maes research

discovery. knowledge. innovation.

michigan agricultural experiment station

two thousand nine annual report

MISSION STATEMENT

The mission of MAES is to engage in innovative, leading-edge research that ensures the wise use of agricultural, natural and community resources and enhances 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 MAES to be one of the most successful experiment stations in the country. This success is due to the efforts of outstanding researchers; close partnerships and collaborations with Michigan State University Extension, federal and state agencies, commodity groups and other key stakeholders; and exceptional legislative support.

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2009 Annual Report

MANAGING EDITORS' 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

On sea lampreys, Buruli ulcer and a new kind of ketchup

STEVEN G. PUEPPKE

This message comes at a time of great challenge and significant change for the Michigan Agricultural Experiment Station (MAES). On the one hand, our state's food and agricultural industry continues to be a stabilizing influence on Michigan's battered economy, contributing more than $71 billion in annual receipts. This is a fifth of the state's economic output and represents more than 1 million jobs. On the other hand, our budget is under significant stress as the state copes with the economic woes brought on by the current recession.

MAES is the research engine that energizes the state's food and agricultural industry. We pride ourselves on being responsive, listening to Michigan citizens, and addressing the food, agriculture and natural resource issues they see as priorities. We are also attuned to what's happening in 21st century science and ever on the lookout for new tools that may have been developed with other things in mind but that can be adapted to solve food and agricultural problems.

The $5.4 million U.S. Department of Agriculture grant that Dave Douches, Robin Buell and collaborators received in 2008 is an example of how this works. The science is fancy — all of the clever new molecular genetic techniques, many originating in fields such as medicine and computer science. Yet the goal is something we can all understand: improvement of tomatoes and potatoes, two of the world's most important food crops.

Literally hundreds of MAES scientists are at work every day, applying the latest — a gizmo, an elegant mathematical model, sometimes a new theory — to solve a problem that matters. This brings us to sea lampreys, Buruli ulcer and ketchup. Although one might not immediately associate these subjects with the MAES, each exemplifies our mission and relates to Michigan and the rest of the world.

Sea lampreys were accidentally introduced to the Great Lakes during the past century and have become enormously destructive pests in the waters that surround Michigan. They attach themselves to fish and, well, they suck out their insides. If you are a fish, this is not good. But it is also not good for the aquatic environment or for Michigan's fishing and fisheries industries. The U.S. and Canadian governments spend $15 million a year trying to control sea lampreys, just in the Great Lakes.

To address this challenge, MAES scientist Weiming Li identified a chemical that male lampreys use to lure females for mating. Li and members of his laboratory synthesized an artificial version of it and are now at work testing this substance as a control method (fake love scent means females get confused and can't find males and that means no baby lampreys). This research has received enormous attention in the scientific community and national media because it may offer a practical, environmentally-friendly way to help rid the Great Lakes of this nasty pest.

Buruli ulcer, like sea lampreys, is an undesirable guest. It is a devastating, leprosy-like tropical disease that produces sores and lesions on the arms and legs of children throughout West Africa, especially in Ghana. It cripples and kills and, in the process, destroys the social and emotional lives of children and families.

Buruli ulcer is caused by a bacterium, and the disease is associated with aquatic insects that live in ecologically disturbed waters. But no one really understands how water and insects fit into the disease cycle. MAES scientist Rich Merritt is searching for these connections by marrying geographic information systems mapping, molecular biology, and good old on-the-ground sampling and analysis of waterways and insect communities in Africa.

And then there's ketchup. I like to coat my food with it, but ketchup contains a lot of salt, something we're all trying to limit in our diets. Now MAES scientist Kris Berglund has discovered a way to help us with this challenge. Kris didn't have nutrition on his mind when he started a project back in the 1990s to discover novel uses for corn. What he found was a substance — lysine — that acts as an effective deicer. And if something can substitute for salt on roadways and sidewalks, could it also substitute for salt in foods? The answer is yes, and today this natural, corn-based product — known as AlsoSalt — is being sold commercially and used in no-salt-added ketchup.

So there you have it: MAES research that is helping to protect our state's fishery, water resources and related industries; MAES research that both exemplifies Michigan State University's global mission and seeks to improve the human condition; and MAES research that is being transformed into products that benefit human health. There are collateral benefits to this research as well. We are training young scientists, stimulating economic activity, and drawing a positive media spotlight on our state. It's all part of the MAES mission. Enjoy this year's annual report!

Steven G. Pueppke
MAES Director

MAES Faculty Honors

The awards and recognition that MAES researchers receive each year continue to impress. Some of the highlights for 2008–2009 are:

Joe Arvai, MAES judgment and decision making researcher and director of the MSU Environmental Science and Policy Program, was part of a national expert panel that published a report aimed at helping federal, state and local officials make better decisions about affecting climate change.

Christoph Benning, MAES biochemistry and molecular biology researcher, was named editor-in-chief of The Plant Journal, an international journal devoted to publishing original research papers on fundamental plant biology problems.

Lawrence Busch, MAES scientist, MSU distinguished professor and director of the MSU Institute for Food and Agricultural Standards, was elected a foreign member of the prestigious French Society of Agriculture.

Bruce Dale, MAES chemical engineering and materials science researcher and internationally recognized expert in biofuels research, became a member of the Geneva-based International Centre for Trade and Sustainable Development's steering committee to help create a series of white papers on climate change, agriculture and trade.

Dean Della Penna, MAES biochemistry and molecular biology researcher, and **C. Robin Buell**, MAES plant biology scientist, were named fellows of the American Association for the Advancement of Science. Della Penna was honored for outstanding contributions in plant biochemical genetics and vitamin biosynthesis. Buell was recognized for distinguished contributions to plant and microbial genomics and genome biology.

James Kelly, MAES crop and soil sciences researcher, was named a fellow of the Crop Science Society of America. Kelly has released 34 dry bean varieties in 11 commercial seed classes.

Doo-Hong Min, MAES crop and soil scientist and Extension forage specialist, received a merit award from the American Forage and Grassland Council for his superior contributions to forage and grassland agriculture.

Jim Pestka, MAES food science and human nutrition researcher, was cited by ScienceWatch.com for the publication of 59 papers on mycotoxins from 1998 to 2008, which gave him the No. 1 rank in this category among 9,727 authors.

Tom Reardon, MAES agricultural economist and internationally recognized expert on global agrifood markets, was named to a national experts committee convened by the Chicago Council on Global Affairs to provide critical input on the current food crisis and poverty alleviation strategies in developing countries.

Jinhua Zhao, MAES agricultural economist, won top honors in a research paper competition sponsored by the Harvard Project on International Climate Agreements for his policy concept on how to best approach the nation's greenhouse gas emissions.

Two MAES crop and soil sciences researchers received awards from the Weed Science Society of America (WSSA). **Karen Renner** was named a WSSA fellow, and **Christy L. Sprague** received the Outstanding Early Career Weed Scientist Award.

Three MAES scientists were named MSU distinguished professors: **Mike Allen**, animal science and dairy cattle nutrition; **Pamela Fraker**, biochemistry and microbiology and food science and human nutrition; and **G. Philip Robertson**, crop and soil sciences.

MSU Distinguished Faculty Awards went to six MAES scientists: **Christoph Benning**, biochemistry and molecular biology; **Robert Hausinger**, microbiology and molecular genetics; **Sheng-Yang He**, plant biology and member of the MSU Plant Research Lab; **Thomas Reardon**, agricultural, food and resource economics; **Joan Rose**, MAES-affiliated water scientist; and **J. Mark Scriber**, entomology. **Katherine Alaimo**, MAES food science and human nutrition researcher, received a Teacher-Scholar Award.

FOOD AND HEALTH

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

From fighting the flu in humans and bovine viral diarrhea virus in cattle to controlling disease in agriculturally important crops such as cherries and soybeans, Michigan Agricultural Experiment Station (MAES) researchers are hard at work to provide Michigan growers and commodity groups with the critical information and resources they need to remain viable and competitive in the global economy, and consumers with knowledge that helps ensure their health and well-being. The projects highlighted in this section provide a snapshot of the innovative and important research being done in this priority area.

[Stemming the Tide of **Cherry Disease**]

PHOTO: GEORGE SUNDIN

Cherry diseases such as brown rot (above) can cause major crop losses in severe disease years if not carefully managed.

With cash receipts of $78.2 million in 2008, Michigan cherries are doing their part to help keep Michigan's economy out of the pits. Michigan is the No. 1 producer of tart cherries in the United States, supplying 70 to 75 percent of the nation's total crop, and ranks No. 4 nationally in sweet cherry production, according to U.S. Department of Agriculture data.

Like other crop producers, cherry growers worry about the effects of diseases and insects on productivity, profitability and product quality. In particular, several fungal diseases — cherry leaf spot, brown rot and *Armillaria* root rot — cause concern for producers. If left unchecked, any of them could spell disaster for the state's cherry industry.

To help protect this valuable Michigan commodity, MAES plant pathologists George Sundin and Ray Hammerschmidt are working closely with cherry growers to control cherry diseases and minimize crop loss.

Cherry leaf spot, caused by the fungal pathogen *Blumeriella jaapii*, is arguably the most damaging fungal pathogen of tart cherry. The fungus primarily attacks the leaves and causes them to drop prematurely, reducing a tree's ability to carry out photosynthesis and move carbohydrates down to the roots. As a result, the roots contain more water than sugar solution. During a hard winter, the roots can freeze. This can either kill the tree or greatly reduce fruit production in the next season.

"I've seen instances where entire orchards have been killed because of leaf spot and early defoliation the previous year," Sundin said. "Right now, we're managing the disease pretty effectively in Michigan. Our main challenge is dealing with fungicide resistance."

In the past three years, Sundin and his team discovered that the cherry leaf spot pathogen developed resistance to one of the major fungicide groups, and that fungicide-resistant strains had spread throughout Michigan.

"Unfortunately, we don't have biological controls or many other viable fungicide options," Sundin said, "so we're revisiting some of the older materials that were used, one being copper. It's highly effective against cherry leaf spot but can be somewhat toxic to the trees when it builds up in the soil, so we're exploring ways to alleviate that toxicity."

Another challenge to cherry growers is brown rot, a fungal disease that infects the fruit itself and rots it away. Caused by the fungal pathogen *Monollinia fructicola*, brown rot can cause extensive field losses of sweet and tart cherries if conditions favorable for disease development occur during the flowering, fruit development or harvest.

"Brown rot is a bigger problem with sweet cherries than with tart cherries," Sundin said. "In 2008, the disease caused about a 20 percent loss in Michigan's sweet cherry crop. This is another

"There are **limited control options** for these diseases. We have to protect them because, **if we lose them, we won't be able to grow cherries** in Michigan." • GEORGE SUNDIN

fungus where we're studying sensitivities to the various fungicides growers rely on."

Armillaria, a soil-borne fungus that causes a root rot disease is also a serious problem in cherry production areas of Michigan. The fungus produces rootlike structures called rhizomorphs that move through the soil from infected to non-infected areas, penetrating the cherry roots and infecting the trees.

"Affected trees may exhibit poor growth for one to several years and then die suddenly," Hammerschmidt said. "Unlike cherry leaf spot or brown rot, it can take years to see symptoms developing in trees."

Hammerschmidt and members of his lab are addressing this problem on a couple of fronts. Using modern molecular techniques, they have developed diagnostic tools to determine the presence or absence of *Armillaria* in current and potential orchard sites and to identify, in affected sites, which of the four species of *Armillaria* found in Michigan are causing the root rot. The tools are currently being tested at the MAES Northwest Michigan Horticultural Research Station in Traverse City.

Hammerschmidt is also conducting fundamental research into the mechanisms of the disease.

"There's been a lot of research on the ecology of these organisms but not a lot on the basic biology of the disease and its interactions with the host," he explained. "One of the things we hope to do is find a way to interfere with rhizomorph formation to help reduce the threat of infection.

"Prevention and vigilance are huge factors in managing these diseases," Hammerschmidt said. "Beyond that, fungicide use, optimal timing for application and ongoing research is the other part of the equation."

"There are limited control options for these diseases," Sundin added. "We have to protect them because, if we lose them, we won't be able to grow cherries in Michigan. Effectively managing these fungicides and investigating new means of control is critical to the survival and vitality of this important industry." ●

[Countering the Flu with **Calories**]

Flu season is upon us, and this year Americans face both seasonal flu and the H1N1 virus (commonly referred to as swine flu). An estimated 36,000 people die from the flu annually, and several hundred thousand are hospitalized, according to the Centers for Disease Control and Prevention (CDC). With the added threat of the H1N1 virus, experts are forecasting an unusually severe flu season this winter.

When most people have the flu, the last thing they want to do is eat. However, research conducted by MAES nutrition immunology scientist Elizabeth Gardner suggests that consuming more calories during flu season could help ward off the virus and/or result in a speedier recovery.

Using a mouse model, Gardner and members of her laboratory are exploring the effects of caloric restriction on the primary immune response to influenza infection. Caloric restriction is the practice of reducing the intake of calories while maintaining adequate vitamins and minerals.

"Initially we thought caloric restriction would be desirable in fighting the flu because it extends life span, and one of its benefits is improved immune function," Gardner said. "So we hypothesized that calorically restricting the animal would improve its immune function. We found the complete opposite was true."

Gardner's research showed that mice on a calorie-restricted diet were more likely to die during the first few days of infection than mice on a normal diet.

Individuals who are infected with the flu virus don't have antibodies to fight the infection, Gardner explained. The body relies on cells that recognize the virus and try to kill it. These natural killer cells, which draw on the body's energy stores, act as the first line of defense in the fight against viruses.

"Our studies showed that, with caloric restriction, the natural killer cell response is reduced in older mice, so the virus is more likely to accumulate," she said. "We wanted to find out how to improve the immune response when the vaccine isn't effective."

In Gardner's research, both regularly fed mice and calorically restricted mice exposed to the virus exhibited decreased food intake as they tried to fight off infection. Yet the mice on calorically restricted diets took longer to recover and exhibited increased mortality, weight loss and other negative effects. Although both sets of mice took in appropriate vitamins and minerals, the mice consuming normal amounts of food recovered faster.

"Use **nutrition to your benefit.** If you **get the flu, try to eat** through it."

• ELIZABETH GARDNER

"Animals with fat stores have a source of energy, but calorically restricted animals have to start using sources other than fat, and that really has a taxing effect," Gardner said. "It's fine for adults to restrict their calorie intake eight months out of the year, but during the four months of flu season, they need to have reserves in order to fight a virus."

Gardner said that the flu vaccine has a 70 percent to 90 percent efficacy rate in young people, but seniors have a much lower response, so they are at greater risk for complications such as pneumonia. The CDC includes a significantly larger at-risk segment of the population for the H1N1 virus — including children and youth ages 6 to 24 — compared to seasonal flu viruses.

"Flu shots don't guarantee protection because they are formulated months in advance and with the hope that the vaccinating strains are similar to those that might infect the population," Gardner said. "With new threats such as the H1N1 virus, people should take every precaution they can to stay healthy. At-risk populations should increase calories but not fat intake, eating foods high in protein and antioxidants."

Gardner now is investigating the mechanisms responsible for decreased immune function during caloric restriction and hopes her research in nutritional immunology will lead to a better understanding of how diet affects the immune system and the best conditions for a body to quickly and successfully fight infections.

The bottom line this flu season?

"Use nutrition to your benefit," Gardner said. "If you get the flu, try to eat through it." ●

PHOTO: KURT STEPNITZ

Findings from MAES researcher Elizabeth Gardner's lab suggest that people who consume fewer calories during flu season could have a harder time fighting the influenza virus.

[Eradicating **BVDV** One Herd at a Time]

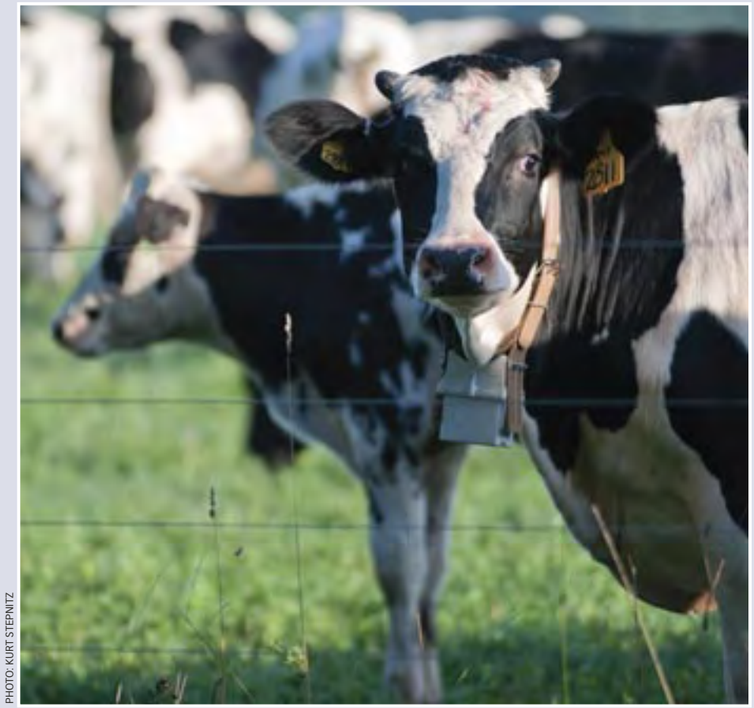

PHOTO: KURT STEPNITZ

Seventy to 90 percent of all bovine viral diarrhea virus (BVDV) infections occur without the appearance of clinical signs.

Wiping out a virus that spreads the same way a cold or the flu does might be impossible in humans, but MAES researchers are hoping to do this for the entire cattle population in the Upper Peninsula of Michigan.

The virus in question — bovine viral diarrhea virus (BVDV) — is a highly contagious disease that spreads quickly through a herd. Like the flu in humans, BVDV is spread through nasal secretions, saliva and direct contact. It's especially troublesome in feedlots and barns. Animals infected with the virus encounter reproduction, respiratory and immune system problems that can lead to thousands of dollars in losses for a farm. It is estimated that BVDV is the most costly viral disease in today's U.S. cattle herds, costing approximately $2 billion per year.

"BVDV is an underlying issue on many farms," said Steve Bolin, MAES scientist with the MSU Diagnostic Center for Population and Animal Health. "Some cattle are born with BVDV and carry it for life. It's not uncommon to have a 'Typhoid Mary' living in a herd."

In 2007, Bolin and MAES large animal clinical scientist Dan Grooms teamed up with MSU Extension dairy and livestock educator Ben Bartlett to develop and launch the Michigan Upper Peninsula BVDV Eradication Project — the first of its kind in the nation.

"One of our objectives is to see if it's possible to develop a feasible voluntary approach to eradicate a specific disease within a geographic area," Grooms said. "We chose the Upper Peninsula because of its easily defined region. If we are successful with the program there, a similar approach could be implemented in other regions of the state or the United States."

The challenge was to develop a program that was simple and convenient for cattle producers. There is no mandate that they test for the virus. The team enlisted the help of local veterinarians, the Michigan Department of Agriculture, the U.S. Department of Agriculture and MSU Extension.

A phased system was devised that divides the Upper Peninsula into sections to make testing the region's 700 cattle herds manageable. The aggressive three-step program includes educating producers about the disease, testing to determine the rate of infection — if any — present in a herd, and training on how to implement control management strategies, including proper vaccination and biosecurity measures.

"**Some cattle are born with BVDV** and carry it for life. It's **not uncommon to have a 'Typhoid Mary'** living in a herd." • STEVE BOLIN

"To get a high level of participation, we had to make everything as easy as possible, from how we sign people up to how we collect information from them to how they submit samples," Bolin said. "Cattle producers who opt into the program receive a testing kit with instructions and bring the samples — in the form of ear notches — to their county MSU Extension office. Trained personnel ship the samples to the Diagnostic Center for Population and Animal Health at MSU, where they are tested and recorded in a database."

"The key to eradicating BVDV from a herd is to eliminate any persistently infected (PI) cattle," Grooms said. "PI cattle transmit the virus to their unborn fetuses. The PI cows become unsuspecting disease reservoirs, spreading disease both on and between farms."

Currently, testing is being conducted in the eastern part of the Upper Peninsula, with central and southern regions to follow in the next several years. To date, between 10,000 and 11,000 animals have been tested, most of which are calves. If a calf tests negative for BVDV, it means its mother is also free of the virus. The number of verified BVDV-free animals tested through the program has reached approximately 20,000.

Although the project is still in progress, other states already have shown interest in this approach.

"Producer-driven programs can be successful in eradicating disease," Bolin said. "This ultimately is a grass-roots effort. No plan will work if you don't have people at the bottom of the pyramid to support it." ●

[Breeding **Bug-resistant Soybeans**]

"Hate" is a strong word, but soybean growers truly hate soybean aphids, the most damaging soybean pest in the north central United States. Now MAES crop and soil scientist Dechun Wang is turning the tables on the destructive yellow creature, breeding new varieties of soybeans that aphids hate.

Wang followed soybean aphids to Michigan, beginning his breeding program at MSU in 2001, just a year after the pests were discovered in the United States. Since then he has been developing aphid-resistant germ plasm specifically tailored to Michigan's northern climate and early-maturing soybean varieties.

"It takes 8 to 12 years to develop a new soybean variety," Wang said. "Promising results may happen in 4 years, but we need to conduct long-term, widespread field trials to make sure there are no surprises for growers."

In 2008, more than 400 lines developed from Wang's aphid-resistant germ plasm were tested throughout Michigan and evaluated for yield, lodging, maturity and seed quality. Six aphid-resistant lines were also evaluated for aphid resistance in seven states in the north central region — Illinois, Iowa, Kansas, Michigan, Minnesota, South Dakota and Wisconsin.

Michigan farmers raise more than 75 million bushels of soybeans on nearly 2 million acres of farmland annually. Prior to 2000, few, if any, soybean acres were treated with insecticides.

"So far, my resistance has held up," Wang said. "When the resistance is incorporated into commercial soybean varieties, no insecticide is needed to control aphids. This can save soybean growers tens of millions of dollars in an aphid outbreak year."

Soybean aphids are barely visible to the naked eye, but they caused an estimated $120 million in losses for U.S. soybean growers in 2003. In 2005, the year of the last large soybean aphid outbreak in Michigan, 42 percent of the state's soybean acreage was treated with insecticides to control the pest. This increased production costs by $6.7 million.

Soybean aphids suck plant sap and secrete sticky honeydew that promotes the growth of a sooty black mold on plant leaves.

"It takes aphids **just five days to produce** more babies, and **aphids are born pregnant**, so the regeneration **cycle is incredibly fast.**" • DECHUN WANG

Sprouting wings later in their life cycle allows aphids to use their needle-like mouths to transmit viruses rapidly.

"In the field, we will inoculate a plant with just two aphids, and the entire plant will be totally covered by aphids in a few weeks," Wang said. "It takes aphids just five days to produce more babies, and aphids are born pregnant, so the regeneration cycle is incredibly fast."

PHOTO: CHRIS DIFONZO

Discovered in North America in 2000, the soybean aphid is now the most damaging soybean insect pest in Michigan and the Midwest.

Just as Wang's first aphid-resistant germ plasm, E06902, is being used in commercial variety development, the industry has requested licensing for his latest promising germ plasm, E07906-2. This new germ plasm also shows resistance to Japanese beetle, another pest eating away at grower profits.

"We will continue to develop better germ plasm material in the near future, but the soybean seed companies and the Michigan Soybean Promotion Committee (MSPC) don't want to wait," Wang said. "They've seen our progress this year, and they want to move the newest germ plasm into development immediately.

"All major seed companies except one are using our aphid-resistant germ plasm to develop aphid-resistant varieties," he added. "It's very rewarding. If someone wants your germ plasm, you know you've done something useful."

Though soybean aphid continues to take a bite out of grower profits, the MSPC has put Wang on alert for another destructive pest — a fungal disease known as sudden death syndrome (SDS), previously found only in southern regions of the United States. A small area of SDS was discovered last year in Michigan.

"The breeding program has to start as soon as we know there is a threat, and the industry helps me make sure that research is under way to meet grower concerns and challenges," Wang said. "The soybean committee knows what farmers need, so they find the right researcher to address the problem."

Wang said a graduate student in his laboratory has already started evaluating germ plasm for resistance to SDS.

"I could work in my lab on just molecular genetics, but I also like to work with the real concerns of growers," Wang said. "I want to see the impact that farmers want to see, that they have asked for. This work allows me to do something different, something special, something with immediate impact." ●

ENVIRONMENTAL STEWARDSHIP

and Natural Resources Policy and Management

The need to develop economically and environmentally sound approaches to address environmental and natural resources challenges is increasingly important. Policies, practices 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 showcased in this section reflect some of the innovative research being done by Michigan Agricultural Experiment Station (MAES) scientists in this area to help individuals, communities, natural resources managers and policy makers at all levels make informed decisions and wise choices.

PHOTO: PAT SORANNO

The nesting dynamics of black bass in several Michigan lakes are being studied to determine the effects of shoreline habitat alteration associated with residential development and spring fishing on these important fish populations.

[Putting **Freshwater Resources** on the Map]

Although Michigan is widely known as the "Great Lakes State," it is also home to more than 10,000 freshwater lakes larger than 5 acres, 30,000 miles of streams and almost 10,000 square miles of wetlands. Freshwater resources also include groundwater and are used for fishing, swimming and other recreation, irrigation and drinking water.

State agencies — primarily the departments of Natural Resources (DNR) and Environmental Quality (DEQ) — have the enormous task of managing these freshwater resources to make sure all needs are met as fully as possible; overseeing fish stocking, fishing regulations and herbicide applications to control aquatic plants; and setting withdrawal regulations and assessing the impact of urban development.

MAES fisheries and wildlife scientists Mary Bremigan and Patricia Soranno, along with Kendra Cheruvelil, MSU assistant professor of fisheries and wildlife, are working to create tools for water managers that look at freshwater resources in a landscape context instead of considering each lake or stream as a single ecosystem.

"We call our research 'landscape limnology,'" Soranno explained. "We're studying lakes, streams, wetlands and groundwater as they interact with one another and with land-based features, natural and man-made, to understand how all these factors affect freshwater processes."

The scientists pointed out that many environmental issues have causes that range in scale from local to global. Developing solutions requires considering interactions that take place at all scales. Invasive species establishment, for example, may be linked to an increase in water temperature associated with global warming, the interconnectivity of inland lakes and streams, and the type of development along the shoreline.

"The landscape approach is really the only way to study these types of issues," Cheruvelil said. "If you look at only one ecosystem, you can't figure out the whole picture."

"We believe that we need to study the freshwater landscape much as ecologists and geographers have been studying terrestrial landscapes to determine the effects of patterns on ecosystem processes," Bremigan added. "Understanding how these processes respond to changes in the landscape is critical for wise management and conservation of freshwater habitats."

The scientists start with geographical information systems (GIS) data from satellites and aerial photos, including information on land use around the freshwater resources, soil makeup and bedrock geology. This information is combined with data collected in the field, such as fish population numbers and nutrient levels, as well as socioeconomic data, to create models that incorporate multiple layers of information and variables. Tools are then developed to address specific management issues.

"One of our first projects — the development of an inland lake classification system and statistical models — has helped improve lake monitoring and assessment programs," Soranno said.

Soranno and Cheruvelil also worked with the DEQ to develop a landscape-based model to set standards for nutrient levels in lakes and steams. Lake nutrient levels are used to judge whether a state is meeting Clean Water Act requirements. Half of the surface water in the United States doesn't meet water quality standards, often because of high nutrient levels. The scientists' model allows the state to determine a standard for each lake on the basis of its surrounding landscape. The researchers are now working with two tribes in Minnesota to set nutrient levels for the lakes that the tribes manage.

"The **landscape approach** is really the only way to **study these types of issues.** If you look at **only one ecosystem**, you **can't figure out the whole** picture." • KENDRA CHERUVELIL

As more shoreline is developed, many fear that fish populations will go down. Black bass, for example, like to nest in weedy shallow waters near the shore. Bremigan's research has shown that, as shoreline development increased, bass nesting success declined. When bass anglers asked the state to extend the season for black bass, Bremigan was part of the team that helped evaluate the potential outcomes of a longer season. She's now expanded her research to investigate the combined effects of angling and shoreline development on bass populations.

Cheruvelil recently completed the largest study to date on the effect of water clarity on lakefront property values of nearly 1,400 properties on 137 lakes in 20 southwestern Michigan counties. The results? Location matters.

"In some lakes, yes, the cleaner the water, the higher the property value," Cheruvelil said. "But not in all lakes. It really depends on the region in which the lake is located. There isn't a simple answer." ●

[Branching Out to **Fight Poverty, Slow Global Warming**]

What do a village of small-acreage farmers growing Jatropha trees in Thailand and carbon markets have in common? Both are part of an innovative venture called Carbon2Markets. The program combines agroforestry with emerging carbon financial markets to help farmers in 10 developing Asian and African countries boost their standards of living and slow climate change.

"This initiative is an attempt to take some of our fundamental science off the laboratory bench and put it into practice," said David Skole, MAES forestry researcher and leader of the Carbon2Markets program. "We've been doing basic research on the global carbon cycle, the role of tropical forest conversion and climate for more than 20 years. The last few years, we've turned our attention to what we could do on the solution side of climate change, particularly related to carbon dioxide."

Carbon dioxide is an increasingly prevalent greenhouse gas that traps heat in the atmosphere. Trees, other vegetation and soil trap, or sequester, that carbon. In a world market where carbon emissions are tallied and assigned a price, growers in poor nations could profit from their land use choices.

To take advantage of this opportunity, Skole and the Carbon2Markets team first developed basic forest inventory techniques that assess how much a tree has grown and how

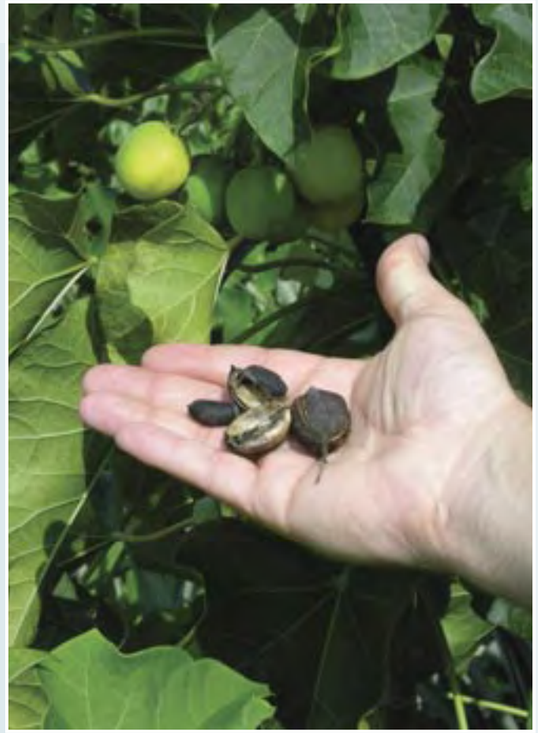

PHOTO: JAY H. SAMEK

Mature Jatropha trees produce seeds that can be crushed and processed into biodiesel to run farm equipment.

> "The ability to **link tree planting with** near-term payments through the **emerging carbon markets** has the potential to **positively affect millions of lives.**" • DAVID SKOLE

much mass it has put on over time to determine the amount of carbon it contains.

"All trees and plants, when they grow, take carbon dioxide out of the atmosphere," Skole explained. "Through photosynthesis, that carbon dioxide gets turned into the biomass, the material that forms the structure of the tree or plant, which makes up most of its weight, its mass."

The group is also using satellite imaging systems to enhance the use of these basic techniques in a variety of landscapes.

"First we use global positioning system satellites to locate the fields where the trees are growing," Skole explained. "Then we use Earth observation satellites that image the land and measure reflected light from the surface. Because these satellites carry highly technical imaging devices – sensors — we can use them to measure plant growth and photosynthesis properties. The technology also allows us to cover very large areas of land at a very low cost."

Accurately and cost-effectively measuring stored carbon offers farmers the potential to enhance their incomes through the global carbon market, Skole said. Carbon2Markets has agreements in place with the Chicago Climate Exchange to provide farmers with a market for the carbon credits.

"For example, a Thai farmer who planted trees on about 3 acres would earn about $40 per year from the carbon market at current prices," Skole said. "A 25-acre plot could earn up to $400 per year – a significant amount in a region of Thailand where the average annual income is about $1,200."

The farmers also use and sell the forest products they grow. Jatropha tree nuts can be used to make biodiesel, which is then used to run farm equipment or produce energy for a village. Another high-value crop, shea tree nuts, yields shea butter, a staple ingredient in high-end moisturizing lotion. The trees also provide food, timber and medicines.

In addition to applying the right tools and techniques, partnerships at all levels – from national and local governments to communities, farmer co-ops and individual farmers — are critical to the success of the Carbon2Markets program, Skole said.

"You need to partner with governments at the national level because they are very interested in their commitment to climate treaties," he said. "But then you have to work all the way down to the farmers, because they're interested in their incomes, their livelihoods, their own farms."

The bottom line? Growing smart, sustainable crops can reduce greenhouse gases while increasing family income, which means a greener future for everyone.

"The ability to link tree planting with near-term payments through the emerging carbon markets – with additional payments from other tree products coming online in subsequent years — has the potential to positively affect millions of lives," Skole said. "And the continued generation of high-value tree products such as fruits and oil-producing nuts serves to protect the stored carbon from being harvested as fuel wood, burned and re-released into the atmosphere." ●

[Fermenting **Fodder** into **Fuel**]

Fueling the future is growing in some interesting directions these days. As climate change challenges continue to crop up around fossil fuel use and greenhouse gas emissions such as carbon dioxide, identifying renewable fuel materials and developing processes that produce environmentally friendly, cost-competitive biofuels are becoming increasingly important.

Michigan State University (MSU) scientists are at the forefront of biofuels research and have made Michigan a leader in producing biofuels from cellulose and hemicellulose, the complex sugars that make grasses, plant stems and stalks, and leaves rigid.

Unlike simple sugars or even starches in the grains of plants, such as corn kernels, cellulose doesn't dissolve in water. This is good for keeping plants healthy, but it's a problem for making biofuels. Before the complex sugars in cellulose and hemicellulose can be converted into ethanol or other biofuels, they have to be broken down into simple sugars. Because the process is difficult to do efficiently, it can significantly raise production costs. This is part of the reason why cellulosic biofuels aren't available commercially. Yet.

PHOTO: KURT STEPNITZ

After biomass (plant material) has been pretreated with the AFEX process, it looks somewhat like popcorn — slightly puffed up and dry.

Bruce Dale, MAES chemical engineer and associate director of the MSU Office of Biobased Technologies is studying ways to use agricultural waste — the plant debris left after crops are harvested — as raw material for biofuels.

We can produce ethanol and other transportation fuels from cellulosic materials," said Dale, who has more than 30 years' experience in studying pretreatments to make cellulose easier to break down. "There are some studies that show we can produce cellulosic ethanol for about $1 per gallon when the technology is fully mature. We're not there yet, but I believe we should be able to get cellulosic biofuels to the pump for about $2 per gallon in the relatively near future."

Dale has developed a process, ammonia fiber expansion (AFEX), to pretreat cellulosic biomass with ammonia. MSU has received several patents on the process.

"The AFEX process makes the breakdown of cellulose and hemicellulose more efficient," Dale explained. "Using enzymes alone, about 15 percent of cellulose and hemicellulose is broken down into simple sugars; when AFEX is used before adding the enzymes, more than 90 percent of the cellulose and hemicellulose is broken down into fermentable sugars."

The AFEX pretreatment process also increases the value of some cellulosic materials for other uses, such as feed for dairy and beef cows. Dale is collaborating with MAES animal scientist Michael Allen to evaluate the feed potential of several types of pretreated cellulosic plant materials.

Cellulosic materials that have been treated with the AFEX process are also easier and less expensive than raw, untreated materials to turn into pellets. Combined with regional biomass processing centers, pretreatment and pelletizing could solve a major logistical issue in the cellulosic biofuels industry.

"Because cellulosic materials are bulky, it's expensive to ship them very far," Dale explained. "Getting enough of these materials together in one place is a challenge that the regional biomass processing centers would address. If we 'densify' the cellulosic materials into pellets, it's likely that the traditional corn grain handling equipment will work to load and unload the materials, further simplifying the logistical and transport issues."

> "... I believe we should be able to get **cellulosic biofuels to the pump** for about **$2 per gallon** in the **relatively near future.**" • BRUCE DALE

Dale sees the processing centers producing not only the processed biomass that will go to biorefineries but eventually byproducts, biobyproducts if you will, including fertilizers, animal feeds, enzymes for the biorefining industry, and perhaps nutraceutical products for use by other industries.

In addition to the progress being made with biomass processes and logistics, Michigan State is partnering with Michigan Technological University to provide research support to the Massachusetts-based Mascoma Corporation as the company works to build one of the nation's first cellulosic ethanol plants in Chippewa County in the Upper Peninsula of Michigan.

"The biomass supply chain is very important to creating a stable cellulosic biofuel industry and a stable bioeconomy for Michigan," Dale said. "This is an area that hasn't received a lot of attention, and it is one we are trying to address in our work." ●

[Taking Steps to Reduce Carbon's Footprint with Biofuels]

PHOTO: COURTESY DB CLIMATE CHANGE ADVISORS

The world's first scientifically-valid, real-time carbon counter was unveiled in New York in June 2009. The red line graph on the counter (above) shows that CO2 concentration levels in the atmosphere are now higher than they have been in the past 800,000 years.

Carbon dioxide (CO_2) is second only to water vapor in its contribution to the greenhouse effect. Annual emissions of this greenhouse gas (GHG) have grown by about 80 percent since 1970 and represent 77 percent of GHG emissions generated by human activity (primarily through fossil fuel use), according to the Intergovernmental Panel on Climate Change.

Of significant concern to climate change experts is that CO_2 is a "stock pollutant," a long-lived contaminant (the half-life of atmospheric CO_2 can be over 100 years) that the environment has little or no capacity to absorb. As a result, it accumulates and persists in the atmosphere over time, causing increased damage as more pollutant is emitted.

To address this critical issue, increased attention is being paid to the role that biofuels can play in reducing CO_2 emissions. Over the past decade, researchers have relied on an assessment model known as life cycle analysis (LCA), which calculates the environmental impact of a product, process or service from production to final disposal or, in the case of biofuels, from field to wheels.

"The big question is, as we vary the capacity of biofuels, **how big an impact are we going to see?"** • JINHUA ZHAO

Although this tool allows researchers to accurately assess the energy requirements and land conversion effects of biofuels to determine potential emissions savings when compared with fossil fuels, MAES agricultural economist Jinhua Zhao said that the current LCA framework is based on a static view of the energy sector and ignores a very important factor — the impact of biofuel development on fossil fuel supply and CO_2 emissions over time.

"Global climate change is not simply about the quantity of GHG emissions – it's about the time profile of the emissions," he said. "Stock pollutants require extended periods of time to be dissipated. If the growth of biofuels moves the fossil fuel supply to future periods, it will help alleviate increases in CO_2 concentration levels by spreading out their release."

To evaluate the long-run carbon footprint of biofuels , Zhao developed a model to investigate how current and future biofuels growth influences the supply of conventional fossil fuels.

Liquid biofuels — ethanol and biodiesel — currently make up about 4 percent of the total U.S. liquid fuel consumption. Zhao contends that this small share is why researchers have typically ignored the impact of biofuels development on oil supply (U.S. oil consumption is currently 20.7 million barrels per day, according to World Watch Institute). But, he said, if you tabulate these numbers using a long-run dynamic model, even a very small percentage significantly shifts the oil supply pattern.

"For example, if for each year over 20 years there are 85 million barrels of biofuels produced, that's seventeen hundred thousand million barrels," Zhao said. "That small quantity may not reduce the total amount of fossil fuel ultimately used, but it will significantly change the time pattern related to how many barrels are going to be supplied now versus in the future."

This will happen for two reasons, Zhao said.

"First, the next generation of biofuels is projected to be economically competitive within 10 years," he explained. "Once this happens, the market will be more responsive to price signals in the fuels supply sector, which in turn, will influence the decisions that oil producers make over time about how many barrels of oil they extract from the ground to maintain profits and market share.

"Second, whenever oil prices increase, the total market shrinks because demand is lower — gasoline prices are higher, people are driving less, so less fuel is consumed. As a result, even at their current capacity, the market share of biofuels in the transportation fuel arena is going to be higher because the total market is smaller."

Zhao has completed work on his model and is now tabulating data to determine the magnitude of the shift.

"The big question is, as we vary the capacity of biofuels, how big an impact are we going to see?" he said. "We know there will be shifts, we just don't know by how much. Future biofuel supply through next generation technologies will play a critical role in this analysis."

The new data will have policy implications as well, Zhao said.

"This dynamic model will more accurately reflect the true GHG effects of biofuels, which will help determine the most effective government policies and federal funding recommendations in this arena," he said. "The sooner we can achieve a larger biofuels capacity, the more pronounced the effect will be on shifting the fossil fuel supply and reducing CO_2 emissions." ●

ENHANCING PROFITABILITY

in Agriculture and Natural Resources

Agriculture's essential role in growing and sustaining Michigan's economy is undeniable — production agriculture, food processing and related agribusinesses generate an estimated $71.3 billion annually and employ about 1 million Michigan residents. Additionally, Michigan produces more than 200 commodities on a commercial basis and is second only to California in agricultural diversity. Michigan Agricultural Experiment Station (MAES) researchers from a range of disciplines are working to foster a globally competitive agricultural production system and are providing the research underpinnings for many of the state's agricultural success stories.

[Sorting, Scanning, Sniffing the Way to Less Chestnut Decay]

PHOTO: RANDIHAUSKEN VIA FLICKR

As the Michigan chestnut industry grows from hundreds to thousands of pounds of product each year, MAES researchers are testing technologies such as CT scanning and electronic noses to help identify the healthiest, most profitable chestnuts.

Floating chestnuts used to mean sinking profits for chestnut growers around the world, but MAES researchers have found problems with the age-old selection practice and are working toward a high-tech solution.

For centuries, chestnuts have been discarded if they float, because healthy chestnuts tend to sink. But studies have proven this post-harvest sorting method unreliable, with some healthy floating chestnuts being discarded and some decayed, empty or damaged chestnuts ultimately making their way to consumers.

Since blight wiped out the American chestnut forests in the 1940s, domestic chestnut lovers have relied on European and Asian imports to satisfy their chestnut cravings. Now the development of blight-resistant chestnut tree varieties has Michigan leading the nation's growing domestic chestnut industry with the most acres devoted to chestnut production and the largest number of chestnut-growing farmers, according to the 2007 U.S. Department of Agriculture Census. As demand increases, MAES scientists are helping the industry scale their production practices up from boutique to commercial.

"The most important reason for establishing a domestic chestnut industry is to provide a more profitable, diversified enterprise for commodity growers, which, in turn, will offer a good product for the consumer," said Dan Guyer, MAES biosystems and agricultural engineering researcher. "It will also allow us to rely less on imported chestnuts, which tend to be lower in quality and often arrive in a moldy and/or rotted condition. Domestic chestnuts can also rot, however, and the greater the production the more likely rot will appear."

Guyer has teamed with doctoral student Irwin Donis-González to develop a non-invasive technique to detect internal decay in fresh, unpeeled chestnuts and study its commercial viability for the burgeoning industry.

"Seeing inside a chestnut is like looking at your toes through a leather boot," Guyer said. "We can't destroy the product or rely on a process that has been proven to have a high error rate, so we are testing some of the same technologies that the medical industry and other industries use to non-invasively detect internal decay in chestnuts."

Like many crops, Michigan chestnuts are harvested once a year and placed in cold storage for future processing or distribution.

"Despite their name, chestnuts aren't nuts, they're a fruit," Guyer said. "They have high water content and get bruised and diseased if not cared for properly. You wouldn't leave fresh cherries out on a table and bump them around; chestnuts also need to be treated with care."

To see beyond "the boot" — chestnuts' tough outer shell — Guyer and Donis-González evaluated technologies such as ultrasound, X-rays and CT scanning to get an inside look. More than

> "We **can determine a really good or a really rotten chestnut,** but the **gray area is the problem.** The product that may or may not be sorted out **will determine whether a grower is profitable."** • DAN GUYER

a year of research indicates that CT scanning appears to give the most reliable information about internal chestnut structure.

"We have to take what the human mind does in interpreting images and translate it into an algorithm to develop a reliable computer-based model," Guyer said. "We can determine a really good or a really rotten chestnut, but the gray area is the problem. The product that may or may not be sorted out will determine whether a grower is profitable."

Donis-González said that the team is simultaneously working on determining the underlying physiological and biological causes of chestnut decay.

"In nature, deer do not eat rotten, bad, decayed chestnuts. Deer don't need a CT scan to know which chestnuts are good, so how do we determine what we're missing? What do they smell that we can't?" Donis-González asked.

Profiling the volatiles emitted from chestnuts could lead to the development of laboratory sensors, also called electronic noses, that could distinguish decayed from healthy chestnuts. Commercial portable electronic noses are available for other industries, but sorting systems based on the technology have not been commercialized yet.

"So we must determine the best methodology. Then automate the decision. Then scale it up for operation in a packing house," Guyer said. "We're talking about going from scanning several chestnuts per hour to 10 per second. We've taken the first steps toward making that a possibility." ●

[Jumping Genes Pack a New Look at Plant Evolution]

At first glance, NBA great Michael Jordan would be a slam dunk to win a jumping contest with a plant. Jordan had a 48-inch vertical leap; everyone knows plants can't jump. But MAES horticultural scientist Ning Jiang has found that certain parts of a plant's genome can jump; her research explains how these relative unknowns are potentially star players in the process of plant evolution.

Jiang studies transposable elements — so called "jumping genes" — in plants. The genome sequence is in a certain order. If the order of the genetic material changes, a gene's function can change. Transposable elements have the ability to move around in the genome, potentially disrupting normal gene function.

"In humans, jumping genes don't move that much," she explained, "but in plants there is much more activity than in mammals. It could be one possible reason why some plant genomes are so much larger than mammal genomes. In general, the genome size is proportional to the number of transposable elements there are."

Indian corn is an example. An ear of Indian corn can be mainly rows and rows of purple kernels. Then a yellow kernel suddenly shows up. That's due to a transposable element inserting itself into the gene responsible for the purple color.

One month after Jiang arrived at Michigan State University (MSU) in 2004, she published her second paper in the noted British journal Nature. The paper focused on a specific type of jumping gene, mutator-like transposable elements, called MULEs. Some MULEs carry fragments of genes with them — they're called Pack-MULEs.

Although Pack-MULEs were initially reported about 20 years ago, they weren't considered significant because very few had been discovered.

"Because the Pack-MULEs are moving gene fragments around, they have the potential to create a new gene," she said.

PHOTO: KURT STEPNITZ

MAES researcher Ning Jiang's lab is studying the function of some Pack-MULES using *Arabidopsis* plants *(above)* to better understand the roles they play in plant growth regulation.

"Just because they're there doesn't mean they're actually creating genes, but we're starting to figure out their potential impact on plant evolution."

A native of China, Jiang is a scientist with a personal link to her field of study, transposable elements in the genomic sequences of cereals, including rice, which she calls "the most important food for me."

The rice genome was sequenced in 2002 and contains about 430 million base pairs. After the genome was sequenced, scientists, including Jiang, began working on identifying genes and their functions, as well as how genes copy themselves. The first Pack-MULE Jiang found in rice was carrying one of the genes that triggers cold response in plants.

In 1998, MAES molecular geneticist Mike Thomashow and colleagues found that increasing a plant's expression of certain regulatory genes, called CBF genes, helps plants withstand freezing temperatures, drought and high salt concentrations.

Jiang's familiarity with Thomashow's work made her wonder why a supposedly insignificant transposable element was carrying around such an important gene. Her team took a genomewide approach, using special software to look at the entire rice genome sequence and ultimately found more than 3,000 Pack-MULEs.

"My research has been influenced by Dr. Thomashow's work," she said. "The CBF gene created by a transposable element uncovered the abundance of Pack-MULEs in the plant genome. It shows that transposable elements may play a bigger role in plant evolution than was previously thought. My goal now is to prove that Pack-MULEs are really doing something in plants."

Jiang is studying the function of some Pack-MULEs in *Arabidopsis*, a member of the mustard family that often is used as a model plant by scientists because of its relatively simple genome, as well as rice, which is more complex. Early results suggest that one of the Pack-MULEs seems to promote flowering when it is expressed in *Arabidopsis*.

Jiang said the information she's discovered about this particular Pack-MULE could be used to regulate the growth of plants such as petunias. Most growers want plants to be in flower when they're for sale because consumers are more likely to buy a plant that's blooming. Activating the Pack-MULE would allow growers to start the plants later in the season, instead of in January, so greenhouses wouldn't have to be heated as long and growers would save money.

> "My goal now is to **prove that Pack-MULEs are really doing something in plants."** • NING JIANG

"That's my hypothesis," Jiang said. "We need to prove that it works in *Arabidopsis* and then in other plants." ●

[Using **Bacterial Matchmaking** to Create **Fuel Cells**]

When describing the experience of meeting the perfect partner, many people use phrases such as "it was electric" or "when we met, the sparks flew" or "the air was charged with electricity." MAES microbiology and molecular genetics and crop and soil sciences researcher Gemma Reguera finds these descriptors very apt in her work with partnering the right microbes to develop a process that can be harnessed to produce clean, cheap electricity and fuel from plant biomass.

Since coming to MSU three years ago, Reguera has specifically been studying *Geobacter sulfurreducens*, a bacterium that lives in environments full of metal.

PHOTO: GORDON SHETLER

Cultures of photosynthetic bacteria *(above)* are used to develop microbial fuel cells that convert light into energy. Their green color is caused by the chlorophyll pigment that the bacteria use to fix the light.

The *Geobacter* species has a unique metabolism — it moves electrons to survive. The bacterium uses fermentation byproducts that reduce the efficiency of the process used to produce biofuels such as ethanol. *Geobacter* takes out the electrons in the byproducts and transfers them to metal oxides. The process is similar to the way people breathe in oxygen and exhale carbon dioxide, except that *Geobacter* takes in electrons and protons and then expels electrons, a basic form of energy. Reguera's lab has found that the metal oxides can be replaced with electrodes so the *Geobacter* produces electricity from waste fermentation products.

"We started with *G. sulfurreducens* because it can use fermentation byproducts and ethanol wasn't one of them," Reguera explained. "And everything that it does is environmentally friendly. This bacterium is not a human pathogen.

"Our idea was to find another bacterium to partner with the *Geobacter* to see if we could make the reaction bigger," she continued. "But we were very particular about the type of organism we wanted. It had to degrade biomass and produce only food for the *Geobacter*."

Reguera's lab found the perfect partner in another type of bacterium that breaks down agricultural waste, producing a byproduct that is about 80 percent ethanol and 20 percent food for the *Geobacter*, which rapidly converted the byproduct to electricity. The process seems amazingly efficient. No other byproducts are produced, only ethanol, carbon dioxide and electricity.

Using the bacterial couple, Reguera designed a palm-sized microbial fuel cell in her lab that converts plant biomass into electrical power and produces cellulosic ethanol.

"Our challenge is to scale up the process," she said. "The scale we have now is good for genetic engineering, so we can manipulate the bugs and make the process faster and more efficient. Productivity is key for industry. If this type of fuel cell is to be commercially viable, we need to speed up the process and make it larger."

Reguera is collaborating with MAES chemical engineering and materials science researcher Bruce Dale to convert chemically pretreated agricultural waste into ethanol and electricity. The bacterial partners in the microbial fuel cell can remove toxic products that result from biomass pretreatments and produce ethanol from agricultural waste for a fraction of the current cost, an attractive platform for cellulosic ethanol biorefineries. Current estimates show that the fuel cells would simultaneously generate about 25 percent of the electricity needed by the biorefinery.

Reguera also has looked at how *Geobacter* produces electricity. Her lab discovered that the bacterium can grow in thick stacks on electrodes using electrically active hairlike filaments known as pili, which transfer electrons from cell to cell. The pili form a type of electronic network throughout the bacterial community, which works like a nanopower grid. The discovery hints at other promising ways to produce electricity from bacteria and at new applications for these microbial "nanowires" in biotechnology.

"When conditions for growth are unfavorable, *Geobacter* produces the pili so electrons can be transferred without damage to the bacterium. Our lab was the first to prove that these filaments were conductive. Now we want to know why the filaments are conductive and how we can get other bacteria to produce them."

Reguera credits the relatively quick success she's had to the dedication, intelligence and inquisitiveness of the people who work in her lab.

> **"If this type of fuel cell** is to be **commercially viable**, we need to **speed up the process and make it larger."** ● GEMMA REGUERA

"The bugs are good to work on, but the people are better," she said. "Everything is integrated, and everyone has to know how to do the entire process from the primary research to the application. It's very rewarding to mentor students and show them how small technologies can make a huge impact." ●

[Boosting **Oil Production in Plants** using a **New "Wrinkle"**]

Writers aren't the only ones with "novel" ideas. Every day, new discoveries and technological breakthroughs fill the pages of scientific journals and the popular press as researchers pursue questions and hypotheses important to scientific advancement and our quality of life. An increasingly important area of scientific inquiry is basic research aimed at solving some of the most complex problems in converting natural materials to energy. A key focus of much of this research is photosynthesis in plants.

For more than 25 years, the laboratory of MAES biochemistry and molecular biology researcher Christoph Benning has been studying photosynthesis in the seeds of oil-producing plants to identify the regulatory switches that control this process in the developing seed embryo.

"Although scientists have long known that plants use photosynthesis to convert sunlight into chemical energy, there is less understanding of the actual process and how this happens," Benning said. "The idea was that if we could isolate the genes or genetic pathways responsible for the regulation of oil synthesis in seeds, we could potentially alter the metabolism of the plant and increase seed oil content for food, biofuels and animal applications."

Using the seeds of the *Arabidopsis* plant — a mustard species commonly used for genetic research — Benning and his team ran screens to identify seed mutants that couldn't accumulate oil so that they could explore what, exactly, was preventing this from happening. About 300 potential mutants were initially identified. The group eventually narrowed the field down to two seed lines that met their research criteria — they contained very

"We **named these seeds Wrinkled1** because they **looked like raisins** — brown, wrinkled and full of sugar." • CHRISTOPH BENNING

little oil, and the mutation was occurring in the seed embryo, not somewhere else in the plant.

"We named these seeds Wrinkled1 because they looked like raisins — brown, wrinkled and full of sugar," Benning said. "Because the sugar in these seeds is not converted into oil, it is subsequently dissolved in water, which evaporates as the seed dries, causing it to wrinkle."

PHOTO: NICOLE FOCKS

Analysis of theWrinkled1 mutant *(above)* indicated an 80 percent reduction in seed oil content, an increased accumulation of soluble sugars and an inability to convert sugars into oil.

Benning and his team next turned their attention to identifying the defect in the mutant seed that led to its inability to accumulate oil. Using genetic mapping, they identified a gene that regulates oil accumulation in plant seed.

"This gene encodes a transcription regulator protein (also dubbed Wrinkled1)," he explained. "When we put this gene into *Arabidopsis* and overproduced the Wrinkled1 protein, the seeds made more oil. This was a major breakthrough in our research."

MSU patented Wrinkled1 and last fall licensed the technology to BASF Plant Sciences for further development of enhanced soybean and canola varieties. The license does not cover application of the technology to other widely used oil-producing plants such as sunflower, safflower, peanut and palm, so others can explore its potential in additional crops.

Benning believes that this transcription factor can be used to make oil in the vegetative parts of the plant as well as the seeds.

"This is the next phase of our research," he said. "We've already been able to produce oil droplets in *Arabidopsis* leaves, and we're exploring the possibility of developing a rutabaga line that produces oil — rather than starch — in the root. If we can turn on the oil pathway in the rutabaga root, we believe we can trick it into making carbohydrates into oil. Converting even half of these carbohydrates into oil would create a new biofuel crop that potentially has a higher oil yield than canola."

Benning is also confident that Wrinkled1 can be used to produce oil in straw and grasses to enhance their nutritional value as feedstock.

"Rice straw is a perfect poster child for this research," he said. "There are millions of tons of rice straw produced every year in Asia, and it's pretty worthless. A very small amount is fed to water buffalo, which is about the only animal that can digest it, but there's not much nutrition in it. Most of it is burned off the fields by farmers because they can't use it. If we could get rice straw to have better nutritional value, it could be used as animal feedstock. Given rice straw's quantity, that would be extremely useful.

"These basic research findings are significant in advancing the engineering of oil-producing plants," Benning said. "They will help write a new chapter on the development of production schemes that will enhance the quantity, quality and profitability of both traditional and non-traditional crops." ●

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 Agricultural Experiment Station (MAES) mission. In research initiatives ranging from controlling insect pests and exploring the complexities of plant metabolism to enhancing meat quality and improving the health and performance of race horses, MAES researchers continually discover new and more effective ways to help protect and enhance our food and fiber supply and improve human and animal welfare. The stories in this section provide a snapshot of the significant research being done in this area.

[Attracting More **Sustainable Apple Production**]

PHOTO: KURT STEPNITZ

Researchers estimate that up to 40 percent of Michigan apple growers are using pheromones as an alternative to broad-spectrum insecticides as they protect their crops from the destructive codling moth. Farmers continue to increase their profits while MAES researchers discover ways to make the process more effective and profitable.

Fruit growers are increasingly battling the destructive codling moth (*Cydia pomonella*) pest through the use of mating disruption. Pheromone dispensers tied in fruit trees confuse male insects by emitting more powerful synthetic pheromones than their real female counterparts produce. Once the males find the dispensers, they don't respond to the female moth pheromones. Unfertilized females don't lay eggs. The effect is a reduced pest population.

In essence, it's bug birth control.

When codling moths do mate, females lay fertilized eggs on the leaf or fruit of an apple tree. Immediately after hatching, each larva burrows into the fruit, where it is the proverbial worm in the apple. Though not related to earthworms, codling moth infestations are directly related to reducing profits for apple growers around the world.

Jim Miller, MAES entomology researcher, is part of a team working to send male moths chasing down synthetic-pheromone-scented paths on a fruitless search for fertile females in apple orchards. Mating disruption is widely used, Miller said, but validating the scientific reasoning about how and why it works has been his work for the past decade.

"I had been working in the area of insect-plant interaction and away from pheromones for years when I was given the opportunity to come back to it," Miller said. "Taking another look at sex attraction pheromones with fresh eyes, I realized that they are some of the most potent tools we have, but we didn't really know how they work. Now the seeds of ideas we planted more than 10 years ago are really bearing fruit."

Years of laboratory testing and analysis were expanded into a large, field-based test using 20 large cages built in an abandoned Michigan apple orchard. Miller's laboratory-developed theoretical framework was validated by controlling variables such as moth density, pheromone source location by moths and male moth retention time. The result is two simple algebraic equations of attraction and competitive attraction that can be used by growers and their industry partners to tailor mating disruption products.

"The amount of pheromone found in the standard mating disruption product these days was originally selected rather arbitrarily. Our evidence now shows that we are likely to get the same effect using less chemical," Miller said. "This means that mating disruption products can continue to be effective in crop protection but cost less for growers to buy.

"My motivation is to get pheromone products to work well all of the time so that growers can use them with confidence. Our goal is to take the mystery out of mating disruption," Miller said.

"My motivation is to **get pheromone products to work well** all of the time so that growers can **use them with confidence**. Our goal is to take the **mystery out of mating disruption.**" • JIM MILLER

Mating disruption is not a panacea to solve the codling moth problem, however.

"Codling moths will never be completely eliminated from the ecosystem. Mating disruption works when pest levels are relatively low. If you have an outbreak, you'll need a heavy-duty insecticide," Miller said. "What we're doing is birth control by diminishing mating so females are not fertile and the population is reduced."

Three commercial companies have already expressed interest in using Miller's findings to improve their mating disruption products, but Miller said he is most proud that the comprehensive theoretical framework may be applicable elsewhere in the natural and social sciences.

"I'm very proud that we did this work at Michigan State," Miller said. "It feels good to produce really good science that has practical applications for industry." ●

[Getting to the **Root** of **Plant Metabolism**]

Humans can't hold a candle to plants in maintaining successful, long-term relationships. Since first populating the land more than 450 million years ago, plants have participated in a symbiotic relationship that brings together the roots of land plant species and a group of microscopic fungi, known as arbuscular mycorrhiza (AM), to great mutual benefit. Collectively, AM fungi move several billion tons of nutrients out of the soil and into plants each year. From the plants, the fungi receive fixed carbon, an element they need to survive.

"This is arguably the world's most important symbiosis," said MAES plant biologist Yair Shachar-Hill. "More than 80 percent of plants in the world have this relationship, and it's been shown that three-quarters of the nitrogen that a plant acquires can be obtained through this fungus. In fossil records, you see the same symbiosis that you see today."

Although almost every plant family engages in this relationship, Shachar-Hill said that it's been difficult to study because it all takes place below-ground at a microscopic level and is regulated by a very complex, multi-branched central network.

"Over the years, we've had to develop chemical analysis and molecular biology tools to undertake this research," Shachar-Hill said. "Although we know almost all of the enzymes and many of the transporters that compose this network, until recently, we knew very little about how nitrogen is actually transferred from fungus to plant."

For the past two years, Shachar-Hill and members of his lab have been identifying all the genes in the pathway that allows the AM fungus to take up nitrogen from the soil, metabolize and transport it into the plant, and then break it down and release it in a form the host plants can use. The researchers are now completing work on identifying the specific parts — genes, enzymes, proteins — involved in the process to determine how it is regulated.

"A deeper understanding of this nitrogen movement and its regulation could ultimately lead to more efficient use of nitrogen-based fertilizers, more productive output for organic farming operations and an improved ability to manage natural ecosystems," Shachar-Hill said.

Another key focus in Shachar-Hill's lab is the general area of plant metabolism as it relates to producing biofuels. Research efforts include investigating starch, protein and oil production in developing seeds; inducing oil production in the vegetative parts of key agricultural crops such as canola and soybean; and boosting the oil production potential of algae. Shachar-Hill's lab

"Plants have the capability to make extremely concentrated forms of **high value products — they just need to be persuaded."** YAIR SHACHAR-HILL

is collaborating closely with MAES researchers Christoph Benning and John Ohlrogge, both internationally recognized for their research into plant lipid (fat) metabolism.

"Plants are very good at making oil in their seeds, but there's limited potential for making improvements in per-acre yields based just on increases in seed oil," Shachar-Hill said. "However, if we can get algae and other plants to make 30 percent oil by weight in their leaves, stems and cells, that would translate into a game-changing revolution."

PHOTO: STACY LACLAIR

Cultures of the single-celled green alga *Chlamydomonas* are being analyzed by the labs of MAES researchers Shachar-Hill, Benning and others to improve understanding of the routes, rates and regulation of metabolic flow into oil.

Shachar-Hill said that algae, in particular, are exciting for several reasons — they already make oil at very high levels under the right conditions, they can be grown in areas where nothing else grows, they can be grown year round, and their growth rates are far greater than land plants — an acre of pond produces more than five times as much plant material in algae per year as a field. But, he added, there are technical hurdles to algae's oil production potential.

"Algae make lots of oil only when they are unhappy — when they are under nitrogen stress or some other nutrient limitation," he said. "At that point, they stop growing and fill up with fat. But we want them to keep growing so that there's continuous oil production. Figuring out how to achieve that is our next research challenge."

Some of Shachar-Hill's findings are being applied on a larger scale. He and his team have been working with two biotech companies to try to improve oil production and overall yields in corn.

"Corn is a highly productive crop, but it makes mostly starch," he explained. "Right now, corn seed oil content is only about 5 or 6 percent. Corn would be a much more valuable commodity if we could get 20 or 30 percent of the corn seed to be oil. That would translate into a multi-billion dollar economic shot in the arm for the Midwest.

"Plants have the capability to make extremely concentrated forms of high value products — they just need to be persuaded," Shachar-Hill said. "Developing and applying methods to analyze the detailed pattern of central metabolism and transport in plant systems is an important part of the efforts to improve agriculture in Michigan and worldwide." ●

[Identifying the Genetics of **Mouth-watering Meat**]

People may disagree about which cut of pork is best — chops, ribs, ham, roast or cutlet — but the response to a succulent piece of meat, perfectly prepared, is just about universal: "Mmmmmmmmm."

Pork producers may try to rear animals with consistently high meat quality year after year, but currently, meat quality can't truly be determined until after an animal is slaughtered and the cuts of meat are graded. Farmers can extrapolate ideas about meat quality on the basis of an animal's appearance, size and other characteristics. Animals thought to have the best meat quality are bred to continue those positive traits in the herd; animals deemed to have lower quality meat aren't used for breeding.

PHOTO: COURTESY OF CATHY ERNST

The recent sequencing of the pig genome will help researchers develop new DNA-based tools to identify and select genetically superior pigs that resist infectious diseases, have larger litters and produce quality cuts of meat for consumers.

"Ultimately, meat quality is an end-of-life-issue," said Cathy Ernst, MAES animal science researcher, who specializes in pork and beef genetics. "If desirable traits are found after slaughter, it's too late to use that animal in the breeding herd and pass those traits on to the next generation."

Ernst is studying the molecular genetics of pigs, looking for the combination of genes responsible for controlling meat quality. Her experiments are comparing DNA from pigs across the world judged to have outstanding meat quality to identify common genes. She and her colleagues from Michigan State University, the University of Wisconsin and Embrapa Pecuária Sul in Brazil have just completed a genomewide expression quantitative trait loci analysis for pigs. This is the first time that this type of analysis has been done in livestock.

Quantitative traits are traits believed to be the result of interactions between two or more genes and the environment. Quantitative trait loci are stretches of DNA that are closely linked to the genes related to the trait — in this case, meat quality. The pig genome is similar in size to the human genome and is estimated to be about 2.7 billion base pairs. Because there are so many genes to look at, the quantitative trait loci analysis is considered one of the first steps in identifying and sequencing the genes responsible for meat quality.

Ernst's ultimate goal is to offer pork producers an inexpensive, easy test for meat quality and production efficiency, allowing the farmers to make much more informed decisions about breeding and culling long before slaughter. She envisions a simple blood test that analyzes DNA and could determine whether the gene combinations for high quality meat and efficient production are present.

"We're helping to identify economically important genes in pigs," she explained. "There are some genetic tests commercially available now, but they don't look at the full genome. Whole genome marker sets that look at thousands of markers have become available in the past year for research use, but they're prohibitively expensive from an application perspec-

tive. Farmers can't afford to spend $200 per pig to do genotype testing. We want to figure out the smallest number of markers that indicate the most superior animals and then create a test for just those markers. That will make the test less expensive and more feasible for more producers."

"We're **helping to identify** economically **important genes** in pigs." • CATHY ERNST

Ernst and her colleagues are analyzing approximately 60,000 markers in the pig genome — they hope to get that number down to a few hundred for the test.

Though some traits related to meat quality are specific to particular breeds, many are fairly universal, including:

- Flavor and juiciness, which are related to water-holding capacity and the quantity of intramuscular fat, also known as marbling, and
- Tenderness, which is influenced by protein breakdown, connective tissue characteristics and other factors.

"Our research will determine if a common marker set can be used for different breeds or if each breed will need a breed-specific marker set," Ernst said.

Pork producers also want animals that have good growth rates and reproductive performance, traits that are controlled by different genes. Combining marker information into a single DNA test that evaluates an animal's overall performance potential will make the most economic and environmental sense for farmers.

"All the desired traits have to be considered in a production system," Ernst said. ●

[Reining in **Exercise-induced Pulmonary Hemorrhage** in **Horses**]

And they're off! A team of MAES researchers is strong out of the gate in their bid to gain ground on exercise-induced pulmonary hemorrhage (EIPH), a poorly understood respiratory disease that affects the health and performance of up to 80 percent of race horses worldwide.

MAES pathologist Kurt Williams, in collaboration with MAES equine researchers Fred Derksen and Ed Robinson, is conducting pacesetting research to pinpoint the cause and pathology of EIPH, a disease that causes bleeding in the lungs of horses as a result of high intensity exercise.

"EIPH is a very common, long-standing problem in the majority of strenuously exercised horses — draft horses, barrel-racing horses, standardbred and thoroughbred race horses," Williams said.

"In the old days, EIPH really wasn't well known except in the most severe cases, where the bleeding was bad enough that the horses bled out of their noses. For years, nobody knew where that blood came from. It wasn't until the fiberoptic endoscope [a lighted optical instrument used in human medicine to get a deep look inside the body] began to be used in equine research that scientists were able to look into the airways of horses and realize, no, the blood is not coming from the upper airways — it's actually coming from down in the lungs."

Williams explained that because EIPH is not typically fatal, researchers haven't had the opportunity to look at the lung tissues of these horses to see what changes are happening at the most basic level that might explain why they develop the condition. Until recently.

"We were put in touch with a veterinarian in Singapore who had horses that had to be euthanized because they were severe bleeders," Williams said. "He agreed to provide us with lung tissues from these horses to do our research — that's really what got this project started."

As Williams began to evaluate the pathology within the horses' lungs, he came across some changes that hadn't been described before.

"What we ended up finding is that these horses have chronic scarring around their pulmonary veins," Williams said. "This scarring makes the veins less flexible and unable to cope with the significant increase in blood pressure that occurs during intense exercise. As a result, we think that the blood backs up into the lung capillaries, and the capillary walls fail and start to leak. There are many other changes going on in the lungs as a consequence of this condition, but we're pretty certain that the linch pin, the focal point of lung injury, is at the level of these pulmonary veins."

"**Pulmonary vein hypertension**, we think, is the driving force **behind the changes** in the lung **that leads to EIPH.**" • KURT WILLIAMS

PHOTO: HEATHER DEFEUTER-RUPP

The opportunity to conduct a thorough examination of pulmonary veins in the equine lung will ultimately yield new insights into the pathology of exercise-induced pulmonary hemorrhage in horses.

Following this discovery, the group received additional funding to investigate tissues in U.S. horses to more thoroughly map the distribution of these changes.

"Now that we're able to look at a larger pool of animals — the Singapore study involved a relatively small number of animals — the findings are very consistent," Williams said. "Pulmonary vein hypertension, we think, is the driving force behind the changes in the lung that leads to EIPH," Williams said. "This discovery is pretty exciting — it's one of those 'Eureka!' moments."

Although gratified with this breakthrough, Williams is quick to add that finding ways to stop EIPH is trickier and is going to be a longer-term process.

"It's one thing to understand that there's a pulmonary vein problem in the lungs of these horses," he said, "but then the question becomes why is it happening in the first place? We've started studies to examine some of the molecular aspects to try to understand what happens in these veins at the genetic level — what switches get turned on or off that cause them to develop this scar tissue. It's going to take some time to really understand what's causing this vascular change."

Despite the challenges ahead, Williams believes that their recent research advances put them on a firm track to ultimately avert or mitigate the effects of EIPH.

"These findings ultimately will allow us to intervene in creative ways to prevent EIPH from occurring in these horses," he said. "The information will also provide equine veterinarians and horse owners with a better understanding of the condition. In short, the welfare of the animals will be better, and the people in the racehorse industry will be happier because the horses won't have this problem." ●

FAMILIES AND COMMUNITY VITALITY

Strong families do not live in isolation. Healthy, vital communities with an active citizenry are better equipped to address the challenges facing many of today's families. The Michigan Agricultural Experiment Station (MAES) supports communities and families through research in the areas of youth, family dynamics, demographics, and rural and urban community security. The projects highlighted in this section are just a sample of community-related research projects that benefit Michigan and its residents.

[Helping **Youths Cope** with a **Parent's** Psychiatric **Illness**]

PHOTO: TRACKS VIA ISTOCKPHOTO

Brainstorming activities were one of the tools used in YES! youth group sessions to help describe and demystify psychiatric disorders for participants.

Mental health disorders take a significant emotional toll, not only on adults who experience them but also on the children affected by their parents' condition. That's why MAES researcher Joanne Riebschleger and her team are reaching out to this often invisible population to provide early intervention programs targeting youths with a parent suffering with a major psychiatric illness.

Riebschleger said that youths who have a parent with a psychiatric illness experience stressors that include separation from caregivers, isolation, poverty, worries about stigma or parental suicide, and feelings of responsibility for the parent's symptoms. Common psychiatric illnesses include bipolar disorder, schizophrenia and major depression.

"There is a real need to reach these children, who are essentially hidden in plain sight," Riebschleger said. "No service agency claims children of parents with a psychiatric illness, and mental health services are often underfunded, so it's difficult to adequately serve this population."

According to the National Institute of Mental Health, about one in four adults suffers from a diagnosable mental disorder in any given year. In the United States, that translates to 57.7 million people over the age of 18. Nearly half of public mental health services consumers have children, so the numbers of unidentified and underserved at-risk youth are significant.

Riebschleger's multi-disciplinary research team includes individuals from the Michigan State University School of Social Work, University Outreach and Engagement, the Department of Psychology, and the Department of Family and Child Ecology, as

"There is a **real need to reach these children,** who are essentially **hidden in plain sight."** JOANNE RIEBSCHLEGER

well as the national office of the Alliance for Children and Families. The group developed an intervention program for at-risk youths whose parents suffer from a psychiatric illness. The program, Youth Education and Support (YES!), targeted middle school youths between the ages of 11 and 15 and consisted of six weekly, two-hour sessions that educated participants about mental health disorders and taught coping skills. The team also worked with community mental health agencies in Michigan to run pilot tests with participants.

Each YES! session addressed a specific topic and included group discussion, a craft activity, a physical activity and a take-home assignment. Group activities included brainstorming a list of words that describe mental illness, telling stories about ways that people with psychiatric disorders get treated, learning about famous people who have psychiatric disorders and using art projects to illustrate various emotions. Participants also created personal crisis plans with steps to follow and people to contact when they felt stressed, and activities that make them feel better when they're under stress.

"Young people are so ingrained with stigma," Riebschleger said. "A lot of our work was dedicated to myth-busting their misconceptions about the psychiatric disorders that they see in the media or hear about from their peers. The biggest takeaway for the youths was the realization that you can't tell whether a person has a psychiatric illness by looking at them."

In addition to issues of stigma and coping, the youths who participated in the education program learned about treatment options available and how to seek help if they were to develop a psychiatric illness. Therefore, Riebschleger said, they would be more likely to seek treatment at an early stage.

The researchers are revising the pilot program to include more sessions that emphasize coping skills. The team plans to apply for federal funding for continued testing and development. The ultimate goal is to create an evidence-based program that will be part of mainstream mental health services for youths.

"Mental illness will always be hard to treat because so often it isn't talked about, even among family members," Riebschleger said. "We hope this program will help change the way psychiatric illnesses are viewed by society." ●

[Making Child's Play of **Food Advertising** with **Online Games**]

Many studies have found that advertising influences the foods that children ask for, buy and eat. As expenditures on selling food to children have increased (companies spend nearly $10 billion per year marketing food products to kids), so have children's weights. In the past 20 years, U.S. childhood obesity rates have more than tripled. The National Center for Health Statistics reports that 17 percent of children aged 2 to 19 are overweight.

A 2005 study found that candy, other sweets and soft drinks were the top products in television ads aimed at kids. Another study found that 89 percent of the foods advertised during children's television programming were classified as unhealthy; most were especially high in sugar.

"It's a complex issue, but overall, there is evidence that marketing to kids does shape their food choices and contributes to childhood obesity," said MAES advertising researcher Elizabeth Quilliam. "But we really don't know how much."

To help tease apart any cause-and-effect relationship, Quilliam is studying online games that incorporate branded food products, dubbed "advergames."

Instead of passively watching as they do with television ads, children actively participate in online game playing, which may lead to positive feelings about the game and the products in it. And though children's television shows are required to make a clear distinction between the program and advertising, some researchers wonder if younger children can separate the persuasion from the entertainment in online advergames.

"It's a **complex issue**, but overall, there is evidence that **marketing to kids does shape their food choices** and **contributes to childhood obesity."** ELIZABETH QUILLIAM

"I'm interested in the games because, unlike television, where ads are limited to 30 seconds, there is no limit on how long a child can stay online," Quilliam said. "They may be playing advergames for hours and interacting with the food products the entire time. We suspect that these online games affect children differently, but we need to do the research to see if that's true."

Quilliam and colleagues first analyzed advergames in 2006, evaluating 250 games for brand integration strategies, the extent to which the advergames educated children about nutrition and healthy eating, the types of food promoted by the games and the proportion of products in the games that were classified as low-nutrient foods.

The researchers found that almost all the foods featured were high in fat, salt and sugar — about 84 percent of advergame products were classified as low-nutrient foods. The study also found that very few advergames educated children about nutrition and health issues.

"From a policy perspective, there's been a lot of discussion about how food marketing to kids may be contributing to childhood obesity," Quilliam said. "But we haven't seen any regulatory changes."

In a proactive move, 15 of the largest food and beverage companies joined the Children's Food and Beverage Advertising Initiative (CFBAI), a voluntary group launched in 2006, whose members have pledged to devote at least half of their

PHOTO: KURT STEPNITZ

Concerned about the high rates of childhood obesity in the United States, researchers and others are exploring the nature and scope of online food advertising aimed at children to help inform the decision making process for policymakers, advocates and industry.

television, radio, print and online advertising aimed at children younger than 12 to "better-for-you foods" and/or messages that encourage good nutrition and healthy lifestyles. Four of the companies have pledged to stop marketing directly to children younger than 12. Ten of the companies have pledged that all advertising aimed at kids will be for foods and beverages that meet the company's nutritional standards. The nutritional standards used to determine better-for-you foods appear to be somewhat less than stringent: under Kellogg standards, Froot Loops are considered better-for-you — even though a 1-cup serving contains 13 grams of sugar (41 percent of the product by weight). In comparison, a serving of three Chips Ahoy chocolate chip cookies has 10 grams of sugar, and a serving of 11 Gummi Bears candies has 13 grams of sugar.

Another self-regulatory program, the Children's Advertising Review Unit (CARU), sets guidelines for product advertising

directed at kids in all media, as well as online privacy practices that affect children. CARU guidelines aim to ensure that advertising directed at children is not misleading, unfair or inappropriate for the intended audience.

"We're updating our study because the CARU guidelines now include online content and advergames," Quilliam said. "We want to know if this is having an effect on the types of foods being promoted in the advergames. We're also going to compare advergames for products made by CFBAI companies to those of non-participants to see if there is a difference in the types of foods being promoted. Ultimately, we want to understand how the games work and see if the same techniques can be used to promote healthy eating habits. That would be a nice contribution to make." ●

PHOTO: CHRISTINE VOGT

Michigan's White Pine Trail, stretching from Grand Rapids to Cadillac, is located on a former rail bed and sees year round activity, including bicycling, inline skating, snowmobiling and skiing.

[Understanding what **Drives Tourism** and **Outdoor Recreation**]

Two of the major factors that have had the most impact on tourism and outdoor recreation in the past few decades are technology and suburban sprawl. Technology — especially the Internet — influences how people obtain travel information, and the establishment of new communities poses challenges to alternative modes of transportation and safety.

MAES researcher Christine Vogt studies consumer behavior related to tourism and outdoor recreation. Her research assesses how new technology and sprawl affect people's decisions and helps tourism and recreation industries understand how and why people use their services. This information is especially relevant in Michigan, where tourism is one of the top industries, and where local communities are trying to diversify their economies.

"There's a real marketing component to it," Vogt said. "In parks and recreation, a lot of tourism information is free, many of the parks people visit are free, and the view of the scenic environment where people choose to move is free, but it's still a consumer experience."

Technology has transformed how people obtain travel information. A service that once was ubiquitous throughout the United States — the visitor welcome center — is vanishing in some places such as Wisconsin, which has closed all of its welcome centers. Travelers are less likely to stop at these centers for information because of the growing access to mobile phones with Internet capabilities and the global positioning system used by many in their vehicles.

During the past 10 years, Vogt has worked with the Michigan Economic Development Corporation, which manages the state's 14 welcome centers, to improve understanding of the changing needs of visitors and reevaluate the materials they provide.

"Historically, we've relied on maps and guidebooks," Vogt said. "We still have those forms of information, but there will come a day when they cease to exist."

Vogt noted that even though Web-based information and services are replacing older forms of communication, they can leave out some segments of society. Older people, people in lower income brackets and non-English-speaking visitors may not be able to access information electronically as easily as the rest of the population.

Another area of Vogt's research focuses on non-motorized transportation. Decades of suburban sprawl throughout the country created increased levels of vehicle travel and isolated communities, but the renewed concern about physical activity and health has brought about an interest in creating walkable communities.

"The most available corridor for community trails is rail lines," Vogt said. "Michigan has miles and miles of unused or abandoned rails."

Vogt and her colleagues studied about a dozen trails across the state (in Kent, Oakland, Grand Traverse and Ingham counties) to gather data on how visitors — locals and tourists — use the trails.

In another project called Safe Roads to Schools, Vogt is surveying the attitudes of students and parents in more than 100 Michigan schools in an effort to encourage more students to walk or bike to school. Many schools are considering cutting bus services and, in some communities, more than half of the students are driven to school by parents. At the same time, federal funding to schools continues to increase for state-run programs that create safer conditions for students to walk to school — constructing new sidewalks and trails, for instance, and improving lighting and signage.

Sprawl also can have unintentional but dangerous consequences. Vogt pointed out that the United States loses 1 million acres of forestland a year as new suburbs pop up and people build retirement homes. The risk of fire during outdoor recreation activities and damage to manmade structures increases when communities spring up around national and state forests and parks. There's a national effort to draw attention to the issue, and Vogt is working with forest service officials at the local level to educate residents and officials on the risks of living in fire-prone areas.

"Loss of housing is an issue," Vogt said. "Insurance companies spread the risk and everyone has to pay. The forest service is concerned about the growing number of people building

"There's a real **marketing component** to it. In parks and recreation, **a lot of tourism information is free**, many of the **parks people visit are free**, and the **view of the scenic environment where people choose to move is free, but it's still a consumer experience."** ● CHRISTINE VOGT

homes in high fire-risk locales. It's a matter of being proactive by educating residents and potential residents, as well as local decision makers, about risks."

Another challenge is to encourage homeowners to build where trees are cleared and to use building materials and vegetation that can reduce their risk of fire damage.

"Again, it's a matter of being proactive and influencing people before they make decisions," Vogt said. "Investing in alternative transportation systems and fire prevention efforts, and reaching people on a human level can encourage behaviors that have a number of health benefits – for both people and communities." ●

[Stopping **Rural "Bright Flight"**]

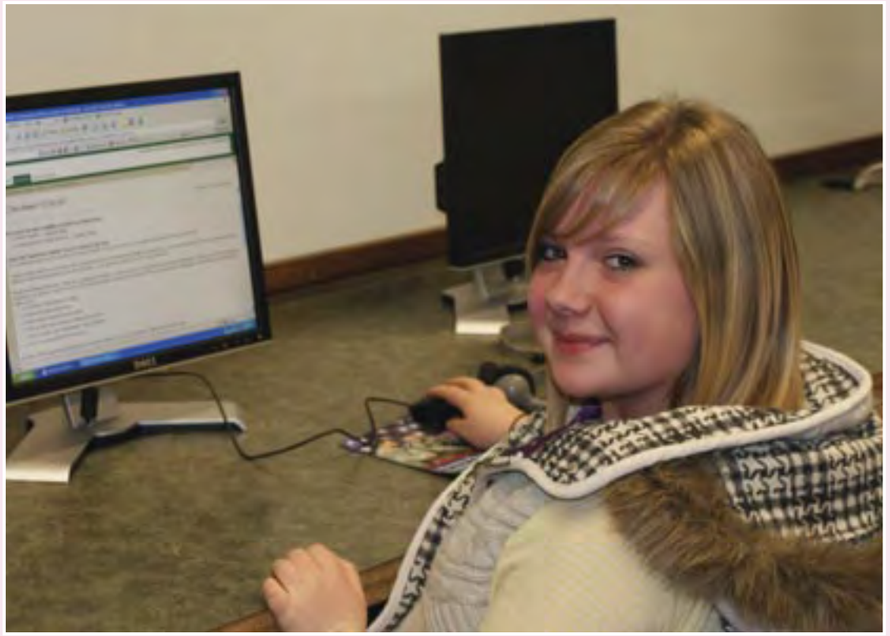

PHOTO: WANDA REPKE

Alayna Foran, an Ishpeming High School student participating in the Community Ties project, checks an assignment for an MSU course about developing online content.

Young people throughout the nation who grow up in rural communities often face a tough choice when they graduate from college: should I stay or should I go? The widespread belief that professional opportunities are available only in large cities takes a toll on rural enterprise. Now a team of researchers at Michigan State University (MSU) is harnessing the powers of broadband Internet service and social media to help rural communities retain young talent.

"Young people leave and don't come back," said telecommunications, information studies and media researcher Robert LaRose, who is leading an MAES-supported study to develop methods to stem "bright flight." "This deprives communities of their brightest people, and it deprives young people who feel they have to move away from home to find work."

In 2008, LaRose and his colleagues launched the Community Ties project — a social media Web site for rural residents in northern Michigan — to forge new social ties among youths and local entrepreneurs through online social networking and community development activities. The initiative — a team effort involving four MSU researchers (including MAES information and communication technology researcher Cliff Lampe), two research assistants, an MSU Extension employee and 12 community organizers — brings together students from four high schools and members of the business community in Grand Traverse, Marquette, Oscoda and Otsego counties.

"The main goal of the project is to enhance the economic vitality of rural communities by building a diversified workforce equipped with the skills required for success in an information economy," LaRose said. "Using social media and networking activities, we aim to build the community attachment of rural youths, raise awareness about local entrepreneurial careers, expand social circles of rural youths, and increase contact between youths and rural entrepreneurs."

The group kicked off the project by holding forums to attract students and adults, and hired students to work as community organizers and spokespeople to assist in forming connections with local businesses. Once on board, students developed entrepreneurial skills by creating e-commerce Web sites for their high schools to sell merchandise. In 2009, an internship competition was added to the project that paired students with local businesses, providing young people with valuable work experience and business people with assistance in the workplace at no extra cost.

Users can access the main Web site — www.communityties.us — and select their county's Web site, where they can create profiles, post or view job opportunities, participate in virtual job shadowing, and interact in online forums. All Community Ties members go through an application process that includes a criminal background check to ensure that the online community remains a safe place for collaboration between youths and adults.

"The professional landscape is changing dramatically," LaRose said. "As technology advances and becomes more accessible, there is less need to move to a new location for a job, especially for a position in a technology-related field."

In a previous rural broadband use research project, LaRose and his colleagues found that when broadband service was made available in rural areas in Michigan, Texas and Kentucky, the adoption of broadband Internet connections increased in three of the four communities surveyed. However, rural broadband use matched that in urban areas only where infrastructure grants were coupled with community-based efforts to promote effective use of the service to residents.

"Just providing broadband isn't enough," LaRose said. "More rural residents need to learn about the benefits of high-speed service. The nation's broadband gap is beginning to close in some communities thanks to the federal stimulus bill, which allocated $7.2 billion to upgrade broadband service to rural areas in the United States."

Although the Community Ties research project now is in its final year, LaRose hopes the online community can sustain itself, perhaps by offering course credit to students who participate in internships or work experiences in their community.

"The challenge now is to create a new model for rural economies — especially in Michigan — which is among the states with the highest unemployment rates in the nation," he said. ●

"Young people leave and don't come back. This **deprives communities of their brightest** people, and it deprives young people who **feel they have to move** away from home **to find work."** ROBERT LAROSE

[Michigan Agricultural Experiment Station]

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Jon F. Bartholic, Director
Institute of Water Research

[MAES Field Stations]

1. CLARKSVILLE HORTICULTURAL EXPERIMENT STATION

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

2. DUNBAR FOREST EXPERIMENT STATION

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

3. 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

4. W. K. KELLOGG EXPERIMENTAL FOREST

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

5. LAKE CITY EXPERIMENT STATION

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

6. MONTCALM RESEARCH FARM

4747 McBride Road
Lakeview, MI 48850
Phone: 989-365-3473
Farm Manager: Bruce Sackett

7. MUCK SOILS RESEARCH FARM

9422 Herbison Road
Laingsburg, MI 48848
Phone: 517-641-4062
Farm Manager: Mitch Fabus

8. NORTHWEST MICHIGAN HORTICULTURAL RESEARCH STATION

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

9. FRED RUSS FOREST EXPERIMENT STATION

20673 Marcellus Highway
Decatur, MI 49045
Phone: 269-782-5652
Non-resident Forester: Greg Kowalewski

10. SAGINAW VALLEY RESEARCH AND EXTENSION CENTER

9923 1/2 Krueger Road
Frankenmuth, MI 48734
Phone: 989-245-2060
Farm Manager: Paul Horny

11. SOUTHWEST MICHIGAN RESEARCH AND EXTENSION CENTER

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

12. TREVOR NICHOLS RESEARCH COMPLEX

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

13. UPPER PENINSULA EXPERIMENT STATION

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

14. UPPER PENINSULA TREE IMPROVEMENT CENTER

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

15. EAST LANSING FIELD RESEARCH FACILITIES

2346 Spartan Way
East Lansing, MI 48824
Phone: 517-355-3272
Director: Charles J. Reid

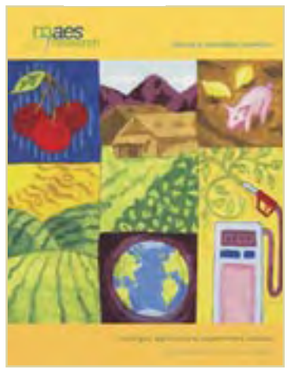
[Publications and Resources]

MAES encompasses the work of more than 300 scientists in six colleges at MSU: Agriculture and Natural Resources, Communication Arts and Sciences, Engineering, Natural Science, Social Science and Veterinary Medicine.

A general **MAES brochure** which outlines the mission of MAES is available upon request by sending an **e-mail to: maesdir@msu.edu.**

The **MAES field station brochure** highlights each of the 15 field stations and their specific research. No matter their official names — experiment stations, research farms, complexes or experimental forests — all are part of a statewide network of campus laboratories and off-campus field station facilities that make up the MAES. In addition to agricultural production research, MAES scientists are investigating topics that range from alternative energy and biofuels production to childhood obesity, community development, environmental stewardship, food safety and the quality of life of Michigan youth and families.

This brochure is available upon request by sending an **e-mail to: maesdir@msu.edu.**



The **2009 MAES Annual Report** provides brief narratives of some of this year's important, innovative research. The accomplishments and discoveries highlighted in this report demonstrate why MAES continues to be one of the most successful agricultural experiment stations in the country.

Futures, published two times a year by MAES, is available as a free subscription in the United States. *Futures* is written in non-scientific terms for the general public. Each issue profiles the work of several MAES scientists organized around a specific topic. Recent issues have focused on an in-depth look at the MAES and new research frontiers. To subscribe, send an **e-mail to: maesdir@msu.edu.**

MAES Research: Outstanding in the Field

Winter/Spring 2009

No matter their official names — experiment stations, research farms and complexes, or experimental forests — all are part of a network of campus labs and off-campus field research facilities that make up the Michigan Agricultural Experiment Station. The 14 outlying field stations plus the on-campus research farms focus on the research needs of the agricultural and natural resources industries and rural communities in their particular locations. All this research is aimed at providing growers and commodity groups with the critical information they need to stay competitive and productive, and to help them keep pace with a constantly changing social and economic environment.

New Research Frontiers: Today's "what if..." becomes tomorrow's practical application

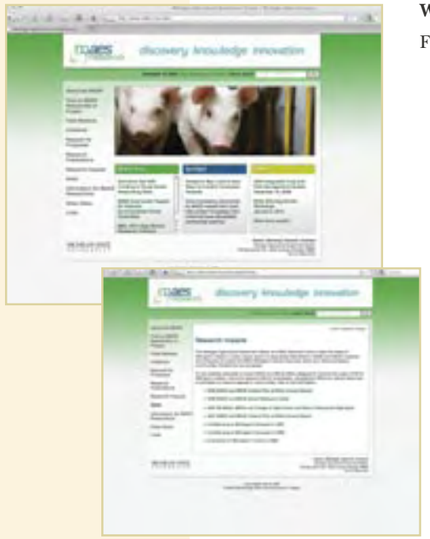
Summer/Fall 2009

The Michigan Agricultural Experiment Station's rich history of excellence and innovation makes Michigan State unique among state research institutions. Throughout the years, the MAES has funded the visionary work of scientists whose ideas sometimes were met with uncertainty, but ultimately led to advances that have benefitted people, the environment and the economy around the world. This issue of *Futures* profiles the work of several relatively new MAES scientists who are continuing to serve as catalysts for multidisciplinary research in cutting-edge areas.

[Publications and Resources [CONTINUED]]

The monthly **MAES eNewsletter** is an electronic newsletter that highlights all of the latest accomplishments and discoveries by MAES scientists. If you would like to receive the MAES eNewsletter, please send an **e-mail to: maesdir@msu.edu.**

Ever wonder what MAES is doing in your area? Sign on to **www.maes.msu.edu** and click on **video news** to learn about tart cherry research, beet and bean research, planting and harvesting techniques and biofuels. Each field station video clip provides an in-depth look at the research being done at that location.



WWW.MAES.MSU.EDU

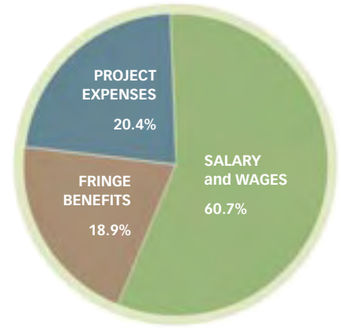
Features on the site include:

- An MAES overview
- A searchable database of MAES researchers and projects
- Field station information
- Research publications
- Research impacts
- Resource links to MSU, government, commodity groups, Michigan agriculture and natural resources organizations and experiment station directors associations
- Upcoming agriculture-related events
- Video news

[Financial Report]

July 1, 2008 to June 30, 2009

DISTRIBUTION OF APPROPRIATED FUNDS



INCOME:

Federal Appropriation	
Hatch	$ 4,473774
McIntire-Stennis	$ 258,396
Hatch RRF	$ 1,078,862
Hatch Animal and Disease, Section 1433	$ 69,532
Total Federal Appropriations	$ 5,880,564
State Appropriations	$ 34,336,200
Total Appropriations	$ 40,216,764
Grant — Federal, State and Private*	$ 75,203,594
TOTAL INCOME	**$ 115,420,358**

EXPENSES:

Salaries	$ 24,416,966
Fringe Benefits	$ 7,614,289
Project Expenses	$ 8,185,509
Grants — Federal, State and Private*	$ 75,203,594
TOTAL EXPENSES	**$ 115,420,358**

PERSONNEL

(Full-time Equivalents Funded From Appropriated Funds)

Research Staff	
Professor	65.52
Associate Professors	34.68
Assistant Professors	23.76
Research Associates and Specialists	11.30
TOTAL RESEARCH STAFF**	**135.26**
Support Staff	
Administrative Professionals	71.48
Supervisors	27.19
Clerical	24.50
Technicians	3.98
TOTAL SUPPORT STAFF	**127.15**

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

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

[Production Credits]

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The MAES has one goal —
to make Michigan's economy as viable, environmentally sound
and as sustainable as possible.

maes research

discovery.
knowledge.
innovation.

maes research
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Michigan State University
East Lansing, Michigan 48824-1039

MICHIGAN STATE UNIVERSITY

SR-129/January 2010