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MICHIGAN AGRICULTURAL EXPERIMENT STATION

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looking into futures

The Michigan Bioeconomy

In the two years since President Lou Anna Simon created the MSU Office of Biobased Technologies (OBT), researchers have mined the university's land-grant and now world-grant tradition of offering practical, science-based answers to questions facing the bioeconomy.

In 2007, MSU and the University of Wisconsin-Madison received a Department of Energy (DOE) grant to establish the Great Lakes Bioenergy Research Center (GLBRC), one of three DOE bioenergy research centers in the country. MSU is receiving approximately $50 million for basic research aimed at solving some of the most complex problems in converting biomass to advanced biofuels.

"In Michigan, our research and development emphasis is on making renewable fuels from cellulose — trees, stems and stalks that aren't food products," said Steve Pueppke, MAES director, who also serves as director of the OBT. "Cellulosic biofuels allow the state to tap forestland — land that isn't in the food system — to make fuel."

The MAES and the OBT are separate entities, but many MAES scientists are heavily involved in bioeconomy research — Pueppke isn't the only person to wear two hats. MAES scientist Bruce Dale serves as an OBT associate director, and MAES researcher Ken Keegstra is also scientific director for the GLBRC. Ray Miller, MAES U.P. forest properties manager, recently added forest biomass development coordinator to his myriad duties, in recognition of the growing importance of cellulose as a raw material for bioproducts.

In this issue of *Futures*, you can read about MAES research taking place through a number of disciplines with one goal in mind: making Michigan's bioeconomy as economically viable, as environmentally sound and as sustainable as it can be.

The 2008 Farm Bill, enacted this past summer, provides $1 billion for renewable energy technology and research, including loan guarantees for biorefineries and support for the USDA and DOE Biomass Research and Development Initiative. MAES researchers are helping producers understand the implications of many of the programs contained in the farm bill and assisting them in figuring out which programs are best suited for their farms.

The rise in food prices has touched off heated debate on diverting agricultural crops from the food system to make biofuel. But biofuel production is just one of multiple factors affecting the cost of food. MAES scientists have conducted research to help explain all the variables that have caused food prices to spike.

But does society really have to choose between food and fuel? MAES scientists are studying all the angles of making fuel from trees and other non-food crops to offer information to policymakers and the public and forge partnerships with state agencies and other universities to help Michigan carve out its niche in the bioeconomy.

Part of the attraction of making products from renewable resources is a hoped-for beneficial effect on climate change. MSU is positioning itself to play a leading role in finding solutions for and managing the effects of climate change.

MAES researchers study more than big-picture bioeconomy issues. They also conduct research that makes campus operations part of the bioeconomy. MAES researcher Dennis Miller has set up canola seed crushing and processing machines at the MSU Biorefinery Training Facility at the Michigan Brewing Company in Webberville. He and his team turn canola oil into biodiesel in small batches and are now testing the biofuel in MSU Grounds Maintenance equipment on campus. The goal is to demonstrate that local co-ops can process canola oil into biodiesel that can be used to power farm equipment, offering farmers a cash crop option with multiple markets.

We hope you enjoy this issue of *Futures* on MAES bioeconomy research and that it helps you understand a little more about the Michigan Agricultural Experiment Station and the research it funds. If you have comments about this issue or would like to subscribe (it's free!), send a note to *Futures* Editor, 109 Agriculture Hall, Michigan State University, East Lansing, MI 48824-1039, or send an e-mail to depolo@msu.edu. You also can call 517-355-0123.

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::: Jamie DePolo

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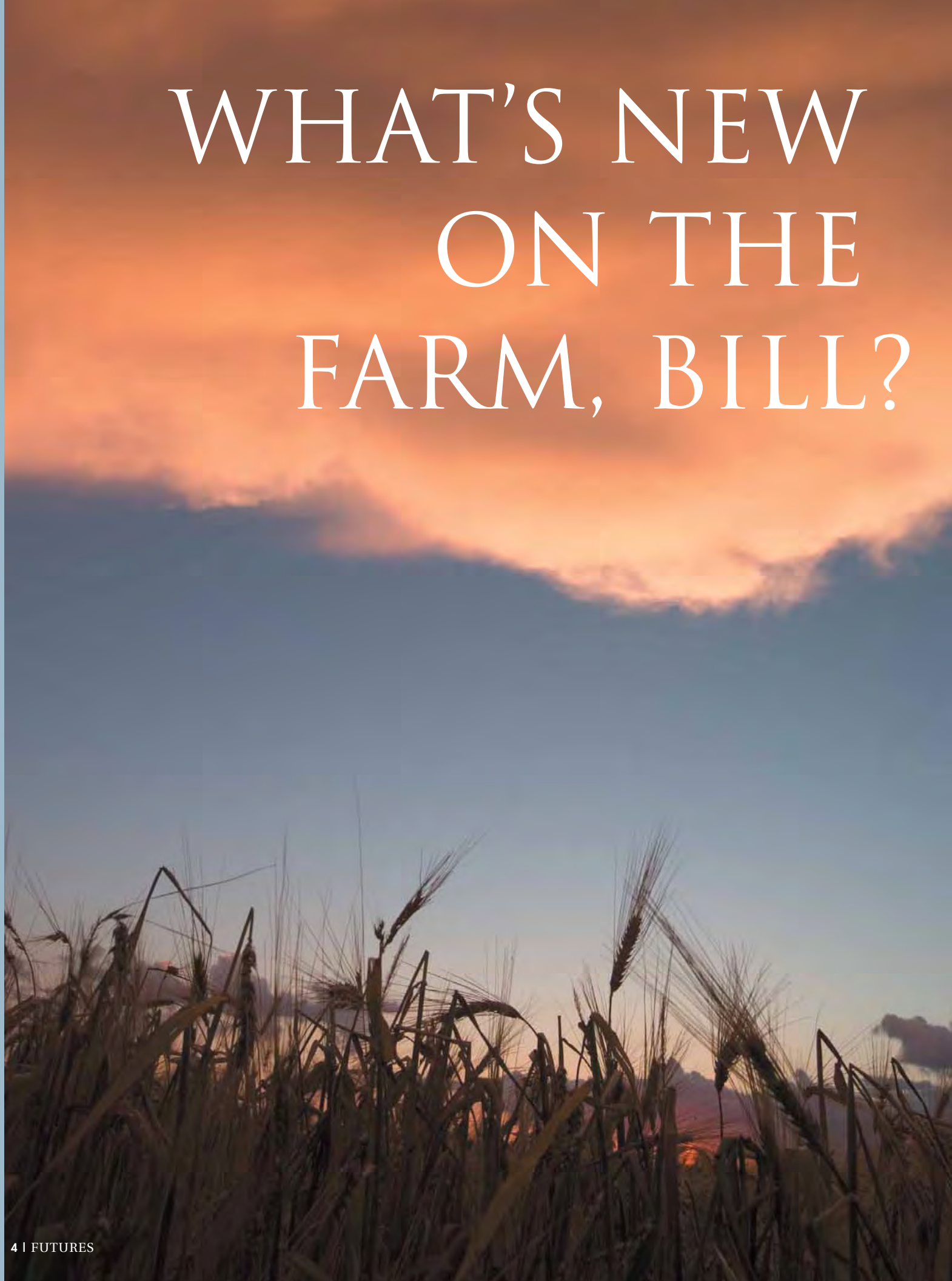
WHAT'S NEW ON THE FARM, BILL?



BREAKING NEW GROUND IN THE FOOD, FUEL AND FIBER FIELDS

The 2008 Farm Bill makes historic new investments in food, farm, conservation and energy programs.

What do school lunches, land conservation, specialty crops and renewable energy have in common? They're all part of the 2008 Farm Bill, groundbreaking legislation that invests significantly beyond the traditional land and furrow programs for which the legislation was created decades ago.

"The farm bill has its roots in the Depression years, when it was, indeed, a farm bill," said MAES agricultural economist Dave Schweikhardt. "Its purpose was to balance supply and demand for major farm commodities — corn, wheat, cotton, rice, peanuts, tobacco and milk — so that prices supported a decent purchasing power for farmers. Period. Then, in 1973, the food stamp program was added, bringing a huge new set of actors into the process. As land conservation and environmental programs were added to the farm bill in the mid-1980s, it morphed into something that's a lot bigger than what comes to mind when you hear the words 'farm bill.'"

Supersized is more like it. The Agricultural Adjustment Act of 1933, considered the first modern farm bill, contained 23 pages and three sections (known as titles) – agricultural adjustment, agricultural credits and financing. Today, at 600-plus pages and 15 titles, the farm bill — according to many — is one of the most significant forces affecting farming, food and land use in the United States.

"In one way or another, this legislation affects all of us, from the clothes we wear and the food we eat to the water we drink, the air we breathe, and the energy that powers our homes, vehicles and places of work," said Jeff Armstrong, dean of the MSU College of Agriculture and Natural Resources and chairperson of the Board on Agriculture Assembly Farm Bill Committee for the 2008 Farm Bill. "This is a bill we should all understand and care about."

MAES agricultural economist Dave Schweikhardt has analyzed farm bill legislation for nearly 20 years. He says the farm bill has morphed into something much bigger than its name suggests.

The 2008 Farm Bill: A Tough Row to Hoe

The 2008 Farm Bill, enacted this past summer, garnered the unprecedented support of more than 1,000 organizations representing the nation's agriculture, conservation and nutrition interests, from the American Beekeeping Federation and Bread for the World to Women Involved in Farm Economics and the YMCA.

So what sparked all the attention? Schweikhardt — who has followed farm bill legislation for almost 20 years — said widespread agreement that more funding was needed for conservation and nutrition programs and the unexpected challenges posed by food and fuel price inflation brought things to a boil.

"Concerns around food and fuel issues really began to pick up steam in farm bill deliberations toward the end of 2007," Schweikhardt said. "For example, when what was assumed would be a reasonable budget for nutrition programs was suddenly being eaten up by higher prices, the nutrition community weighed in heavily and said, 'We've got to have more budget resources because there are food banks that will run out of food in February or March.'

"Because farm bills are overhauled every five or six years, work on this legislation begins a couple years before it's actually passed," he continued. "So when people were getting ready for this farm bill in 2006, things looked a lot different than they do today. Once the food and fuel issue took off, new demands kept getting added, and more and more interests were drawn in. Is that good or bad? I don't know, but, in my opinion, what saved the farm bill in the end was the broad coalition of support it received around some really unique circumstances and unexpected issues. A number of new and expanded initiatives ended up in the farm bill that wouldn't have been included otherwise."

Specialty Crops: A League of Their Own

Valued at more than $49 billion in 2007, the U.S. specialty crop industry is a major contributor to the nation's economy. According to the Agricultural Statistics Service of the U.S. Department of Agriculture (USDA), sales of fruits, vegetables and tree nuts account for almost one-third of all crop cash receipts in the country, and nearly every state is involved in commercial specialty crop production. In Michigan, cash receipts from specialty crops totaled $1.72 billion in 2007 and represented more than half of all the state's crop receipts.

"Michigan is second only to California in the number of agricultural commodities and is a major producer of many specialty crops, including apples, blueberries, tart cherries, asparagus, celery and potatoes," Armstrong said. "Without new funding, the ability of MSU and the state's agriculture industry to address critical issues in this sector will be curtailed."

Traditionally, specialty crops have had to compete with major commodities such as corn, wheat and soybeans for federal funding. One of the most significant additions to the 2008 Farm Bill is the inclusion of mandatory funding for specialty crops.

"If you want to pick one really big thing in the farm bill, this is it," said Doug Buhler, MAES associate director. "Funding specifically mandated and authorized for specialty crops is a watershed event. It provides an important opportunity — through the newly created Specialty Crop Research Initiative (SCRI) — to fund research in an area that is a very high priority for Michigan."

These new federal dollars also are very complementary to the research funding provided over the past 10 years through Project GREEEN (Generating Research and Extension to meet Economic and Environmental Needs), Michigan's plant agriculture initiative housed at MSU, Buhler said.

"This is the first time there's been a program at the national level that can serve as a steppingstone from GREEEN funding to federal program support," he said. "The ability to combine the funding support provided by commodity groups and Project GREEEN with SCRI competitive grant dollars positions our scientists to engage in the critical plant research needed to ensure that Michigan's specialty crop industry remains a vital contributor to the state's economy and overall well-being. The SCRI program isn't perfect, but it's the best we've ever had, and we'll continue to work to make it better."

Specialty crop commodity groups played a major role in securing additional funding and program support for their industry.

THE 2008 FARM BILL GARNERED THE UNPRECEDENTED SUPPORT OF MORE THAN 1,000 ORGANIZATIONS REPRESENTING THE NATION'S AGRICULTURE, CONSERVATION AND NUTRITION INTERESTS.

"Although a number of things occurred during the farm bill process that resulted in more funding and programs for specialty crops, perhaps the most important is that a diverse group of commodity groups banded together and worked very hard to make this happen," Buhler said.

"Because there hasn't been an umbrella organization to bring and hold specialty crop groups together, at the end of the farm bill process when the going gets tough, most groups feel compelled to cut and run and put their own package forward," said Phil Korson, president of the Cherry Marketing Institute (CMI), a national research and promotion group that represents U.S. cherry growers, and executive director of the Michigan Cherry Committee and the Michigan Association of Cherry Producers.

To ensure a more cohesive specialty crop agenda with more political force, several commodity groups teamed up to create the Specialty Crop Farm Bill Alliance (SCFBA), a national coalition of more than 120 organizations (including CMI) representing 350 specialty crops. Its efforts helped secure $230 million in mandatory funding for the SCRI as well as policy and funding support for other specialty crop priorities, including organic farming, trade assistance, disaster relief, conservation and local competitiveness projects, food safety, and invasive pests and disease.

"For the first time, the farm bill recognizes the priorities of an industry that accounts for more than half of all crop value in the country," Korson said. "That's pretty monumental. Equally as important, if we don't fund programs that advance the specialty crop industry so it can compete in a global market, it won't exist. It's a national security issue to make sure that we have a strong, vibrant fruit and vegetable production system in this country. And Michigan specialty crop producers and researchers are an important part of that equation."

A Bigger Place at the Table for Fruits and Vegetables

Rising food prices, coupled with increased public interest in healthy food and growing concerns over obesity, diabetes and other health issues, led the SCFBA and groups and organizations across the United States to join the nutrition community in its demand for more funding and stronger programs to support the nutritional health and well-being of the nation's children and low-income families.

When the ink dried on the 2008 Farm Bill, it included $10.3 billion in new funding for nutrition programs, $1.26 billion more dollars for the Emergency Assistance Food Program and $50 million in 2008 to immediately address shortages at food pantries. In total, nearly 75 percent of the bill's funding is devoted to food stamps and other nutrition programs.

"Another exciting addition was the appropriation of $1.02 billion to expand the USDA Fruit and Vegetable Snack Program from a test program to all 50 states," said John Bakker, Michigan Asparagus Advisory Board executive director. "The expansion of this program will help develop lifelong healthy eating habits for 4.5 million children by providing fresh produce in our nation's schools."

With the diversity of fruits and vegetables grown in Michigan, this program is especially beneficial to Michigan specialty crop producers and consumers, Bakker said.

"We want to get fresh asparagus into the schools," Bakker said. "The program is a great way to expose kids to fruits and vegetables."

"This farm bill also contains increased funding for fruit and vegetable producers to help deliver surplus produce into school lunch programs," Korson added. "For example, last year the cherry industry distributed more than 18 million pounds of cherries to schools nationally."

For the first time, the farm bill recognizes the priorities of the specialty crop industry, which accounts for more than half of all crop value in the country. "That's pretty monumental," says Phil Korson, president of the Cherry Marketing Institute.

In addition to critical funding, better coordination among various aspects of USDA research, extension and teaching initiatives will be of tremendous long-term benefit to consumers, Armstrong said.

"They will continue to have safe food," he said. "It will be sustainable, accessible and affordable and serve to boost the economic vitality and people's quality of life in Michigan and nationally."

Cultivating More Tools for the Trade

Crop and livestock producers, operating at the mercy of disastrous weather events and market price fluctuations over which they have no control, are vulnerable to

"NATIONALLY, THIS FARM BILL WILL GO DOWN IN HISTORY AS A BIT OF A TURNING POINT BECAUSE IT INCLUDES SO MANY NEW ACTORS, PROGRAMS AND APPROACHES."

variations in prices and yields. For this reason, federal commodity programs that provide financial assistance (subsidies) to protect farmers against unexpected price fluctuations have been around for more than six decades.

"Although farm subsidies are considered important for maintaining a safe and secure food supply, they protect only against price, not against losses in crop yield," Schweikhardt said. "That leaves a pretty big hole in the agricultural safety net for farmers that suffer significant losses due to drought, floods and other natural disasters. In addition, current subsidy programs have been criticized for distorting the market, being linked to politically set prices and paying out without documentation of loss."

John Bakker, executive director of the Michigan Asparagus Advisory Board, says expanding the USDA Fruit and Vegetable Snack Program will put more fresh produce in schools.

In an effort to provide better protection for farmers, less potential for market distortion and greater equity across crops, a new income support initiative — the Average Crop Revenue Election (ACRE) program — was added to the 2008 Farm Bill.

"ACRE is designed to protect farmers against unexpected losses in revenue (price multiplied by yield) rather than just price," Schweikhardt said. "Farmers can choose to continue with the current program, or they can enroll in ACRE beginning in 2009."

To help producers better understand the provisions and implications of ACRE, Schweikhardt and several other agricultural economists at MSU are developing decision-making tools to help farmers determine which program works better for their farms.

"Putting these materials together and getting them out to growers will be a major emphasis for us this winter because ACRE is one of the first programs in the farm bill that farmers will have to make a decision on in the coming year," Schweikhardt said. "Once a farmer enrolls in the program, he or she is committed for the life of this farm bill, so it's critical to do everything we can to make sure Michigan farmers have the tools they need to make an informed decision."

Another shift in the 2008 Farm Bill that Schweikhardt considers significant — especially for Michigan, given its unique resources — is the creation of the Conservation Stewardship Program (CSP), which rewards farmers for good stewardship practices. Originally passed in the 2002 Farm Bill as the Conservation Security Program, it was available only in certain watersheds. The CSP now has a continuous and nationwide signup, with mandatory funding to enroll 12.7 million acres a year through 2017.

"The Conservation Reserve Program was added to the farm bill in 1985 to allow farmers to enroll highly erodible cropland or environmentally sensitive lands into an acreage idling program," Schweikhardt said. "Although there's a place for this type of land conservation practice, if we're going to successfully deal with the environmental issues we face in agriculture these days, it's probably not going to happen simply by removing land from production."

The CSP is designed to develop working lands so they can stay in production, Schweikhardt explained. In addition to helping commodity crop producers, the program also provides technical assistance to organic and specialty crop producers.

"The program addresses conservation and environmental issues by providing financial incentives to farmers who implement conservation practices," he said. "For example, a farmer might need to employ soil conservation, water quality, water quantity (irrigation) or possibly wildlife habitat protection measures to keep cropland viable. The CSP is an important new conservation tool for farmers in Michigan and nationally. Optimizing productive cropland while preserving our natural resources is in everyone's best interest."

A New Energy Future

"Another critical area for Michigan is the development of our bioeconomy," Armstrong said. "Our governor, state and federal legislators, and business, labor and educa-

CREATE-21: BUILDING STRONGER FEDERAL-STATE RELATIONSHIPS

Jeff Armstrong

Throughout the 2008 Farm Bill process, an unprecedented number of alliances and coalitions formed to strategize and push for farm bill provisions important to them. One of the more significant alliances, according to many, was CREATE-21 (Creating Research, Extension and Teaching Excellence for the 21st century). Established by the National Association of State Universities and Land-Grant Colleges, the group was charged with developing a proposal to improve the integration and efficiency of research, teaching and extension activities coordinated by and funded through the U.S. Department of Agriculture (USDA).

"A few years ago, the future for research, teaching and extension in the land-grant system was bleak," said Jeff Armstrong, dean of the MSU College of Agriculture and Natural Resources and co-chairperson of CREATE-21. "In 2005, a group of deans and directors from land-grant institutions across the country formed a think tank to look at how to strengthen the USDA system, enhance responsiveness to stakeholders, better coordinate the system, and secure more funds to bolster capacity and competitive grants."

Once the group started deliberating, it found that for every dollar the USDA spends in competitive funds, the National Institutes of Health (NIH) spends $120.

"Human health and all aspects of the NIH are very important, but are America's food, fiber and fuel issues 1/120th as important?" Armstrong said. "There are dozens of critical and urgent national problems that will not be solved within an acceptable time frame unless USDA science program levels are increased substantially and immediately."

In response to the think tank's findings, CREATE-21 was established.

"CREATE-21 is the result of a deliberative process to rethink the basic structure of the federal-state partnership that guides, manages and funds research, education and outreach for America's food, agriculture and natural resources sectors," Armstrong said. "The group worked diligently over the past two years to reach consensus within the land-grant community and among our external partners about how to update and improve this federal-state partnership to meet the needs of the 21st century. I think the results of these efforts speak for themselves in the 2008 Farm Bill."

CREATE-21's efforts were successful in:

- The creation of the National Institute of Food and Agriculture (formerly the Cooperative State Research, Education and Extension Service), a highly visible, high profile agency that puts research, education and extension efforts on a level with the NIH and the National Science Foundation.
- The establishment of six new USDA divisions housed in the newly created Research, Education and Extension Office: renewable energy, natural resources and environment; food safety, nutrition and health; plant health and production and plant products; animal health and production and health products; agriculture systems and technology; and agriculture economics and rural communities.
- The creation of the Agriculture and Food Research Initiative, a premier research program that will provide competitive grants to colleges and universities, agricultural experiment stations and other organizations conducting research in food and agricultural sciences. Funding authorization for competitive grants increased from $500 million in the 2002 Farm Bill to $700 million in the 2008 Farm Bill.
- Increased funding for beginning farmers and ranchers.
- Increased funding for historically black colleges and universities, Native American colleges and small land-grant universities.
- Increased funding for renewable fuels, feedstocks and energy efficiency.
- The creation of new initiatives for specialty crop and organic production.

"Unity and preparation go hand in hand," Armstrong said. "Think tank members, the CREATE-21 initiative and other farm bill committees worked hard to engage the entire system and develop support for these changes. U.S. Senator Debbie Stabenow's leadership in supporting key provisions of the farm bill and in ushering it through the long, often complex legislation process was also crucial and greatly appreciated."

Armstrong and Steve Pueppke, director of both the MAES and the MSU Office of Biobased Technologies, serve on the Farm Bill Implementation Assistance Committee, which was established this summer to provide input and suggestions as the USDA implements the research title of the legislation.

"At MSU and our colleague institutions, we are proud that our research, education and extension programs have helped to resolve past food crises across our state and nation and around the world," Armstrong said. "As we face new challenges in providing nutritious food to our neighbors down the street and around the world, the investment that this farm bill makes in our colleges and universities will pay off in knowledge and innovation that will help us fight this fight."

::: Val Osowski

Steve Pueppke, who serves as director of both the MAES and the Office of Biobased Technologies, says the renewable energy funding in the farm bill ultimately will improve the environment and address important economic issues.

tional leaders have been virtually unanimous in supporting efforts to make Michigan a national leader in developing renewable fuels and other biobased products. Farm bill provisions in this area provide farmer incentives to promote the production of home-grown renewable fuels and products and funding that allows entrepreneurs to develop innovative biobased industries that will help transform Michigan's economy."

The 2008 Farm Bill provides $1 billion to fund programs that will leverage renewable energy investments in new technologies and feedstocks. This includes $320 million in loan guarantees for biorefineries and $120 million for the Biomass Research and Development Program, which coordinates research and development activities to improve livestock feed and efficiencies in biofuel production.

"There are many signs that the bioeconomy is becoming a reality, not just in Michigan but around the nation and the world," said Steve Pueppke, MAES director, who also serves as director of the MSU Office of Biobased Technologies. "American consumers feel the sting of high energy prices and know that this energy comes from sources that will eventually run out. Many people are uncomfortable with the nation's dependency on foreign oil — the concept of renewable energy is something everyone can feel good about."

Although $1 billion nationally over five years is the proverbial drop in the bucket compared with the dollars needed in the renewable energy arena, Pueppke noted that farm bill funding can help leverage industry investments and provide incentives to encourage sustainable production of renewable energy.

"The important thing is to find opportunities or ideas that fit with the money available," Pueppke said. "For example, farm bill funding might support larger investments in technologies to convert cellulose-based raw materials into biofuels or renewable energy standards that provide profitable and environmentally sustainable market opportunities for crop, tree and livestock producers. Regardless, it's clear that the promise and potential of creating a thriving economy based on research and the development of clean, safe and renewable biofuels, chemicals and materials have captured the attention of politicians and the public in a big way. Renewable energy is our future."

2008-2012: Plowing Ahead

Many involved in the 2008 Farm Bill process agree that substantial gains were made and that the legislation is moving U.S. farm policies and programs in the right direction. Over the next five years, the $280 billion-plus farm bill will serve as a roadmap for federal agricultural research, teaching and outreach funding.

"Nationally, this farm bill will go down in history as a bit of a turning point because it includes so many new actors, programs and approaches," Schweikhardt said. "Beyond the United States, we haven't really seen what the impact is going to be. There was initially some controversy over U.S. and European levels of subsidies versus the levels of subsidies in other countries, but right now, people are more concerned about higher prices than they are about subsidy levels."

"Locally, the challenge will be to effectively coordinate funds from Project GREEEN and our industry partners to maximize the competitiveness of our scientists for federal funds," Buhler added. "The bottom line is that we have some exciting new opportunities."

Another exciting opportunity afforded in the farm bill is its support of renewable energy initiatives.

"The renewable energy funding provided in this farm bill builds on earlier achievements and will ultimately help to sustain our working lands, improve the environment and address some of the most important economic and political challenges of our times," Pueppke said.

"It will be particularly interesting to see what decisions are made around biomass production issues in the next year or so," he continued. "In the meantime, Michigan's bioeconomy will continue to yield new businesses, jobs and intellectual property. We've had success, but there's enormous potential for more."

Although the farm bill is now history (and historical), Armstrong emphasized that vigilance, leadership and continued collaboration are needed to protect new gains and build a solid foundation for the long haul.

"This is a marathon, not a sprint," he said. "All of us in research, education and extension need to work collectively with decision makers, industry leaders and legislators to find a viable long-term solution for the sustainability of food, fuel and fiber supplies in Michigan, the nation and the world."

::: Val Osowski

Food Price Increase Ingredients:

A Recipe for Disaster?

Biofuels are just one of multiple factors affecting the cost of food. MAES scientists explain all the variables that have caused prices for some staples to skyrocket.

According to information from the U.S. Department of Agriculture (USDA), the Consumer Price Index for all food was up 6 percent from July 2007 to July 2008. Egg prices are up 16.3 percent from last year, cheese costs 14.5 percent more, beef prices are 4.6 percent higher, fresh vegetables are up 12 percent, and cereals and bakery products are 12.1 percent higher.

Around the world, prices have increased even more. The World Bank estimates that global food prices have increased by 83 percent over the past three years — rice alone was up 141 percent from January through April 2008.

Everyone buying food knows he or she is spending more, but it's a little startling to see the amount of the increase in print. Fingers were pointed immediately at the government's mandated ethanol production — diverting agricultural crops from the food supply to biofuel raw materials was responsible for the huge increase. Or so it seemed, according to media reports.

"We have to put food inflation in perspective," said MAES scientist Chris Peterson, who holds the Nowlin chair for consumer responsive agriculture and serves as director of the MSU Product Center for Agriculture and Natural Resources. "Food inflation has gone from just under 3 percent per year to 4.5 to 6 percent per year. The average U.S. consumer spends less than 10 percent of disposable income on food. The increase means an extra $100 to $120 for food per year. For the average person, that can be done.

Research by Chris Peterson *(left)* and Bill Knudson shows that the increase in food prices is due to a combination of factors, not just grains for biofuels. Peterson is director of the MSU Product Center for Agriculture and Natural Resources, and Knudson is a marketing economist for the center.

"But for the poor, here and around the world, that increase is substantial," Peterson continued. "They're spending 50 percent or more of their disposable income on food and may have to make some hard choices."

"What's really gone up is energy," said Jim Hilker, professor of agricultural, food and resource economics and MSU Extension marketing specialist. Hilker maintains a market outlook and probabilistic price forecast Web site for grain and livestock. "Higher energy costs are really driving up food costs. Costs are up for grain farmers for fuel, energy, fertilizer and seed. These are all having an effect on food prices. Ethanol is being blamed for the increase in the cost of food, but I don't think we're seeing the full effect of ethanol yet."

According to analyses done by Peterson, MAES agricultural economist Dave Schweikhardt and Bill Knudson, product marketing economist for the Product Center, biofuels have contributed to the increase in food prices, but the size of this contribution is up for debate, depending on the source of information. Some sources estimate ethanol is responsible for about 33 percent of the increase in food costs; others swing wildly from 3 percent to more than 75 percent.

All the scientists agreed that what is clear is that the rise in food costs is due to a combination of factors, some that happened suddenly without much warning and some that had been taking place over time and were expected.

"There are basically four things that have led to higher prices for food," said MAES scientist Mike Hamm, who holds the C.S. Mott chair for sustainable agriculture. "First, we've seen an increase in global population. We've also experienced water shortages around the world. Australian rice production has been way down because of severe drought. Then there is the increase in the cost of energy, and finally, the use of food crops for uses other than food."

"It seems like the increase happened overnight, but it didn't, really," Peterson said. "There has been a gradual increase in consumption around the world, and supplies have been dwindling at the same time."

"It's an extremely complex situation," Hilker added. "Even economists can't fully parse out all the nuances. But I think we'd all probably agree that the two biggest factors are oil prices and wheat shortages around the world."

The Role of Biofuels

As Peterson pointed out, studies on the effect of diverting corn and other food crops to biofuels have produced drastically different results.

"Several credible sources say that the maximum impact of biofuels would be one-third of the rise in food prices," Peterson said. "But I've seen studies saying the impact ranges from 3 percent of the increase — from the USDA — to 78 percent of the increase — from the United Nations."

Knudson cited a study by Iowa State University scientists that determined that consumers paid 1.1 percent more for food in 2007 as a result of increased corn grain ethanol production.

"So that's about 25 percent of the increase," Knudson said.

"Biofuels being responsible for about 15 to 30 percent of the increase in food seems accurate to me," Peterson added.

The United States isn't the only country that has mandated biofuel production. The European Union has regulations in

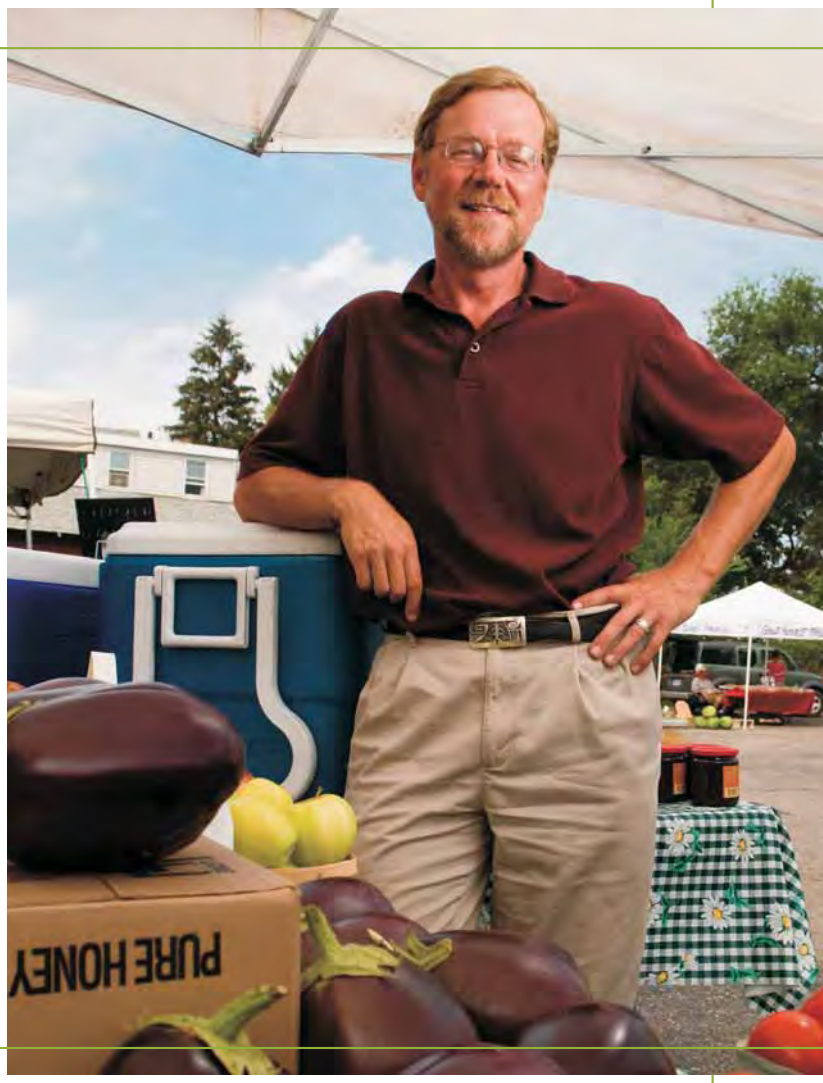
place to ensure that biofuels make up 10 percent of fuel used for transportation by 2020. Europe uses more diesel fuel than the United States, but Knudson and Schweikhardt agreed that it won't be able to produce enough biodiesel raw materials to meet the demand.

"So Russia and the Ukraine are growing more rapeseed [canola] to meet the demand, as is Canada," Knudson said. "This will reduce the supply of food and put upward pressure on wheat and other food crops that could be grown on the land."

In the United States, the high price of soybean oil has made it unprofitable to convert soybean oil to biodiesel — the food demand has effectively eliminated the fuel market.

Whatever the final effect of biofuels on food prices, higher ethanol production has affected corn prices, and higher corn prices have affected the prices of other commodities, such as wheat and soybeans. But Hilker pointed out that these commodity price increases are minor and are not the main source of food price inflation.

"The farm commodity portion of the price of food is relatively small, with the exception of eggs and wheat," he explained. "If you double the commodity price, it doesn't double the price of food, but it still raises costs somewhat. Commodity price increases affect bakeries and processors more — people who can pass along the higher cost. Because wheat goes directly into food people eat, as opposed to corn, which goes to livestock feed, when wheat prices go up, consumers feel the effects more."



MAES scientist Mike Hamm holds the C.S. Mott chair for sustainable agriculture. "Everyone should have the right to a healthy diet," he says. "For lower income people, it's a bigger issue than food vs. energy."

Energy Prices — the Real Culprit?

Diesel fuel powers the machines that plow, plant, harvest and haul crops to markets. Natural gas is used to dry grain. Higher energy costs, especially higher diesel fuel prices, are the primary reason for higher food prices, according to MAES scientists.

"Everyone is feeling the pinch at the pump," said Steve Pueppke, MAES director, who is also director of the MSU Office of Biobased Technologies. "Separate from any other factors, higher energy costs are making it more expensive to transport food, which in turn has led to higher food prices."

"Researchers at Texas A&M University consider higher energy costs as the driving force affecting the agricultural industry," Knudson added. "It would appear to be a huge effect."

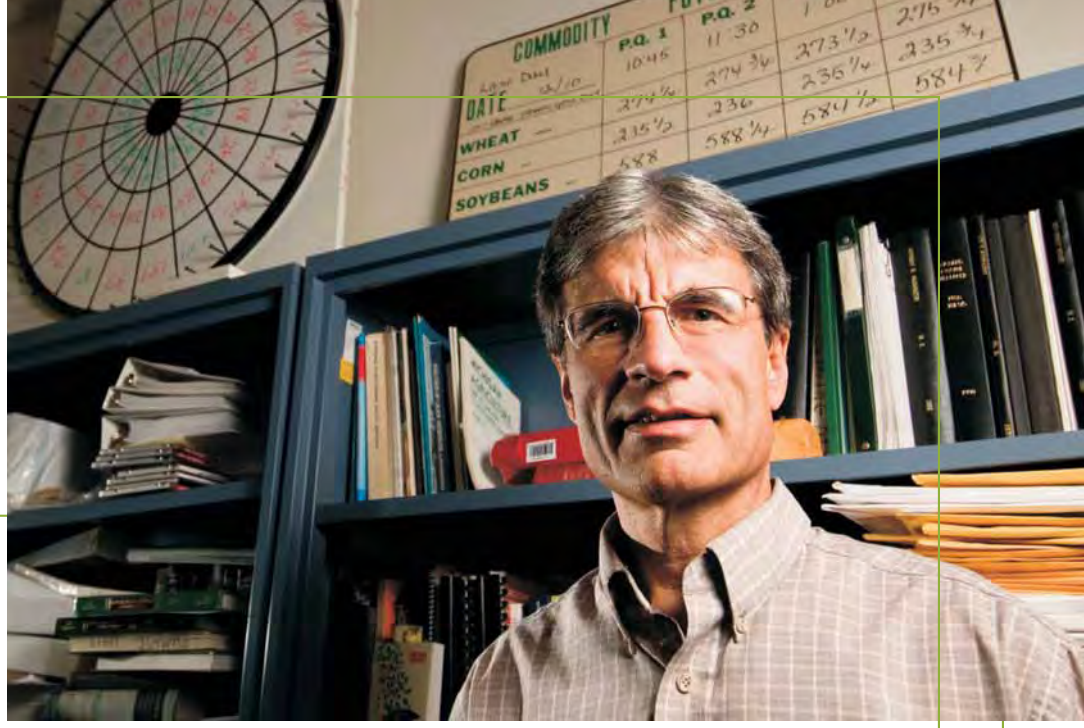
The per barrel cost of oil has gone from $70 to $140 (or higher) in the past two years, three times more than the increase in food prices, Peterson said. In addition to transporting crops, higher energy prices also affect the cost of transporting everything that is needed for growing food, including fertilizers and other soil amendments, chemicals to control pests and other inputs.

"I don't think anyone has looked specifically at how the cost of fuel has affected food prices," Peterson said. "People in the supply chain and food manufacturers are really hurting. Their raw materials have gone up 25 percent."

"If oil keeps going up, there is no way corn prices can go down," Hilker explained. "It's all tied together. Can oil prices go down? They might, but demand will always be there."

According to Hilker, some of the variables that may lower the price of oil are:

- Developing technology to extract oil from sand. "Western Canada has been very successful at this."



Agricultural economist Jim Hilker says that higher energy costs, not the use of grain for ethanol production, are driving up food costs. "The two biggest factors are oil prices and wheat shortages around the world."

- Fewer car trips. "If people drive less, we'll use less gas. If demand goes down, so do prices."
- Better home insulation. "This will reduce the demand for heating oil."
- Energy conservation. "But even if we all reduce a little, the world's population is growing, so I'm not sure a little reduction will help that much."
- An end to the war in Iraq. "If the war ended, we would definitely see lower oil prices."

A More Affluent World Demands More Food

As people in developing countries increase their incomes, one of the first things they do is eat more food, especially more meat, and a wider variety of foods. In a sense, they begin to eat like consumers in developed countries and move away from traditional eating habits. So instead of eating rice, people switch to wheat products, such as breads. They also eat out more often. In 1979, the average person in China ate about 2,330 calories per day. In 2003, it was about 2,940, an increase of more than 26 percent. In India, per capita calories consumed went from 2,080 in 1979 to 2,440 in 2003, an increase of about 17 percent.

At the same time, the populations of these two countries are also going up — about one-third of the world's population is either Chinese or Indian. From 1979 to 2003, the number of daily calories consumed in China went up by about 1.55 trillion. In India the increase was 1.20 trillion. This increase in demand is another reason why food prices are higher.

"It appears that consumers in developing countries are switching from plant protein to animal protein as income goes up," Knudson said. "Global meat production increased by more than 3 percent per year from 1985 to 1990. It's slowed since then, but it's still higher than the growth rate for grains and oilseeds. The increase in meat production increased demand for grains for feed, which caused them to go up."

"A billion people need about 1.2 trillion pounds of food," said Mike Hamm. "In China and India, the two largest and fastest growing countries, food production is not keeping up with population increases, so they're looking to import more meat and dairy products."

The Incredible Shrinking Dollar

In the past three years, the U.S. dollar declined dramatically compared with other currencies:

- 36.4 percent compared with the Brazilian real.
- 18 percent compared with the Canadian dollar.
- 14.6 percent compared with the Chinese yuan.
- 14.5 percent compared with the euro.
- 8 percent compared with the Indian rupee.
- 2.5 percent compared with the Japanese yen.

The decline in the dollar made U.S. agricultural exports much less expensive than those of other countries. So the demand for American agricultural products increased, and prices in the United States went up. At the same time, products imported into the United States, such as oil and food, were more expensive because the dollar was buying less.

"When oil costs $142 per barrel, the United States pays about $1.75 billion per day to import it," Peterson said. "That makes the cost of just about everything go up."

Extreme Weather and Short Supplies

Mother Nature also heaped some less than benevolent weather on the globe over the past few years, which caused

supplies of important commodities to drop to record lows.

"Drought reduced yields in Russia, the Ukraine and South Africa in 2006," Knudson said. "Australia, which is a major wheat exporter, essentially had complete crop failures in 2006 and 2007. Australia also used to produce a lot of rice, but after several years of bad yields, many farmers sold their water rights, so they can't produce any rice at all anymore."

Droughts, dry springs and flooding during harvest caused lower than expected yields for wheat and rice in 2007 in northern and southeastern Europe, the United States, Canada, Turkey and Argentina.

"The world's supplies of corn and wheat are the lowest they've been in 40 years," Peterson added. "At the end of 2007, we had only a month's supply of wheat and corn on hand, so any disruptions caused a panic."

Declining agricultural productivity growth for grains used for human food has compounded the supply problem.

"Productivity for agricultural food grains had gone down," Peterson said. "Feed grain productivity is still increasing. But there's been no investment in productivity research for food because food was cheap — there was no incentive. The government just isn't funding any productivity research."

Knudson and Peterson pointed out that agricultural productivity was going up by about 2 percent per year in the '80s and '90s. In the past decade, it has fallen to less than 1 percent per year. If the world's population increases by 1.3 percent per year as it's expected to do over the next 50 years, agricultural productivity won't even be keeping up with all the new mouths to feed — never mind that each person is eating more.

"If agricultural productivity doesn't start going up, we won't be able to replenish supplies, and food will be fundamentally more expensive," Peterson said.

As supplies have shrunk and prices have increased, many countries have enacted policies that restrict exports and encourage imports. Knudson said that 26 nations restrict rice exports. China, Argentina, Russia, Egypt, India, Thailand and others have increased export taxes or placed export quotas on in-demand commodities such as wheat and rice. India, Serbia and the Ukraine have banned wheat exports, and Vietnam, Egypt and Indonesia have banned rice exports. These policies keep prices low domestically but make global prices go up. The policies also discourage production investments — there are no incentives for farmers to increase yields because the prices they're receiving are low compared with global prices.

"In the most extreme cases, food that could have been used in other countries is wasted because it's not exported," Knudson said. "For example, because of export quotas in the Ukraine, $100 million worth of grain was dumped into the Black Sea because it became rotten."

A Perfect Storm

Essentially, a precise confluence of events all contributed to the increase in food prices. But the issue is fundamentally one of supply and demand — if supply can't meet demand, then prices go up. And if prices are high, farmers will increase production to take advantage of them.

"Higher prices will eventually lead to higher levels of production," Knudson said. "More acres will go into production, and the acres that are already in production will be farmed more intensively."

European wheat production is estimated to be 13 percent higher in 2008 than in 2007, India is predicting a record cereal harvest, and output is expected to go up in China. In the United States, it's estimated that farmers withdrew more than 2 million acres of land from the Conservation Reserve Program to increase agricultural production in 2008.

In the long run, the economists agreed, the markets will adjust. But in the short run, higher food prices are reducing the standard of living for consumers, and this has serious implications for people in the United States and for people around the world who spend the bulk of their income on food.

"For lower income people, it's a bigger issue than food vs. energy," Hamm said. "It's really an issue of social justice. Everyone should have the right to a healthy diet, but that's not the way our system is set up. We need to make a healthy diet a priority for people. It's an issue of food access."

::: Jamie DePolo

Food vs. Fuel

The question has been posed in print, debated on the radio and argued about by talking heads on television talk shows: should agricultural crops be used to make biofuels if diverting them from the food supply is causing the price of food to spike? Should the quantity of ethanol produced in the United States, mandated by the most recent Energy Bill, be lowered or waived? And if we're not making ethanol or other biofuels, how will the country ever be less dependent on imported petroleum?

"The fear that the fuel versus food debate causes creates the risk that people will perceive they have to choose between *only* food and *only* fuel," said MAES scientist Chris Peterson, who holds the Nowlin Chair for Consumer Responsive Agriculture and directs the MSU Product Center for Agriculture and Natural Resources. "There is definitely room for both, and we definitely have long-term needs for both."

Analyses by Peterson, MAES agricultural economist Dave Schweikhardt and Bill Knudson, product marketing economist for the Product Center, conclude that biofuels have contributed to the increase in food prices, but exactly how much of the increase can be attributed to biofuels is unclear. *(See related story on what influences the cost of food on page 11.)*

"Several credible sources say that the maximum impact of biofuels would be one-third of the rise in food prices," Peterson said. "But I've seen studies saying the impact ranges from 3 percent of the increase — from the U.S. Department of Agriculture — to 78 percent of the increase — from the United Nations."

Knudson cited a study by Iowa State University scientists that determined that consumers paid 1.1 percent more for food in 2007 as a result of more corn grain ethanol production.

"So that's about 25 percent of the increase," Knudson said.

"Biofuels being responsible for about 15 to 30 percent of the increase in food seems accurate to me," Peterson added.

Does society really have to choose between food and fuel?

MAES scientists are studying all the angles of making fuel from trees and other non-food crops to offer information to policymakers and the public and forge partnerships with state agencies and other universities to help Michigan carve out its niche in the emerging bioeconomy.

From Forests to Fuels

Forests cover more than half of Michigan's land, and the 19.3 million acres of trees is a 5 percent increase since 1980, according to statistics from the Michigan Department of Natural Resources. With 18.6 million acres of timberland (forestland classified as timberland must meet minimum timber production standards), Michigan is behind only Georgia, Oregon, Alabama and North Carolina in timberland acreage.

Trees and other plants are a huge potential source of energy — each year, the biomass in the Earth's plants captures about eight times the total amount of energy used by people from oil, coal, natural gas, wind, water, etc. But about 90 percent of this energy in fibrous plant biomass isn't readily available because it's locked up in cellulose and hemicellulose, the complex sugars that make tree trunks, grasses, plant stems and stalks, and leaves rigid. Unlike the simple sugars in the grains of plants, such as corn kernels, cellulose and hemicellulose don't dissolve in water. This is good for keeping plants healthy and helping them thrive, but it's a problem for making biofuels. Before the complex sugars can be converted into ethanol or other biofuels, they have to be broken down into simple sugars, such as glucose, by enzymes.

Doing that cost effectively has been the main issue slowing cellulosic biofuel production. Because the process is difficult to do efficiently, it can significantly raise production costs. This is why cellulosic biofuels aren't available commercially. Yet.

"In Michigan, our research and development emphasis is on making renewable fuels from cellulose — trees, stems and stalks that aren't food products," said Steve Pueppke, MAES director and director of the MSU Office of Biobased Technologies. "If the cellulose comes from crops that we're already growing, we can increase fuel production from crop residues without further effects on food prices. Cellulosic biofuels also would allow the state to tap forestland — land that isn't in the food system — to make fuel."

"Right now, the cheapest ethanol on the market is made from Brazilian sugar cane, which isn't cellulosic ethanol," added Ray Miller, who oversees forestry research at MAES properties in the Upper Peninsula, serves as director of the U.P. Tree Improvement Center in Escanaba and was named MAES forest biomass development coordinator in September in recognition of the growing importance of cellulose as a raw material for bioproducts. "We really don't know how much cellulosic ethanol will cost when it comes on the market, but there is a suspicion that it will cost more than ethanol made from corn grain. With that said, we also know that the cellulosic ethanol industry will get more efficient, which will bring the price down. And we also may find that there are other fuels such as dimethyl ether or biogas that may be better biofuel choices than ethanol. Ethanol may be a transition fuel. There's a lot of research work to be done."

MAES scientists and other researchers at Michigan State have made Michigan a leader in cellulosic biofuel research. Michigan State, along with Michigan Technological University, is providing research support to the Massachusetts-based Mascoma Corporation as the company works to build the nation's first cellulosic ethanol plant in Chippewa County in the Upper Peninsula.

"We can produce ethanol and other transportation fuels from cellulosic materials," said Bruce Dale, MAES chemical engineer, who has more than 30 years' experience in studying pretreatments to make cellulose easier to break down. Dale also serves as associate director of the MSU Office of Biobased Technologies. "There are some studies that say we should be able to produce cellulosic ethanol for about $1 per gallon. We're not there yet, but I believe we should be able to get cellulosic biofuels to the pump for about $2 per gallon. One of the most important things that we as scientists can do is to help everyone understand the difference between making biofuels from grain and making biofuels from cellulose.

"Support for making ethanol from corn grain has attracted some negative attention because food prices have gone up," Dale continued. "But what's been overlooked is how much energy is needed to make food and, therefore, how much of the increase in food prices has been driven by energy prices. Because the raw material for cellulosic ethanol is considered waste in many cases — the branches, stalks and stems of harvested crops — it's cheaper than the raw material for corn grain ethanol. Once the technology and supply chain for cellulosic ethanol is mature, I think cellulosic ethanol will cost about $2 per gallon to produce."

Dale has developed a pretreatment 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. 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. After treatment, the plant material comes out looking a bit like popcorn — slightly puffed up and dry.

The AFEX pretreatment process also increases the value of some cellulosic materials as feed for dairy and beef cows. This may provide some welcome relief to producers who have been squeezed by rising corn prices. Dale is working with MAES animal scientist Michael Allen to evaluate the feed potential of several pretreated cellulosic 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. Therefore, another facet of Dale's research is studying the potential for regional biomass processing centers.

"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 traditional corn grain handling equipment will work to load and unload the materials."

Dale envisions biomass processing centers located approximately every 10 to 20 miles in areas producing cellulosic biofuel raw materials. Processing centers would create jobs in rural areas and increase the value of the raw materials. Dale; MAES agricultural, food and resource economics scientist Satish Joshi; and doctoral student Joe Carolan are using a grant from General Motors to better define the economics, job creation and logistical issues surrounding the regional biomass processing centers.

Besides the processed biomass that will go to biorefineries, Dale

Briefing Congress on the Sustainability of Cellulosic Biofuels

Michigan State University is known internationally for its work on sustainability, especially research on the ecology of agricultural systems done at the Long-Term Ecological Research (LTER) site at the Kellogg Biological Station in Hickory Corners.

The national LTER network, funded by the National Science Foundation, is made up of 26 sites for study of ecology and environmental biology to provide a better understanding the ecology of both natural and managed systems. The MSU site, established in 1988, is the only site in the network to focus on agriculture. Research at the MSU LTER site looks at how biodiversity — plants, animals and microbes in agricultural landscapes — contributes to farm productivity, environmental performance and profitability. The site attracts researchers from all over the world and is available to any scientist with a legitimate research interest.

Two MAES scientists who conduct research at the MSU LTER and are members of the Great Lakes Bioenergy Research Center took part in an Ecological Society of America-hosted U.S. House and Senate briefing on the sustainability of cellulosic biofuels in June.

Phil Robertson, MAES crop and soil scientist and director of the MSU LTER program, and Doug Landis, MAES entomology researcher, discussed the ecological and economic considerations surrounding the use of cellulosic biomass to produce biofuels. Madhu Khanna, agricultural economist at the University of Illinois, also participated.

Landis spoke about the value, both environmental and monetary, of maintaining high levels of biodiversity in agricultural systems. Growing cellulosic crops can help maintain high biodiversity levels because farmers can grow a greater variety of crops and more complex mixtures of plant species than if they were growing only food crops. A mixture of native grass and tree crops can keep wildlife habitat intact and support vital ecosystem services, including those that help other crops in the landscape.

"Our research is focused on identifying the impact of various biofuel crops on the biodiversity of agricultural landscapes," Landis explained. "Carefully selected cellulosic crops could enhance agricultural landscape diversity, pest suppression, pollination and wildlife while reducing greenhouse gases. We have a historic opportunity to use science to guide policy in ways that would allow cellulosic biofuel crops to be a win-win for agriculture and the environment."

Robertson spoke about the economic, environmental and social elements of biofuel sustainability. Cellulosic crops can be grown on land that is not suitable for food crops, so they would help to reduce the perceived competition for land that underlies the food versus fuel discussion. Cellulosic biofuel systems can help mitigate carbon dioxide emissions as well as clean water and air, but achieving the benefits requires proper balancing of environmental aspects and economic incentives.

All three scientists cautioned that cellulosic biofuel environmental benefits are not guaranteed — they depend on the crops chosen, the management practices used and the geographic location of the crops.

Far left: **"One of the most important things that we as scientists can do is to help everyone understand the difference between making biofuels from grain and making biofuels from cellulose," says MAES scientist Bruce Dale.**

Near left: **Poplar (left) and willow trees growing in a test plantation on the MSU campus are potential raw materials for cellulosic biofuels.**

sees the processing centers eventually creating byproducts — bybio-products — possibly nitrogen fertilizer, proteins for animal feed, enzymes for the biorefining industry, and minerals and other nutraceutical products that can be used by other industries.

"The biomass supply chain is very important to creating a stable cellulosic biofuel industry and a stable bioeconomy for Michigan," Pueppke said. "This is an area that hasn't received a lot of attention, so we're pleased to partner with GM on the project."

Biofuel Crop Building Blocks

As more research focuses on ethanol, biodiesel and other renewable fuels, most experts predict that scientists will develop varieties of crops designed specifically to be converted into biofuels. In Dale's opinion, this also will help defuse the food vs. fuel controversy because food crops will stay in the food system.

"The ultimate success of biofuels will be determined largely by the ability to manipulate plants at the genetic, seed and field levels," Dale said. "MSU is the premier place for this work to be done. We have one of the top three plant science programs in the world. MSU is the foremost university worldwide in the field of plant metabolism and biochemistry. MSU researchers such as Christoph Benning, John Ohlrogge, Dean Della Penna, Yair Shachar-Hill and Ken Keegstra are manipulating non-food plants — woody plants and grasses — so the conversion process from biomass to biofuel is more efficient. This research is going to fundamentally change biofuel production."

In part, it was expertise in plant science that helped MSU, in partnership with the University of Wisconsin-Madison, receive funding for the Great Lakes Bioenergy Research Center (GLBRC) from the U.S. Department of Energy (DOE) in 2007. The GLBRC, one of three DOE bioenergy research centers, conducts basic research aimed at solving some of the most complex problems in converting natural materials to energy. MSU's $50 million portion of the grant is the largest federal grant exclusively for research endeavors in university history.

Benning, MAES biochemistry and molecular biology researcher and member of the GLBRC, announced the identification of a new protein necessary for chloroplast development in a paper in the August 2008 issue of the journal The Plant Cell. The discovery could lead to plant varieties tailored for biofuel production. Other members of the research team are Changcheng Xu, research assistant professor of biochemistry and molecular biology; Jillian Fan, research technician; and Adam Cornish, a biochemistry undergraduate student at the time of the research who is now a graduate student.

Chloroplasts are specialized compartments in plant cells that convert sunlight, carbon dioxide and water into sugars and oxygen ("fuel" for the plant) during photosynthesis. The newly discovered protein, trigalactosyldiacylglycerol 4 (TGD4), offers insight into how the process works.

"Nobody knew how this mechanism worked before we described this protein," Benning explained. "This protein directly affects photosynthesis and how plants create biomass and oils."

Benning's research shows how TGD4 is essential for the plant to make chloroplasts. Plants that don't have the protein die before they can develop beyond the embryonic stage.

Most plants that are used to produce oils that are converted into biofuels or biochemicals — corn, soybeans and canola, for example — accumulate the oil in their seeds, which is almost always the part of the plant used for food or feed. Understanding how TGD4 works may allow scientists to create plants that accumulate high levels of oil in other parts of that plant that are normally considered waste, such as the leaves.

"We've found that if the TGD4 protein is malfunctioning, the plant then accumulates oil in its leaves," Benning said. "More research is needed so we can completely understand the mechanism of operation. But if the plant is storing oil in its leaves, there could be more oil per plant, which could make production of biofuels more efficient."

C. Robin Buell, MAES plant biology researcher, is using a joint grant from the DOE and the U.S. Department of Agriculture to create an easily accessible, Web-based database of genomic information on crops that can be used to make cellulosic ethanol.

"Ultimately, this will allow us to create better biofuel crops," Buell said. "Right now, about half of the biofuel crops don't have genomic databases, and the ones that do are in many places and are annotated differently, so it's difficult to compare and use the information."

Buell and Kevin Childs, a postdoctoral researcher in her lab, are using the grant to centralize the genomic databases, create uniform

Far left: **As forest biomass development coordinator, MAES scientist Ray Miller will oversee many of the forest-based biofuel relationships between MSU and other entities.**

Left: **MSU forestry researchers are studying the best way to grow and harvest varieties of willow trees for biofuels.**

annotations (notes or descriptions of the genomes), provide data-mining and search tools, and provide a Web site for scientists from around the world to access the databases. They also will regularly update the information. Genomic databases contain information on the molecular biology and genetics of a particular species.

"Our biofuel genomic database portal will include information on any crop that can be used to produce cellulosic ethanol, including all the grasses — such as corn, rice, maize and wheat — and other biofuel species such as poplar, willow and pine," Buell explained. "This will save researchers a lot of effort, so we expect it to be a valuable resource for scientists at MSU and around the world."

A Gut Reaction to Biofuels

As the state's land-grant university, Michigan State has a long tradition of providing practical, science-based answers to some of society's most pressing problems. Bioeconomy issues are no exception as MSU biofuel research moves from the lab to the private sector through licensing and commercialization agreements.

A recent example is MSU technology that uses enzymes from a microbe in a cow's stomach to create plants that can be more efficiently turned into biofuel. These enzymes, which allow a cow to digest grasses and other plant fibers, can be used to turn fiber from other plants into simple sugars. Mariam Sticklen, MSU professor of crop and soil sciences, discovered a way to insert a gene from a bacterium in a cow's stomach into a corn plant so the plant then makes the enzymes in its leaves. This makes the fiber in corn leaves and stalks easier to convert into simple sugars, which can then be turned into biofuels or other valuable chemicals.

"This technology is a step ahead for science, for technology and for producing fuel in our own country," Sticklen said.

Edenspace Systems Corp., a plant biotechnology company that develops new crops for biofuels and environmental cleanup, licensed the technology and expects to use it to release biofuel corn varieties directly to growers as well as sublicense the technology to other companies that want to add the gene to their corn varieties. The company also will investigate using the technology in other biofuel crops such as sorghum, switchgrass and sugar cane.

"We're excited to start commercializing this technology," said Bruce Ferguson, president of Edenspace. "We've been helping to fund Dr. Sticklen's research for the past four years. This is a very productive extension of that work."

Sticklen's corn variety for biofuel production, Spartan Corn III, contains all three enzymes necessary to convert the cellulose in plant fiber into sugars that can be made into biofuel. Spartan Corn III builds on Sticklen's earlier research on biofuel corn varieties. The first version, released in 2007, cuts cellulose into large pieces with an enzyme from a microbe that lives in hot spring water. Spartan Corn II, with a gene from a naturally occurring fungus, takes the large cellulose pieces created by the first enzyme and breaks them into sugar pairs. Spartan Corn III, with the cow stomach microbes, produces an enzyme that separates pairs of sugar molecules into simple sugars, which can be readily converted into ethanol or other biofuels or chemicals.

Because of the regulations surrounding the release of transgenic crops, Ferguson estimated that the new biofuel varieties would be available commercially in 2011 at the earliest.

Building the Business of Biofuel

Besides research, creating a renewable fuel industry in Michigan requires coalition and network building to disseminate information, assist entrepreneurs and ensure that all interested groups have a voice in the process. So Michigan State researchers are reaching out across the state and around the world to develop bioeconomy partnerships.

Adding "forest biomass development coordinator" to his duties means that MAES forestry researcher Miller will coordinate many of the forest-based biofuel relationships between MSU and other entities, including Michigan Technological University, the Michigan Economic Development Corp. and the Swedish Forest Agency.

"I'm now the university's point person for forest biomass production," Miller said. "Besides working with faculty members in the Forestry Department who are already studying cellulosic biomass, I'll be learning more about what's going on outside forestry so I can connect faculty members from across departments."

Experts agree: environmental standards needed for biofuels

Phil Robertson

The United States lacks the standards to ensure that producing biofuels from cellulose won't cause environmental harm, says a distinguished group of international scientists. But because the industry is so young, policymakers have an exceptional opportunity to develop incentive programs to ensure the industry doesn't harm the environment.

"Environmental standards are needed now, before the industry moves out of its research and development phase," said Phil Robertson, MAES crop and soil sciences researcher and lead author of the paper "Sustainable Biofuels Redux" published in the Oct. 3 issue of the journal Science. "With production standards and incentive programs, cellulosic biofuel cropping systems could provide significant environmental benefits."

Currently, all the commercial ethanol produced in the United States is made from grain, primarily corn. Robertson said that science has shown that almost all intensive grain-based cropping systems, as currently managed, cause environmental harm. As director of the MSU Long-Term Ecological Research program at the Kellogg Biological Station, part of Robertson's research focuses on management practices that can reduce these negative effects.

"We can soften the environmental impacts by using strategies such as no-till farming to minimize erosion and planting cover crops to sequester carbon and reduce nitrogen and phosphorus run-off," he said. "But few farmers use all of the best available practices because there are limited incentives — and many disincentives — for them to do so. As the technology to make biofuels from cellulose is refined and commercialized, we believe it's crucial that the industry and legislators adopt policies that reward environmentally sustainable production practices for cellulosic biofuels. It's equally important for grain-based systems."

This is one of the first times such a large and diverse group of internationally recognized scientists have spoken with one voice on the issue. The 23 authors are some of the world's top ecologists, agronomists, conservation biologists and economists. The paper is the result of discussions that took place at a spring workshop on the environmental sustainability of biofuels sponsored by the Ecological Society of America.

"This was truly a collaborative effort," Robertson said. "There are strong and divergent scientific opinions on the sustainability of biofuel cropping systems. That this group, with its diverse backgrounds and professional experiences, can come to consensus is remarkable. Decision-makers should take notice."

In addition to Robertson, other authors are: Virginia H. Dale, Oak Ridge National Laboratory; Otto C. Doering, Purdue University; Steven P. Hamburg, Brown University; Jerry M. Melillo, Woods Hole Marine Biological Laboratory; Michele M. Wander, University of Illinois; William J. Parton, Colorado State University; Paul R. Adler, U.S. Department of Agriculture Agricultural Research Service; Jacob Barney, University of California-Davis; Richard M. Cruse, Iowa State University; Clifford S. Duke, Ecological Society of America; Philip M. Fearnside, National Institute for Research in the Amazon; Ronald F. Follett, U.S. Department of Agriculture Agricultural Research Service; Holly K. Gibbs, University of Wisconsin-Madison; Jose Goldemberg, University of São Paulo; David J. Mladenoff, University of Wisconsin-Madison; Dennis Ojima, The H. John Heinz Center for Science, Economics, and the Environment; Michael W. Palmer, Oklahoma State University; Andrew Sharpley, University of Arkansas; Linda Wallace, University of Oklahoma; Kathleen C. Weathers, Cary Institute of Ecosystem Studies; John A. Wiens, PRBO Conservation Science; and Wallace W. Wilhelm, U.S. Department of Agriculture Agricultural Research Service.

MSU's biofuels partnership with Michigan Tech was hailed by Gov. Jennifer Granholm when it was announced last year.

"Finding alternative sources of energy and fuel is going to be critical for our nation and can mean thousands of jobs for Michigan citizens," she said. "Our state has the assets to be a leader in this sector, and we are looking to our universities to provide the knowledge to get us there. I'm delighted Michigan State and Michigan Tech are going to be working together on research to refine fuel from forest products."

By combining their biofuel expertise, the universities are creating new collaborative research, outreach and economic development programs centered on fuels and energy made from forest biomass. The programs are overseen by an eight-member Renewable Fuels Working Group made up of four scientists from each university.

Members of the Renewable Fuels Working Group are, from Michigan State: Miller; Kyung-Hwan Han, MAES forestry researcher; Daniel Keathley, Forestry Department chairperson; and Chris Saffron, MAES forestry and biosystems and agricultural engineer-

ing scientist. From Michigan Tech: Margaret Gale, School of Forest Resources and Environmental Science dean; Jeffrey Naber, associate professor of mechanical engineering-engineering mechanics; David Shonnard, professor of chemical engineering; and Barry Solomon, professor of social sciences. Miller and Shonnard are co-chairpersons of the group.

Miller and Shonnard also were part of the contingent that traveled to Sweden with Granholm and members of the Michigan Economic Development Corp. last August. During the visit, Chemrec AB, a Swedish company, and the NewPage Corp., which operates a paper mill in Escanaba, signed a memorandum of understanding to explore developing a plant to produce fuels from woody biomass at the Escanaba paper mill. Miller maintains liaison with both Chemrec and NewPage to provide advice and research support.

With his colleagues on the Renewable Fuels Working Group, Miller hosted a biofuels summit in Escanaba in February attended by 50 representatives of businesses from all aspects of the forest-based bioeconomy and state and local government agencies.

The goal of the summit was to identify key questions the universities should address in three priority areas: feedstock production, feedstock supply chains, and feedstock conversion systems and integration. The summit also furthered the MSU-Sweden relationship by featuring presentations from four Swedish bioenergy researchers, who explained Sweden's transition to renewable fuels. Sweden has 69 million acres of forestland and an enormous forest products industry, so wood is the raw material of choice for Sweden's bioeconomy. Miller and other researchers believe that Michigan can use Sweden as a model when developing the state's forest-based bioeconomy.

In April, the working group released a list of five critical research and outreach needs:

- Complete a comprehensive, detailed inventory of forest-associated woody biomass feedstocks in Michigan.
- Establish sustainability guidelines for the management and use of forest-associated woody biomass based on sound scientific results.
- Aggressively expand technology and information transfer to forest landowners, bioeconomy industries and the general public in an accurate, unbiased and user-friendly way.
- Develop a supply chain model to be used to understand the effects of technological innovation on economic, biological and ecological factors throughout the system.
- Continue technological innovation in woody feedstock production, harvesting, transportation and conversion within the context of the supply chain model.

The working group is forming steering committees for each identified critical area. Work on some of the projects, such as the woody biomass feedstock inventory, has started.

Miller also maintains liaison with the Boston-based Mascoma Corporation, the company that plans to build the country's first cellulosic ethanol plant in the U.P.

Many areas in the state where forest product industries have declined may be perfect locations for cellulosic biofuel companies, Miller suggested.

"There are places in the state where the markets for forestry products have fallen away; the mills have shut down, and the infrastructure that was in place is starting to fall apart — the truckers and the loggers are gone," he said. "Southwestern Michigan is a good example of that. There would be no competition for small trees harvested there."

In places such as the U.P., where the forest industry remains strong, a company using trees to make fuel would be in competition with existing paper mills and other forest product businesses. Miller pointed out that the state grows more wood than it uses, so meeting the potential increased demand is certainly possible.

"But the infrastructure to harvest and handle trees for cellulosic biofuel production won't be put in place until there's a market," Miller said. "Policymakers need to look at what will entice biorefineries to locate here, as well as what will entice landowners to cultivate the types of trees needed for biofuel production. Policy could have a huge effect on the future of Michigan's bioeconomy — even more than technology. That's why we're working so hard to provide sound, science-based information to everyone involved.

"There isn't one thing that's going to make us energy-independent," Miller continued. "It's not as simple as substituting one fuel for another. Replacing all the gasoline the country uses with ethanol won't help us in the long run. If we turned every kernel of corn into ethanol, it would offset only about 12 percent of our gasoline use. We have to use less and be more thoughtful about how we use it. People are worried about using forests for energy, but we're not talking about turning forests into farms. By working together, we can do this intelligently in a way that benefits both the economy and the environment."

::: Jamie DePolo

Climate Change and Carbon:

What's in Stor(ag)e?

As the red rises in thermometers worldwide, MSU is positioning itself to play a leadership role in addressing emerging climate change issues and opportunities.

Whether you believe in prophecies that foretell of horrendous natural disasters signaling the "end of days" or that human activity is a major cause of global warming, scientific experts agree that the Earth's climate is changing.

Research shows that the world is now hotter than at any time during the past 1,000 years. Climate model projections summarized by the Intergovernmental Panel on Climate Change indicate that average global surface temperature will likely rise an additional 2 degrees to 11 degrees F by 2100.

Like global temperatures, average temperatures in the United States are on the rise. According to the U.S. Climate Change Science Program, the past decade was the warmest in more than a century. Along with temperature, increases in the number of heavy precipitation events and changes in snow cover have also been observed. Climate trend data paint a similar picture for Michigan and the Great Lakes region *(see box on page 25)*.

Scientific experts worldwide are predicting rises in sea levels, increased plant and animal extinctions, changes in species ranges, changes in agricultural yields, more intense and frequent storms, and increased drought, fire, flooding and heat waves if current climate trends continue.

"I was just shocked when I was in Scotland earlier this year and producers there were sharing with me what has happened in recent years as the winters have become warmer," said Steve Pueppke, director of the MAES and the Office of Biobased Technologies.

Scotland has a big potato industry. To keep their potato fields productive, producers rotate their potatoes with other crops such as carrots. In the past, winter frost killed the potato tubers left in the soil after harvest, but winters have now warmed to the point that these tubers survive and sprout the next year.

"We visited a field where farmers planted carrots and it was full of potatoes," Pueppke said. "It was astounding to see. This doesn't have anything directly to do with Michigan and we weren't even talking about climate change. This was just about, 'Look, my worst weed is my own potatoes because of the warmer winters.'"

The Heat is On

This is one of countless increasingly common examples of the kinds of changes occurring as global temperatures rise. So what's causing all the heat?

Scientific evidence shows that, since the beginning of the Industrial Revolution, there has been a steady increase in the emission of certain compounds known as greenhouse gases because of their ability to absorb and trap heat. As the concentrations of these gases — primarily carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_20) — increase in the atmosphere, they act like a big blanket, trapping heat and increasing the average temperature of the Earth's surface over time. This process is commonly known as global warming.

Steve Pueppke is director of the MAES and the Office of Biobased Technologies (OBT). An OBT-commissioned report found that MSU has some strong climate change research programs and the potential to be a national leader in the area.

In the United States, greenhouse gas emissions come primarily from the combustion of fossil fuels in energy use. According to the Energy Information Administration, carbon dioxide has increased by more than 30 percent over preindustrial concentrations in the atmosphere, causing an enhanced greenhouse effect. During the past 20 years, almost 75 percent of greenhouse gas emissions have been produced from the burning of fossil fuels by automobiles and power plants.

"It is becoming increasingly clear that managing these emissions is critical if we want to slow global warming and reduce the amount of carbon entering the atmosphere," Pueppke said. "Four or five years ago, we weren't talking about carbon, and certainly not in agriculture circles. But as concerns about the agriculture industry's contribution to global warming began to surface, we started exploring how agricultural lands might also be used to capture and store carbon."

Tracking Agriculture's Carbon Footprint

"Until global warming, there wasn't a compelling practical reason to understand how carbon accumulation and disappearance affect the global carbon cycle," said Phil Robertson, MAES crop and soil scientist and director of the Long-Term Ecological Research (LTER) Program in Agricultural Ecology at the W.K. Kellogg Biological Station. "Before, most of the research on soil carbon dynamics was a local soil fertility issue."

The LTER is a unique, multidisciplinary research program that provides the knowledge and expertise required to look at agriculture from a whole-systems perspective, from fuel use to greenhouse gases, Robertson said.

"With higher temperatures and longer growing seasons, there is even more potential for carbon to be lost from the soil as microbes turn soil carbon into CO_2," he said. "What we're ultimately trying to do is manage atmospheric climate change to keep CO_2 levels within acceptable limits."

Robertson said there are three principal approaches to reduce the carbon footprint of agriculture.

"One approach is to reduce the amount of fossil fuel and other carbon inputs used in cropping systems," he said. "We can do that by using biofuels instead of fossil fuels, using legume cover crops to reduce nitrogen fertilizer needs, using no-till practices to reduce fuel use, and by controlling pests with biocontrol measures rather than manufactured pesticides."

Carbon inputs also can be reduced by growing perennial rather than annual crops.

"Perennial crops such as hay and the cellulosic biofuel crops of the future have a very low carbon footprint," Robertson said. "They're planted once and then, once a year, they're harvested and fertilized, so there are substantially fewer inputs required in those systems."

A second way to reduce the carbon footprint of agriculture at the field level is carbon sequestration — the process of storing carbon, captured from the air, in soil.

"This can be done by using no-till to increase the amount of carbon held in soil," Robertson said. "We're not adding any more carbon to the soil; we're slowing down the decomposition of carbon-containing plant residues that are left in the field. Tilling the soil stimulates soil microbes to use residues quickly. By not tilling, we're slowing decomposition. We can also slow decomposition by planting legume cover crops whose leaves have more complex carbon molecules and so are difficult for microbes to break down. The bottom line is that carbon accumulates in the soil rather than being released into the atmosphere."

A third way is to reduce the non-CO_2 greenhouse gases that are produced in agriculture, Robertson said.

"Nitrous oxide is the principal one," Robertson said. "N_20 gas is produced naturally by soil bacteria and has 300 times the global warming potential of CO_2. In other words, keeping one ton of N_20 from going into the

atmosphere is equivalent to storing 300 tons of soil carbon from the standpoint of greenhouse gas management. So we can realize a big impact very quickly. N_2O loss can be reduced with better nitrogen management because it's mainly excess nitrogen in soil that bacteria turn into N_2O."

Methane is another non-CO_2 greenhouse gas produced in agriculture, but it's produced by animals rather than soil bacteria unless the soil is flooded.

"In both cattle and flooded soils, there are bacteria called methanogens that produce and emit methane as part of their normal metabolism. But because our soils are rarely flooded — we don't grow much rice in Michigan — we don't get much methane generation in Michigan field crops."

In fact, most of Michigan's cropland soils contain bacteria called methanotrophs that consume methane from the atmosphere rather than emit it, Robertson continued.

"Although this is cutting-edge research and still far from application, we know that, in most natural ecosystems, soil methanotrophs can take up a fair amount of methane," he said. "But when an ecosystem is cleared for agriculture, the soil's ability to consume methane is shut off — it's about 10 percent of what it was prior to being cleared. With research, we are trying to understand this lost methane consumption by asking what it is about agricultural soils that inhibits methanotrophs. Restoring a soil's lost capacity to consume methane could be another valuable way to reduce agriculture's carbon footprint."

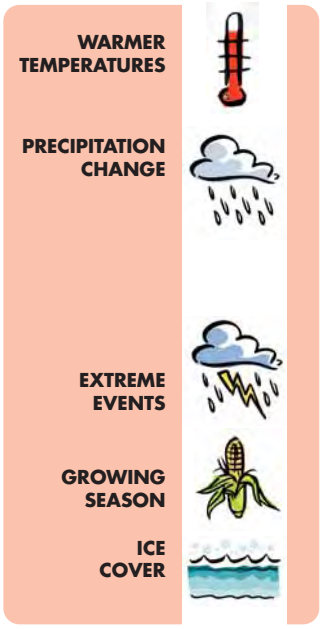
Phil Robertson's research through the Long-Term Ecological Research Program may help Michigan farmers participate in future carbon and greenhouse gas markets.

Robertson's research may help Michigan producers enter the carbon and greenhouse gas market of the future. In the next few years, he believes that Michigan growers will have the opportunity to participate in a "cap and trade" carbon system — a regulatory program that will limit new CO_2 emissions to those that can be offset by credits for carbon storage or greenhouse gas avoidance elsewhere. These credits could be earned by farmers practicing no-till, for example, and then sold to CO_2-emitting industries.

"Right now, there is a very active carbon market in Europe, where carbon trading is around $50 per metric ton today," Robertson said. "And as the cap on emissions comes down in order to meet new national CO_2 targets,

PROJECTED CLIMATE CHANGES IN MICHIGAN

(from Union of Concerned Scientists Web site)



A 5 to 10 degree F rise in winter and a 7 to 13 degree F rise in summer temperatures by the end of the century are projected.

Although average annual precipitation may not change much, an overall drier climate is expected because rainfall cannot compensate for the increase in evaporation resulting from greater temperatures. Michigan may see drier soils and more droughts. Seasonally, winter precipitation is expected to increase by 5 to 25 percent while summer precipitation is expected to remain the same.

Extreme heat will be more common, and the frequency of heavy rainstorms will increase and could be 50 to 100 percent higher than today.

The growing season could be 8 to 10 weeks longer.

Declines in ice cover on the Great Lakes and inland lakes have been recorded over the past 100 to 150 years and are expected to continue.

Sustainable Michigan Endowed Project: Welcome to Integration Station

All aboard! The Sustainable Michigan Endowed Project (SMEP) is ready to help place Michigan on a sustainable track to the future.

SMEP was created in 2002 with an endowment from the W.K. Kellogg Foundation. Its purpose is to share the viewpoints, methodologies, projects, leadership, research agendas and policy analyses of its members, and to serve as a catalyst for multidisciplinary research that contributes to healthier communities, economies and ecosystems in the Great Lakes state. SMEP also provides seed grants to MSU researchers for Michigan-specific sustainability research.

Jeff Armstrong, dean of the MSU College of Agriculture and Natural Resources, directs SMEP, and Sandra Batie, MAES agricultural economist and Elton R. Smith professor of agricultural and food policy at MSU, is responsible for fund oversight and implementation. Armstrong and Batie are co-architects of the project.

"Once we received funding, it took a couple of years to get started because we promised the Kellogg Foundation that the SMEP executive committee would be composed of endowed chairs," Batie said. "When the money was requested, one other endowed chair and I were on faculty, so we had to wait until the rest of them arrived."

Six colleges — Agriculture and Natural Resources, Arts and Letters, Communication Arts and Sciences, Natural Science, Social Science and Veterinary Medicine — house SMEP faculty and staff members in 11 departments and the School of Journalism.

The first order of business was to get SMEP members on board and settled.

"First we had to get acquainted and get comfortable working together," Batie said. "Then we had to figure out what we meant by sustainability, how it relates to research and engagement, and how SMEP can link them in a way that makes a difference to Michigan's future through informing dialogue and debate around critical sustainability issues in Michigan."

SMEP member Dave Beede, MAES animal scientist who holds the C.E. Meadows Endowed Chair, said his work around the efficiency and environmental sustainability of dairy production — including animal nutrition and dairy industry carbon contributions — is greatly informed by his involvement in the group.

"With SMEP, there's the social part, the economic part, the environmental part and the ecological part, but, more than that, there's an integration of all these aspects in our thought processes," Beede said. "Some of the research that SMEP members are doing and what they are thinking about are mind-bending. I pick up a lot of good ideas. SMEP provides the opportunity to think about and frame issues in the context of Michigan that you might not otherwise have."

Following two years of building upon its collective common ground and the discovery of insights within the group, SMEP turned its attention to how it could deepen its and others' understanding of the sustainability concept and make its work more cohesive. To date, the group has convened a number of dialogue sessions and three academies to further inform its efforts, both within and outside of the MSU community.

One of the areas that SMEP focused on to increase understanding of the complexities of sustainability is the bioeconomy.

"We've worked very hard to understand sustainability and its various elements," Batie said. "You can't think about sustainability in any great level of detail unless you have a specific topic, so we picked the bioeconomy."

Last fall, 90 experts from academia, industry, state government and non-governmental organizations attended a bioeconomy academy in Plymouth, Mich., to discuss how Michigan might restructure itself as a strong, emerging, sustainable bioeconomy and to address the question "What are the key issues of a bioeconomy that would place Michigan on a more sustainable trajectory?"

Attendees heard presentations and

the value of practices such as carbon sequestration will increase, and one source of those carbon credits is likely to be agriculture.

"We need to ensure that Michigan farmers have opportunities to enter the carbon trading market when it becomes available," he continued. "Reducing methane emissions from cattle and dairy operations is one opportunity. Soil carbon sequestration is another opportunity, and we're working to provide the science needed to allow N_2O credits to become another."

By working now to curb heat-trapping emissions, Robertson is confident that Michigan agriculture can help reduce both the pace and the magnitude of global warming and be more successful in adjusting its agricultural, environmental and socioeconomic approaches to cope with the changing climate.

"Even incremental decreases in the emissions of CO_2 will bring benefits," he said.

Carbon Storage: Acres of Opportunity

One way to increase the amount of carbon that agricultural land can sequester or store is through tillage management. Several methods of tillage are used in crop production: conventional tillage, minimum or reduced-tillage, and no-till.

MAES crop and soil scientist and Extension forage specialist Doo-Hong Min has spent the past three years studying the effect of various tillage practices on carbon sequestration and greenhouse gas reduction in forage-based dairy systems.

participated in scenario building and open space forums where they discussed issues such as envisioning Michigan's bioeconomy in a global context, defining Michigan's role as a steward of the Great Lakes, developing a carbon framework for a Michigan bioeconomy and examining the meaning of rural regional sustainability.

"It was clear at the end of this academy that sustainability has to be an ever-increasing part of every business decision maker's approach to the world," said Chris Peterson, MAES agricultural economist who holds the Nowlin Chair of Consumer Responsive Agriculture. "As the population grows and resources become more stretched, each and every one of us is going to bump into limits that will be increasingly hard to escape unless we are working together and really focused on sustainability.

"Beyond the bioeconomy, it is also clear that major food firms and agrifood businesses in the world are evolving strategies to be more sustainable," continued Peterson, who is also the director of the MSU Product Center for Agriculture and Natural Resources. "Having SMEP here at MSU provides the opportunity to create new relationships with these corporations to help them accomplish this."

"I don't know of anywhere else in the nation that has anything like SMEP," Batie said. "It's a high-powered think tank that's multidisciplinary and involves people who do extensive engagement and research who then come together and relate it to Michigan. It certainly has implications nationally, internationally and globally, but the SMEP framework starts with Michigan and works outward."

"SMEP has brought together a constellation of top faculty members strategically focused in key areas of sustainability," Armstrong said. "The synergy and impact of this collective expertise have been enormous, as these academic stars have collaborated and cultivated scholarship across departments, disciplines and colleges."

But is there a way to measure SMEP success?

"SMEP can consider itself successful when there is a richer civil discourse about sustainability on campus and between campuses, businesses, governments and non-governmental organizations," Peterson said. "In part, SMEP's success can't be measured until we can look back 10 years from now and ask if Michigan a more sustainable place than it would have otherwise been by what we did."

Batie agreed.

"SMEP's success will depend on the long-term engagement of all stakeholders in the process to develop a feasible approach to conserve the natural environment while stimulating a sustainable business environment. That's the ticket."

SMEP-funded Grants

Measurement and Interpretation of the "Heartbeat of the City" through its Acoustic Signatures — Stuart Gage, Department of Entomology

Integrating Ecological and Social Dimensions for Sustainable Management of Michigan's Jack Pine Resource — David Rothstein and Larry Leefers, Department of Forestry, and Deborah McCullough, Department of Entomology and Department of Forestry

Enhancing Michigan's Rural Communities with a More Sustainable Agricultural Sector — Suzanne Thornsbury, Department of Agricultural, Food and Resource Economics

Assessment of Environmental Variables and Anthropogenic Impacts to Microbial-induced Egg Mortality of Lake Sturgeon: An Imperiled Native Great Lakes Fish — Kim Scribner, Department of Fisheries and Wildlife and Department of Zoology, and Terence Marsh, Department of Microbiology and Molecular Genetics

Graduate Education in Sustainability: Socioeconomic Well-being in Michigan and the Genuine Progress Indicator (GPI) — Robert Richardson, Department of Community, Agriculture, Recreation and Resource Studies

::: Val Osowski

"This research is important to Michigan because alfalfa is a premium forage for the state's dairy industry and because there hasn't been any research done that looks at carbon change differences between no-till and conventional tillage practices in alfalfa-based forage systems," Min said.

Min planted four combinations of alfalfa and alfalfa-grass mixtures that are common Michigan livestock feed forages: alfalfa, festuolium (a combination of meadow fescue and either perennial ryegrass or Italian ryegrass), orchardgrass and timothy. Test plots were planted in 2006, and yield and soil-carbon change data were collected and analyzed in 2007 and 2008.

"The downside of carbon sequestration research is that it's not something that can provide definitive answers in two or three years — it takes decades or centuries to accurately discern how much carbon is being captured and stored long term. But we wanted to set a baseline to build upon in the future."

In other tillage studies around the country, researchers are finding that no-till definitely sequesters more carbon than conventional tillage practices, Min said.

"That makes sense because conventional tillage practices disturb the soil several times, oxidizing the soil organic matter and, in so doing, releasing a lot of CO_2 into the air," Min said. "In no-till situations, soil organic matter and crop residue are not disturbed, so the carbon in organic matter can be stored in the soil and become more stable over time. Research findings have

shown that no-till practices can help reduce carbon releases in agriculture by about 20 percent. Another benefit of no-till is that farmers can save a lot on fuel costs from reduced equipment use and further reduce the amount of carbon released into the air."

MAES forage scientist Doo-Hong Min conducts research on tillage practices and carbon sequestration at the Upper Peninsula Experiment Station in Chatham. In the future, he'd like to expand his research to collect greenhouse gases continuously during the growing season.

As a forage specialist, Min is also interested in carbon sequestration and grazing practices.

"With grazing, more carbon is sequestered in the soil because animals produce and deposit a lot of manure on pastures," Min said. "Grazing animals also serve as a natural mower, so there's no need for farm equipment or fossil fuel use in managing these pastures. Another benefit is that residual forage plant materials such as leaves, stems and roots die on pasture and are stored over time as a stable organic carbon in the soil."

Min and his team want to expand their research to include the monitoring of CO_2, CH_4 and N_20 emissions in no-till and conventionally tilled plots.

"We want to collect greenhouse gases continuously during the growing season using a chamber installed on the ground that has a vial and syringe that sucks up greenhouse gases leaving the soil," Min explained. "These gases are very changeable. That's why, rather than random or occasional sampling, we want to do continuous monitoring."

Although Min concedes that such an approach is expensive and labor-intensive, the ability to correlate soil carbon exchange with these other greenhouse gas emissions is critical to developing effective greenhouse gas reducing practices.

"With data from this type of research, we could develop mathematical models that show us whether a particular tillage or cropping practice was a significant contributor to the reduction of greenhouse gas emissions and/or sequestering carbon," he explained.

Whatever aspect of agriculture is being explored to help reduce greenhouse gas emissions into the environment, researchers from across many disciplines must work together to develop solutions and strategies that will be effective and sustainable, Min emphasized.

"In order to be successful, carbon sequestration research must be multidisciplinary and integrated," Min said. "Forage scientists, animal scientists, soil scientists, agricultural economists and rural sociologists are all part of addressing the issues we face. We have to look at the big picture rather than just a single aspect. That's very important."

A New Climate for Leadership

The sky is the limit when the topic is the complexities and nuances brought on by global climate change.

"The broad, disciplinary nature of climate change research requires that a wide range of expertise and institutional support be applied if MSU intends to strengthen its role in national and international climate research," Pueppke said. "MAES researchers have a deep expertise in plant and agricultural sciences across a wide range of specialties that can provide solutions to increase land-based carbon absorption and reduce carbon releases. If MSU is going to play a leadership role in climate change, we need to build on this capacity."

In early 2008, the MSU Office of Biobased Technologies (OBT) engaged Shepherd Advisors to gain a better understanding of the strengths and potential opportunities in climate change research for MSU, particularly as they relate to efforts to advance the bioeconomy.

"The OBT is increasingly exploring the roles of agriculture and the bioeconomy in addressing climate change solutions and seeking to better understand the role of MSU in addressing climate change challenges," Pueppke said.

Shepherd Advisors inventoried programs and leadership in climate change research, evaluated external stakeholders' needs and identified potential opportunities for MSU to become a stronger univer-

sity contributor in researching and finding solutions for mitigating and adapting to climate change. Its report, presented to the OBT in August, stated that MSU has strong competitive advantages in a number of research niches, such as regional impacts and modeling, integrated analysis and forecasting, human-natural systems and solutions/adaptation science. The report also stated that MSU has significant opportunities to address the solutions and management aspects of climate change scenarios and to help make climate change science understandable and applicable to real-world decision makers.

"MSU has a growing group of successful researchers that are carving out a niche to address the physical, biological and chemical understanding of climate processes, as well as the social, political and business applications that are critical to successfully adapt to and diminish the effects of climate change," Pueppke said. "The Shepherd Advisors report confirms that MSU has the potential to play a leadership role in addressing the solution and management aspects of climate change. The question now is how we further address this key issue for Michigan and the world."

Weathering Climate Change

To successfully navigate the opportunities and challenges posed by the changing climate, Pueppke believes it is essential to build on such research.

"The broad, multidisciplinary nature of climate change research requires a wide range of expertise and institutional support," Pueppke said. "We at MSU have made the argument that our 150 years of knowing how to work with the agricultural community positions us perfectly as something new comes down the pike. There is a lot of promise and potential in the research being done in the climate change and bioeconomy arenas that can contribute to Michigan's economy and help us adjust to the shifts that climate change brings about."

If climate change research is going to be effective and add value to Michigan's economic and environmental future, the results need to be disseminated to farmers and the public, Min said.

"If research is done only for its own sake, there isn't an appeal to a lot of people," Min said. "We need to get this information out. Otherwise, farmers will tend to farm as their ancestors did, and many of them won't change unless there is a compelling reason to move from these 'tried-and-true' practices. Disseminating this information will also help consumers understand why certain things are happening and to think more seriously about reducing carbon emissions from their cars or homes — it can have a domino effect on people's way of thinking."

Providing farmers with incentives to transition from conventional practices to more economically and environmentally sustainable practices is also critical in addressing climate change issues related to agricultural land use, Robertson said.

"Farmers aren't going to adopt new practices unless it makes economic sense, and it's not going to make economic sense unless there are some compelling incentives," Robertson said. "The bottom line is that if we are serious about promoting practices that reduce greenhouse gases in agriculture, we need to be serious about creating an infrastructure that pays for them as well."

There is credible evidence that our climate is changing and that if projected trends don't change, things will happen that have long-term impacts and will be extraordinarily difficult to undo, Pueppke said.

"What folks should be concerned about is that their children and grandchildren will have to deal with the consequences of climate change," he said. "On the list of things to worry about, we, understandably, tend to focus on the mortgage, gas prices and the war. That makes it a little tough to insert, 'By the way, the atmosphere is going to be too warm in 2070,' but we really need to keep that in mind. Reliable, science-based information on how climate affects Michigan's agricultural and bioeconomy industries currently will help us design and create new products and technology as we consider how to respond to future changes in climate."

::: Val Osowski

home-grown fuel

MAES research to demonstrate the feasibility of local, small biodiesel cooperatives allows MSU to harness the power of canola.

MAES chemical engineering researcher Dennis Miller stands on the floor of the MSU Biorefinery Training Facility at the Michigan Brewing Company (MBC) in Webberville. He holds a glass jar filled with tiny, black spheres about the size of poppy seeds. Though small, each canola seed is gushing with oil — a single seed is more than 40 percent oil, making canola one of the world's most oil-dense crops. In comparison, a soybean is only 18 percent oil and a kernel of corn is 4 percent oil. Miller and other scientists believe canola has the potential to play a dominant role in unclenching the grip that imported petroleum-based fuels and chemicals have on Michigan, as well as offering growers new markets for a high-value crop.

"Just about all the food-grade canola oil used in this country — about 1.5 billion pounds — is imported," Miller explained. "The point of this research is to show farmers that canola can be successfully grown as a cash crop — that there are multiple markets for it — and then demonstrate that local co-ops can crush the seed and process the oil into biodiesel, which can then be used to power tractors and other equipment. We can actually close the loop and produce fuel entirely within the state."

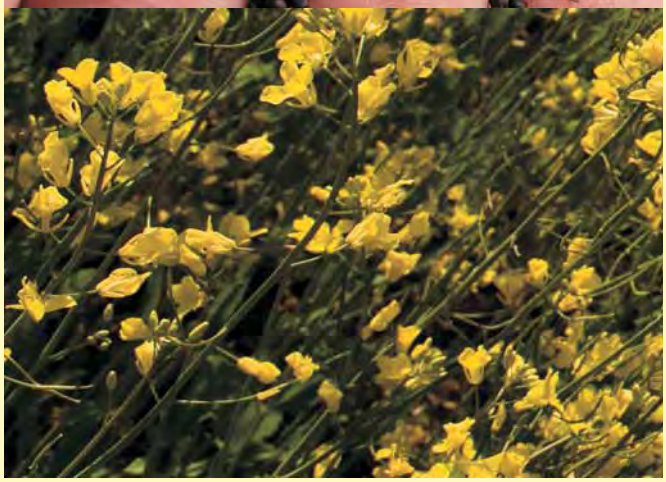
Growing Yellow to Go Green

A relatively young crop, canola was developed in the 1970s by Canadian plant breeders, who removed non-nutritional components from rapeseed. Officially, rapeseed and canola are different crops, though the names are used interchangeably at times. An annual field crop, canola has varieties that can be planted in the fall or the spring and produces fields full of sunny yellow flowers on plants about 4 or 5 feet tall. The flowers produce 3-inch seed pods, with about 30 seeds in each pod.

The name "canola" comes from "**Ca**nada" and "**o**il, **l**ow **a**cid." Canola oil is very low in saturated fat and has become a popular diet choice for people looking to trim their saturated fat intake. After the canola seeds are crushed and the oil is extracted, the leftover meal is used for animal feed, pet food and fertilizer. The seeds also can be burned in a stove much like a corn stove.

Michigan farmers grew only a few hundred acres of canola in 2007, a relatively miniscule amount compared with the hundreds of thousands of acres of corn, wheat, soybeans, sugar beets and dry beans planted in the state.

"We were up to about 15,000 acres of canola in Michigan in the late 1980s," explained Russ Freed, MAES crop and soil sciences researcher, who's been



Top: **MAES scientist Dennis Miller is working on a project to show Michigan growers how canola (in the field around him) can be grown and then crushed locally, processed into biodiesel (as in the flask in his hand) and used to fuel farm equipment.**

Middle: **Canola seeds pack power into a small package. Each seed is more than 40 percent oil (10 times the amount in corn).**

Bottom: **Canola has varieties for both fall and spring planting. A field of 20 acres can yield about 11 tons of seed.**

Top: **Jim Peterson, of MSU Landscape Services, tested in his equipment some of the biodiesel that Miller and his team made. Tests continue through the fall.**

Above: **(left to right) Lars Peereboom, Dan Blackledge and Dennis Miller with sacks of canola seed waiting to be crushed at the MSU Biorefinery Training Facility at the Michigan Brewing Company. The scientists have been making 50-gallon batches of biodiesel to test various procedures.**

MAES crop and soil scientist Russ Freed has been breeding canola for 8 years. One of his goals as a breeder is to develop varieties that can take advantage of canola's hybrid vigor, which will significantly increase yields.

working on breeding canola for eight years. "Our problem is that we don't really have a market for the crop in Michigan. The closest processing plant is in Windsor, and much of the canola was grown in the northern part of the state. The farther farmers have to truck a crop to sell it, the less money they make on it, so canola production fell off quite a bit. We want to make it easier for farmers to market their canola. With corn and soybeans, farmers can go to a local elevator. With canola, the crop has to be shipped out of state."

But canola's high oil concentration makes the crop especially attractive to scientists and business entrepreneurs looking for plant oils that can be processed into alternative fuels such as biodiesel, as well as other biochemicals and products.

Miller was one such scientist, and Dan Blackledge was one such entrepreneur. A former software company owner, Blackledge had sold that business and was looking to start a biodiesel company. In doing research on the MAES Web site, he read an article about Miller's biofuel research and proposed a meeting. Over lunch in 2007, the two shared ideas about how Michigan could develop a biofuel market that would be profitable for both farmers and processors. The meal ultimately resulted in a research project on making biodiesel from canola that just received a second year of funding from the MAES. Miller and Freed are the lead investigators; Blackledge serves as project manager.

"The focus of the project's second year is marketing, for both food and biofuel uses of canola," Blackledge explained. "One of my jobs is to find all the canola oil users in Michigan, no matter if the oil is being used for food or fuel. We want to connect with all of them so growers have options."

"Canola has tremendous potential," Freed added. "Michigan is a great place to develop that market."

Making Canola Attractive to Growers

Because canola acreage was so low in Michigan, one of the project's aims in its first year was to convince Michigan growers that the crop could be grown profitably. Blackledge worked with Jerry Lindquist, MSU Extension (MSUE) director in Osceola County, and George Silva, MSUE director in Eaton County, to recruit farmers in the two counties to plant 130 acres of winter canola and 70 acres of spring canola. Winter canola, like winter wheat, is planted in mid-September and harvested in July. Spring canola is planted in spring after the threat of frost has passed and harvested in early September. Winter canola has about 30 percent higher yield than spring canola, Freed said.

"Canola can take advantage of hybrid vigor," he said, "but there aren't really very many varieties that are exploiting that yet. Once we do that, there will be significant increases in yields, which will be a plus for growers."

Freed helped the growers decide which varieties of canola to plant, and the project provided the seed. Blackledge planted 20 acres of canola on his farm in Marion and lost his entire winter crop this year.

"So I have firsthand experience with some of the pain growers feel," he said. "There also was significant hail damage in Eaton County that caused a reduction in yields."

Despite the damage, the first field of 20 acres yielded 11 tons of seeds. This past summer, Miller and Lars Peereboom, a visiting

Julie Jensen *(left)* and Zachary Thompson, both chemical engineering undergraduate students, prepare equipment for processing canola oil at the test facilities at the MSU Biorefinery Training Facility. The students get hands-on experience with the entire biodiesel processing procedure.

chemical engineering research associate, established crushing and biodiesel processing facilities at the MSU Biorefinery Training Facility. They also worked out transportation and storage logistics for the canola seed.

"We want to make sure everything works and offer recommendations on how to do things," Peereboom explained. "So we bought and set up a crusher and figured out how to make it run optimally. Any biodiesel we make has to meet ASTM [American Society for Testing and Materials] standards, so we figured out the best way to do that. Food-grade canola oil requires additional processing and filtering, as well as special cleaning procedures for the equipment. Our goal in the first year was to establish operating parameters, and in the second year, we'll test and confirm the food-grade parameters. This way, communities or co-ops can use what we're doing as a model — we're working out the bugs for them."

Miller said the crusher can smash 1 ton of seeds per day and estimated that 1 ton of seeds would produce 100 gallons of biodiesel. The scientists can make up to 250 gallons at a time but have been making 50-gallon batches to test various procedures. Undergraduate chemical engineering students helping with the biodiesel production process are gaining valuable hands-on experience.

"It's really fantastic that we have this facility at MBC so the students can actually work with the equipment, crush the seeds and make the biofuel," Miller said.

The canola meal left after the seeds are crushed, known as "cake," is collected and used as animal food on campus. MSUE director Silva is distributing some of the meal to Eaton County farmers in the project. The researchers also have been making biodiesel from waste grease collected from MSU kitchens by Kruger Commodities, one of the university's recycling partners.

"We've been testing different processing methods, again to evaluate the various techniques and the quality of the biodiesel," Miller added. "MSU Grounds has a mandate to be greener, so they're looking at using more biofuels. They're already using B5 [a blend of 5 percent biodiesel and 95 percent petroleum diesel] in some equipment and have tried B20 but had some problems with it. They're now testing out the biodiesel that we made."

All the researchers agreed that biodiesel is not the optimal fuel for Michigan — it becomes very thick at cold temperatures and won't flow through engines.

"But this is also why it's a good fuel for farming," Miller said. "It's ideal for equipment that runs all day, like a lot of farm equipment does. And since most Michigan farm work is done in the spring, summer and fall, when the weather is moderate, the fuel's viscosity isn't an issue."

According to Miller and Peereboom, the biggest complaint about biodiesel is that it cleans gunk out of fuel tanks, which then clogs the fuel filter.

"If you have a newer engine, biodiesel will keep it clean," Miller explained. "It's an excellent degreaser. We tell people who are going to use biodiesel for the first time in an older engine to pick up a couple of extra fuel filters because they're probably going to have to replace the one they have."

A Fuel for Michigan, of Michigan

As the researchers concluded the first year of research in September 2008, they had successfully shown that canola could be grown, crushed, processed and made into biodiesel with a profitable return for farmers. A large portion of the canola oil and the biodiesel made at the Webberville facilities will return to campus for other research projects on biofuels, bioplastics and fuel additives. Bobby Mason, MBC owner, will use some of the biodiesel to fire the company's beer tanks. The MSU Grounds Department will continue to use some of the biodiesel in its equipment. Farmers who participated in the project by growing the canola have the option of using some of the biodiesel in their tractors and other equipment.

As the second year begins, the researchers would like to have 600 acres of canola planted for the project. Blackledge is again working with Lindquist and Silva to recruit growers and plans to double his own canola plot to 40 acres.

As food prices have gone up in the past year — the price of canola oil is currently 65 cents per pound — farmers can make more money selling canola to be processed into food-grade oil rather than biodiesel. But the researchers believe that the biodiesel market will rebound and get stronger.

"We think the market will shake out a little bit," Blackledge said. "As more canola is planted, we will learn more about where the highest value markets are and be better able to take advantage of them. But it's also an issue of fuel independence."

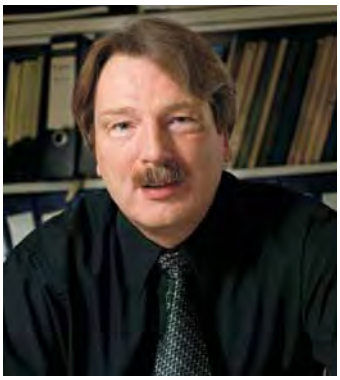
"Almost all the original biodiesel business models were based on canola oil that cost 30 cents per pound," Freed added. "So it's more profitable for farmers to sell to food processors. But there's more to life than economic gain. Just about every farmer is environmentally responsible, and many believe that using biodiesel, especially biodiesel that is wholly from Michigan, is a good way to uphold this responsibility."

"Everyone is very pleased with the results so far," Miller said. "We anticipate the second year being even more successful. We hope to be able to give any interested groups a blueprint of how they can do this at the local level."

::: Jamie DePolo

Research *in the news*

MSU Scientists Find New Gene that Helps Plants Beat the Heat



Christoph Benning

MSU plant scientists have discovered another piece of the genetic puzzle, one that controls how plants respond to high temperatures. That may allow plant breeders to create new varieties of crops that flourish in warmer, drier climates.

The MSU researchers found that the gene bZIP28 helps regulate heat stress response in *Arabidopsis thaliana*, a member of the mustard family used as a model plant for genetic studies. This is the first time bZIP28 has been shown to play a role in heat tolerance. The research was published in the Oct. 6 issue of the Proceedings of the National Academy of Sciences.

"We also found that bZIP28 was responding to signals from the endoplasmic reticulum, which is the first time the ER has been shown to be involved with the response to heat," said Robert Larkin, assistant professor of biochemistry and molecular biology and corresponding author of the paper. "We're finding that heat tolerance is a more complex process than was first thought."

Previous research has shown that the nucleus, the "brain" of the cell, and cytosol, the fluid inside cells, play a role in how plants respond to heat. The endoplasmic reticulum, a membrane in the cell that consists of small tubes and sac-like structures, is mainly responsible for packaging and storing proteins in the cell.

Christoph Benning, MAES biochemistry and molecular biology scientist and a member of the research team, said the scientists were looking for genes that turn other genes on and off and are tied to cell membranes. These membrane-tethered gene switches are seen in animals but hadn't been studied in great detail in plants.

"The bZIP28 protein is anchored in the endoplasmic reticulum, away from its place of action," Benning explained. "But when the plant is stressed by heat, one end of bZIP28 is cut off and moves into the nucleus of the cell, where it can turn on other genes to control the heat response. Understanding how the whole mechanism works will be the subject of more research."

Plants with an inactive bZIP28 gene die as soon as temperatures reach a certain level.

Other scientists on the research team are Federica Brandizzi, MSU associate professor of plant biology and member of the Plant Research Lab, and Hangbo Gao, former MSU postdoctoral research associate.

The work was sponsored by the MSU-DOE Plant Research Lab. Benning's research also is supported by the Michigan Agricultural Experiment Station.

MAES Scientist Named Editor of International Plant Research Journal

In recognition of his ability to recognize and review original research, as well as his own scientific contributions, Christoph Benning, MAES biochemistry and molecular biology researcher, has been named the next editor-in-chief of The Plant Journal, an international journal devoted to publishing original research papers on fundamental plant biology problems.

"It is an awesome responsibility but also a tremendous opportunity to serve the scientific community in this way," Benning said. "The Plant Journal is one of the top three peer-reviewed journals in the plant sciences. I've served on the journal's editorial board for almost seven years and recently co-edited a special issue of The Plant Journal on using plant biomass for biofuels and biomaterials, which gave me additional insights into the inner workings of publishing."

Benning's research focuses on lipid metabolism in plants, algae and photosynthetic bacteria. He is using his basic research discoveries to develop new biofuel crops.

A prolific researcher, author, presenter and mentor, Benning also holds a number of patents and invention disclosures. He also serves on the editorial board of The Journal of Biological Chemistry and is former monitoring editor of Plant Physiology. He also serves on National Science Foundation review panels.

"I have worked with Christoph for several years and have been impressed by the breadth of his knowledge," said Harry Klee, current editor-in-chief of The Plant Journal. "It is essential that the editor-in-chief be able to understand and evaluate work covering the breadth of plant biology. I am very comfortable turning over this responsibility to Christoph."

Benning came to MSU as an assistant professor of biochemistry and molecular biology in 1998 and was named professor in 2005. He received his doctorate in genetics from MSU in 1991 and his master's diploma in biology in 1986 from Albert-Ludwigs-Universität in Freiburg, Germany.

Benning will begin serving as co-editor with Klee in 2009 and will become sole editor-in-chief in 2010.

To access the special issue of The Plant Journal that Benning co-edited, go to http://www3.interscience.wiley.com/journal/120090038/issue.

MAES Scientist to Create Genomic Clearinghouse for Biofuel Crops

A Michigan Agricultural Experiment Station scientist is creating an easily accessible, Web-based database of genomic information on crops that can be used to make ethanol, thanks to a joint grant from the U.S. departments of Agriculture (USDA) and Energy (DOE).

"Ultimately, this will allow us to create better biofuel crops," said C. Robin Buell, MAES plant biology researcher. "Right now, about half of the biofuel crops don't have genomic databases, and the ones that do are in many different places and are annotated differently, which makes it difficult to compare and use the information."

Buell and Kevin Childs, postdoctoral researcher in her lab, will use the $540,000 grant to centralize the genomic databases, create uniform annotations (notes or descriptions of the genomes), provide data-mining and search tools, and provide a Web site for scientists from around the world to access the databases. They will also regularly update the information. Genomic databases contain information on the molecular biology and genetics of a particular species.

"Our biofuel genomic database portal will include information on any crop that can be used to produce cellulosic ethanol, including all the grasses — such as corn, rice, maize and wheat — and other biofuel

species such as poplar, willow and pine," Buell explained. "This will save researchers a lot of effort, so we expect it to be a valuable resource for scientists at MSU and around the world."

"Cellulosic biofuels offer one of the best near- to mid-term alternatives we have, on the energy production side, to reduce reliance on imported oil and cut greenhouse gas emissions while continuing to meet the nation's transportation energy needs," said Raymond Orbach, DOE undersecretary for science. "Developing cost-effective means of producing cellulosic biofuels on a national scale poses major scientific challenges — these grants will help in developing the type of transformational breakthroughs needed in basic science to make this happen."

MSU Receives $5.4 Million Specialty Crop Grant

Dave Douches

Michigan State University has received a four-year, $5.4 million grant to improve the quality, yield, drought tolerance and disease resistance of potatoes and tomatoes, two of the world's most important crops and significant contributors to Michigan's $67 billion agricultural economy.

The MSU grant is the largest of the nine grants awarded by the U.S. Department of Agriculture (USDA) Cooperative State Research, Education and Extension Service (CSREES) National Research Initiative Plant Genome Program — it represented more than half of the $9.4 million award total.

Led by two MAES scientists — Dave Douches, crop and soil sciences researcher, and Robin Buell, plant biology researcher — the project aims to use emerging DNA sequence data with basic research data to improve potato and tomato varieties. Other researchers, educators and Extension specialists from MSU, Ohio State University, Cornell University, the University of California-Davis and Oregon State University are also working on the project.

"Potatoes and tomatoes are important vegetable crops that are challenged by disease and pests," Douches said. "Enhancing our ability to tackle these problems from a genetic angle will improve the quality of produce for consumers and processors and provide potato and tomato growers with varieties that are more pest- and disease-resistant."

"Pests and diseases continue to be a serious problem in Michigan potato production," said Ben Kudwa, executive director of the Michigan Potato Industry Commission. "Michigan potato growers continue to incur significant financial losses as a result of pests such as the Colorado potato beetle and diseases such as potato late blight and potato scab when intervention measures to control them are unsuccessful. This level of funding, combined with the expertise and leadership of Dave Douches and the rest of the project team, will help ensure that the potato and specialty crop industries remain strong and viable in Michigan and beyond."

The MSU program will be administered under the Cooperative Agriculture Project (CAP), a USDA-CSREES program that funds multiyear, multi-institutional collaborative projects. Past CAP programs have focused on rice, wheat, barley and conifers.

"This is the first non-grain/forestry project funded under the CAP program and the first project that's working on two species," Buell said. "The potato is the most important vegetable worldwide, and the *Solanaceae* family — which includes potatoes, tomatoes, peppers and eggplants — is the most important vegetable family, period, so this represents a very important and significant investment by the USDA."

The project team also will develop a course for graduate students, offer workshops and practical training for plant breeders, and create online networking resources for plant breeders, seed industry professionals, Extension specialists and practitioners.

"It is extremely gratifying to see this innovative and important research be acknowledged and supported by the USDA, and it is a testament to the caliber of researchers we have here at MSU," said MAES director Steve Pueppke. "Research funding at this level is essential to improving agricultural efficiency and sustainability and addressing critical and emerging national priorities and needs."

Playing It Safe — MSU Research Shows that People Avoid Risk in the Face of Mounting Economic Losses

Joe Arvai

Individual investors are liquidating their holdings at record levels as financial markets sink, often absorbing losses to avoid possibly worse pain later. Contradicting the counsel of many financial advisers, it also flies in the face of widely accepted behavioral theory and reinforces recent research by Michigan State University scientists.

In short: People suffering lengthy periods of economic loss tend to swallow their losses, cash out and hunker down. Nobel Prize-winning "prospect theory," meanwhile, predicts that people will be more likely to gamble to recoup their losses.

"Our results challenge prospect theory," said Joe Arvai, associate director of the MSU Environmental Science and Policy Program and MAES scientist. "As people are pulling money out of their retirement accounts and choosing the relatively safe, risk-averse option of putting it in a bank, they're validating our results."

Arvai is a member of the MSU Cognitive Science Program. In research he published last December with Louie Rivers, MSU assistant professor who studies decision making and risk, people were given money to play a simple game. It was set up so people repeatedly lost money. Prospect theory predicts that players would gamble to recover their losses so after the game ended, players were given an opportunity to enter a lottery in which they could win back their money.

"What we found was that people didn't like gambling in this context," Arvai said. "They were very averse to risk and preferred

to take a sure loss over a big gamble to get their lost money back."

"In today's economic situation, leaving money in a 401(k) account is a gamble, the higher-risk option," Rivers explained. "The safer but costly approach is to pull the money out and that's what many people seem to be doing."

Record redemptions from equity mutual funds and flight from bond funds have been recorded the past two months, while cash is being stashed in what one financial analyst called "mattress-equivalent savings vehicles" by worried investors.

The MSU research was funded by the National Science Foundation. Arvai's research also is supported by the Michigan Agricultural Experiment Station.

MSU Leverages Public, Private Funds for Farm Waste-to-Energy Project

Steven Safferman

State and foundation grants exceeding $3 million will assist Michigan State University researchers in developing technology for small farms to turn animal waste into usable heat, electricity and other valuable products.

MSU's planned Anaerobic Digestion Research and Education (ADRE) Center will consolidate new and existing programs in a 3,280-square-foot building south of the main campus, at MSU's expanding farm animal and environmental research complex.

Researchers aim to develop and commercialize turnkey digester/microturbine modules for affordable waste-to-power systems for small and mid-sized farms.

"The initiating of the center completes our vision for a continuum of research capabilities from theoretical calculations to laboratory-scale, bench-scale, pilot-scale and farm-scale anaerobic digestion research," said Steven Safferman, the center's director and MAES biosystems and agricultural engineering researcher.

A two-year, $1.5 million Michigan Public Service Commission research grant "recognizes MSU's strong capacity to address the critical issues of sustainability of animal agriculture and the need for renewable energy and economic development in Michigan," department chairperson Ajit Srivastava said.

An additional three-year grant totaling $1.5 million from a private southeastern Michigan foundation to build the facility and fund new programs "is an excellent example of how universities and foundations can work together to address critical issues of society such as food, environment and energy," Srivastava added. (The foundation prefers to remain anonymous.)

Farm waste management is a growing issue because of concerns over food contamination, pollutant runoff, odor and, most recently, greenhouse gas emissions. Petrochemical cost spikes, meanwhile, have added to farmers' costs for fertilizer and fuel. The MSU ADRE Center will develop ways to efficiently convert manure liquids into methane for heat and electricity while extracting fiber for soil enrichment or ethanol manufacture and water for irrigation. Other valuable outputs could include animal feed and algae, which can be processed into biofuels.

Anaerobic digestion is not a new concept and has been applied in recent years by some large dairy farms to generate power. Development of scalable modular systems could allow smaller farms, those with fewer than 500 head of cattle, to convert waste into valuable resources. Despite the loss of two-thirds of U.S. dairies since 1988, such smaller operations still account for 53 percent of the 71,510 remaining dairies and 48 percent of U.S. milk production, according to the U.S. Department of Agriculture.

"The enhanced revenues and reduced pollution from the proposed system will significantly improve the quality of life and health of residents in rural communities and turn an environmental and economic liability into a public and private asset," said project lead investigator Wei Liao, an assistant professor of biosystems and agricultural engineering. "It is our hope that success at this level will lead to extensive applications of similar technology throughout Michigan and the nation."

The ADRE Center also is expected to conduct contract testing of related equipment and processes to help support itself, and to house a recently created farm energy auditing program that could conduct digester/power system feasibility studies for dairy clients. The center is slated for completion by mid- to late 2009.

The farm energy audit program is supported by a two-year, $250,000 grant, also from the private foundation. MSU will contribute another $230,000 toward the cost of managing and operating the ADRE Center.

MAES Scientist Honored for Contributions to Furthering the Scientific Community

Decades of service and dedication to the scientific community have earned Kay Gross, MAES plant biologist and director of the MSU W.K. Kellogg Biological Station, a prestigious national ecology award.

Gross received the 2008 Distinguished Service Citation from the Ecological Society of America (ESA) on Aug. 4. The award recognizes Gross' commitment and service to the ESA as well as her dedication to furthering the scientific community.

"We are very pleased to see Kay recognized for her outstanding work and contributions," said MAES director Steve Pueppke. "She is a testament to the high caliber of researchers with whom we are privileged to work. Her presence and participation in an organization such as ESA increases the credibility and visibility of the strong environmental and ecological research conducted by the MAES and MSU."

Gross has been involved with the ESA since 1976 and has served as both vice president and president of the society. She has been broadly involved in the society and has made several contributions that still have large impacts today. Early in her career, Gross worked on establishing long-term archives of ecological data sets that are still used as a resource for ecologists today. She was also instrumental in the establishment of the National Center for Ecological Analysis and Synthesis, an organization that supports cross-disciplinary research by using existing data to address fundamental issues in ecology and allied fields and their application to management and policy.

More recently, she made a commitment to obtaining funding for postdoctoral stu-

dents to continue their ecological research. Working with the Andrew W. Mellon Foundation and the National Parks Foundation, Gross was successful in establishing a postdoctoral fellowship program that supported research in U.S. national parks. During the 6 years the program was in place, it supported 20 fellows on 2- to 3-year fellowships. Gross has continued to work with the ESA to find continuing funding for this program after Mellon Foundation support ended in 2006. Despite this setback, she is still committed to finding financial backing for postdoctoral scientists.

"This is a critical time in establishing a successful career, particularly for women scientists," Gross explained. "There is a gap between when students finish their doctorates and when they get jobs where there aren't many places for them to secure funding. I want to create more resources for these students so that they can write their own proposals and fund their own research."

Gross is also a university distinguished professor on the faculty of the MSU Department of Plant Biology.

Forest Biomass Development Coordinator Named

Ray Miller

With 19.3 million acres of forestland, Michigan is primed to be a national leader in producing renewable fuels from cellulose — trees, stems and stalks that aren't food products.

In recognition of the growing importance of trees as raw materials for bioproducts, Raymond Miller, who oversees forestry research at Michigan Agricultural Experiment Station (MAES) properties in the Upper Peninsula and serves as director of the U.P. Tree Improvement Center, added MAES forest biomass development coordinator to his duties Sept. 1.

In this new role, Miller will coordinate many of the forest-based biofuel relationships between Michigan State University and other entities, including Michigan Technological University, the Michigan Economic Development Corp. and the Swedish Forest Agency. He also will work with Michigan State University Extension to facilitate education and outreach on the bioeconomy.

"I'm now the university's point person for forest biomass production," Miller said. "Besides working with faculty members in the Forestry Department that are already studying cellulosic biomass, I'll be learning more about what's going on outside forestry so I can connect faculty members from across departments."

In 2007, MSU announced a biofuel partnership with Michigan Tech to create new collaborative research, outreach and economic development programs centered on fuels and energy made from forest biomass. The programs are overseen by the eight-member Renewable Fuels Working Group, made up of four scientists from each university. Miller and David Shonnard, Michigan Tech professor of chemical engineering, are co-chairpersons of the group.

With his colleagues on the Renewable Fuels Working Group, Miller hosted a biofuels summit in Escanaba in February attended by 50 representatives of businesses from all aspects of the forest-based bioeconomy and state and local government agencies. The goal of the summit was to identify key questions the universities should address in three priority areas: feedstock production, feedstock supply chains, and feedstock conversion systems and integration. The summit also furthered the MSU-Sweden relationship by featuring presentations from four Swedish bioenergy researchers, who explained Sweden's transition to renewable fuels. Sweden has 69 million acres of forestland and an enormous forest products industry, so wood is the raw material of choice for Sweden's bioeconomy. Miller and other researchers believe that Michigan can use Sweden as a model when developing the state's forest-based bioeconomy.

"I'm very pleased that Ray has added this new role to his responsibilities," said Steve Pueppke, MAES director, who also heads the MSU Office of Biobased Technologies. "This formalizes a lot of the work he has been doing and will solidify our relationships with businesses and state agencies. Our research and development emphasis is on making cellulosic biofuels, and it makes sense for Ray to help lead this effort."

Miller's research focuses on forest establishment and management systems and how various systems affect growth and yield. He came to MSU as a research assistant in 1978 and served as associate director of the Michigan Cooperative Tree Improvement Program from 1981 to 1988, after which he was named manager of the U.P. Tree Improvement Center in Escanaba. The U.P. Tree Improvement Center is one of 14 MAES field research stations located around the state.

Miller received his bachelor's degree in forest resource management in 1975 and his master's degree in silvics in 1978 from the State University of New York, Syracuse. He received his doctorate in forestry from MSU in 1984.

MAES Dry Bean Breeder Named CSSA Fellow

James D. Kelly

James D. Kelly, MAES crop and soil sciences researcher, has been named a fellow of the Crop Science Society of America (CSSA). It is the highest recognition bestowed by the CSSA, awarded to no more than 0.3 percent of the organization's active and emeritus members annually.

Kelly directs the MSU dry bean breeding and genetics program, using molecular markers to assist in selection for enhanced yield, plant architecture, processing quality, drought tolerance and disease resistance. He serves as faculty coordinator of the Saginaw Valley Dry Bean and Sugar Beet Research

Farm, one of 14 MAES field stations.

Kelly pioneered the development of basic molecular tools to enhance the efficiency of bean breeding that are now widely used by bean breeders throughout the world. He has released 34 dry bean varieties in 11 commercial seed classes that have helped diversify bean production in Michigan and contributed to lower production costs.

"This is a very well-deserved honor," said Doug Buhler, MAES associate director. "Jim is a world leader in dry bean breeding and genetics research and his contributions have benefited people in Michigan and around the world."

Kelly's international work includes serving as principal investigator for the Pulse Collaborative Research Support Program, which has resulted in the release of six successful bean varieties for Mexico and four varieties for Ecuador. He is also president of the Bean Improvement Cooperative (BIC), a volunteer organization promoting the exchange of information and materials for the improvement of bean production worldwide.

Kelly received a bachelor's degree in botany and a bachelor of agriculture degree in agricultural botany from Queens University of Belfast, Northern Ireland, and master's and doctoral degrees in plant breeding and genetics from the University of Wisconsin. He has been an MSU faculty member since 1980. He received the Distinguished Faculty Award from MSU in 2007. Kelly also has been honored by the Michigan Crop Improvement Association with an Honorary Membership Award, the Meritorious Service Award and the Distinguished Achievement Award.

Former MAES Scientist Honored for Lifetime Achievements

Larry Copeland, professor emeritus of crop and soil sciences and former MAES researcher, received the 2008 Legacy Alumni Award from the Oregon State University College of Agricultural Sciences at its annual Dean's Dinner Oct. 31. Copeland was recognized for his distinguished record of professional achievements since graduating from his alma mater.

"Dr. Copeland is very deserving of this prestigious award," said Jim Kells, chairperson of the MSU Crop and Soil Sciences Department. "He is recognized nationally and internationally as a leading expert in seed science and technology, and his contributions to agriculture in Michigan and the United States are significant."

MAES associate director Doug Buhler concurred.

"Dr. Copeland has made tremendous contributions across the board in seed science and technology," Buhler said. "His work has benefited students, the industry and science. His books and publications assure that his work will continue to have a positive impact for years to come."

Copeland, also affiliated with MSU Extension, spent his entire MSU career teaching and conducting research on seed technology and field crops. He also consulted in seed technology programs in Southeast Asia, India and Africa, and he is author and co-author of several books on seed science and technology, including Seed Purity and Taxonomy, the first new handbook of seed testing and taxonomy in more than 50 years and the most comprehensive and up-to-date resource available for seed analysts. Published in June 2008, the book is available from MSU Press.

MSU Farms Donate Fresh Produce to Local Food Banks

Today's economy is leaving many families facing tough choices.

That's where a partnership between MSU and the Greater Lansing Food Bank (GLFB) comes in. The partnership, in its 25th year, is all about providing those families, individuals and agencies with fresh produce from MSU farms.

The GLFB provides volunteers through its Garden Project Gleaning Program to harvest surplus produce from the on-campus farms and distributes it to low-income families, individuals and agencies that serve those in need.

The food is distributed to food pantries, human services organizations and residents of low-income housing. The thorough field harvest completed by the volunteers benefits the farm, but the main priority is benefiting the undernourished people in the greater Lansing area.

"We see this as a wonderful outgrowth of the research programs that take place at the campus farms," said Doug Buhler, MAES associate director. "It is gratifying to see MSU farm staff members partner with the local community in this way. Providing quality food and supporting the nutritional health and well-being of needy members of our community is really in the spirit of an institution like MSU."

So far this year, the on-campus farms have donated nearly 69,000 pounds of fresh vegetables and fruits, including sweet corn, cherries, pears, tomatoes, peppers, squash, cucumbers, dried beans, onions, zucchini and cabbage. The GLFB estimates that the donated food is worth $74,677.55.

"Fresh fruits and vegetables are some of the foods most lacking in diets of low-income individuals," said Anne Rauscher, director of the Garden Project. "The partnership between MSU and the gleaners is a wonderful way to ensure that fresh, local foods get to people who need them."

Last year, the on-campus farms and gleaners teamed up to give more than 220,000 pounds of fresh foods to the GLFB.

This year, the numbers are still being tabulated — harvest of the on-campus farms is about halfway done, said Gary Zehr, who manages the plant pathology farm.

The donated crops were harvested from crop and soil sciences farms, horticulture farms, the muck farm and the plant pathology farm. As of Sept. 17, the crop and soil sciences farms had donated 3,840 pounds; the horticulture farms, 15,083 pounds; the muck farm, 4,815 pounds; and the plant pathology farm, 45,221 pounds.

All four on-campus farms are part of the MAES on-campus field station. The on-campus research farms provide land and facilities for research conducted by MSU faculty members in the departments of Forestry, Entomology, Plant Pathology, Animal Science, Crop and Soil Sciences and Horticulture, and the College of Veterinary Medicine.

"Much of our research is conducted and paid for by industry, so we can't really sell the crops — that would compete with the people we're trying to help," said Ray Hammerschmidt, chairperson of the Department of Plant Pathology. "The gleaning project provides good quality produce to people who have a real need for the nutrients available in fresh produce. The crops go to a much better use than making compost."

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