboration with researchers in the Department of Forest and Wildlife Ecology at the University of Wisconsin and the Department of Forest Resources at the University of Minnesota along with researchers at the Great Lakes Bioenergy Center and the MSU Forest Biomass Innovation Center (FBIC) in Escanaba, one of 13 AgBioResearch facilities in Michigan.

"We want to quantify the soil impacts, greenhouse gas [GHG] emissions and biomass production associated with short-rotation woody cropping systems across a wide range of site conditions," said Rothstein, an associate professor in the MSU Department of Forestry. "This information can be used in predictive models to assess the true environmental impacts and benefits of expanded bioenergy plantations and assist in the sustainable deployment of short-rotation woody biomass crops across the Great Lakes."

The idea of this project is to take marginal or abandoned agricultural lands in the northern parts of these lake states and use the land for growing energy crops. This would minimize competition for land used for food production, which tends to be concentrated in the southern parts of the region.

"The other rationale is that we are not harvesting wood for energy from existing forests," Rothstein said. "The existing forests are providing important environmental services already. In my view, focusing on the marginal lands is important for both reasons. We rely on forests for timber, recreation and climate mitigation — they pull a lot of CO_2 out of the atmosphere."

Willow and popular are considered good to use for biofuels production because they have been bred for rapid growth and have a low nutrient and nitrogen demand compared with other crops. In addition, they grow well on underutilized, fallow land, and once the crop is established, it requires very little maintenance and fertilizer.

PHOTO: COURTESY OF RAY MILLER, FBIC

Brad Bender, operations forester with the MSU Forest Biomass Innovation Center (FBIC), works in a 3-year-old willow plantation at the center, in Escanaba, Mich.

"Being climate-neutral is the ideal — the CO_2 emitted to the atmosphere when you utilize biomass energy should be balanced by CO_2 taken up through photosynthesis. My interest is in understanding how well these things approach the ideal," said Rothstein, who was recently awarded a U.S. Department of Agriculture grant to advance his research efforts.

Rothstein said. "What we have put together is a whole series of sites that can capture the variability in soils and climates."

Rothstein believes, however, that the variability is predictable.

"So, the end point is to use that information to better understand how much we can grow, where we should grow it and where we should not grow it," he said.

"We know that the world is a diverse place. We cannot expect the same results if you grow the same crops in different locations. What we have put together is a whole series of sites that can capture the variability in soils and climates." • DAVID ROTHSTEIN

The research team has established experimental plantations in northern Minnesota, Wisconsin and Michigan, and carries out measurements at four additional test sites established by MSU AgBioResearch throughout northern Michigan. There also is an experimental plantation at the FBIC to compare conventional tillage, reduced tillage and no-tillage methods on hybrid poplar.

The most important finding to date is that carbon sequestration and greenhouse gas emissions vary across the landscape.

"We know that the world is a diverse place. We cannot expect the same results if you grow the same crops in different locations,"

Rothstein and the research team hope to produce real-world maps that would show the best sites for this type of biomass production.

"That would be useful for landowners, if they want to get into those markets," Rothstein said. "It also would be useful for industry and policymakers. If companies are going to build a new bioenergy plant, they will want to locate where there is a lot of potential to produce and easily transport the biomass feedstock." ●

[Partnering to defend the nation's water resources from nutrient pollution]

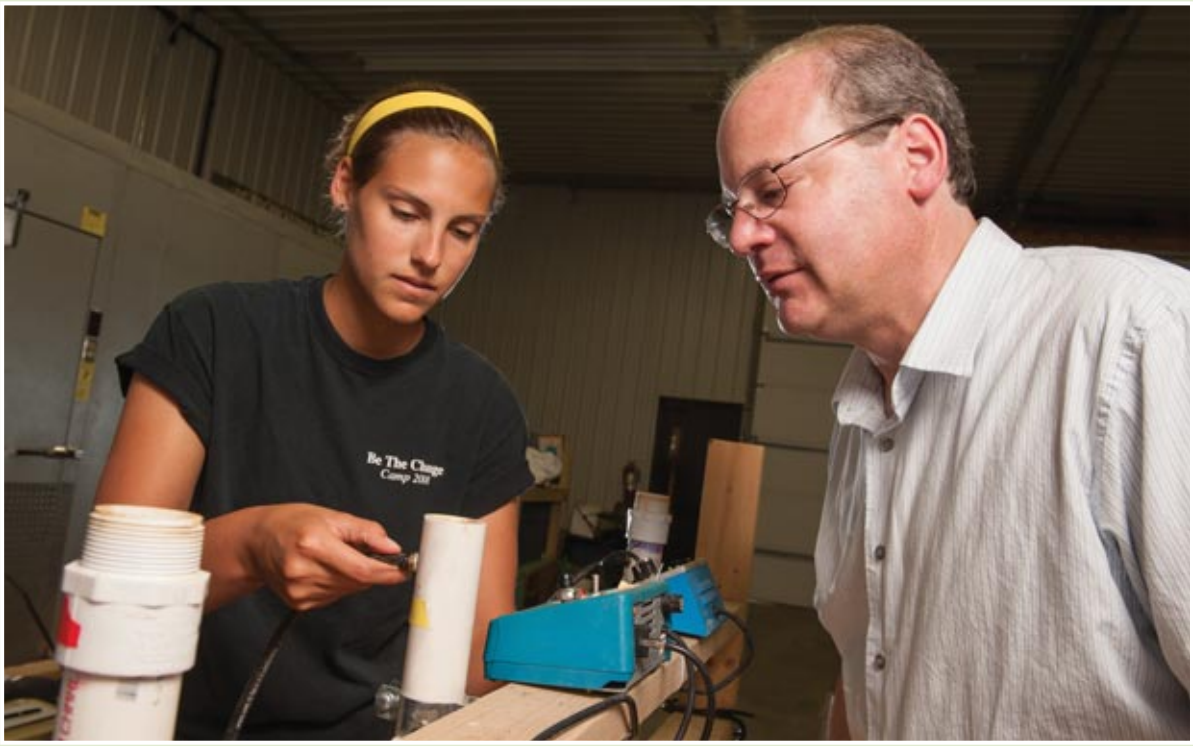


PHOTO: KURT STEPNITZ, MSU CABS

Steven Safferman, associate professor of biosystems and agricultural engineering, and industry colleagues are devising a cost-effective way of recovering phosphorous from wastewater. MSU student Hayley Betker *(left)* assists Safferman in the lab.

Nutrient pollution — the presence of excess nitrogen and phosphorus in the environment — is one of the country's most widespread and costly environmental issues, according to the U.S. Environmental Protection Agency. For states in the Great Lakes region, removing phosphorus from water is a matter of particular concern.

"Phosphorus is an issue because too much of it in water causes ecological damage by way of eutrophication, a process where water bodies receive excess nutrients that stimulate excessive plant growth, rendering it a potential health hazard and unsuitable for recreational use," said Michigan State University (MSU) AgBioResearch scientist Steven Safferman.

Safferman has been collaborating with colleagues at MetaMateria Technologies in Columbus, Ohio, to test a cost-efficient material that the group created to remove phosphors from on-site wastewater. The success of this product could reduce the environmental impact of phosphorus, change how water is treated in wastewater treatment facilities and affect how phosphorus is collected for use in the United States.

"Phosphorus is very difficult to remove from water," explained Safferman, MSU associate professor of biosystems and agricultural engineering. "Unlike other pollutants that can be transformed into gases that leave water passively, phosphorus has to be removed physically. There are ways to chemically precipitate phosphorus from wastewater on a large scale, but it is difficult on a small scale because the process is complex and an operator is required to oversee it. Small treatment sites in homes and clusters of buildings need a solution that will remove the pollutant in spite of those last three conditions — many of these facilities are automated and don't employ an operator to manage the process on a frequent basis.

"There's also a lot of concern about meeting the new regulations," Safferman added. "Many proposed regulations have the phosphorus level so low that traditional products and practices can't meet them. Technologies must be created that can meet these new levels."

MetaMateria Technologies is relying on the independent testing of Safferman and his colleagues to assess the effectiveness of the material the group created.

"The medium was already being used in a lot of different

applications as an environmental filtration system," Safferman said. "When we started, this was a very basic material — it worked, but it didn't work very well. This company brought in a lot of ideas on how to change it and manufacture it, and we're seeing some really great results."

With the input of Safferman and his team, MetaMateria has produced several generations of the media that can retain significant amounts of phosphorus. Their alterations have given the material a large surface area and enhanced it with iron nanoparticles — two characteristics that encourage phosphorus to attach to it.

"Our role in this is to continue to test the material," Safferman said. "We use real wastewater to test new generations of media to see if they're better or worse. In addition to providing this independent research, we are developing design equations — the information that engineers need to make use of the product and to know when it needs to be replaced."

Moving forward, Safferman, also an MSU Extension specialist, will focus on how the phosphorus being recovered from the media can be used in other applications.

"Phosphorus is finite — we have a limited supply in the United States, and we have to mine most of it from other countries," Safferman said. "Why throw it away after we remove it from wastewater? That's wasteful, and it's expensive to create new media. We've started looking at how to regenerate the media and how to use the phosphorus it collects. We're also comparing the cost of getting phosphorus off our media with the cost of getting phosphorus from mines, and the preliminary estimates look extremely promising. From there, we want to explore how to remove phosphorus from animal manure, another place we find it in abundance.

"This project is a great example of industry-university partnership," Safferman added. "It meets the mission of my research program in many ways, and it meets MetaMateria's mission as a small business trying to produce a product. It's also a different role for the university. It isn't just a fundamental research project — it's a very applied project that will have a direct impact on the environment and on industry." ●

> **"Many proposed regulations have the phosphorus level so low that traditional products and practices can't meet them. Technologies must be created that can meet these new levels."** ● STEVEN SAFFERMAN

[Fishing for results to restore fabled Great Lakes species]

The lake sturgeon is the largest and longest-lived Great Lakes fish species. Sturgeon can survive for up to 100 years, grow 6 to 8 feet long and weigh over 130 pounds. However, this species, once harvested for both sport and commercial fisheries, is now present at less than 1 percent of its historical abundance and is listed as a threatened species in Michigan.

MSU AgBioResearch evolutionary ecologist Kim Scribner is working on a long-term research project to investigate management practices and environmental factors that affect lake sturgeon with the hopes of rebuilding populations of the species.

"Sturgeon live in large freshwater lakes such as the Great Lakes, but they spawn in rivers, and therein lies a big part of the problem," said Scribner, a professor in the MSU Department of Fisheries and Wildlife and a PERM (Partnership for Ecosystem Research and Management) faculty member who works closely with the Fisheries Division of the Michigan Department of Natural Resources. "Almost all of the large rivers in the state where sturgeon once spawned now have dams, so the fish cannot reach suitable breeding habitat in the rivers, and some, like those we are studying in Black Lake, are trapped above the dam. So, in part, the dams have sustained the large decline in sturgeon abundance."

Black Lake, located in Cheboygan and Presque Isle counties, offers a unique research site that provides access to sturgeon during all parts of the life cycle.

"We have complete access to the fish at every stage of life." said Scribner. "We have tagged about 1200 adults (200 to 250 each year), and we can sample eggs, fry and juveniles. We also can characterize aspects of species ecology, such as how often they reproduce and environmental variables that affect reproductive success."

A sturgeon does not reach sexual maturity until it is 15 to 25 years old and does not reproduce every year.

"One of the biggest impediments to sturgeon recovery is the lack of natural reproduction," Scribner said. "Many sturgeon do not survive to adulthood, so we are trying to determine where

PHOTO: COURTESY OF KIM SCRIBNER

Volunteer Gary Stranaly *(left)* helps John Bauman, a master's degree student in the MSU Department of Fisheries and Wildlife, with one of the many lake sturgeon that have been tagged as part of an extensive research project.

in the life cycle high rates of mortality occur. We conduct observations in the river and experimental work in our streamside facility to dissect the species' complicated life history. This has allowed us to characterize important aspects of species biology that other researchers can use. That's one of the major contributions of this research."

The streamside facility at Black Lake is also used to produce genetic crosses for restoration and other research.

"Oftentimes we identify relationships in the stream that may suggest something fundamentally important, but in the stream environment it is extremely complicated," Scribner explained. "By reducing the complexity down to a few factors in an experimental setting, we can evaluate variables that affect growth and survival."

One new area of research collaboration is with MSU microbiologist Terence Marsh because bacteria appear to be a major source of mortality at the egg stage. The embryos have to develop before the bacteria completely envelop them. With Marsh's help, Scribner is trying to understand more about microbial communities in hopes that that understanding will lead to ways to predict the environmental conditions that affect the magnitude of this problem.

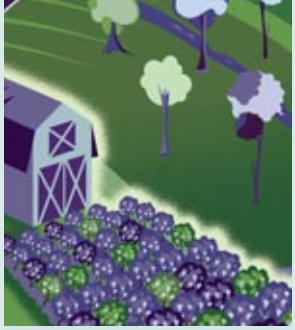
Answers to the research questions have not come quickly, however.

"These long-term ecological studies are very rare but necessary for an animal that is extremely long-lived," Scribner said. "Studies of long duration are necessary to determine what is affecting population abundance, reproduction and levels of mortality."

While the research is ongoing, the data collected is not only useful for fisheries personnel but provides the basis for a website that Scribner hopes will help science, technology, engineering and mathematics teachers in grades K-12 use the data for classroom instruction. The website — http://www.fw.msu.edu/glsturgeon — helps students with lessons on math and probability theories as well as biology.

"I hope we are inspiring the next generation to have a greater appreciation of fish and natural resources, using sturgeon as an ambassador." • KIM SCRIBNER

"I hope we are inspiring the next generation to have a greater appreciation of fish and natural resources, using sturgeon as an ambassador," Scribner explained. "Kids come to our facility at Black Lake and are very excited about what we are doing. We hope that the website can generate excitement as a 'virtual resource' to accomplish something similar to a place-based experience. This is a great way to use our long-term data to provide a public service and help young people gain a greater understanding of natural resources." ●



secure food and fiber systems

Sustaining a safe, secure food and fiber system and keeping people and animals healthy make up a large and important part of the Michigan State University AgBioResearch mission.

In research initiatives from reducing the use of antibiotics in cattle and improving human wastewater treatment and manure disposal practices to investigating deadly bacterial infections and advancing organic production practices, AgBioResearch scientists continually discover innovative ways to help protect and enhance our food and fiber supply and improve human and animal welfare. The stories in this section showcase some of the significant research being done in this area.

[Reducing mastitis and antibiotic use in dairy cattle: a win-win situation]

PHOTO: KURT STEPNITZ, MSU CABS

State-of-the-art robotic milking parlors like this one have helped reduce the occurrence of mastitis in Michigan. These modern-day facilities are well-ventilated and help to keep the cows clean, dry and comfortable.

Mastitis, an infection of a cow's udder, is the most common infectious disease in dairy cattle in North America. The average cost of mastitis to a farmer is $300 to $600 per occurrence because the infection reduces milk production and decreases the well-being of the animal.

A cooperative project involving the U.S. and Canada with support from the U.S. Department of Agriculture (USDA) has helped to greatly reduce mastitis. Michigan State University (MSU) AgBioResearch veterinarian Ronald Erskine is involved in the project and sees positive results.

"Definitely in the past 10 years, there has been slow but steady progress in reducing mastitis, but there is always room to improve," said Erskine, a professor in the MSU College of Veterinary Medicine and an Extension specialist. "In Michigan, we are fortunate to have a strong alliance between producers, dairy cooperatives, MSU Extension, the MSU College of Veterinary Medicine and regulatory professionals. Michigan is consistently one of the top states in mastitis control and production of quality milk."

Caused by bacteria, mastitis is most often transmitted by contact with the milking machine or through contaminated hands or materials. It can be very mild and some cows get over it naturally. In other cases, however, antibiotics and other drugs may be required.

"That brings in a whole set of additional costs to producers — the cost of the drugs, labor to administer the drugs, and the need to discard the milk because milk from a cow that has been given drugs cannot go to market," Erskine explained. "If we can find better ways to prevent the disease from occurring, then we don't need to use drugs. It's good for farmers, good for consumers and good for the health of the cow. It's a win-win situation. That's the objective of the USDA project: to prevent mastitis from ever occurring."

One factor in reducing the occurrence of mastitis in Michigan has been significant changes in dairy cattle housing. The modern-day barn is well-ventilated and helps to keep the cows clean, dry and comfortable.

"This was a pivotal step," Erskine said. "If an effort is not

> "In **Michigan, we are fortunate** to have a **strong alliance** between producers, dairy cooperatives, Extension, the MSU College of Veterinary Medicine and regulatory professionals. **Michigan is consistently one of the top states in mastitis control** and production of quality milk." • RONALD ERSKINE

made to keep the cows clean, dry and comfortable, all the planning and research in the world doesn't go anywhere."

Work to prevent mastitis starts every morning in the milking parlor.

"That's where you see the first signs of mastitis. The people doing the milking are the boots on the ground."

Therefore, the Michigan Milk Producers Association (MMPA) offered training sessions and worked with producers in educating employees. That training, coupled with the outreach efforts by MSU Extension, has led to a better understanding of milking procedures and a reduction in mastitis.

Erskine points out that the progress in Michigan would not have taken place without the producers and co-op managers identifying mastitis as a critical issue to address. In addition, pharmaceutical companies are supporting continuing education for dairy farmers and others involved in the industry.

An added factor in trying to control and reduce mastitis is the changing dairy industry itself.

"When I started in practice 30 years ago, 40-cow dairies were the norm, with family members running the operation," Erskine said. "Now the average herd size is over 200 cows, and it is not uncommon to see dairy farms with 30 to 40 employees and 3,000 cows. Many dairy producers have been thrust into the role of human relations managers. They know their cows and how to provide for them, but their employee management skills may vary."

Erskine and other researchers involved in the project encourage herd managers to build team spirit with workers and to point out to employees the benefits of reducing mastitis.

Another issue is trained employees straying from standardized protocols and procedures.

"Most of the time, how the protocol gets done is what makes the difference between success and failure in the milking parlor," Erskine said. "We need to redouble efforts on employee training and education on dairy farms and emphasize staying with protocols. It's human nature for people to go through training and then drift away from the protocol. We are really going to seek ways in the dairy farm community to encourage workers to keep to the proper procedures." •

[Cultivating **pest management practices** to help Michigan's **organic** and **conventional growers**]

Consumer demand for organically produced goods has shown double-digit growth for well over a decade. Organic products are now available in nearly 75 percent of conventional grocery stores, and they often have substantial price premiums to growers over conventional products, according to data from the U. S. Department of Agriculture (USDA) Economic Research Service.

MSU AgBioResearch entomologist Matthew Grieshop is monitoring the organic growth trend and focusing research on organic pest management practices to benefit not only organic growers but conventional ones as well.

"As a researcher, I am interested in a better understanding of the natural principles that allow us to produce better food, so my research interests focus on how to grow food with less energy expenditure and fewer negative impacts on the surrounding environment," said Grieshop, an assistant professor in the MSU Department of Entomology and an Extension specialist.

There is a legal definition for organic products, and the USDA National Organic Program oversees certification of farms and crops. The organic farming movement started in the 1930s and '40s in response to the use of synthetic fertilizers and hybrid crops. Today, the main thrust is eliminating synthetic pesticides, but overall it has many aspects.

Field crops, such as corn, soybeans and dry beans, are Michigan's largest organically grown crops, with 15,000 to 20,000 acres of certified organic fields in the Thumb region alone. Smaller acreages of certified organic blueberries, tree fruit crops and vegetables occur throughout the state.

Typically, Grieshop has 12 to 16 projects going at any one

> "Just about **everything we do in the organic research** is potentially applicable on the conventional side. It **doesn't mean that conventional apple or cherry growers have to become organic**, but they can **incorporate some organic practices** into their conventional management plan."
>
> • MATTHEW GRIESHOP

time. He works with tree fruits and greenhouse-grown bedding plants. He is also beginning to work with farmers who are starting small, diversified farms in urban areas.

One current project is examining ways to best manage the orchard floor.

This U.S. Department of Agriculture stamp is used to signify that a product is organically grown. Research at MSU is monitoring the organic growth trend and focusing on pest management practices to benefit organic as well as conventional production.

"We are looking at using repetitive cultivation for managing weeds," Grieshop said. "If you maintain a herbicide strip, that's a dead zone under the trees. The decay cycle is interrupted, and you are not returning carbon to the soil. Whether this type of floor management is done on conventional or certified organic orchards, it has a lot of potential impacts on weed and pest management, soil biology, and the water- and nutrient-holding capacity of the soil."

In his research, Grieshop allows weeds to grow underneath the trees, but he disturbs them repeatedly throughout the season. A ground-driven, three-point cultivation implement is used to cultivate around the trees.

"We are treating the weeds almost like a cover crop," Grieshop explained. "We have data to show that we can make nitrogen more available to the tree with this system than by using a herbicide strip. We let the weeds grow up and collect nitrogen, and then we knock them down. This serves as a catch for carbon and other nutrients instead of having a dead zone where the only thing there are the tree roots."

Grieshop conducts the research in conventional orchards because he wants to compare areas with and without a herbicide strip. He cannot do this on an organic farm because herbicides are not permitted.

This type of floor management in orchards obviously has applications for organic farming, but Grieshop believes the bigger impact may end up being on conventional orchards.

"Just about everything we do in the organic research is potentially applicable on the conventional side," Grieshop explained. "It doesn't mean that conventional apple or cherry growers have to become organic, but they can incorporate some organic practices into their conventional management plan. What excites me more than anything else is having this field laboratory with organic growers and being able to take ideas that they are using, develop new ideas and then make them more broadly available."

Grieshop also sees big opportunities with small, diversified farms, and he is ramping up a research program to work with these farmers.

"My initial interest is helping growers develop biological control resources on the farm. These diversified farms generally have tens to hundreds of crop species/varieties that create unique pest management challenges and opportunities."

Sometimes growers just need someone to help them understand why a certain practice might work and how it could replace what they normally do.

"I don't have all the answers, but I can help growers find answers and share ideas," Grieshop said. "One of the best parts of my job is the collaboration with growers." ●

[Bridging the gap to **protect** two of the **Earth's greatest resources: soil and water**]

PHOTO: NATASHA BERRYMAN

(From left) **MSU graduate students Michael Roberts and Jason Ding collect soil samples from a Michigan farm as part of research being conducted by Hui Li, MSU associate professor of environmental and soil chemistry.**

Water and soil are two of the most important resources on earth — water is a source of life, and soil plays a variety of critical roles. As described by the Soil Science Society of America, soil is a filter for water and a habitat for important biodiversity. Between the two, they are the basis of our nation's agroecosystems, working together to supply the world with feed, food and fuel.

Research over the past several decades shows that these critical resources are being compromised by human wastewater treatment and manure disposal practices. Michigan State University (MSU) AgBioResearch scientist Hui Li is conducting research to explore this emerging issue in greater detail.

"Every year, billions of pounds of biosolids [nutrient-rich organic materials, often used as fertilizer] are produced from animal manure and sewage sludge from municipal wastewater treatment plants," said Li, MSU associate professor of environmental and soil chemistry. "Some of these biosolids are applied to agricultural fields, a practice that has raised concerns about the potential for these excess plant nutrients to cause eutrophication and groundwater contamination through runoff or leaching."

More recently, the release of pharmaceuticals from antimicrobial agents found in personal care products into the environment has become a major concern.

"We now know that these compounds show up in the effluent from wastewater treatment plants," Li said. "The treatment processes used by these facilities are not specific to removing pharmaceuticals or hormones — they were designed for other contaminants. As a result, a high percentage of these chemicals survive the treatment process and are discharged into water resources that we consume and use every day.

"Another issue relates to animal agriculture," Li continued. "Antibiotics and hormones are used in some livestock feed to increase the growth rate of animals and to ensure their health. The animals don't metabolize much of the antibiotics — up to 95 percent of them end up in an animal's manure or urine. When this manure is applied to fields, so are the antibiotics. These compounds then move from the manure into the soil and the surrounding environment, including surface water and groundwater."

Li said that, although the antibiotics and hormones that are being passed into the waters and soils are at low concentrations, human exposure to them is constant.

"The consequences of chronic exposure to an undefined mixture of bioactive chemicals at low concentrations are

"The results obtained from our **pharmaceutical studies** provide the basis to **improve best management practices for land application of biosolids** and will help shape the **development** of regulations for these **emerging contaminants.**" • HUI LI

unknown but are, potentially, of enormous significance," he said. "Current concerns include the development and spread of antibiotic-resistant bacterial strains, harmful effects on the reproductive health of wildlife, chemical contamination of surface waters from runoff and groundwater contamination."

In January 2005, Li initiated research to study the interactions of pharmaceuticals with soil and water. During the past seven years, he has developed an integrated research program and established collaborations with MSU colleagues to explore issues such as environmental surveillance, sorption, transformation, bioavailability and plant uptake of pharmaceuticals.

Because so little was known about how these pharmaceuticals and hormones behave in the environment or their effect on various ecosystems and human health, the U.S. Environmental Protection Agency (EPA) couldn't regulate them with the standing models of conventional organic contaminants.

"The results obtained from our pharmaceutical studies provide the basis to improve best management practices for land application of biosolids and will help shape the development of regulations for these emerging contaminants," Li said.

Moving forward, Li's research will focus on two key areas. First, he wants to understand the environmental fate of the pharmaceuticals and how these chemicals behave in soil and water. Second, Li and his team will focus on understanding bacteria's antibiotic resistance from a chemistry standpoint.

"We want to know how antimicrobial agents in the soil or the water become bioavailable to bacteria and how the bacteria are affected by the properties and changing conditions of these media," Li said. "The results will provide decision makers with information about the various environmental conditions that can cause changes in a bacterium's ability to be more or less resistant to antibiotics. These insights will also play a key role in the development of standards and regulations and enable decision makers to take the best approach to soil and water management as they work to protect these valuable resources.

"There's a gap in the understanding of the relationship between the interactions of pharmaceuticals in soil and water and their impact on human and ecosystem health," he added. "We're exploring that relationship and trying to bridge that gap." •

[Shedding new light on bacterial infections]

Food-borne infections are a major public health concern in the United States — estimated to cause 48 million illnesses and 3,036 deaths each year, with annual costs of more than $77 billion. In the United States in 2011, *Salmonella*, *Campylobacter* and Shiga toxin-producing *Escherichia coli* (STEC) caused more than 2.8 million infections. Health-related costs associated with STEC infections alone were estimated at more than $750 million in 2010; *Salmonella* and *Campylobacter* costs exceeded $32.3 billion and $6.9 billion, respectively.*

Those daunting statistics are spurring research by MSU AgBioResearch microbiologist and epidemiologist Shannon Manning, who is working on two studies on STEC.

One project involves the human clinical disease aspects of STEC. Manning collaborates with the Michigan Department of Community Health (MDCH), which has a surveillance system to get *Escherichia coli (E. coli)* isolates from patients.

"In the lab, we characterize these isolates by genotyping to look at their genetic background," Manning explained. "We hope to figure out the characteristics of those bacteria that cause the most severe disease in an effort to develop prevention strategies aimed at decreasing the burden of illness."

Because of the MDCH surveillance system, Manning and her research group were able to recover a STEC O104:H4 isolate that caused a deadly outbreak in Germany in 2011. While visiting the country, one Michigan patient became infected and developed hemolytic uremic syndrome (HUS), the most severe complication of STEC infections, which can result in kidney failure and death.

"The highest number of deaths that we have ever seen for an *E. coli* outbreak occurred in Germany and was caused by this strain of *E. coli* O104:H4. There were 54 deaths and more than 3,800 people infected," Manning said. "Therefore, when we

received the strain from the MDCH, our primary goal was to figure out why it was so virulent and caused such a high frequency of disease."

This particular strain of *E. coli*, 0104:H4 shares some characteristics with other deadly *E. coli* bacteria, but it was not the typical STEC strain. Manning and her research team discovered why the strain was so powerful — its ability to form a biofilm during infection. That doesn't happen with other STEC strains, such as *E. coli* O157.

"When the bacterial cells are in a biofilm, we demonstrated that they are capable of producing more Shiga toxin, which is responsible for kidney damage and can result in death in some people. So we think that biofilm formation may be responsible for the high frequency of HUS and death associated with the O104:H4 outbreak in Germany."

Manning is already focused on the next phase of this research by creating, in the lab, mutant strains in an effort to prevent the bacterium from forming a biofilm. This could potentially decrease the likelihood of more severe disease because bacterial cells that are surviving outside a biofilm produce less toxin.

PHOTO: MSU AGBIORESEARCH

Shiga toxin-producing *Escherichia coli* (STEC) are the cause of millions of infections every year and amount to steep health care costs. Above, the bacteria grow in a petri dish in a laboratory at Michigan State University.

> **"The highest number of deaths that we have ever seen for an *E. coli* outbreak occurred in Germany and was caused by this strain of *E. coli* O104:H4. There were 54 deaths and more than 3,800 people infected."**
>
> • SHANNON MANNING

Another part of Manning's research involves screening cattle, the animals considered to be the primary reservoir for STEC.

"Cattle shed the organism in their feces, and the bacterium can end up contaminating meat products," Manning explained. "In addition, recycling manure for use as a fertilizer may be one of the reasons that we're seeing more STEC outbreaks originating in produce."

Manning's research team has sampled more than 1,600 cattle in Michigan in the past two years. The next steps are to better understand which strains pulled from the cattle are most similar to those strains typically seen in human infections, and to identify characteristics that are most important for the disease process.

"We believe that there is a subset of strains in cattle that are not capable of causing disease in humans, and that only a small number of strains have the ability to survive in food products and the subsequent passage through the human gastrointestinal tract. These are the strains that we worry about and want to understand better," Manning said.

The ultimate goal is to identify factors that can be modified to decrease the level of *E.coli* shedding in cattle, especially if it involves farm management practices such as changing feed types, bedding types or sanitation conditions.

"I hope that some of my findings will have an impact on future disease prevention practices and will ultimately reduce the number of people who are affected by STEC infections," Manning said. ●

**Centers for Disease Control*

enhancing profitability

Agriculture's essential role in growing and sustaining Michigan's economy is undeniable — the sector is the state's second leading industry and employs about 1 million Michigan residents.

Michigan State University AgBioResearch scientists from many different disciplines are working to provide growers, commodity groups and natural resource managers with the critical information and tools they need to remain viable and competitive. Their research is broad in scope, ranging from the development of bioderived fuels and improved agricultural production systems to enhanced tolerance of plants to climate change and innovative ways to enhance horticulture sales. This section features some of the significant work being done in this area.

[Gaining insight into consumer behaviors toward horticultural purchases]

PHOTO: COURTESY BRIDGET BEHE LAB

Using an eye-tracking device researchers are able to tell exactly where and how long a consumer looks at a horticulture display. The red area signifies where consumers looked the most. In this case, it was the signage.

Consumer behavior has always been important for retailers, but with increased climate change and changing weather patterns, this information has also become critical to horticulturists. With a slower economy and growing public concern over water usage in some parts of the country, horticulturists have seen sporadic sales declines, often drought-related. Michigan State University (MSU) AgBioResearch scientist Bridget Behe is working to change that by closely observing consumer behaviors and determining what types of information eventually lead to a purchase.

Specifically, Behe has been studying how horticulturists can better investigate industry demand for their products and how they can best market to that demand.

"I think that, as an industry, we've become very good at growing beautiful things that people want to buy but not as savvy at marketing those things," she said.

Behe and her research team are using eye-tracking technology (a tool originally developed for the medical field) to determine how consumers look at a product and, ultimately, how they make purchasing decisions.

"We know that eye motion is the fastest movement that the body can make," said Behe, a professor in the MSU Department of Horticulture and an Extension specialist. "We can tell that when an eye stops, it indicates focus of attention and is a signal that the individual is cognitively processing what he/she is looking at."

Her findings indicate an interesting relationship between the amount of information provided with the plant and whether a purchase is made. Behe said the odds increase when the price, plant material and other information about the plant are packaged together. When consumers look at displays containing only price or plant information, the correlation between viewing and purchasing becomes much weaker.

"If we have pretty plants, that's a good start, but we've got to create the combination of plants and point-of-purchase information, and that goes beyond price," she said. "Point-of-purchase information and the plant material and the price — that's the most compelling package. The field is wide open for this type of investigation, and we believe it will substantially help all retailers improve the shopping experience and, hopefully, sell more profitable products. "

In other published studies, Behe has found that up to half of Americans will search online for information about plants and gardening. And of those who do search, 19 percent are more likely to make a plant purchase. These findings are essential to horticulture retailers, many of whom operate on less than 10 acres and generate less than $500,000 in revenue.

"If you have a nearly 20 percent chance of increasing their likelihood of a purchase, you want to provide that information so potential customers can search online and find what they're looking for," she said. "Maybe that information is a recipe using that plant in a prepared dish, or where to plant the specimen, or a companion plant that goes along with it. Retailers need to have that extra information available for their customers 24/7."

Further research into this topic will include investigating the influence of using QR (quick response) codes and other smart-phone applications consumers can use while shopping.

"If we have **pretty plants**, that's a good start, but we've **got to create the combination of plants and point-of-purchase information**, and that goes beyond price. Point-of purchase information and the plant material and the price — **that's the most compelling package.**"

• BRIDGET BEHE

In addition to looking at how consumers gain and review information, Behe has also been studying the differences in how consumers in different regions of the world perceive low-water-use plants. Comparing consumer behaviors in Australia and the United States, Behe found that concern over water usage is higher among consumers in drought-sensitive areas and given more consideration when making a purchase. Behe wants to use these results to help growers and retailers better prepare for challenging situations.

"We want to understand a little bit more about how we can communicate the information about lower water use in the landscape and lower use in production to a consumer who is concerned about that," she said.

Horticulturists, especially those in Michigan, have been receptive to her findings.

"They're as interested in the research and excited as we are to see the results," she said. "We want to know how we even get people up to the display to interact with the plants, and how we get them more interested in that product category. We want to be proactively prepared, to arm them with the information before they need it. Then their displays will likely compel people to take a look, consider a purchase longer and eventually tip them toward making that purchase." ●

[Advancing **biofuels and chemicals** from **renewable feedstocks**]

Ethanol, derived in large part in the United States from corn, is an alcohol used almost exclusively as a biofuel additive for gasoline. In 2011, worldwide ethanol fuel production reached more than 22 billion gallons, with the U.S. leading the way with 62 percent of the total.*

Dennis Miller, Michigan State University (MSU) professor of chemical engineering and materials science, is exploring the formation of ethanol and related alcohol forms in an effort to help bolster biofuel production.

"Ethanol has two carbons, butanol has four carbons, and then we make a group of alcohols that have six and eight carbons, and you can build this group of even-numbered alcohols," said the MSU AgBioResearch scientist. "We do this in the lab through a reaction chemistry called condensation, whereby the alcohols combine and react with one another and form a higher alcohol. Ultimately, we want to identify ways to use different forms of alcohol as feedstock to produce even higher value products. Ethanol as a fuel additive is really a low-value place for it to be used, and we're looking to upgrade it."

Miller is particularly focused on butanol, which has several uses and commands a greater price than ethanol.

"Butanol is a good gasoline additive. It's a good solvent in industry, and it's an intermediate in industry — used in very large quantities," he said. "There's a huge market, especially here in Michigan. The idea of taking ethanol and making butanol will help the farmer and the ethanol plant that are scraping by by bringing a higher value product into the commodity market."

Butanol is also a highly efficient renewable energy source.

"We can get about a 70 percent yield of butanol from ethanol," he said. "We make some of the higher alcohols also, and again, they're useful. Our goal is to be able to control that reaction chemistry so that we can choose the type of alcohol we want to make and make it in very high yields."

A primary focus has been on developing catalyst materials that trigger the alcohol formation under specific conditions.

"If we can do that, we will have little waste and a very efficient process," he said. "It will be green, clean and economical."

Esters, which are formed by combining an organic acid with an alcohol, could also be a viable option, Miller added.

"There are a number of organic acids that are commonly made from biomass," he said. "We're looking at combining these acids and alcohols to make esters. Esters have uses as fuels, as

PHOTO: MSU AGBIORESEARCH

Research at MSU is exploring the formation of ethanol and related alcohol forms in an effort to help bolster biofuel production.

solvents and sometimes to make plastics."

Recently Miller has also been looking at what he calls "mixed alcohol esterifications."

"Let's say we did a reaction with ethanol and we made some butanol," he said. "Instead of separating and purifying, we could take that alcohol mixture that contains ethanol, butanol and maybe a little of the higher alcohols (C-6 alcohols) and react those together with an organic acid to make a mixed ester. Those mixtures do well as fuels. They also do well as solvents. Sometimes a mixture of materials has better solvent properties than just a single chemical."

Miller started his research in the late 1980s and has since been inspired by collaborations taking place at MSU and, specifically, at the Michigan Biotechnology Institute.

> "People would say, **'Why are you doing this type of work with those dirty biomolecules?'** and we'd say, **'Well, someday we think that they're going to be important.'** Now I'll bet about **70 percent** of the work you see in catalysis has to do with **renewables."**
>
> • DENNIS MILLER

"I started long before it was fashionable to think about renewable feedstocks," he said. "People would say, 'Why are you doing this type of work with those dirty biomolecules?' and we'd say, 'Well, someday we think that they're going to be important.' Now I'll bet about 70 percent of the work you see in catalysis has to do with renewables."

Despite considerable progress, Miller said there is much work on the horizon.

"We're in the very early stages of seeing a significant fraction of our consumer goods made from renewables. We are still very much petroleum-based," he said. "Our job at the university is to develop these types of technologies and abilities, and when the time is right and they become economically feasible, they'll be ready and people will take them."

Miller said his lab focuses on applied research that explores solutions that are practical and economical. He plans to continue examining less-processed biomass feedstocks that are available at lower costs than in the past. ●

**Renewable Fuels Association (March 2012).*

[Providing **tools** to help address **climate change,** prevent **environmental harm**]

Average summer temperatures in the Midwest are projected to increase by 3°F over the next few decades and could increase by over 10°F by the end of this century. This temperature shift would make summers in Michigan feel more like those in present-day Oklahoma.*

Jiaguo Qi, director of the Center for Global Change and Earth Observations and professor in the Department of Geography, is studying how climate change along with agricultural shifts toward bioenergy crops is influencing agricultural productivity and ecosystem services. He is working to identify early warning

PHOTO: MSU AGBIORESEARCH

Studies are investigating how climate change and agricultural trends toward bioenergy crops influence agricultural productivity and ecosystem services in general.

signs to help avoid major crop loss due to extreme weather events. Another emphasis is developing viable production alternatives to lessen the environmental damage that contributes to global warming trends.

"We're not focused only on climate warming trends but also on shifts in climate patterns, the lengthening of growing seasons, increases in extreme climate events such as drought and flood, or extreme cold and hot days that affect crop growth and survival. These all influence how farmers manage agricultural land and mitigate potential losses," said the MSU AgBioResearch scientist. "Also, we're seeing a push to reduce fossil fuels and to generate biofuels, and that has resulted in the expansion of crops such as corn and soybean to regions where they are not traditionally grown."

One of the results is that agriculture is becoming more productive and, at the same time, intensively managed through increased use of fertilizers, irrigation and crop rotation, Qi said.

"One of the beneficial consequences is that we have more food production, and that's a good thing," he said. "But we also need to look at the unintended consequences, such as greenhouse gas emission and nitrogen leaching that causes water eutrophication [an ecosystem response that typically results in excessive plant growth or decay]. The implication of this environmental degradation in general also puts greater pressure on water resources."

Qi is using satellite images and other geographical technologies to determine the location and rate of biofuel crop expansion. Implications of carbon and nitrogen leaching and global warming as a result of the expansion can also be assessed and reported to the farmer and/or farm manager.

> "This **past year in Michigan** was an example of altered or **changed climate**, and it **significantly affected the crops**. Not just the **drought but also the early warming** that triggered some blossoms of trees, and then **all of a sudden they froze** — so that's the **climate variability**."
>
> JIAGUO QI

"A lot of time farmers just don't know," Qi said. "It's not that they're not willing to make change — they don't know what options they have. Balancing the benefits and impacts and then looking at the tradeoffs and providing science-based options that they can consider adopting are important."

Qi said that 2012 serves as an unpleasant reminder of climate variability and its potential to significantly reduce crop production and cause tremendous financial loss.

"This past year in Michigan was an example of altered or changed climate, and it significantly affected the crops," he said.

"Not just the drought but also the early warming that triggered some blossoms of trees, and then all of a sudden they froze — so that's the climate variability. Even if you don't see continued dry spells, this early warming triggering early growth and then sudden freezing makes agriculture suffer much more significantly than the drought itself."

Some of the models that Qi has drafted are being applied to agricultural systems as far away as Senegal, West Africa, where the shortage of food and hunger are major issues.

"We can use some models to predict what the agricultural production would be, to know how the weather will affect their cropping system," he said. "We have models that produce estimates of a particular crop production based on historical and current weather patterns, and the technologies developed for Senegal might be able to be applied in Michigan to provide some early warning analysis, especially for intensively managed systems."

Qi said he is confident that his research will continue to be of value to agricultural industries in Michigan and around the world.

"There are some people who don't seem to believe that we can do anything in regard to these climate issues, but the reality is that, with all of the information we have at our fingertips, we can provide early warnings and offer viable options and alternatives," he said.

"All too often people rush to actions, thinking they can solve the problem at hand. They react without thinking about the long-term impact, such as greenhouse gas emissions and methane, etc. And those emissions could have significant impacts on the climate, which would further affect agricultural productivity." ●

*U.S. *Global Change Research Program*

[In the driver's seat: Engineering the building block for an eco-friendly tire]

Most tires are made from rubber, whose main ingredient is extracted from latex-bearing trees. This process is not considered particularly eco-friendly or sustainable. In pursuit of an alternative, a team of Michigan State University (MSU) scientists has gained some traction, particularly with the automotive industry, by exploring biotechnical ways to produce a manmade version of rubber from isoprene. Isoprene is the basic building block of rubber. It also is a gas given off by some trees, mosses and ferns.

Tom Sharkey, professor and chair of the MSU Department of Biochemistry and Molecular Biology, has been studying the regulation and function of isoprene synthesis in leaves for decades. His lab is responsible for finding almost all of the known genes for enzymes that make isoprene.

"It turns out that trees make a tremendous amount of isoprene," he said. "It was very surprising to learn just how much. It's more than all of the unburned gasoline, etc., that enters the atmosphere — it's just amazing, similar to the total amount of methane that goes into the atmosphere."

PHOTO: COURTESY OF TOM SHARKEY LAB

A robot built by the MSU research team tests the isoprene strains, up to 6,000 per day, with remarkable speed and efficiency.

Isoprene emitted from trees is too dilute to collect, however, so Sharkey is working to determine its genetic basis and eventually a biological source of isoprene. The search has been fueled by rising rubber prices, among several industry concerns.

"Currently, rubber is harvested from trees that are susceptible to various diseases," said the MSU AgBioResearch scientist. "The trees originally came from Brazil, but rubber plantations there were destroyed by a fungus. Now the trees are mostly grown in Southeast Asia. If the fungus was to get established there, the amount of rubber we would have for making tires and all sorts of things would be in severe jeopardy. This has the rubber companies quite frightened."

Other researchers have made isoprene from petroleum, but Sharkey said automotive tire companies now want a biotechno-

> **"Isoprene sells for about two to three times the amount that you could sell biofuels for. The market for liquid isoprene is over a billion dollars a year, so if we had just 10 percent of it, we'd be doing well."**
>
> TOM SHARKEY

logical, renewable alternative. (About one-third of car tires are made from isoprene, and the rest from latex from trees.) He is working to produce bio-isoprene using the enzymes he has cloned. Eventually Sharkey hopes the process will be able to take in carbon dioxide and discharge bio-isoprene using sunlight as the energy source.

Considerable strides have been made over the past year, thanks in large part to a robot built by the research team, he said. The machine searches the isoprene strains with remarkable speed and efficiency.

"When you look for new enzymes, you can make libraries of 10,000 or more strains that have to be searched to find one that might have the gene that you're interested in," he said. "With the robot, we can test as many as 6,000 strains per day and drink coffee. That's a big difference — before we tested 100 per day and didn't have time to do anything else."

Sharkey, who is working with ZuvaChem, Inc., said he is committed to achieving a commercial method to consistently achieve high yields of isoprene from bacteria or yeast.

"Right now the process works fine at the laboratory scale, but there are some things we need to improve to make the process commercially viable," he said. "We've made some improvements, but I'm hopeful for a really big step forward in 2013 in the types of enzymes available."

Sharkey said the work has strong economic potential, especially for Michigan, which heavily relies on the automotive industry.

"In our research, we're basically developing end products for biomass," he said. "If we generate biomass by growing corn or switchgrass or anything for biofuels, we can also use it to make isoprene. That provides even more markets and, in fact, higher value markets for biomass produced in Michigan.

"Isoprene sells for about two to three times the amount that you could sell biofuels for," he said. "The market for liquid isoprene is over a billion dollars a year, so if we had just 10 percent of it, we'd be doing well."

While researchers pursue manmade alternatives, isoprene continues to be emitted by many plants possibly as a mechanism to combat heat stress. This theory, known as thermotolerance, was developed by Sharkey and his colleagues in the mid '90s.

"There have been major discussions about how isoprene synthase (an enzyme that catalysis a synthesis process) came about," he said. "All that we know now indicates that it probably has a single origin in evolution. But it's also clear there were fundamentally different sources of these genes." ●

[Exploring how plants survive freezing temperatures]

The late spring frosts of 2012, which resulted in near devastation to several sectors of Michigan agriculture, underline the importance of learning more about freezing tolerance in plants and, ultimately, determining crops best suited to specific geographical locations.

Michigan State University (MSU) AgBioResearch scientist and university distinguished professor Michael Thomashow has been studying freezing tolerance in plants since arriving on campus nearly 25 years ago. The member of the National Academy of Sciences is also responsible for identifying the plant CBF (C-repeat binding factor) regulatory proteins as the master switches that regulate genes for withstanding freezing temperatures.

"The major agricultural losses of 2012 demonstrate that freezing tolerance isn't a dead scientific topic and that it is worthy of study," he said. "With climate change — even though things are warming up — freezing tolerance remains a major environmental stress. It is also important because of its application to drought tolerance."

In fact, freezing tolerance and drought tolerance have an underlying common mechanism: an ability to survive without water.

"The genes that make up the CBF pathway impart tolerance to dehydration stress, a major cause of freezing and drought damage," he said. "Ideally, we'd like to be able to turn the CBF switches on when they're needed for freezing and/or drought tolerance."

Consequently, a major focus of the work has been on understanding how plants sense low temperature and how they process the information to activate the CBF pathway. Thomashow has shown that circadian rhythms — changes in

metabolism and physiology that follow a 24-hour cycle — prompt a plant's ability to defend against cold weather. In addition, his lab has recently identified regulatory genes that control expression of the CBF pathway in response to day length.

"During the summer months when the days are long, these regulatory genes turn off expression of the CBF pathway and prevent allocation of precious resources to unneeded freezing tolerance," he said. "Then, as the day length shortens, the plants sense this as a harbinger of the coming cold, and the regulatory genes turn on the CBF pathway, leading to an increase in freezing tolerance that helps prevent potential damage from early frost."

Thomashow adds that the timing of these breakthroughs couldn't be better.

"With the price of gene sequencing coming down and the development of sophisticated technologies for being able to look at a lot of genetic variation, we're able to look at phenotypes of plants under varying environmental conditions," he said. "And that's all pretty exciting in creating and improving the next generation of crops."

It is one objective of a collaborative effort on campus at the MSU-DOE (Department of Energy) Plant Research Lab, which is led by Thomashow.

"Today, we're being challenged to have plant biology more directly related to energy — to the capture of solar energy and, from that, to energy deposits — things like cell walls and energy-rich molecules," he said. "Some of the things we're trying to understand are how a plant takes that energy and fixes carbon, or how it decides to put it into growth or defense mechanisms."

These findings are critical to identifying sustainable sources of biomass.

"With climate change, when environmental conditions are more variable, we really have to have a basic understanding of how plants respond to dynamic environmental factors and control tolerance to extremes in temperature and drought, and how these factors affect the activation of plant disease mechanisms and control growth," Thomashow said. "We need this information to design improved crops for food and also for the development of plants for sustainable production of bioenergy.

"Imagine a farmer someday reading the morning paper and saying to his wife, 'Hey, darling, a week from now we're going to have freezing temperatures. I need to get out there today and spray this newly developed, inexpensive and environmentally safe chemical that activates freezing tolerance.' Companies are trying to develop such systems. We are contributing the basic biology to this so that they can take the knowledge to the field and implement it."

PHOTO: MSU AGBIORESEARCH

Discovering how trees and plants survive the freezing temperatures is especially crucial for an agriculturally rich state like Michigan. It also has direct applications to drought tolerance.

ArborGen, Inc., is one company using the knowledge from MSU to examine ways to efficiently produce eucalyptus for biomass in southern Alabama. The plant is typically grown in southern Florida because of its lack of freezing tolerance.

> "With climate change — even though things are warming up — freezing tolerance remains a major environmental stress. It is also important because of its application to drought tolerance." • MICHAEL THOMASHOW

"What they've done is introduce the CBF system into the eucalyptus plants, and now they can be grown throughout the Gulf Coast region," he said. "It's another fine example of research being done at MSU that is helping to solve real-world problems." ●

families and community vitality

Healthy, vital communities with an active citizenry are well-equipped to address the challenges facing many of today's families.

Whether it's research to improve how military families deal with the emotional stress of deployment, developing ways to help municipalities address financial issues or protecting people from the threat of domestic violence, Michigan State University AgBioResearch scientists are helping people learn and make healthy, well-informed choices. The projects highlighted in this section are just a sample of the work being done in this priority area to benefit both Michigan residents and people worldwide.

[Helping **military families cope** with the **stress of deployment**]

PHOTO: KURT STEPNITZ, MSU CABS

MSU AgBioResearch marriage and family therapist Adrian Blow is using grants totaling $1.5 million to help National Guard members and their families cope with the stress of deployment.

More than 19,000 service members from the Michigan National Guard have served in Iraq and Afghanistan as part of the U.S. military presence there. War is stressful and challenging; soldiers are exposed to potentially traumatic experiences, and families have to adapt to their loved ones' deployment.

MSU AgBioResearch marriage and family therapist Adrian Blow has a pair of grants totaling $1.5 million to help National Guard members and their families cope with the stress of deployment.

Blow was originally approached by the Michigan National Guard to make presentations at reintegration events that take place after a unit returns home. Now he has been working with the National Guard for more than five years. His research is based around families and health, so these projects are a natural fit.

"National Guard service members and their families have unique circumstances that distinguish them from their active-duty counterparts," said Blow, an associate professor in the Department of Human Development and Family Studies (HDFS) and director of the MSU Couples and Family Program. "The largest stressors for these citizen soldiers entail transitions into and out of active-duty status, including changes in health benefits and long-term job security as they return to the civilian work force postdeployment. In addition, National Guard families face life after deployment in communities where residents may know little about their struggles."

One of Blow's research projects is a three-year study funded by the U.S. Department of Defense on family resiliency through the deployment cycle. Blow is collecting predeployment data and will do follow-up for the next two years. Blow will lead the resiliency study with Lisa Gorman, who received her doctoral degree from HDFS and is now a program director at the Michigan Public Health Institute.

"Our goal is to look at how families cope," Blow explained. "We want to know what makes them strong in the face of transition and change."

In addition to the Michigan Public Health Institute, Blow is working with researchers from the University of Michigan and Virginia Polytechnic Institute and State University for this study.

The second grant is funded by the Ethel and James Flinn Foundation in Detroit. Partners include the Military Family Research Institute at Purdue University and the Center for Deployment Psychology in Bethesda, Md. This grant will train 1,000

> **"The wars are winding down, but the issues that these veterans have faced will not go away. We know from Vietnam-era veterans that the issues will be around for the next 10 to 20 years or more."** • ADRIAN BLOW

mental health providers to work with service members in a program called Star Behavioral Health Providers (SBHP).

"We will train them in evidence-based practices that fit the military profile," Blow said. "One of the issues that military personnel face is whom can they trust. The plan is to add the names of mental health providers trained in military sensitivity to a website to add an extra trust factor."

Blow has already identified some key factors that help military families deal with stress.

"Many families adapt to unexpected and stressful events such as deployment, but these events challenge family functioning. Families that do best have strong support systems and are able to communicate well in times of stress and adversity," Blow explained. "Resilient families are able to negotiate these stresses and grow in spite of these challenges. More efforts are needed to understand what makes families strong in the face of adversity, including internal processes and external resources."

He has found families that are more flexible and talk through problems have an advantage, and that relatives and friends are an important part of the support systems. In addition, National Guard members who have satisfying jobs when they return from deployment tend to do better than those who do not.

"Another emerging factor is that families tend to do better if they believe in what they are doing, such as an important cause outside of themselves," Blow explained. "That ultimately leads to what gives people meaning in their lives. That's a big factor in what keeps people strong in the face of stress."

The ultimate goals of the study are to feed the information gained, especially about the impact on families and what families might need to do better, to policymakers at the local and national levels. Also, the lessons learned can help inform future reintegration efforts.

Blow is concerned that the research support for these issues will dry up.

"The wars are winding down, but the issues that these veterans have faced will not go away. We know from Vietnam-era veterans that the issues will be around for the next 10 to 20 years or more." ●

[Making **positive changes in Flint** with **greening projects**]

The glory days of Flint, Michigan, are long gone. Today the city is an iconic symbol of deindustrialization, urban decay and violence. But this is a place where people live, where residents still hope for better times.

In an effort to contribute to ongoing initiatives by Flint residents, MSU AgBioResearch scientist Stephen Gasteyer has been involved in a three-year intervention in two Flint neighborhoods to improve their physical surroundings. The project was spearheaded by MSU turfgrass expert Thomas A. Nikolai, who obtained funding from The Scott's Company and the Michigan Turfgrass Foundation and 10 donated mowers from the John Deere Company. The study, done in cooperation with the Genesee County Land Bank, measured the social impacts of landscape maintenance. Gasteyer's role in the project was to do a social assessment.

"The project involved clearing overgrown common areas and adjacent vacant lots in two Flint neighborhoods," said Gasteyer, an assistant professor in the MSU Department of Sociology. "The idea was to determine the social impacts of community-based land use transformation and determine if the development of a more vibrant social ecology mitigates the effects of structural decline."

Now that the common areas have been cleared, there are indications that people are coming together. Membership in Code Red, a cell phone network neighborhood watch program, has increased. If neighbors see something happening, they can let all the people in the network know, so it becomes a neighbor-to-neighbor support system. There also have been two successful community gatherings in one of the new common areas. In the other neighborhood, residents are talking about reestablishing the local baseball team to play in the common area.

Funding for the project officially ended in September 2012, but Gasteyer wants to finish the work implied by the funding and is in the middle of analyzing survey results to put numbers on what has been accomplished. Rachel Johansen, a doctoral student in sociology, has worked with Gasteyer on the project.

> "What we **learned from this intervention** is that **improving the physical surroundings** is just a **drop in the bucket.** Improving surroundings needs to be **part of a larger project.**"
>
> STEPHEN GASTEYER

"What we learned from this intervention is that improving the physical surroundings is just a drop in the bucket," Gasteyer explained. "Improving surroundings needs to be part of a larger project."

In both neighborhoods, residents are most concerned about housing abandonment and its link to crime.

"That dominates the conversation in these neighborhoods," Gasteyer said. "People are always at the mercy of these upsurges of violence, so quality of life is an important aspect and has been part of the work we are doing there."

PHOTO: COURTESY OF STEPHEN GASTEYER

Work to clear overgrown common areas and adjacent vacant lots in two Flint neighborhoods is part of a research project to determine if there is a social impact on residents there.

The two neighborhoods are in different areas of Flint and have different demographics and types of housing, but the results from the project are the same in each.

"This greening project has been successful in leveraging other resources for investment in the community," Gasteyer said. "However, the reality is that Flint continues to spiral down economically. There are structural problems that create conditions for urban violence, plus defunding of basic services, including police and fire, so you have ongoing and worsening issues in these neighborhoods. There is now literature about the positive effects of greening of neighborhoods, and we can point to those positive effects from initiatives, but in the absence of the funding of other services that control violence, these projects are not going to be a panacea for urban violence."

The other point that Gasteyer makes is that working with neighborhood associations is very important, but there have to be broader connections.

"We cannot go in with a technical fix. We have to think about other policy implications and the broader social environment of trying to improve neighborhoods within cities suffering significant economic crime," Gasteyer said. "In the end, things learned in Flint can be applied elsewhere."

Gasteyer is already thinking about ways to deepen the relationship with the communities involved in the original project by moving beyond turfgrass and helping communities think about what to do next and how people outside the community can assist them in doing that.

At the same time, he is stepping back and looking at the number of engagement projects being undertaken by MSU and other organizations in Flint.

"We should think about the assets that MSU — and other universities and organizations — bring to the table and how to better connect all of these initiatives," Gasteyer said. "Some projects may not connect, but there still could be an exchange of information. Where there is a connection, there may be ways to leverage opportunities and create synergies that better help Flint." ●

[Crunching the numbers to help Michigan cities]

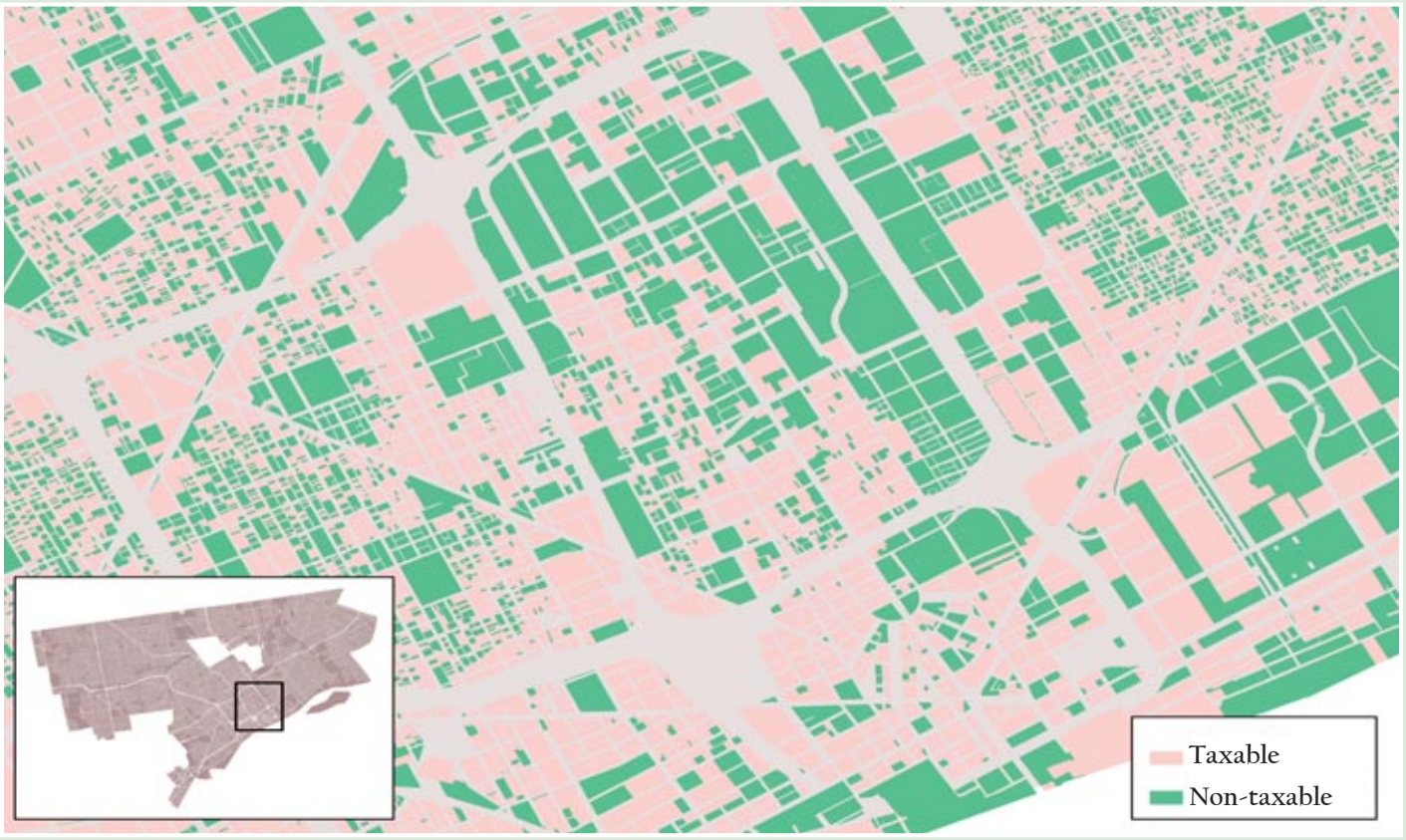


ILLUSTRATION COURTESY OF MARK SKIDMORE

This illustration shows taxable and non-taxable properties in the central part of Detroit from 2010. Illustrations like this help city managers and others see how fiscal policies and practices result in a narrowing of the tax base and thus, reduce revenue generating potential.

When MSU AgBioResearch economist Mark Skidmore came to MSU in 2007 to take the Betty and David Morris Chair in State and Local Government Finance and Policy, his role was to conduct research and provide information on state and local government finances. He quickly found that there was no consistent source of data on the finances of communities throughout the state. This was a major obstacle in what Skidmore had planned to do. Today that roadblock has been overcome, and Skidmore is finding diverse ways to help with the fiscal challenges facing Michigan governments.

"The Michigan Department of Treasury had pieced together some data from year to year on the finances of various communities, but it was not comprehensive," said Skidmore, whose endowed chair position is with the MSU Department of Agricultural, Food, and Resource Economics. He also is a professor in the MSU Department of Economics and an Extension specialist.

Skidmore proposed using a standard database system available online and rolling the information obtained from local communities, which are required to submit yearly financial reports, into a general online database that everyone could access. The process took three years, but now it is a fully functioning system.

"Ordinary citizens and fiscal planners alike can look at what their communities are doing relative to other communities," Skidmore explained. "From a researcher's standpoint, it is a great resource, and from a local unit standpoint, it allows users to compare data to see what each community is doing financially."

The Lincoln Institute of Land Policy in Cambridge, Mass., and Morris Chair resources provided funding for the web portal. The data is available at http://f65.mitreasury.msu.edu.

In collaboration with Eric Scorsone, an MSU Extension specialist and economist, Skidmore used the data to evaluate fiscal challenges across all Michigan cities. They identified factors that have led to the decline in revenues and an increase in costs for many communities in recent years.

"One area where many cuts were made is in parks and recreation; capital spending was often put off, but essential services, such as police and fire, were not cut," Skidmore said.

Recently Skidmore and Gary Sands, an associate professor in

> "In the case of **Detroit**, many **properties have gone into tax foreclosure**. The **city has taken ownership of those properties** and has **not moved them back into the private sector**, so a **huge chunk** of the city is **city-owned property**." • MARK SKIDMORE

the Department of Geography and Urban Planning at Wayne State University, were asked by a Detroit council member to provide options for property tax reform in Detroit.

"Normally, the tax base of a city depends on the market value of property, but there are things that narrow that down, like statewide policies such as the taxable value cap," Skidmore explained. "The state equalized value (SEV) of properties is supposed to reflect market value, but the taxable value, which is the base of the property tax, is allowed to grow only at the rate of inflation as long as the same person owns the property. If a property is sold, the taxable value is reset, so in any given neighborhood you may have two homeowners with homes of similar value who pay substantially different tax rates."

In addition, various types of abatement programs that exempt properties from taxation also narrow the tax base.

"In the case of Detroit, many properties have gone into tax foreclosure. The city has taken ownership of those properties and has not moved them back into the private sector, so a huge chunk of the city is city-owned property," Skidmore said.

Skidmore and Sands provided several alternatives to the traditional property tax. One idea was to impose a broad-based tax on land.

"That way you reset the tax base to include all of the properties in the city, but it has implications on who pays the tax, and there still is no money for land the city owns," Skidmore said. "But this is not just a Detroit issue. Many Michigan communities are trying to capture additional tax revenues to balance budgets. However, it will take a broader effort beyond balancing the books to help places such as Detroit and other cities become vital, healthy communities. "

One idea that Skidmore would like to see implemented statewide is the elimination of the taxable value cap so that Michigan's tax base more accurately reflects market value.

"The politically feasible way to do this might be that, as a property is sold, the value reverts to the state equalized value (SEV), and from that point on, the property is taxed at the SEV," Skidmore said. "Over time, all property would revert to SEV and be taxed accordingly." •

[Helping **communities stay safe** and **violence-free**]

Violence permeates American life. Sometimes — such as mass shootings in public places — news coverage assures that it is seen widely. Sometimes violence happens in families, where it may go largely unnoticed. From infants to the elderly, violence affects people in all stages of life.

MSU AgBioResearch public health scientist April Zeoli wants to help communities stay safe and violence-free. Her main field of investigation is the prevention of intimate partner violence and homicide through the use of public health policy.

One current project is a study of women going through child custody cases with former partners who were and may still be abusive. The women were recruited through domestic violence service agencies, and identified themselves as having experienced domestic violence.

"The main thrust is to determine whether and how women stay safe after initiating a custody case," explained Zeoli, who is an assistant professor in the MSU School of Criminal Justice. "These women often cannot start new lives because they are tied to the abusers through the children. It is up to the court how much custody each parent is going to get, but it is incredibly rare that a parent loses all rights to the child."

Through the study, Zeoli, in collaboration with Cris Sullivan, a professor in the MSU Department of Psychology, is looking at whether abusers continue to abuse even after custody has been decided by a judge and whether court-imposed custody determinations provide opportunities for abusers to abuse, particularly during child exchanges.

"The time of child exchanges, in which the child goes from one parent to another for parenting time or joint custody arrangements, is critical for mothers because that is when they have direct exposure to their assailants," Zeoli said.

The study, funded by a National Institutes of Health

> "I want to help communities stay safe and violence-free. If we can figure out what makes a community ripe for homicides to move in, then we are much closer to prevention, not just in Newark but in other cities as well." • APRIL ZEOLI

program called Building Interdisciplinary Research Careers in Women's Health, involves interviewing each mother four times over one year. The preliminary findings, based on the first and second interviews, show that 91 percent of the women were abused in some way during the exchanges.

PHOTO: ROSEMARY KEANE

Research is looking at ways to help communities stay safe and free of violence. One area of focus is on the prevention of intimate partner violence.

"The most common form of abuse was emotional abuse," Zeoli said. "Also, in 76 percent of cases, fathers made threats against mothers, and in 50 percent of the cases, fathers made threats against the children or the women's family. In 29 percent of the cases, the fathers made death threats. It is important to remember that the child is right there, witnessing all of this."

Other results show that 29 percent of the fathers physically abused the mothers during the exchanges, and 24 percent of the women reported that they were injured during the child exchanges.

Zeoli wants to look at ways to prevent abuse during exchanges and keep mothers and children safer.

"As we get more data, we will be better able to determine if protective orders or supervised exchanges increase women's safety," Zeoli said. "We can make a difference in the lives of these women and children. We just have to continue to investigate how, so we can put evidence-based interventions into place."

Zeoli also recently led a team of MSU researchers in tracking homicides in Newark, N.J. The data, spanning more than 25 years, was collected by Jesenia Pizarro, an associate professor in the School of Criminal Justice, who grew up in Newark.

The researchers wanted to see if the spread of homicides in Newark could be modeled in a similar way to the spread of disease.

"Homicide clusters in Newark moved in the way we expected, given a susceptible population. Homicide clusters first appeared in the economically depressed center of Newark and moved into western and southern Newark, areas with high poverty rates. Homicide stayed out of northern and eastern parts of the city, possibly because those areas were the most vibrant economically."

The research team would like to continue the study by testing additional variables, such as shifts in economics, demographics shifts and public housing.

"I want to help communities stay safe and violence-free," Zeoli said. "If we can figure out what makes a community ripe for homicides to move in, then we are much closer to prevention, not just in Newark but in other cities as well." ●

[MSU AgBioResearch]

AgBioResearch Staff

As of 1-1-2013

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John C. Baker — Associate Director

Doug Buhler — Senior Associate Dean

Bev Riedinger — Business and Finance Manager

Jackie DeSander — Administrative Assistant

Tonia DuMont — Executive Staff Assistant

Linda Haubert — Projects Administrator

Bill Humphrey — Preaward Coordinator

Holly Whetstone — Communications Manager

AgBioResearch Affiliated Deans

As of 1-1-2013

Fred Poston — Dean; College of Agriculture and Natural Resources

Pam Whitten — Dean; College of Communication Arts & Sciences

Satish Udpa — Dean; College of Engineering

R. James Kirkpatrick — Dean; College of Natural Science

Marietta L. Baba — Dean; College of Social Science

Christopher M. Brown — Dean; College of Veterinary Medicine

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As of 1-1-2013

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Janice Swanson, Chairperson; Animal Science

Thomas D. Sharkey — Chairperson; Biochemistry and Molecular Biology

Ajit K. Srivastava — Chairperson; Biosystems and Agricultural Engineering

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Michael Kaplowitz — Chairperson; Community, Agriculture, Recreation and Resource Studies

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Joseph H. Hotchkiss — Director; School of Packaging

Jill McCutcheon — Chairperson; Pathobiology and Diagnostic Investigation

David Kreulen — Acting Chairperson; Physiology

Richard E. Triemer — Chairperson; Plant Biology

Michael F. Thomashow — Director; Plant Research Laboratory (MSU-DOE)

Gary R. Anderson — Director; School of Social Work

Raymond Jussaume — Chairperson; Sociology

Charles Steinfield — Chairperson; Telecommunications, Information Studies and Media

Jon F. Bartholic — Director; Institute of Water Research

[AgBioResearch Centers]

1 CLARKSVILLE RESEARCH CENTER

9302 Portland Road
Clarksville, MI 48815
Phone: 616-693-2193
Farm Manager: Jerry Skeltis

2 DUNBAR FOREST

12839 S. Scenic Drive
Rt. 1, Box 179
Sault Ste. Marie, MI 49783
Phone: 906-632-3932
Non-resident Forester: Ray Miller

3 FRED RUSS FOREST

20673 Marcellus Highway
Decatur, MI 49045
Phone: 269-731-4597
Non-resident Forester: Greg Kowalewski

4 LAKE CITY RESEARCH CENTER

5401 W. Jennings Road
Lake City, MI 49651
Phone: 231-839-4608
Farm Manager: Doug Carmichael

5 MONTCALM RESEARCH CENTER

4629 W. McBrides Road
Lakeview, MI 48850
Phone: 989-365-3473
Farm Manager: Bruce Sackett

6 MSU FOREST BIOMASS INNOVATION CENTER

6005 J Road
Escanaba, MI 49829
Phone: 906-786-1575
Farm Manager: Ray Miller

7 NORTHWEST MICHIGAN HORTICULTURAL RESEARCH CENTER

6686 S. Center Highway
Traverse City, MI 49684
Phone: 231-946-1510
Farm Manager: Bill Klein

8 SAGINAW VALLEY RESEARCH AND EXTENSION CENTER

3775 S. Reese Road
Frankenmuth, MI 48734
Phone: 989-652-8014
Farm Manager: Paul Horny

9 SOUTHWEST MICHIGAN RESEARCH AND EXTENSION CENTER

1791 Hillandale Road
Benton Harbor, MI 49022
Phone: 269-944-1477
Farm Manager: Dave Francis

10 TREVOR NICHOLS RESEARCH CENTER

6237 124th Avenue
Fennville, MI 49408
Phone: 269-561-5040
Farm Manager: Matt Daly

11 UPPER PENINSULA RESEARCH AND EXTENSION CENTER

P.O. Box 168
E3774 University Drive
Chatham, MI 49816
Phone: 906-439-5114
Farm Manager: Paul Naasz

12 W. K. KELLOGG BIOLOGICAL STATION

3700 E. Gull Lake Drive
Hickory Corners, MI 49060
Phone: 269-671-5117
Assistant Director for Facilities and Operations: Phil Barry

13 W. K. KELLOGG EXPERIMENTAL FOREST

7060 N. 42nd Street
Augusta, MI 49012
Phone: 269-731-4597
Resident Forester: Greg Kowalewski

★ SOUTH CAMPUS FIELD RESEARCH FACILITIES

246 Spartan Way
Michigan State University
East Lansing, MI 48824-3005
Phone: 517-355-3272
Director: Charles J. Reid

[Publications and Resources]

BROCHURES

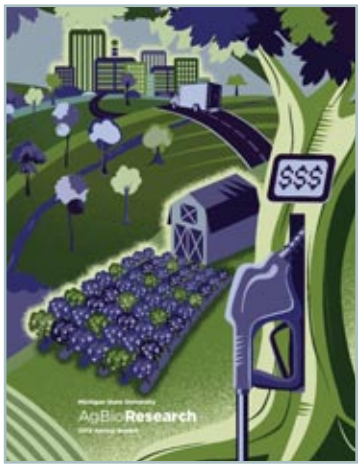
AgBioResearch encompasses the work of nearly 400 scientists in six colleges at MSU: Agriculture and Natural Resources, Communication Arts and Sciences, Engineering, Natural Science, Social Science and Veterinary Medicine.

This **identity brochure**, which provides an introduction to AgBioResearch and the breadth and relevance of its work, is available upon request by sending an email to: **info@agbioresearch.msu.edu**.

The **AgBioResearch centers brochure** highlights each of the 13 outlying research centers and their specific research. These centers focus on the research needs of the agricultural and natural resources industries and rural communities in their part of the state. Projects range from work on forestry and cellulosic ethanol in the Upper Peninsula to cherries in Traverse City, and from wine and juice grapes on the west side of the state to dry beans and sugar beets in the Thumb. One of the facilities, the W.K. Kellogg Biological Station in Hickory Corners, Mich., conducts extensive research on sustainability and other environmental issues.

This brochure is available upon request by sending an email to: **info@agbioresearch.msu.edu**.

ANNUAL REPORT



So what have we done for you lately? This information-packed report delivers brief narratives on some of the year's most innovative research and provides a glimpse of how world-class science is enhancing people's quality of life in Michigan and beyond.

FUTURES MAGAZINE

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

MSU Global Water Initiative

Spring/Summer 2012

Home to 20 percent of the world's fresh water, the Great Lakes region is awash with research opportunities for Michigan State University 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. AgBioResearch is a key player in the initiative's water research mix.

PAYING IT FORWARD: Mentoring Michigan's future scientists

Fall/Winter 2012

We call them teachers, advisers, experts and even friends. But in reality, being a mentor isn't a profession — it's a role. Mentors are often the first people that we look to as valuable sources of information and advice. Read about how AgBioResearch scientists from a variety of research disciplines are serving as mentors to the next generation of researchers and professionals, and how their protégés have gone on to careers that are making a difference as they provide innovative, real-world solutions to boost Michigan's economy, conserve the state's natural resources and enhance the quality of life for Michigan residents.

QUARTERLY NEWSLETTER

A complement to our magazine and annual report, this quarterly electronic publication brings timely news on leading-edge research, events and other information to keep you in the know.

Subscribe to this free publication by sending an email to: **info@agbioresearch.msu.edu**.

MESSAGE FROM THE DIRECTOR

[A miracle every day]

"But I fear that as the decades pass, rising energy costs will seriously challenge agricultural production."

(continued from page 2)

And I saw my first 45-foot-long tomato plant recently in a greenhouse near Schiphol Airport in the Netherlands. The polar opposite of places like Hyderabad, Holland is able to apply cutting-edge technologies to maximize food production on small land footprints. The impressive giant vines were each growing from rectangles of artificial soil the size of several bricks with the help of optimum light, water, temperature and nutrients. We had to suit-up in the agricultural equivalent of hospital gowns to get into the place.

So here's the mega question: are these systems — the way we now grow and the ways that we now distribute food — going to be adequate into the future as urban areas become denser? Or are we going to confront changes that will both challenge and provide opportunities for the current agricultural system, including our own here in Michigan?

I don't believe that there is a single answer to these questions, but I have a hunch that some things are going to change. Water, a resource that was plentiful and cheap during the past century, is going to be scarcer, more expensive and increasingly drawn away from agriculture to meet direct human needs. Agriculture's water footprint will be forced to shrink, and this will likely benefit Michigan, with its relatively plentiful access to this resource.

Energy is also going to cost more, and this will challenge the assumption that we can produce food almost anywhere and economically move it almost anywhere. I suspect that Michigan will enjoy a competitive advantage here, too, because we are close to populous markets in the Midwest and on the eastern seaboard. But I fear that as the decades pass, rising energy costs will seriously challenge agricultural production.

And then there is the wild card that technology waves at us. We now have the capacity to precisely optimize the wavelengths of light in controlled plant growth environments. We can control the movement of air, which affects the efficiency of energy capture from light. We can whip up the perfect cocktail of nutrients for every fruit and vegetable and precisely match them to plant genetics. Precision agriculture also allows us to collect terabytes of data to understand and optimize yield and quality in fields of grain and row crops. All of this technology costs money, but the state-of-the-art is rapidly advancing, our assumptions are changing, and costs—especially computational costs—are coming down.

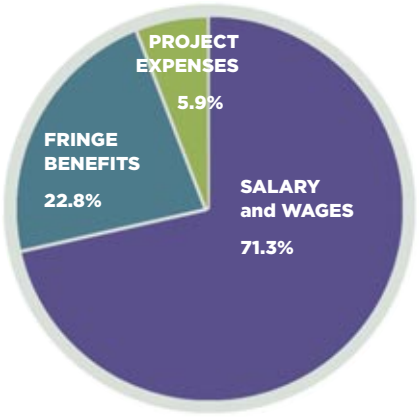
MSU AgBioResearch scientists are working on every one of these issues: on food distribution systems and the potential to position food production closer to the consumer; on water and energy (and the related, much debated issue of climate change); and on technology and its potential to revolutionize the way food is produced and how it makes its way to the consumer's plate. There will be no one answer, no silver bullet. But you will see, as written about in this issue of our annual report, that MSU AgBioResearch continues to keep open its options with the goal of vibrant and robust food production systems, in Michigan—and beyond.

Steven G. Pueppke
MSU AgBioResearch Director

[Financial Report]

7-1-2011 to 6-30-2012

DISTRIBUTION OF APPROPRIATED FUNDS



INCOME:

Federal Appropriation		
Hatch	$	5,184,724
McIntire-Stennis	$	313,620
Hatch RRF	$	1,253,408
Hatch Animal and Disease, Section 1433	$	85,712
Total Federal Appropriations	$	6,837,464
State Appropriations	$	28,260,055
Total Appropriations	$	35,097,519
Grant — Federal, State and Private*	$	66,197,421
TOTAL INCOME	**$**	**101,294,940**

EXPENSES:

Salaries	$	25,029,713
Fringe Benefits	$	8,009,554
Project Expenses	$	2,058,252
Grants — Federal, State and Private*	$	66,197,421
TOTAL EXPENSES	**$**	**101,294,940**

PERSONNEL:

(Full-time Equivalents Funded From Appropriated Funds)

Research Staff	
Professors	70.46
Associate Professors	32.32
Assistant Professors	24.38
Research Associates and Specialists	2.52
TOTAL RESEARCH STAFF**	**129.68**
Support Staff	
Administrative Professionals	58.75
Supervisors	25.35
Clerical	21.04
Technicians	3.21
TOTAL SUPPORT STAFF	**108.35**

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

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

[Production Credits]

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Val Osowski, Communications Manager, AgBioResearch

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MISSION STATEMENT

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

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

Steven G. Pueppke, Director
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MICHIGAN STATE
UNIVERSITY

SR-132/January 2013