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Invasive Species in Michigan:

Controlling the Known and Identifying the Unknown

looking into futures

Invasive Species in Michigan: Controlling the Known and Identifying the Unknown

They arrive in the state under the cover of night and in broad daylight, perhaps swimming in ship ballast water, tucked deep inside wood pallets and packing crates, or in the back of a car returning from vacation.

Michigan's location in the heart of the Great Lakes and its position as a hub of international commerce and travel make the state prime real estate for invasive species looking for a new home. Not all non-native species cause the economic and biological or ecological harm necessary to be classified as invasive, but those that do are estimated to cost the United States more than $137 billion each year.

In this issue of *Futures*, we highlight some of the research being done by Michigan Agricultural Experiment Station scientists to identify, contain and possibly eliminate from Michigan the most destructive invasive species.

MAES scientists Doug Landis and Doug Schemske co-founded the MSU Invasive Species Initiative in 2004 to bring together researchers from various disciplines working on invasives and create a three-pronged approach — teaching, research and outreach — to combat the intruders.

"The predictions are that the number of invasive species will increase, as will the harm and the costs," Schemske says. "MSU has a history of collaborative problem solving, so it made sense to have an initiative like this here."

The emerald ash borer (EAB) is probably the most infamous invasive species. Since it was identified in 2002, the glittering green bug has killed about 30 million ash trees in southeastern Michigan and cost tens of millions of dollars. MAES forest entomologist Deb McCullough has spent the past 6 years studying EAB ecology, and her research results on a pesticide and a possible parasitoid wasp hold promise for new controls.

Some of the most troubling diseases and insects in agriculture are invasive species. The soybean aphid, a native of Asia, is the most damaging soybean pest in the state. Before the aphid was discovered in 2000, soybean farmers rarely treated their fields with insecticides. By 2005, 42 percent of Michigan soybean acreage was treated with insecticides to combat the bug. The fungus-like *Phytophthora capsici*, which causes infected crops to rot in a few days, and the airborne downy mildew pathogen have caused near panic in Michigan's vegetable industries. MAES scientists Chris DiFonzo, Mary Hausbeck, Ray Hammerschmidt and Brad Day are working to find new approaches to detect, treat and control the non-natives.

Invasive plants are a highly debated topic in the horticultural world today. MAES researchers are collaborating with the horticulture industry — in Michigan, the Midwest and nationally — to identify plant characteristics and develop science-based risk/benefit assessment models to address this critical issue.

In Michigan's waters, MAES scientists have helped create awareness and monitoring tools to keep the plant hydrilla out of the state and partnered with state agencies to conduct a very successful purple loosestrife control program.

As Michigan and the rest of the world focus more intensely on producing fuels and energy from grasses and other non-food crops, MAES scientists are making sure these new crops aren't invasive.

We hope you enjoy this issue of *Futures* on invasive species 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.

For the latest information about MAES research and events, I invite you to subscribe to the free MAES e-mail newsletter. Sign up by visiting the MAES Web site at www.maes.msu.edu/news.htm. You also can view this and past issues of *Futures* on the Web site by clicking on the "research publications" tab.

::: Jamie DePolo

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detested, destructive and really expensive

Michigan's location at the crossroads of international commerce and travel makes the state prime real estate for invasive species looking for a new home. The MSU Invasive Species Initiative brings together researchers who are looking at the big picture of controlling the invaders.

MAES entomology researcher Doug Landis inspects a great blue lobelia plant in a campus greenhouse. Landis helped develop the MSU Invasive Species Initiative.

They come under cover of night and in broad daylight, swimming in ship ballast water, hidden in wooden pallets and packing crates, or perhaps tucked in the back of someone's car. Moving invasive species into non-native areas is thought to be the second biggest effect that humans have on the environment. (Directly destroying habitat is probably the largest human environmental effect.) Collectively, invasive species are estimated to cost the United States more than $137 billion each year, which includes costs to control the pests as well as losses in productivity and services provided by the ecosystems affected. ▼

Invasive species come in all shapes, sizes and taxa: plants, insects, spiders, worms, pseudoscorpions, mammals, fish, crustaceans, mollusks, diatoms, and bacteria and other microbes that cause disease. To be considered "invasive," a species must have three main characteristics, according to the U.S. Department of Agriculture's official definition:

- Is non-native to the ecosystem it's in.
- Establishes and spreads in the environment.
- Causes economic or biological/ecological harm.

The ability to thrive and spread rapidly and uncontrollably in its new habitat is a key characteristic. If it doesn't, it's unlikely to cause much damage, either economically or biologically. For example, forsythia is not native to North America. Most species come from Asia or Europe, but unless an unpruned shrub is taking over a backyard, it's unlikely that anyone would label forsythia an invasive species.

"If you think about just some of the most well-known invasive species — emerald ash borer, garlic mustard, purple loosestrife, zebra mussels, soybean aphid — and the problems they've caused, you realize just how vulnerable Michigan is to invasive species introductions," said Doug Landis, MAES entomology scientist, who helped create the MSU Invasive Species Initiative. His research focuses on invasive species ecology and management, as well as figuring out how predators and parasitoids play roles in managing invasive plants and insects.

Landis has extensive experience with invasive species control. In 1997, he began work with the Michigan Department of Natural Resources (DNR), the Michigan Department of Agriculture (MDA) and Michigan Sea Grant to create a control program for purple loosestrife. A tall plant with striking purple flowers, purple loosestrife probably came to Michigan in ship ballast water in the early 1800s. The plant loved Michigan's many riverbanks and wetlands and soon began choking out native plant and disrupting the birds, fish and reptiles that depended on them. Other scientists previously had identified a beetle that feeds on purple loosestrife leaves. Fewer leaves mean fewer flowers, fewer seeds and a less healthy, weaker plant. Landis led the effort to distribute and evaluate the beetle as a biological control agent in Michigan. Purple loosestrife hasn't been completely eliminated, but the program has reduced dramatically the amount of purple loosestrife in many wetlands and allowed native plants to make a comeback.

"Michigan, along with California and Florida, is a hotbed of invasive species," he continued. "Between Great Lakes shipping, international trade and diverse agricultural production systems, there are many niches for invasives to occupy and many pathways for them to get in."

"Despite federal and state laws to manage the spread of invasive species, the predictions are that the number of invasive species will increase, as will the harm and the costs," said MAES scientist Doug Schemske, a plant evolutionary ecologist and co-founder of the Invasive Species Initiative with Landis. "MSU has a history of collaborative problem solving, so it made sense to have an initiative like this here."

"We knew we had a lot of people at MSU doing work on invasive species, so we wanted to bring them all together so we could learn from each other," Landis added. "We sent out an e-mail inviting everyone to a kick-off meeting, and more than 70 people showed up. We thought we were off to a pretty good start."

Proposed by Landis and Schemske in 2003, the initiative was funded by the Office of the Provost, the colleges of Agriculture and Natural Resources and Natural Science, the Environmental Science and Policy Program, the Department of Entomology and

MAES scientist Doug Schemske, a plant evolutionary ecologist and co-founder of the MSU Invasive Species Initiative, says invasive garlic mustard is a problem because it's taking over spring ephemeral habitat and may crowd out native plants.

Rob Ahern, a postdoctoral researcher funded by the MSU Invasive Species Initiative, helped compile and analyze a database of all non-native species in Michigan. The database currently lists 1,263 non-native plants and animals in the state, but new species continue to be added.

the MAES for 2 years in 2004. In 2006, the initiative was funded for another 2 years by the MSU Environmental Research Initiative, which the MAES also helps to fund.

Following in the footsteps of MSU's land-grant heritage, the Invasive Species Initiative has a three-pronged approach of teaching, research and outreach. On campus, the initiative offers a graduate seminar on invasive species ecology, policy and management every other year.

"The seminar gives students exposure to a broad range of issues associated with invasive species," said Rob Ahern, a postdoctoral researcher funded by the initiative, who works in Landis' lab and co-teaches the seminar.

Besides helping with the seminar, Ahern also oversees the initiative's major research project: a database of all non-native species in Michigan, listed taxonomically, a mammoth undertaking. The idea behind the database was to show people the enormity and complexity of the invasive species issue.

What's Here and Where Did It Come From?

To understand the effects that a non-native (and potentially invasive) species could have on the environment, scientists need to know quite a bit about the species' biology, ecology and economics. In most cases, because the species in question is non-native, very little of that information is known. Even if information about the non-native's biology is known, determining its total effect on the ecosystem may be difficult.

"You can definitely quantify economic losses," said Deb McCullough, MAES forest entomologist, who has spent much of the past 5 years studying the biology and ecology of the emerald ash borer in hopes of finding ways to control the pest, which has killed more than 30 million ash trees in southeastern Michigan alone. McCullough has a long history of working on invasive forest pests — she was instrumental in implementing the national "Slow the Spread" program in Michigan to contain the gypsy moth, an invasive pest that feeds on the leaves of a variety of trees and shrubs and caused the largest area of defoliation in Michigan in 1992.

"But ecosystem services are harder to quantify," she pointed out. "For example, we're probably going to lose all the black ash trees in Michigan because of the emerald ash borer. Black ash doesn't have much timber value, but in many swampy areas, it's the only species of tree that grows. Birds and other animals use black ash to perch on — how do we estimate that value?"

If the non-native species doesn't appear to be causing harm right away, research may not be focused on uncovering this necessary information because of budget and resource constraints.

"Many plant species require genetic variation to take hold," Schemske said. "When a non-native species first arrives in Michigan, it may not have the genetic variation necessary, but over time, it's acquired. Then it can start to become a problem. A species also may have to be introduced a couple of times before it takes hold. There may be a long period of steady, slow increase in population, and then we have a sudden population explosion."

"Purple loosestrife and garlic mustard are examples of species that came in and didn't cause obvious harm for a while," Landis explained. "We need some sort of 'watch' or 'species of concern' list so we can start doing the background research now. Once there is an acknowledged problem, decisions often need to be made faster than we can develop the information. We thought that a taxonomic database of all non-native species in Michigan would be a good start to developing this type of watch list and an excellent tool to help understand patterns of biological introduction."

"We really need to understand the scope of the problem so we can assess what we need to do to combat and control it," Ahern added.

So in 2007, armed with a newly minted doctorate in insect population ecology, Ahern came to MSU as a postdoc to compile and analyze the database.

"It's been difficult," Ahern said. "I've been working on it for a year. But I've been very lucky to find good information on plants from Ed Voss, a senior scientist at the University of Michigan Herbarium. What we've compiled is more comprehensive than anything else available nationally."

Currently, the database lists 1,263 non-native plants and animals in Michigan, with plants (948), insects (125) and aquatic invertebrates (56) taking the top three spots, though both Ahern and Landis think non-native bugs probably are grossly underestimated because information just isn't available.

"The numbers are conservative," Landis said. "Right now, the database doesn't include human, plant or animal pathogens — that information is proving very difficult to get. But even with conservative numbers, the database is a good way to show people how big the problem is — there are massive numbers of non-native species in the state already."

The scientists envision the database being used by local and state government officials, agencies, scientists, interested citizens — basically anyone who's interested in the environment.

"Invasive species don't fit neatly into any of the federal, state, local or university jurisdictions in terms of problem solving because they involve so many issues," Ahern said. "Any one group can't solve the problem alone. But if we had something that people could gather around, like this database, that's a start."

Michigan does have a "noxious" list, but it's fairly short (the U.S. Department of Agriculture lists the state as having 17 "invasive and noxious weeds"), and it leans heavily toward weeds that are problems for agriculture, such as bindweed and wild carrot. It also includes poison ivy and poison sumac, which are native to the state. In 2005, the state added 28 aquatic plants, insects and fish to the "prohibited" and "restricted" lists, which means these species can't be brought into the state. Emerald ash borer, snakehead fish and purple loosestrife were some of the invasives that were included in the 2005 legislation. Still, when compared with Ahern's database of 1,200-plus non-native species, it's clear that the official list focuses only on species that are well-documented problems. This is definitely important, but the researchers would like to create a mechanism to identify potential problems and stop them before they cause major environmental or economic damage. The database is the first step in developing that process.

"Everyone who's interested in invasive species has the same problems: we want to prevent the introduction of the invader that isn't here yet and contain the ones that are here before they become a problem," Landis explained. "But how do we do that?"

Invasive Information on the Internet

Now that the first iteration of the database is completed, Landis, Schemske and Ahern want to make it available through the Web and allow other scientists, government officials and the public to participate in recording their observations of non-native species, something akin to the way birdwatchers report avian sightings. Making the database available online also would allow various groups to share information more quickly and easily than is possible now.

"Right now, the DNR does species surveys, but no one else can see the data," Landis said. "It's the same with MDOT [the Michigan Department of Transportation]. We don't have a comprehensive mapping system for invasives in the state. If all these data were in one place, we would have a much better picture of the potential overall impact."

The MSU Invasive Species Initiative sponsors a symposium every other year to allow people who work on invasive species to exchange information and share resources. The 2008 symposium featured keynote speaker Peter Kareiva *(second from left)*, chief scientist for The Nature Conservancy.

During his keynote address at the 2008 Invasive Species Symposium, Peter Kareiva described a formal algorithm developed by Australia that creates a risk score for every non-native plant that enters that country. If the score is above a certain level, the plant is excluded.

MDOT surveys, for example, look at the land the agency is responsible for, which includes the rights-of-way along highways. But data isn't collected on land outside the agency's purview, even if a thriving stand of invasive plants lies just a few feet beyond a right-of-way. When fully functional, the MSU Invasive Species Initiative Web-based database would allow anyone who had completed a short training course in invasive identification to add a sighting to the database, placing a dot in the exact location the invasive species was seen. With seed money from the MSU Environmental Research Initiative and computer programming by Amos Ziegler, a research specialist in the Department of Entomology, the project has moved to the pilot phase and includes the DNR, MDOT and the Michigan Natural Features Inventory as participants. The site is available at: www.misin.msu.edu.

"We're going to start with some selected non-native plants to report on, but the idea is that this type of mapping system could be used for any species," Landis explained. "We're rolling it out as a pilot project to state agencies first so we can figure out how we can best partner to meet everyone's needs."

The pilot project includes Web-based tutorials with photos and descriptions of the various plants to help interested members of the general public become eligible to report invasives, though the public reporting feature may be implemented later. The goal is strictly to build the amount of information available, not to punish anyone for inadvertently bringing a potential invader into the state. In Landis's eyes, it's an advantage to have the database be affiliated with MSU.

"Because the university isn't a regulatory agency, people may feel more comfortable reporting what they've seen," he said. "We're not enforcers, we're data collectors."

Sharing Through Symposia

Since its inception 4 years ago, the initiative has sponsored three symposia on invasive species, the most recent in April. The first two events — in 2005 and 2006 — were aimed primarily at the campus community, the 2008 symposium was designed to appeal to a broader audience, including state agency representatives and scientists at other universities. Landis, Schemske and Ahern made a special effort to invite them.

"We wanted to reach out to people who manage land and water and let them know that MSU has research on invasive species that can help them," Landis said.

"The symposia help increase communication and give everyone a chance to see the resources that are available," Ahern added. "We want to start a dialogue and then create tools to resolve the issues."

Featuring experts on all manner of invasive species, including keynote speaker Peter Kareiva, chief scientist for The Nature Conservancy, the 2008 symposium brought together more than 120 researchers, managers and students to discuss next steps in invasive species research. And they all agreed that a mechanism to proactively identify non-native species that could cause problems in the future would be the best control tool that could be created.

"We're always feeling that we have to wait until we have a problem before we can act," said Gary Whelan, fish production manager for the DNR. "We want to identify the species before they're problems and close the pathways."

At the symposium, Kareiva told the crowd that Australia has developed a formal algorithm that uses answers from about 50 questions asked about each non-native plant that comes into the country to create a risk score. If the score is above a certain level, the plant is excluded. If the score is below a certain level, the plant is allowed in the country. This may be something that could help Michigan scientists as they move forward with invasive species research.

"There are a lot of lessons to be learned from what Australia is doing," added McCullough, also a speaker at the symposium. "Their policies are more intensive than ours are. It's a model to look at and see what we can use."

Schemske said one of the important features of the symposia, especially this year's, is their ability to bring together scientists and policymakers.

"The invasive species problem is so huge, we need to develop sound policy," he explained. "Science can help establish policy to reduce introductions of new non-natives and to evaluate their ecological and economic impacts. What we've seen is that lists often are created after it's too late. Because of the unpredictability of invasives, we need both state and national policies to help solve the problem. There has to be an awareness of what these species can do."

For more information on the MSU Invasive Species Initiative, including resources, MSU courses and a list of MSU experts, visit www.invasivespecies.msu.edu.

::: Jamie DePolo

Winning the Agricultural Invasives War:

An Army of [Every]one

MAES scientists are joining forces with the agriculture industry and others to develop a battle plan to thwart agricultural invasives.

Agriculture is one of Michigan's top three industries. According to the Michigan Department of Agriculture, the state's agrifood system accounts for $63.7 billion in total economic activity and more than 1 million jobs. Michigan also has one of the most diverse agricultural industries in the United States, second only to California in variety of crops grown.

Even though weeds, insects and disease-causing organisms are familiar to those whose livelihood depends on agriculture, new introductions and population explosions of existing invasive species pose significant threats to agriculture and raise serious environmental and economic concerns.

According to the Bureau of Land Management, invasive plants alone infest an estimated 100 million acres in the United States. And every year, they spread across 3 million additional acres — an area twice the size of Delaware. A study from the Office of Technology Assessment reported approximately $97 billion in damages from all 79 exotic species between 1906 and 1991.

"Invasive species are an aggregating problem," said MAES entomologist Doug Landis, who helped create the MSU Invasive Species Initiative. "They don't come over one year and then go away; they add up over time. So the reality is that managing agricultural invasives is part of doing business if you are going to grow commodity 'x' or commodity 'y'."

"We'd like to make invasives less of a reality in agriculture by putting mechanisms in place to prevent new introductions," said

Chris DiFonzo, MAES field crop entomologist, weighs soybeans in her lab. According to DiFonzo, the invasive soybean aphid is now the most damaging soybean insect pest in Michigan. In 2001, soybean aphids reduced yields by 40 percent in fields that weren't treated with insecticides.

Rob Ahern, a postdoctoral researcher who works in Landis' lab. "The most effective way to deal with invasive species is not to let them get here in the first place. For established populations, we need to target invasives we have a good chance to control, rather than diluting our resources by trying to control them all."

The key to being successful with invasives is approaching the problems they create from a broad perspective.

"What people have to understand is that you can't effectively manage an invasive species without looking at the entire system," said MAES field crop entomologist Chris DiFonzo. "You can't just look at plant pathogens or a single predator because they are only one part of an entire system."

Ahern, Landis and DiFonzo agree that what's happening with Michigan soybeans and invasives provides a good example of the challenges faced by the state's agriculture industry.

The Situation Room: Notes from the Field

Soybeans have been cultivated in the United States for almost 250 years. Introduced in 1765, this East Asian legume was first grown on a limited basis for hay. Today, the United States is the world's leading soybean producer and exporter. In 2007, 63.7 million acres of soybeans were harvested at a value of $26.7 billion, according to U.S. Department of Agriculture (UDSA) Economic Research Service. Michigan harvested 1.75 million acres of soybeans, valued at $668 million during the same period.

"Soybeans are an incredibly important crop in the United States and Michigan and are becoming more so with biodiesel," Landis said. "The appearance of the soybean aphid in the United States placed this major crop in economic jeopardy and compounded biodiversity and human health concerns.

Discovered in North America in 2000, the soybean aphid is now the most damaging soybean insect pest in Michigan and the Midwest. Prior to 2000, few, if any, soybean acres were treated with insecticides.

"In 2001, yield loss was over 40 percent in unsprayed versus insecticide-treated research plots," DiFonzo said. "By 2005, commercial spraying for the soybean aphid increased dramatically. Forty-two percent of Michigan soybean acres were treated that season — the highest proportion in the United States that year."

A confluence of factors contributed to the establishment of soybean aphid in Michigan — a plant species that provided the pest with a way to survive the state's harsh winters and the presence of a former invader.

Doug Landis, MAES entomology scientist, says that two species of buckthorn introduced to the United States in the mid-1800s helped the soybean aphid become established here. The aphids lay their eggs in the buckthorn plants in the fall and then feed on the new leaves in the spring before moving to soybeans.

Landis said that two buckthorn species introduced into the United States from Eurasia in the mid-1800s — *Rhamnus cathartica* and *Frangula alnus* — are the keystone of soybean aphid infestation. The aphids lay their eggs along the buds in the fall. The eggs overwinter and hatch in early spring. Aphids feed on the newly emerging buckthorn leaves in May and then move to soybeans in June.

"The interesting thing is that neither of these plants was considered a particularly bad actor in agriculture," Landis said. "They were typically used as windbreaks and hedges around buildings. Years later, the soybean aphid shows up, uses buckthorn as an overwintering host, causes millions of acres of soybeans to be sprayed with pesticides, costs growers millions of dollars and causes environmental harm."

A second player in the soybean scenario is *Harmonia axyridis*, the multicolored Asian lady beetle. An inhabitant of Michigan since the mid-1990s, it has dramatically increased in abundance since the arrival of the soybean aphid.

Harmonia is native to Asia, where it feeds on aphids and other soft-bodied insects that dwell in trees. Through its larval stages, this beetle can consume up to 370 aphids. As an adult, it can consume up to 65 aphids a day. In their native habitat, these lady beetles hibernate (overwinter) in the cracks and crevices of cliff faces. In the United States where cliffs are not prevalent, they seek overwintering sites in and around buildings.

"In addition to being an unwelcome house guest, when disturbed or crushed, these beetles emit an orange liquid that causes stains and odor," Ahern explained. "Some people also develop an allergic reaction to them. They have also been known to bite humans, especially in the fall."

Harmonia is increasingly becoming a pest in grapes and wine production. The beetle aggregates on the fruit and is difficult to remove during harvest. Subsequently, some may be crushed with the grapes during processing.

"The chemicals this bug produces are so potent that it takes only one bug to create a detectable taste in 100 gallons of wine," Ahern said.

Harmonia is also responsible for declines in native lady beetle populations.

"YOU CAN'T EFFECTIVELY MANAGE AN INVASIVE SPECIES WITHOUT LOOKING AT THE ENTIRE SYSTEM. YOU CAN'T LOOK AT PLANT PATHOGENS OR A SINGLE PREDATOR BECAUSE THEY ARE ONLY ONE PART OF AN ENTIRE SYSTEM."

"Even though *Harmonia* is a pretty good predator of the soybean aphid, it's been widely suspected that its arrival and increase has resulted in the decline of native lady beetle populations," Landis explained. "Some may argue that if *Harmonia* is doing the job and it's replaced four or five natives, that's just fine. But those four or five species are then not available to operate in other habitats where this beetle may be less effective."

To address biodiversity concerns and other challenges posed by the soybean aphid, MAES researchers are conducting several studies to gain a better understanding of its thresholds, develop aphid-resistant soybeans and establish an effective method to investigate insecticide resistance in soybean aphids.

MSU scientists are also collaborating in the safety testing and release of *Binodoxys communis*, a tiny wingless wasp that hails from China and Japan, where it has been a long-time natural enemy of soybean aphids. During the summer of 2007, these wasps were released in more than 30 locations throughout the Midwest. Researchers are now waiting to see if the wasp was able to survive this past winter.

Michigan is also one of 10 states participating in a suction trap network that monitors the number of winged aphids caught during their fall flight back to buckthorn. This information is used to forecast aphid outbreaks the following year. The results are reported on a Web site — www.ncipmc.org/traps — where growers, entomologists and crop consultants can track soybean aphid populations. Michigan has five suction trap sites, including one at the MSU entomology research farm.

"According to the suction trap network, there is some risk of a soybean aphid outbreak for Michigan in 2008, with some areas perhaps going over threshold," DiFonzo said. "We'll be monitoring this situation closely."

Another soybean invasive being monitored is Asian soybean rust (ASR). This virulent fungus rode Hurricane Ivan into the southern United States in 2004 (see page 18). Though it's not yet in Michigan, experts expect that sometime soon, environmental conditions will allow the disease to invade more soybean-growing states early in a growing season when it can do serious damage to the crop.

Recent studies indicate that, once ASR is detected, the best defense a soybean farmer has is to apply a fungicide before disease symptoms appear.

"The dilemma becomes whether to spray the crop as a preventive measure even if there's no evidence the disease is present," DiFonzo said. "Tests show that when you spray fungicides on a soybean field to prevent rust, you get more aphids because it also eliminates other fungi that attack and kill aphids," she said.

"Everything you do has a reaction in the system," Ahern added. "With soybean aphids, it's easy to see the direct effects. For invasives with more elusive patterns, nailing them down in a scientifically rigorous way is a real challenge."

Good Scouting: Countering Air and Water Attacks

Michigan cucumber producers are in a major pickle on two fronts. Growers continue to do battle with *Phytophthora capsici*, a fungus-like organism that causes infected crops to rot, devastating a plant in a few days. Downy mildew — an invasive airborne pathogen — came from out of the blue 3 years ago, catching farmers off guard and jeopardizing the state's pickling cucumber crop.

Michigan is the No. 1 pickling cucumber producer in the United States according to the USDA National Agricultural Statistics Service. Pickling cucumber production in Michigan has a farm gate value of $35.9 million, with 29,800 acres of pickles harvested.

Downy mildew is well known for causing catastrophic losses in a short time. Unprotected foliage can become completely infected within 10 days. Downy mildew hadn't been an issue in Michigan because it can't survive its winters.

"Downy mildew is a problem for growers in the southeastern, southwestern and northeastern United States," explained MAES plant pathologist Mary Hausbeck. "It has traveled as far north as Indiana, infecting pumpkins and winter squash, but had never reached Michigan. We've tried to track its movement in case the state had an especially warm fall that allowed the invasive time to move into our area."

Despite that effort, downy mildew reached Michigan undetected. In August 2005, Hausbeck received a phone call from a consultant who said there was downy mildew in a cucumber crop on the west side of the state. Results from a sample confirmed the claim and within a week, the outbreak was across the state.

"There was wholesale panic," Hausbeck said. "We immediately conducted a fungicide trial to bolster chemical recommendations because this particular strain is resistant to the most commonly used downy mildew fungicides. Some growers lost their crop because they didn't understand the importance of spraying their crop right away. It was crazy."

Still unclear how downy mildew made its way to Michigan, Hausbeck and others posited that an especially active early hurricane season in 2005 created unusual wind patterns that brought the pathogen into the area. Michigan cucumber growers were optimistic that it was a one-time deal, but their optimism was short-lived.

"The first week of June, I received a call from a field consultant who was certain there was a downy mildew outbreak on 15 acres of pickling cucumbers in southeastern Michigan," Hausbeck said. "Samples confirmed that the disease was very well- established and producing a tremendous number of spores, so it was just a matter of time before other fields would be infected."

By harvest time, the fungal disease had been confirmed in 28 Michigan counties and had infected thousands of acres of cucumbers. Following a third downy mildew outbreak in 2007, it was clear that something needed to be done to better control the disease.

"No one knows what the problem is," Hausbeck said. "Is it one pathogen type or is there a mix? What has changed? It may be a new pathogen type that has overcome the genetic resistance previously bred into cucumber varieties."

A team of researchers including Hausbeck and MAES researchers Brad Day and Ray Hammerschmidt is using new molecular tools to get at the genetics of these pathogen types.

"We're trying to understand what has changed so breeders can develop more resistant cucumber types," Hausbeck said. "This pathogen doesn't have any respect for the genetic cultivars put in place decades ago. We need to figure it out so that a long-term sustainable approach to control downy mildew can be developed."

In the meantime, field trials continue and spore traps have been set up in six Michigan counties to monitor movement of the fungal pathogen.

"Downy mildew has weakened the pickle industry," Hausbeck said. "It has gone from not needing fungicides to needing three, five or more treatments to stave off this invasive. Downy mildew cost Michigan growers and processors $6.4 million in fungicide and application costs in 2006 and a similar amount in 2007. The industry is at a frightening juncture."

The downy mildew problem is an overlay to another invasive pathogen of cucumbers and other important vegetables — *Phytophthora capsici*. *Phytophthora*, most likely introduced in Michigan by vegetable transplants from the southeast United States in the 1940s and 50s, is a fungus-like organism that that moves via water and water sources such as irrigation. The pathogen infects plant roots, fruits and foliage and causes a blight, or rot, on plants in the cucurbit (e.g., cucumber, pumpkin, summer and winter squash) and solanaceous (tomato, eggplant, pepper) families of crops. *Phytophthora* also causes blight of foliage and pods of fabaceous (snap, wax, lima bean) crops. Infection reduces yields and can kill plants outright within a few days.

In 2007, Michigan growers produced $148 million worth of these vegetables on more than 82,000 acres. When weather conditions are favorable (warm with rain) crop losses to *Phytophthora* can reach 25 percent or higher.

Unlike downy mildew, which has to be reintroduced each year, *Phytophthora* doesn't go away once it's established in a field. It overwinters readily and renders fields very difficult to use without a lot of risk, Hausbeck explained.

Hausbeck and her lab staff are studying the genetics of *Phytophthora* and evaluating cultural methods to help control the pathogen.

"Site selection, water management, raised bed planting to keep root systems dry and correctly-timed fungicide sprays to minimize the amount of fungicides necessary, while maximizing their effectiveness, are practices that can be implemented to help manage this devastating pathogen," Haubeck said.

In 2006, a new, currently unregistered product showed promise in efficacy trials for managing *Phytophthora*, limiting plant death in acorn squash to 28.9 percent (62.5 percent in untreated plants) and the appearance of diseased cucumber plants to 8.3 percent (22.5 percent in untreated plants). Another experimental product decreased plant death in bell peppers by 65 percent and increased yield by 75 percent.

Greenhouse lab studies documented that *Phytophthora* also infects Fraser fir.

"This is an important finding for Michigan vegetable growers who are also Fraser fir growers, so they don't plant Fraser fir on old vegetable ground that's contaminated," Hausbeck said. "This type of research is critical and allows growers to make informed decisions and reduce their risk."

Invasion Tactics: Weeding out the Enemy

Among weeds, MAES crop and soil scientist Christy Sprague and Wes Everman, assistant professor of crop and soil sciences, know who the bad actors are.

Sprague and Everman conduct periodic surveys to ask growers which weeds are the toughest to control. The top three Michigan

An infestation of soybean aphids on a plant. MSU scientists are participating in safety testing and release of *Binodoxys communis*, a wingless wasp that is a natural enemy of the soybean aphid in China and Japan. The wasps were released in 30 locations in 2007 and scientists are studying its winter survival rates.

***Phytophthora capsici,* a fungus-like organism that causes infected plants to rot, has been devastating to Michigan cucumbers. MAES plant pathologist Mary Hausbeck is studying the genetics of *Phytophthora* as well as downy mildew, another problematic vegetable pathogen. Hausbeck also is evaluating cultural techniques growers can use to help control the pathogens.**

invasive weeds consistently cited are giant and common ragweed and common lambsquarters.

"Some of the invasive weeds in our agricultural system, such as giant ragweed, are actually native to Michigan," Sprague said. "Surveys conducted in several Michigan counties this year ranked giant ragweed as one of the most problematic and common weeds in both corn and soybean fields."

Giant ragweed is an early-germinating summer annual weed species commonly found in southern Michigan counties and many areas of the Midwest, including Indiana, Illinois and Ohio. Seed persistence, early seedling emergence and rapid plant growth make this the most competitive weed species in Michigan agronomic crops. This invader can produce more than 10,000 seeds per plant. Growing with corn and soybean, ragweed produces 1,900 and 5,500 seeds per plant respectively. Trials show that season-long competition from two giant ragweed plants per square yard can reduce corn yield 37 percent; one giant ragweed plant per square yard can reduce soybean yield by 52 percent.

Historically, giant ragweed was found mostly in undisturbed areas such as fencerows, drainage ditches and occasionally in floodplain fields. Over the past 20 years, giant ragweed populations have dispersed from their primary habitats into fields in a number of

From surveys, Wes Everman, assistant professor of crop and soil sciences, knows that giant ragweed, common ragweed *(top)* and common lambsquarters *(above)* are the weeds growers consider the toughest to control. While giant ragweed is native to Michigan, common ragweed and common lambsquarters are invasives.

Midwestern states. The cause of this spread is unknown, but it is clear that the weed has adapted to survive agronomic practices such as earlier planting and reduced tillage.

Sprague is participating in a regional project to study the lifecycle of giant ragweed in corn, soybean and bare fields. Seeds are being collected on campus and at the MAES Saginaw Valley Dry Bean and Sugar Beet Research Farm and from sites in Illinois to determine if lifecycle differences are due to the plant's genotype or to climate change. Recent findings show that giant ragweed emergence can start in March and continue into June and sometimes late July, making this weed a significant management challenge.

"Giant ragweed is so ubiquitous in Michigan that eradication isn't an option," Sprague said. "It's in almost every county in the state but it's still primarily in ditch banks, not crop fields. So from a preventive standpoint, understanding the lifecycle and changing emergence patterns of this weed is important."

Two non-native weeds, common lambsquarters and common ragweed also present significant challenges to Michigan field crops.

Common lambsquarters is one of the more competitive weeds, producing 30,000 to 176,000 seeds per plant. Field trials have shown a 13 percent yield loss in corn with one lambsquarters plant per 1.5 feet of row, a 25 percent yield loss in soybeans with less than one plant per row foot and a 48 percent yield loss in sugar beets from one plant per row foot.

Common ragweed, the bane of hay fever sufferers, is an early emerger and averages 3,500 seeds per plant. Field trials show a 10 to 22 percent yield loss in dry beans with one plant per 1.5 row feet. A common ragweed density of two plants per 10 feet reduced soybean yield 30 percent.

"With common ragweed and common lambsquarters, most of our

"GIANT RAGWEED IS SO UBIQUITOUS IN MICHIGAN THAT ERADICATION ISN'T AN OPTION."

MAES weed scientist Christy Sprague is part of a regional project studying the lifecycle of giant ragweed in corn, soybeans and bare fields. Because the weed is in every county in the state, scientists are trying to change its emergence patterns.

research focuses on developing management strategies to minimize crop yield losses," Everman said. "For example, we're studying herbicides and narrow row spacing to see if that helps suppress these weeds and reduce the number of herbicide applications needed. This is important because the use of herbicides over time results in weed resistance, the No. 1 concern in weed science."

Weed scientists have seen a huge shift to the use of glyphosate-resistant or Roundup-ready crops, Sprague noted.

"Roundup-ready crops — those genetically engineered to be resistant to the herbicide glyphosate (Roundup) — are a wonderful tool, but to sustain their effectiveness, growers need to employ other methods such as spraying other herbicides to break up continuous use or employing different crop rotations."

Weed scientists predict that glyphosate resistance will spread and growers should take steps now to manage it. Resistance could greatly diminish the effectiveness of Roundup-ready technology, which is now used on about 90 percent of U.S. soybeans, 50 percent of U.S. corn and 50 percent of Michigan sugar beets.

"There's no silver bullet around the corner if glyphosate fails," Sprague added. "Scouting fields for invasive weeds and rotating herbicides annually is critical to preventing or slowing the spread of resistance."

The Art of War: Prevention is the Best Strategy

In his 6th century B.C. manifesto on military strategies and tactics, The Art of War, Sun Tzu instructed: "One hundred victories in one hundred battles is not the most skillful. Seizing the enemy without fighting is the most skillful."

Scholars on the subject credit Sun Tzu with being the first to recognize the importance of positioning in strategy and that position is affected both by conditions in the physical environment and the opinions and actions of competitors in that environment.

"One shortfall in agriculture is that decisions are made on a farm-by-farm basis, yet each operation influences what happens on neighboring fields," Landis said. "Ultimately, it is the structure of the landscape that allows pests to be problems or gives us the opportunity to do a better job of pest suppression. Planning from a landscape context is a real growth area in research and sustainable agriculture."

"There is a reason for people in agriculture to care about invasives in natural areas and vice versa," Ahern explained. "Controlling buckthorn is a perfect example. Problems have to be addressed collaboratively. Agriculture can't solve all of its own problems and neither can the natural resources community."

Collaboration and communication within the agricultural community also play a significant role in preventing new introductions or reducing the economic and environmental harm these invaders can cause, Hausbeck added.

"Partnerships between scientists, Extension educators, processors, scouts, crop consultants and growers help get the word out when there is a problem so that farmers know how to protect their crops," she said. "In addition, industry support of crop trials and monitoring systems give researchers the ability to provide critical data and develop recommendations that allow growers to respond quickly and appropriately to changing conditions."

Sprague and Everman agree that even though ongoing challenges can be frustrating and sometimes overwhelming, everyone needs to be on the lookout to keep invasives in check.

"Scouting for and reporting suspicious or unknown plants, insects and pathogens and observing changes in their behavior will inform the development of new cultural practices and keep current management tools effective," they said. "Most invasives don't gain a stronghold in heavily managed areas."

"Increasing everybody's knowledge about the influence of invasives and working together to begin solving these problems benefits us all," Landis said. "Prevention is everybody's job."

::: Val Osowski

Agricultural Invasives Watch List

Vigilance is the watchword in stemming introductions of potential agricultural invasives. MAES researchers and the agricultural industry are working tirelessly to set up early warning systems and develop the arsenal necessary to combat these invaders if they arrive. Two of the more troubling agricultural invasives on the Michigan radar screen are Asian soybean rust and plum pox virus.

Plotting to Manage Asian Soybean Rust

Riding air currents worldwide, Asian soybean rust has landed on almost every continent including Africa, Asia, Australia, Europe and North and South America. In 2004, the devastating fungus rode Hurricane Ivan into the United States from South America where the foliar disease caused crop yield losses of up to 80 percent. This invasion threatened the U.S. soybean crop valued at more than $26.7 billion in 2007, according to the U.S. Department of Agriculture (USDA). In that year, the disease was found in 13 southeastern U.S. states and travelled as far north Iowa and Illinois but posed no risk in these two states because of the maturity of the crop at the time of detection.

Soybean rust is a spore-propagated fungus that can infect a plant within six to eight hours of landing. The spore germinates and penetrates the leaf tissue. The fungus absorbs plant nutrients and rapidly reproduces. At the peak of production, millions of spores may be generated daily from an infected field.

The soybean rust fungus does not survive northern winters, so it must be reintroduced each spring.

"We are fortunate that soybean rust has not reached Michigan," said MAES plant pathologist Ray Hammerschmidt, who also serves as coordinator of MSU Diagnostic Services, director of the North Central Plant Diagnostic Network and chair of the MSU Plant Pathology Department. "But it is always possible that environmental conditions will allow the disease to invade more soybean-growing states early in a growing season when the crop is most vulnerable."

Key to detecting the soybean rust fungus are sentinel sites — tiny test plots scattered throughout soybean-producing areas and monitored closely by scientists and Extension agents for the first sign of pathogen presence.

"Detection is the first line of defense against the disease,"

In addition to his work on plum pox and *Armillaria* root rot, MAES scientist Ray Hammerschmidt also serves as director of the North Central Plant Diagnostic Network. The group monitors invasive plant pathogens and oversees sentinel plots to detect any outbreaks as soon as possible so growers can be alerted.

Hammerschmidt said. "Every state with a soybean-producing area has sentinel plots. They serve as an early warning system so that soybean producers can be alerted in time to protect their crops."

Michigan has 20 soybean rust sentinel plots spread throughout the state. Samples are collected from these plots according to a national protocol and sent to Diagnostic Services to be examined. The results are fed through a national Web-based data system — Integrated Pest Management Pest Information Platform for Extension and Education (ipmPIPE) and are then posted to the USDA Web site: www.sbrusa.net. The ipmPIPE data along with weather information provide real-time and historical data on U.S. soybean rust movement.

"One of the benefits of the data collected from soybean rust sentinel plots has been the tremendous savings in fungicides *not* sprayed," Hammerschmidt said. "The information provided through the ipmPIPE system has helped farmers make more informed decisions, helping them save thousands of dollars annually in fungicide and application costs."

At the national level, the USDA Economic Research Service reports that soybean producers who used ipmPIPE during the 2005 season collectively saved as much as $299 million in unnecessary fungicide treatments. Similar savings were realized during the 2006 season.

"Without the right management tools, soybean rust could be detrimental economically and environmentally if it established in Michigan," Hammerschmidt summed up. "The combination of sentinel plots and knowing which fungicides to use and when make this disease manageable if it gets to Michigan.

"Forewarned is forearmed," Hammerschmidt continued. "The key to managing invasive species is to know what's coming and have a system in place to detect these invaders before they become a problem."

Collaborating Key to Controlling Plum Pox

Worldwide, plum pox virus is the most devastating viral disease of stone fruits, including apricots, peaches, plums and nectarines. Reported in southeastern Europe nearly 100 years ago, plum pox is considered the most serious virus of peaches and plums in Europe, with more than 100 million trees infected. Transmitted by aphids or transplanted rootstock, the disease reduces fruit yields by weakening trees and disfiguring fruit, rendering it unmarketable.

Plum pox was first found in North America in Pennsylvania in 1999. Its presence was reported again in the Niagara Falls region of Ontario, Canada in 2000.

Four strains of plum pox have been identified in the world. The strain in North and South America, PPV-D, is not seed-transmitted and is spread only by certain aphid species and through movement of infected plant material. Plum pox poses no human or animal threat, but poses a serious threat to peach and plum crops in Michigan, Hammerschmidt said.

A culture of *Colletotrichum*, a fungus that can infect a variety of agricultural crops, including alfalfa, strawberries and beans. Hammerschmidt also is investigating this pathogen.

According to the Michigan Agricultural Statistics Service, the Michigan peach industry generates $10 million annually, harvesting 5,000 acres on 470 fruit farms. Plum production generates $1 million annually, with 180 fruit growers harvesting 900 acres of plums.

"Since the first report of plum pox in Pennsylvania in 1999, the Michigan Department of Agriculture has conducted surveys of the state's peach, plum, nectarine and apricot plantings," Hammerschmidt said. "In July 2006, a routine sample of 25 percent of the trees at the Southwest Michigan Research and Extension Center in Benton Harbor revealed one infected plum tree in a 3-year-old plum rootstock trial. Samples confirmed that the tree was positive for the 'D' strain of the virus, which is less virulent than the other three strains. Though the 'D' strain can infect peaches, plums, apricots and nectarines, it does not cause disease in cherries."

Taking no chances, the USDA Animal Plant Health and Inspection Service and the Michigan Department of Agriculture established a quarantine that called for eradication of all susceptible trees within 500 meters of the block containing the infected plum, a ban on planting within 1.5 miles and a ban on moving plant material out of a 7.2 mile radius of the infected tree. The quarantine is in place until 2009.

No new plum pox-infected trees have been found in Michigan.

"Collaboration is key to detecting and controlling invasive pathogens such as plum pox," Hammerschmidt said. "If it weren't for the combined efforts of partners at the state, regional and national level when the plum pox was discovered in Michigan, we would not have been able to conduct the surveying needed to protect this valuable commodity. We all need to work together to protect the state's agricultural diversity and economic well-being."

::: Val Osowski

Forest Crusaders Work to Foil Invaders

MAES scientists are working to protect Michigan forestland from attacks by non-native insects, diseases and plants.

Even though almost half of Michigan's land base is covered by trees, "forestland" isn't the first noun that comes to mind when one is surveying metropolitan southeastern Michigan. Similarly, before 2002, most people who lived in the Detroit-Ann Arbor-Pontiac-New Baltimore trapezoid didn't think they had much call to be concerned about invasive species that had a fondness for trees.

A glittering green, goggle-eyed import from Asia changed all that.

The emerald ash borer (EAB) came, saw and conquered Michigan's ash trees. Since its first identification near Detroit in 2002, the EAB has killed about 30 million ash trees in southeastern Michigan alone and cost municipalities, property owners, nursery operators and forest product industries tens of millions of dollars. The bug also has been found in Indiana, Illinois, Maryland, Ohio, Pennsylvania, West Virginia and Ontario, and quarantines and fines have been imposed to prevent people from moving ash trees, logs or firewood out of infested areas.

The pest is so notorious that Gov. Granholm declared May 18-24 EAB Awareness Week as part of an attempt to limit the beetle's spread to the Upper Peninsula.

"Across the Lower Peninsula, Michigan residents have witnessed the loss of millions of ash trees, which in some cases has dramatically changed the landscape of what were once beautiful tree-lined streets," Granholm said. "We continue to fight the battle to save what is left of this precious natural resource and call on residents to join us in that fight."

Adult beetles snack on ash tree foliage but cause minimal damage. Beetle larvae, which look like small white worms, feed on the inner bark of ash trees. Their winding trails disrupt the trees' ability to transport water and nutrients. A few larvae don't hurt a tree, but as EAB populations grow and tree tissues sustain more damage, the leafy canopy thins out and branches begin dying. Even large ash trees will die after 2 to 4 years of heavy EAB infestation.

"We think the EAB probably arrived in the United States in wooden pallets and packing materials carried in cargo ships or airplanes from Asia," said Deb McCullough, MAES forest entomologist, who has spent much of the past 6 years studying several aspects of EAB ecology. "We had to spend a lot of time figuring out the biology of the insect, and we're still working on that. The first time anyone saw the bug in this country, it was immediately a crisis. It isn't a major forest pest in Asia, so there was very little research done on it."

EAB eradication may be a distant dream, but one project that McCullough and her colleagues worked on has offered some exciting results for homeowners

SOME OF THE MOST PROBLEMATIC MICHIGAN FOREST INVASIVES *(CLOCKWISE FROM TOP LEFT)*: THE EMERALD ASH BORER, BEECH BARK DISEASE, GARLIC MUSTARD AND THE SIREX WOODWASP. MILLIONS OF TREES ARE POTENTIALLY AT RISK.

and city foresters who hope to protect valuable landscape ash trees.

McCullough's research showed that emamectin benzoate, sold commercially as Tree-äge™, was "remarkably effective" in controlling EAB. In March, the Michigan Department of Agriculture (MDA) approved a special registration for the product for use in ash trees for controlling EAB. The product also has been used on fruit and vegetable crops. Special registration for Tree-äge™ to treat EAB also was approved in other states this spring, including West Virginia, Ohio and Indiana.

"The results from 2007, our first year of research with the product, were notable," McCullough said. "We had seen some preliminary tests with the product and thought it might work, so we set up research trials in three sites in May 2007."

PHOTO: DAVID CAPPAERT

David Cappaert, Andrea Anulewicz, Chris Pell and MAES scientist Deb McCullough at a field day in Shiawassee County. As the only forest entomologist at MSU, McCullough's research program expands to encompass exotic forest insect pests as they're discovered.

The scientists looked at the mortality rate of adult EAB beetles that were caged with leaves from emamectin benzoate-treated trees, trees treated with other insecticides and non-treated trees. They repeated the trial three times last summer, using more than 1,000 adult beetles in each trial. In each trial, by day three or four, all the beetles caged with leaves from the emamectin benzoate-treated trees were dead. In contrast, at least 70 to 80 percent of the beetles survived when caged with the untreated leaves, and no more than 80 percent of the beetles died when they ate leaves from trees treated with other insecticide products.

Last fall, McCullough and her team cut down and removed the bark from some of the emamectin-benzoate-treated ash trees to see how many EAB larvae were feeding on each tree. The emamectin benzoate-treated trees had more than 99 percent fewer larvae than untreated ash trees.

The results are promising, but McCullough said more research is definitely needed.

"It's a big leap ahead, but we've only got a year's worth of data, so the study is continuing," she said. "This year we're treating some of the trees again but won't treat others so we can see if the emamectin product can be applied every other year instead of annually."

Therese Poland, an entomologist with the U.S. Department of Agriculture (USDA) Forest Service, is working with McCullough on the study, and Phillip Lewis, with the USDA Animal and Plant Health Inspection Service (APHIS), is measuring the amount of each insecticide product in the ash leaves throughout the summer.

Emamectin benzoate has to be purchased and applied by a trained, certified pesticide applicator. The compound is injected into the base of the tree and must be transported by the tree up the trunk and into the branches and leaves to be effective. McCullough said it's likely that emamectin will probably be most effective if a tree is still relatively healthy when it's treated.

"The product affects insects that eat the tissue of ash trees," McCullough explained, "but insects that simply land on or climb on the tree, such as butterflies, shouldn't be affected."

McCullough said that ash trees are wind-pollinated, so there is little chance of bees or other pollinators encountering the product.

"It's not a silver bullet for eradicating EAB across the country, but it could be a quantum leap forward in our ability to slow the spread of this deadly insect," said Ken Rauscher, director of the MDA Pesticide and Plant Pest Management Division. "The product gives municipalities, homeowners and others the opportunity to save landscape trees, municipal park trees or other trees of value that might have otherwise received a death sentence because of EAB."

EAB as an Entrée

As she's been working overtime to understand EAB biology and population dynamics, McCullough and her crew also have been looking for EAB parasitoids — other insects whose larvae develop within a host — in this case, the EAB — and ultimately kill it, usually by eating most or all of its insides. A parasitoid kills only one host in its lifetime, in contrast to predators, which eat and kill many individuals in a lifetime. Because the EAB is not native to North America, it has few natural enemies on this continent. So McCullough was understandably excited about a new wasp that entomology technician David Cappaert found in a state park near Fenton. Cappaert works with McCullough on EAB and has extensive experience with biological control of pests.

"David was peeling ash trees near Fenton and was observant enough to see that a parasitoid appeared to be associated with EAB larvae. When he took logs infested with EAB into the lab, parasitoid wasps with cherry red abdomens began emerging," McCullough said. "He observed this same wasp near Grand Blanc and Flint, too."

The wasp was sent to specialists, who know it's in the genus *Atanycolus*, a family of parasitic wasps. But even the specialists haven't been able to determine the species of the wasps Cappaert found attacking the EAB larvae.

"The entomologist who is most familiar with this group of wasps believes it's a native species, but if so, little is known about its biology or even its basic life cycle," McCullough said. "But it's certainly very exciting. We've been looking for a parasitoid or a predator since 2002, and this is the first one that seems to fit the bill. Woodpeckers will eat anywhere from 2 to 90 percent of EAB larvae at various sites, but because the predation levels vary so widely, they're not a reliable control method."

EAB Arrival

The EAB was first noticed near Detroit in 2002, but no one was exactly sure when the beetle first landed on Michigan ash trees. Did it arrive and immediately start causing damage? Or had it been here for years, slowly building up populations before exploding into an ecological atrocity?

Nathan Siegert, a postdoctoral forest entomology researcher working with McCullough on EAB, developed a way to use dendrochronology — the science of studying tree ring patterns — to figure out when EAB killed a tree. Similar methods also allowed him to figure out when a tree was first infested with EAB.

"The EAB infestation in North America has given us a unique opportunity to reconstruct the temporal and spatial dynamic to find out when EAB became established and how it subsequently spread," Siegert said. "In the core area of infestation near Detroit, we've sampled ash trees across an area encompassing more than 5,800 square miles since 2004."

An emerald ash borer larva. Since its first identification near Detroit in 2002, the emerald ash borer has killed about 30 million ash trees in southeastern Michigan alone. The larvae feed on the inner bark of ash trees, disrupting the trees' ability to transport water and nutrients.

EAB-infested trees were sampled at least every 3 miles on a grid pattern over more than six counties in southeastern Michigan. Ash trees killed by EAB were preferentially sampled over live ash trees.

"A total of 2,175 cross-section cores were collected from 1,036 trees," McCullough added. "And each sample had to be studied under a microscope — it was a tremendous amount of work for Nate. He hasn't added it up, but he's probably individually measured tens of thousands of tree rings."

By measuring how much wood a tree produced each year during its life, the scientists found patterns that could be matched against a chronology — a known pattern of tree growth — created from other trees in the area. Knowing when the EAB first set up shop in a tree and when the tree died will allow the researchers to figure out how long it takes EAB to kill a tree.

"Nate's still analyzing the data," McCullough said. "But the preliminary results suggest that EAB likely arrived in Michigan at least by 1992. That means we didn't pick up its presence until 10 years later, in 2002, when the ash trees started dying. This 10-year lag isn't uncommon — many invasive pests were discovered similarly 10 or more years after they became established."

Part of Deb McCullough's research involves testing insecticides' ability to control the emerald ash borer. While more research needs to be done, early results on emamectin benzoate look promising.

McCullough refers to those organisms as "sleeper species."

"You can't help but wonder what other organisms have arrived and become established that we don't yet know about," she added.

Siegert also collected data at several areas beyond the core EAB infestation in southeastern Michigan — called outlier areas — to figure out when the outlier infestations were established.

"We've been able to determine that nearly all of these isolated outlier sites became infested because EAB was introduced to the area via infested nursery trees, infested firewood and/or infested logs before anyone even knew about EAB," Siegert said.

When completed, Siegert's research results will give the scientists a map that illustrates where the first ash trees were killed by EAB and how ash mortality progressed across southeastern Michigan. This will help efforts under way to manage EAB or slow the rate at which ash mortality advances in other parts of the country.

Preying on Pines and Bringing Down Beech

As the only forest entomologist at MSU, McCullough has seen her research program expand to encompass a variety of other exotic forest insect pests as they've been discovered. Two of the most recent forest invasive pests to cause concern are the Sirex woodwasp, which attacks stressed pine trees, and beech bark disease.

Beech bark disease begins when an invasive scale insect infests American beech trees. The beech scale penetrates the bark on the trunk and branches, creating tiny wounds that allow fungi to enter the tree. Eventually, the fungi, mainly *Nectria coccinea* var. *faginata*, kill the tree.

A native of Europe, Asia and northern Africa, the Sirex woodwasp made its first Michigan appearance when it was collected in a trap in Macomb County in July 2007. In March 2008, the wasp was confirmed in traps in Sanilac County. Sirex attacks pine trees almost exclusively and could become a problem for commercial pine tree producers. Wasp larvae tunnel in pine trunks, disrupting the flow of water and nutrients, much as the EAB does in ash trees. Female wasps also inject a toxic mucus and a fungus into trees while laying eggs, both of which cause more damage. Michigan has at least seven native woodwasps, but they cause little environmental or economic damage and play a role in tree decomposition and other ecological processes.

McCullough is a little less concerned about the Sirex woodwasp than some of the other invasive species, in part because the insect tends to be less of a problem in pine stands that are well-managed.

"In Chile, Australia, New Zealand and Brazil, where

Andrea Anulewicz, a research technician in MAES forest entomologist Deb McCullough's lab, reviews a map of ash tree test sites in Ionia State Park. Because the emerald ash borer isn't native to North America, very little was known about the insect's biology and population dynamics.

Sirex is an important invasive pest, much of the damage occurred in dense, often overstocked stands of non-native pine trees," she explained. "It's good to know where it is so we can keep an eye on it. But in Michigan, we have a complex of insects that attack stressed pines, so Sirex may have competition here."

APHIS scientists are studying whether a nematode could be used as a biocontrol for the Sirex woodwasp in North America as it has in other regions, such as Australia, but McCullough cautioned that there is concern about the impact the nematodes might have on native woodwasps. Regulations and quarantines, common when invasive pests are discovered, are not likely to be very useful for controlling the spread of Sirex, McCullough noted.

"Sirex can fly a long way — maybe 50 miles," she continued, "which makes it very difficult to regulate the insect's spread."

Beech bark disease is of more concern to McCullough, especially in an ecological context. Michigan's beech trees, though not the most prevalent hardwood species, provide habitat for a wide variety of wildlife, including mammals and birds. Beech nuts are a staple food for many animals. And large beech trees, which produce the beech nuts and provide the habitat, are more vulnerable to beech bark disease than smaller trees.

"About 75 million beech trees bigger than 10 inches in diameter occur in Michigan and are likely to die because of beech bark disease," McCullough said.

The beech scale insect came into North America in 1890 from Europe on ornamental trees shipped to Nova Scotia. The disease was first found in Michigan in 2000 in Ludington State Park, although scientists suspect it was established at least 10 years earlier. The disease was found in Bass Lake State Forest Campground in the Upper Peninsula a few months after it was discovered in Ludington. By 2007, the scale had spread across much of the eastern and central U.P. and along the Lake Michigan shoreline, as well as eastward to Cadillac in lower Michigan.

"The scale insect is very small, about 1 millimeter long," McCullough said. "The insects secrete a waxy substance to protect themselves. An infected tree looks woolly. It can start with a couple of white spots, and eventually the whole tree is covered."

All scale insects are female; the eggs develop without fertilization from a male. Because they're so small, the insects can blow in the wind or be moved by birds, people or animals. This portability probably makes it easy for a large area to become infested quickly.

"Animals love beech nuts," McCullough said. "The nuts mature in late summer and fall, which is when the scale larvae are hatching."

Once a larva is suitably situated on a beech tree, its long needle-like feeding parts pierce the tree's thin bark and the insect feeds on tree sap. By itself, this feeding doesn't kill the tree. But the tiny holes the insects leave in the bark make the tree susceptible to infection by the *Nectria* fungus. The fungus kills small patches of the inner bark, which eventually become a large mass, causing a branch or even the entire tree to die. Other insects and fungi that are attracted to dying wood can then invade the tree, weakening it further.

Weakened trees sometimes can snap in half in high winds before they're killed by beech bark disease, which is a concern in recreational or residential areas. To protect hikers and other visitors, more than 200 beech trees along the trails at Tahquamenon Falls State Park have been removed.

McCullough and her team are monitoring the advancing front, examining the population density and also working with MAES fisheries and wildlife scientist Dan Hayes, who is modeling the rate at which beech scale is advancing through Michigan forests.

"We don't really have a good answer for beech bark disease yet," McCullough said. "There are some trees that have lived with scales for 10 years and have no evidence of disease and other trees that have had scales for only 2 years and have disease. There are a few methods that may work for landscape beech trees, including scrubbing the beech scales off the tree before the fungus can infect it. But for beech trees in the forest, we don't have any good answers at this

MAES researcher Doug Landis is studying how garlic mustard spreads in Michigan and is part of a larger consortium of scientists looking for a biological control for the invasive plant. Here he pulls Dame's Rocket from a natural area on the MSU campus.

point. We're working with Bob Heyd, a Michigan Department of Natural Resources forest health specialist, to identify beech trees that may be resistant to beech scale and so are resistant to beech bark disease. In the northeastern United States, about 1 percent of the American beech trees appear to be resistant, and we have a few here in Michigan that we've tagged and are watching. That's a long-term perspective. We need to do whatever we can to keep forests as healthy and diverse as we can."

The Overpowering Herb

When young leaves of garlic mustard are crushed, they give off the spicy aroma of garlic — a fittingly pungent smell for a plant that has strong-armed its way into forests across Michigan, especially in the Lower Peninsula.

Hailing from Europe, garlic mustard is now found in North Africa, India, Sri Lanka, New Zealand and Canada as well as the United States. The plant is all over Michigan, from the Ohio/Indiana border to the Upper Peninsula. First found on Long Island in 1868, garlic mustard may have been brought to this country as a cooking herb, but it's also possible that seeds may have accidentally come across the ocean on clothing or boots or in packing materials.

"Garlic mustard is a problem because it's taking over spring ephemeral habitat [forest floors]," explained Doug Schemske, MAES plant evolutionary ecologist, who helped found the MSU Invasive Species Initiative. "It produces a huge amount of seed, spreads rapidly, and may crowd out native plants such as trout lily, trillium and spring beauty. Garlic mustard just dominates and takes over."

Besides its plentiful seed production, garlic mustard's other advantage is that it starts growing very early in the spring, so it's already fairly well established before the native flowering plants come to life. Research has shown that garlic mustard spreads about 20 feet per year on average, but in some places it can spread 120 feet per year.

Besides displacing native plants, garlic mustard also competes with timber seedlings, changes the composition of the soil and affects the ecosystem's plant-fungi relationships.

Because it's non-native, garlic mustard has no real enemies in Michigan. Animals and insects eat it but not enough to slow its spread. MAES entomology scientist Doug Landis, co-founder of the Invasive Species Initiative with Schemske; doctoral student Jeff Evans; and Schemske are studying how the plant spreads in Michigan and also helping to look for a biocontrol for the plant.

"We've established eight long-term garlic mustard monitoring sites in the southern Lower Peninsula," Landis said. "We're evaluating population changes in garlic mustard, as well as native plants, and assessing the level of herbivore impact that's necessary to regulate garlic mustard."

A consortium of scientists coordinated through Cornell University is studying four weevils that have a voracious appetite for garlic mustard. However, all these weevils are also non-natives, and this understandably raises concerns that introducing them as a remedy may knock the ecosystem further out of alignment.

"An ideal control agent would cause extensive damage to garlic mustard but wouldn't feed on any other species, even if the supply of garlic mustard were completely exhausted," Landis said. "Before any natural enemy is released in the United States, it must undergo extensive testing to demonstrate its safety in its new environment.

"We were part of a similar consortium that implemented a successful biocontrol for purple loosestrife," he continued. "We're hoping that the garlic mustard biocontrol project is just as successful."

::: Jamie DePolo

GOING TO GREAT LENGTHS TO PROTECT GREAT LAKES

RESEARCH BY MAES SCIENTISTS AIMS TO KEEP AQUATIC INVASIVE SPECIES OUT OF THE WATERS THAT DEFINE MICHIGAN AND HELP THE STATE RESPOND TO AQUATIC INVADERS THAT ARE ALREADY HERE.

The Great Lakes are the globe's largest freshwater system, welcoming vessels and the goods they carry from around the world. But along with desirable products, the freighters also have brought in more than 180 aquatic invasive species, including fish, plants, mollusks and disease organisms. The Great Lakes National Program Office of the Environmental Protection Agency estimates that about 55 percent of new species are unintentionally brought to the Great Lakes in the ballast tanks of ocean-going freighters. With direct access to

four of the five lakes, Michigan is especially vulnerable to the foreigners that lurk in ballast water.

Several of the most troublesome invaders' names are familiar to anyone with even a casual interest in the lakes: zebra mussel, purple loosestrife, sea lamprey (see the spring/summer 2007 issue of *Futures* for a story on MAES scientist Weiming Li's research on sea lamprey control). Total economic losses due to aquatic invasive species in the Great Lakes were estimated to be about $5 billion per year in 2005. To encourage everyone to take steps to prevent the introduction and spread of aquatic invasive species, Gov. Granholm declared June 1-8 as 2008 Aquatic Invasive Species Awareness Week in Michigan.

"Ballast water is undoubtedly how VHS [viral hemorrhagic septicemia, a fish disease caused by a virus] came into the Great Lakes," said Gary Whelan, fish production manager for the Michigan Department of Natural Resources (DNR), at the 2008 MSU Invasive Species Symposium in April. "It's been documented in 25 Great Lakes-region fish species and started causing fish kills here in the spring of 2005. Once you have a pathogen in the lakes, you never get rid of it. We're going to have to manage around it."

According to Michigan Sea Grant, a joint program of Michigan State University and the University of Michigan that's part of a national network of 30 university-based programs in coastal states across the country, aquatic species continue to arrive in the Great Lakes at the rate of about one every eight months. In 2005, Michigan enacted a ballast water law that requires ocean-going vessels that engage in port operations in the state to either keep their ballast water on board or use a state-approved treatment method to eliminate any aquatic life before the water is released. Data are being collected to determine if this new law helps slow the migration of aquatic invasive species into the Great Lakes.

To help in this effort to understand the impacts of invasives and keep them out of the Great Lakes, MAES scientists are studying the issues from a variety of perspectives, from education and outreach to biological controls and predator-prey relationships.

It's Big, It's Purple and It's Not a Lovable Dinosaur

The program to combat purple loosestrife is probably the oldest, most well-known and most successful aquatic invasive species control in the state. With showy pinkish purple flowers atop stems that can reach 7 feet in height, the purple loosestrife plant is hard to miss. The seeds of this European native probably came to Michigan in ship ballast water or in the fleece of sheep in the early 1800s. Gardeners, botanists and beekeepers, swept up by the plant's beauty and unaware of its bad habits, helped spread the plant across the United States.

While striking in appearance, the purple loosestrife plant quickly dominates an area and chokes out native plants. This sets off a cascade of changes that disrupts the entire ecosystem.

Purple loosestrife thrives in wetlands, riverbanks and drainage ditches, and it quickly dominates wherever it happens to be, choking out native plants by depriving them of space and sunlight. As native plants decrease, biodiversity goes down. Purple loosestrife has overtaken and changed open-water marshes, a habitat beloved by water birds. This sets off a cascade of changes that disrupt the entire ecosystem, affecting everything from tiny water organisms to birds, muskrats and reptiles.

As part of a national project to search for biological controls for purple loosestrife, researchers at Cornell University identified a Eurasian beetle, *Galerucella calmariensis*, which feasted on purple loosestrife leaves. (Because the plant wasn't native to North America, it didn't have any natural enemies in this country.) The beetle's feeding weakened purple loosestrife, slowing its spread and allowing native plants to make a comeback.

Because *Galerucella* was a non-native species, many years of extensive testing were necessary to determine that it wouldn't cause more problems by becoming invasive itself. The beetle was cleared for release in the early 1990s. The next challenge was to get the beetle population up to a critical mass that could make a dent in purple loosestrife density in the state.

"After initial release, it usually takes 3 to 5 years for populations of these natural enemies to increase to levels where a significant impact on the target weed is seen," said MAES entomologist Doug Landis, who co-founded the MSU Invasive Species Initiative.

Starting in 1997, he worked with the Michigan Department of Natural Resources, Michigan Sea Grant and the Michigan Department of Agriculture to distribute the beetle and evaluate its use as a biological control agent in Michigan.

"We trained elementary and secondary school teachers and gave them curricula so their classes could raise *Galerucella* and then release them in a wetland as a class

project," Landis explained. "Other private citizens also participated in the beetle rearing and release program. It was very successful — hundreds of thousands of beetles were released. You can't go anywhere in southern Michigan with purple loosestrife without seeing the beetles."

Purple loosestrife hasn't been completely eliminated, but the program dramatically reduced its density in wetlands and brought about a resurgence of native wetland plants.

"The program was a biocontrol success," Landis said. "It's self-sustaining now, and other groups oversee the beetle rearing and release program. We still have loosestrife in the state, but it's pretty much controlled by the beetles."

Doug Landis

PHOTO: VIC RAMEY

Hydrilla hasn't been found in Michigan yet, but no one wants to take any chances. The state developed a rapid response plan for invasives using hydrilla as a pilot case.

Heading Off Hydrilla

Hydrilla, an aquatic plant that grows underwater, isn't in Michigan — yet. Scientists and educators are hoping that a public awareness campaign and rapid response plan developed by the Michigan Department of Environmental Quality, in collaboration with MSU Extension, the Great Lakes Commission, and several other agencies and organizations, can prepare the state to address hydrilla and other invasive species.

Originally from India and Korea, hydrilla has invaded at least 19 states and is a major problem in Florida, Texas and a number of other southern states. Florida, for example, spends about $17.5 million per year to manage hydrilla — roughly $1,000 per acre. The plant can grow up to 1 inch per day and forms large, dense mats near the surface of freshwater lakes and ponds. These plant mats make it unpleasant to swim or boat in the water and also restrict water movement, causing sediment to accumulate and creating excellent mosquito breeding grounds. As if this weren't bad enough, the mats also block sunlight, which can negatively affect native plants, animals and fish that live in the water. The plant doesn't seem to have any natural enemies in either Korea or India, though U.S. scientists in the South are starting experiments on a biological control.

"Hydrilla hasn't been found in Michigan yet, but scientists don't want to take any chances," said Carol Swinehart, Michigan Sea Grant Extension specialist. A member of the Hydrilla Task Force, she helped create the awareness campaign and rapid response plan. "The state developed a rapid response plan for invasives and has made hydrilla a pilot case."

The task force's two-pronged approach to hydrilla prevention calls for public education about the plant so that more people can be on the lookout for it and take steps to prevent its introduction, and a rapid response plan to guide state agencies and scientists in case hydrilla does invade Michigan.

Sea Grant produced Hydrilla Hunt I.D. cards featuring a color photo of the plant, a brief description of it and instructions on how to collect a sample. The cards were handed out to thousands of boaters, anglers, lakefront property owners and other concerned citizens. The task force also contacted people who had participated in the purple loosestrife project to see if they were willing to tackle another invasive.

"Hundreds of cards also have been downloaded from the Web site," Swinehart explained. "Four samples have been submitted so far, and none of them was hydrilla, so we haven't had to activate the rapid response plan, knock on wood."

In August 2006, the plant was found in northern Indiana, less than 50 miles from the Michigan border.

Part of the hydrilla awareness campaign included appearances by Helga the Hydrilla, a character designed to encourage boaters, anglers and other interested citizens to learn about the plant and watch for it.

"Indiana went after it intensively," Swinehart explained. "Everyone thinks the outbreak was confined to only one lake, so we think it's been handled. In August 2007, hydrilla turned up in a pond in northern Wisconsin. The pond was drained, and everyone believes that it's been handled there as well. Both states took an eradication approach to it, and we have to thank them for that."

Completely eliminating hydrilla is difficult because broken fragments of the plant can reproduce and thrive, just like its namesake, the many-headed Hydra of Greek mythology, which lived in Lake Lerna and grew two heads for every one that was cut off. Large mechanical harvesters can't be used because small pieces might break off and reinfest the waters. Most state response plans focus on education and monitoring so that hydrilla can be detected immediately and removed by divers while populations are still small. For larger infestations, herbicides must be used with extreme care because they can affect native plants as well as the rest of the ecosystem.

The Michigan Hydrilla Task Force continues to offer information and hopes it doesn't have to activate its rapid response plan.

"2008 is the 20th anniversary of zebra mussels being discovered in the Great Lakes," Swinehart said. "It's amazing to consider the strides we've made toward preventing aquatic invasive species introductions since that time. We have new tools — the Web has made a huge difference. We can take advantage of worldwide expertise in seconds, and it also allows us to get information out to people instantly. But we still need to be vigilant."

Carol Swinehart

The Ecology of Fear

MAES fisheries and wildlife scientist Scott Peacor and doctoral student Kevin Pangle want to change the way people look at the effects of one Great Lakes invader.

Their research focuses on the spiny water flea, *Bythotrephes cederstroemi*, a tiny crustacean with a long, sharp, barbed tail, which hails from Europe and Asia. First found in Lake Michigan in 1986, the spiny water flea most likely traveled across the Atlantic in ship ballast water and is now in all the Great Lakes as well as some inland lakes in the region. The spiny water flea eats daphnia, a common zooplankton found throughout the Great Lakes. Because daphnia is also an important source of food for valuable commercial fish such as whitefish, yellow perch, chubs and bloaters, scientists are concerned that *Bythotrephes* could negatively affect economically important commercial and recreational fisheries. At less than ½ inch long, the spiny water flea is small enough to be considered food for fish that eat daphnia. But the hard exoskeleton and the barbed tail, which makes up about 70 percent of the creature's length, make it difficult for smaller native fish to swallow.

"Our background is studying food webs," Peacor explained. "We're pretty sure the spiny water flea is having an adverse effect on food webs in the Great Lakes. But we want to look at more than just what the spiny water fleas are eating. Eating daphnia is only a small part of the negative effect the spiny water flea is having. Simply looking at what eats what isn't enough to figure out everything that's happening. Those cartoons of the bigger fish eating a smaller fish to describe what's happening in nature may be missing larger factors that govern how species affect one another."

Food webs are networks of interconnecting food chains. Each chain consists of a sequence of organisms eating and being eaten by other organisms.

Working in Lake Michigan and Lake Erie, Peacor and Pangle found that, after the spiny water flea became established, daphnia populations started hiding in deeper, darker waters to avoid being eaten. Though the fearful daphnia did manage to remove themselves from the spiny water flea lunch menu, they found themselves in colder waters less conducive to daphnia reproduction.

Spiny water flea

"The daphnia that weren't eaten were successful in that sense," Peacor said. "But the spiny water flea is still having a negative effect, even though it's nonlethal, because it's ultimately changing the outcome of daphnia reproduction. These changes affect the entire ecosystem and food web. One name for this is the ecology of fear — fear of being eaten is changing the ecosystem more than actually being eaten is."

Peacor and Pangle's research found that the nonlethal effects of the spiny water flea could have up to 10 times the effect of the flea simply eating the daphnia.

"These nonlethal effects mean that looking only at what the predatory spiny water flea eats to measure its impact could greatly underestimate the true effect of the predator," Peacor said. "To gauge the impact of the spiny water flea, different models and new monitoring protocols are necessary."

The spiny water flea also eats bosmina and copepods, two other types of zooplanktons in the Great Lakes, and the scientists expect to see a similar response in these other zooplankton prey.

"Now we're working to show how these nonlethal effects can affect other species and the food web," Pangle added. "We expect to show a compounded, complex effect."

To figure out when daphnia started responding to the spiny water flea's presence, Peacor and Pangle are conducting resurrection ecology experiments. Daphnia lay their eggs in soil, and the eggs can remain there for years before hatching. Other researchers have hatched daphnia eggs that were 100 years old. Peacor and Pangle want to see how newly hatched daphnia from eggs laid in pre-flea times react to the invader.

"Do they sense the predator's scent and take action?" Peacor asked. "Or do they not react because the spiny water flea isn't native to the Great Lakes? We want to see if eggs that were laid before the spiny water flea came here hatch into daphnia that react."

Peacor and Pangle want to find answers to some of the evolutionary questions connected with aquatic invasive species: does the naiveté of the native prey, in this case the daphnia, affect the success of the predator (the spiny water flea)? And how long does it take the native prey to learn to respond to the predators? Will the prey develop different responses the longer the predator is around?

"For example, we know that daphnia can grow tail spines and little bony helmets as protection," Peacor explained, "but it appears that these adaptations don't affect the spiny water flea. But what effect will they have on fish that eat daphnia?"

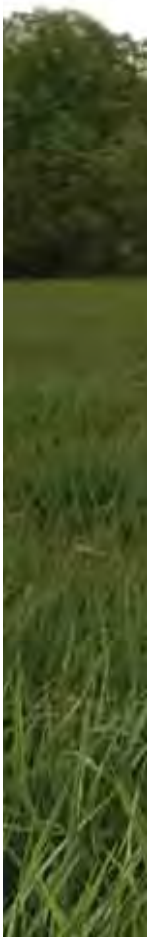
These are the first steps to understanding the spiny water flea's effects on Great Lakes food webs, and the scientists believe the research will create general principles that could apply across species, including between predatory fish and economically important fish prey in the Great Lakes. Peacor said similar fear-induced indirect effects have been seen in other predator-prey relationships, such as wolves and elk, and sharks and turtles. People, too, change their behavior in many circumstances in reaction to threats at both the local and global level.

"If induced traits such as the retreat of the daphnia are qualitatively important, it affects how we construct models to map long-term effects of invasive species, biodiversity and population dynamics," Peacor explained. "It's not a clean addition of effects anymore. Species interactions are dependent on food webs. Our goal is to provide scientific information to ecosystem managers so they can work toward the most desirable outcome."

Scott Peacor and Kevin Pangle

::: Jamie DePolo

Biofuel Building Blocks or Emerging Invaders?



In June 2007, Michigan State and the University of Wisconsin-Madison received $125 million from the Department of Energy (DOE) to establish the DOE Great Lakes Bioenergy Research Center (GLBRC). MSU's $50 million portion of the grant is the largest federal grant exclusively for research endeavors in university history. Several MSU scientists internationally known for plant science research are working on one of the center's research focus areas: breeding new varieties of plants that can be used to make renewable fuels and other energy products.

People mainly grow plants for food, so breeders historically have focused on boosting the yield and nutritional quality of the edible part of the plant. Though ethanol can be made from corn grain and biodiesel can be made from soybeans, many researchers believe that Michigan's niche in the emerging biofuel industry will be converting cellulose — trees, stems and stalks that aren't used for food — into fuel.

"In Michigan, our research and development emphasis is on making renewable fuels from cellulose," said Steve Pueppke, MAES director, who also heads 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. New crops developed specifically for biofuel production will need different properties than crops bred to be used as food."

At the same time, any new crops that are developed have to be sustainable — meaning they can be cultivated and harvested without harming the environment as well as being profitable for growers.

"If we're going to start using plants in significant ways beyond food, a lot of issues come into play that we need to figure out," said Ken Keegstra, MAES plant biology and biochemistry and molecular biology researcher, who serves as executive director of the GLBRC. "Sustainability, competition for food and environmental issues all will have to be addressed."

To do this, another GLBRC research focus area, also led by MAES scientists, is developing a sustainable bioenergy economy. One objective of GLBRC sustainability research is to understand the environmental value and impact of alternative biofuel production systems, including evaluating whether a biofuel crop could be invasive.

Is It Ideal or Is It Invasive?

The potential invasiveness of both new crops bred specifically for biofuel production and existing crops that haven't been commercially cultivated before is an issue that MAES scientist Kurt Thelen thinks about almost every day.

In January, Thelen became the university's first bioenergy crop agronomist. As interest in growing crops for fuel and energy has increased during his almost 10 years at MSU, Thelen's agronomy research has followed suit. In addition to studying how to grow corn, canola and soybeans for maximum yield with minimal environmental impact, he began analyzing crop components for energy quality and looking at fatty acid profiles in relation to potential biofuel production. He also began studying whether marginal land — land that can't be used to grow food crops — could be used to grow bioenergy crops. He also serves as team leader for the GLBRC research area evaluating novel bioenergy crop production systems.

For bioenergy crops, Thelen looks for plants that produce large amounts of biomass and thrive in marginal conditions — poor soils, low moisture, and minimal fertilizer and other nutrient inputs. The plants also should be very competitive, meaning they muscle other plants out of the way when they're competing for the same space. The model bioenergy crop also would be resistant

Grasses and other non-food crops may be ideal raw materials for biofuels. MAES scientists are making sure these new crops aren't invasive.

MAES scientist Kurt Thelen is the university's first bioenergy crop agronomist. He says that the traits that make good bioenergy crops — producing large amounts of biomass and thriving in marginal conditions — are also the traits that make good invasive species. Invasiveness is being carefully evaluated as scientists search for new crops to cultivate for energy.

to diseases and impervious to attacks from insects. These traits are almost identical to those that signal a potential invasive species.

"The characteristics that make an ideal bioenergy crop also make an ideal invasive crop," Thelen said. "There's no question that it's something we have to evaluate carefully as we move forward with bioenergy research. Nobody wants to be the one to unleash a noxious weed on the environment."

Thelen has begun intensive agronomic studies of bioenergy crops such as switchgrass and miscanthus (two grasses) and camelina, a type of canola. He is using some risk assessment model programs that can help evaluate a crop's potential for invasiveness and also has to evaluate the crop's biofuel potential.

One crop that Thelen isn't studying is phragmites, a tall feathery reed. On the surface, it appears to have excellent biofuel properties, and some scientists have considered it for cultivation. But because phragmites grows in wetlands, Thelen sees a host of potential problems.

"Plants like phragmites are of more concern than switchgrass and miscanthus because they grow in wetlands, which are already delicate ecosystems," he said. "There's much more potential for a nonnative species to cause problems there. It makes sense to investigate other plants first."

Both switchgrass and miscanthus produce large amounts of cellulosic biomass, which gives them high marks as potential

MAES scientist Doug Schemske says that after the properties of an optimal bioenergy crop are identified, the ideal situation would be to find a native plant that could be used.

bioenergy crops. They grow rapidly and don't need much fertilizer or water and thrive in a variety of conditions, including Michigan's cool climate.

According to Thelen, switchgrass could be considered a native Michigan species, which lowers its invasive potential down to practically zero. Many home gardeners plant the perennial as an ornamental grass, where it often grows to heights of 6 feet or taller.

"Switchgrass is an original prairie grass of the Midwest and was one of the three main prairie grasses in Michigan," he explained. "There are some states where it's non-native, but you can definitely see it around here."

Miscanthus, on the other hand, hails from the tropical and subtropical regions of African and southern Asia. Though its potential for invasiveness is higher than that of switchgrass, Thelen said there still isn't much cause for alarm.

"Miscanthus isn't very genetically diverse, and most of the varieties are sterile hybrids, so it doesn't produce any seed," he explained. "To put in a crop of miscanthus, you have to plant plugs — pieces of root of established plants. The odds are that it's less likely to be invasive than a plant that produces seed."

MAES scientist Doug Schemske, a plant evolutionary ecologist and co-founder of the MSU Invasive Species Initiative, said that, though sterile hybrids do have a lower likelihood of invasiveness, history has shown that they can occasionally produce viable seed.

"Some species of miscanthus have become invasive in the United States, so there is concern that large-scale production of miscanthus for bioenergy could have undesirable consequences," Schemske explained.

Schemske said that, after the properties of an optimal bioenergy crop are identified, the ideal situation would be to find a native plant that could be used. If no native plants fulfill all the specifications, then non-native plants should be extensively tested for any invasive properties, as well as any ecosystem benefits.

"Native grasses can be grown on soils that aren't suitable for food production," Schemske said. "So people are looking at land in the Conservation Reserve Program as possible sites for growing biofuel crops. If we could plant native grasses there that have dual benefits — they can be used to make biofuel and they also provide nesting areas for endangered grassland birds — that would be a good solution."

Thelen pointed out that, as new varieties of crops are bred, mechanisms are in place to evaluate new germ plasm for invasiveness, with all new varieties subjected to a stringent peer-review process before anything could be released.

"As we move further down the road with breeding programs, we'll be looking at new plants very closely and giving feedback to the breeders on what is and isn't desirable," he said.

"The goal is to have everything on the table when evaluating the crops," Schemske added. "We have to look at all the risks and all the benefits and then decide. That's how MSU science can help inform that discussion."

::: Jamie DePolo

A New Way of Thinking about Field Crops

Because both crops are perennials, growing switchgrass and miscanthus will require farmers used to growing corn or soybeans to undergo somewhat of a mind shift.

"Most field crops are annuals, which means a new crop gets planted each spring," Thelen explained. "A perennial just stays in the ground, overwinters and then emerges again each spring — there's no yearly rotation. It's a different way to think about cropping."

Farmers that grow perennial forages or fruit are familiar with this type of system. But corn and soybean growers may have to stop and think about planting a crop that takes several years to produce something that's harvestable, as is the case with miscanthus.

"Miscanthus is also expensive to establish and hard to get rid of once it's in because it has woody roots," Thelen said. "It's hard to rotate crops in and out. Some farmers may like the flexibility that annual crops give them — if prices go up or down, they can adjust what they plant the next year. We plan to provide information for growers so they know exactly what to expect if they want to consider growing perennial bioenergy crops."

It's Ornamental:

Right Plant, Right Place, Science-based

Invasive plants are a highly debated topic in the horticultural world today. MAES researchers are collaborating with the horticulture industry — in Michigan, the Midwest and nationally — to identify plant characteristics and develop science-based risk/benefit assessment models to address this critical issue.

Although many consider baseball America's favorite pastime, more people participate in gardening than attend major league baseball games. According to the National Garden Association, an estimated 82 million U.S. households (71 percent of the nation's total) participate in flower gardening, landscaping and lawn care, beating out major league baseball game attendance — an estimated 79.3 million people in 2007 according to ticket sale records.

The U.S. Department of Agriculture (USDA) reports that the nursery and landscape industry is the fastest growing segment of U.S. agriculture. Retail sales of lawn and garden products to U.S. consumers totaled $35.1 billion in 2007, a 3 percent increase over 2006.

In Michigan, the horticulture industry contributes $1.2 billion to the state's economy, according to the Michigan Nursery and Landscape Association (MNLA). Nursery and perennial plant producers distribute their products to 35 states, Mexico and Canada, making this sector of the industry the second largest agriculture commodity group in Michigan and the fifth largest nursery industry in the United States.

People's love for gardening has deep roots. As long as humans have traveled between continents, plants have accompanied them. Of the thousands

of non-native plants introduced and distributed in this country for horticultural, agronomic or medicinal uses over the past 300 years, experts estimate that 10 to 15 percent of introduced species will become established and about 10 percent of established species may become invasive. A small percentage of plants introduced into the horticultural trades have been identified as invasive. Well-known examples include purple loosestrife, kudzu and Queen Anne's lace.

"Of the non-native plants in Michigan, only a small portion are considered invasive," said MAES horticulture scientist Robert Schutzki, who has spent 25 years researching the characterization of adaptive traits in plants and ornamental plant management. "Non-native plants vary in adaptability from those that can barely survive to those that find Michigan perfect for growing, reproducing and spreading."

Schutzki added that growing, reproducing and spreading do not constitute invasiveness.

"Invasiveness is linked to environmental, economic and human harm," he said. "The challenge is to document actual harm and develop scientifically sound assessment tools to evaluate established plants and potential new ones and, through these efforts, prevent the further introduction of harmful invasive plants."

Rules of the Game: Defining Invasiveness

Awareness within the horticulture industry about the magnitude of and challenges posed by invasive plants was heightened when the Federal Executive Order on Invasive Species was issued in 1999. The directive defined what constitutes an invasive species, established a National Invasive Species Council and required each state to create its own entity to address the prevention, control and management of non-native invasive species.

The Michigan Invasive Plant Council (MIPC) was established in 2000 and includes representatives from state and federal agencies, universities, nonprofit agencies, private corporations and individuals.

"The invasive plant issue is extremely complex and crosses many disciplines and commodity boundaries," said Schutzki, who is an MIPC member. "Each organization or group has its own perspective, interpretation and agenda when addressing concerns over the classification, use and impact of invasive plants.

What one person sees as harmful may seem benign to another.

"For example, what's determined as harmful in a natural area environment is not necessarily harmful in a built environment — in a landscape context," he explained.

Left: **MAES horticulture scientist Robert Schutzki examines Japanese honeysuckle, a non-native plant, on the MSU campus. Like Japanese honeysuckle *(close-up, right)*, Japanese knotweed (above) and buckthorn *(far right)* are also non-native plants. Schutzki says that only a small portion of non-native plants in Michigan are invasive and the challenge is to document harm and develop scientifically sound assessment tools to evaluate established plants and new introductions.**

In addition, many species have been identified as being invasive simply because they spread, Schutzki said.

"Just because a plant is an aggressive grower doesn't mean it's invasive," he explained. "There are some species whose vegetative growth is a problem, such as kudzu in the South, but the extent or degree of spread with other plants such as common periwinkle (*Vinca minor*) can be misinterpreted and inaccurately classified. *Vinca minor* doesn't jump spatial gaps, so it's not going to spread 100 yards away in another area by virtue of its vegetative growth. Right now, there isn't a standard that says that if a plant spreads this amount, it's invasive, if it doesn't, its not."

"JUST BECAUSE A PLANT IS AN AGGRESSIVE GROWER DOESN'T MEAN IT'S INVASIVE."

Schutzki added that other considerations beyond growth come into play when determining invasiveness.

"You need to look at whether the plant's seeds are subject to long-distance dispersal by wind and wildlife and whether growing conditions are ripe for the plant to aggressively colonize in natural areas," he said.

To facilitate collaboration and a broader discussion on the invasive plant issue, two symposia were conducted to bring natural resource and horticulture communities from across the country to generate a game plan for workable solutions.

The first meeting, held in St. Louis in 2001, resulted in the development of the St. Louis Declaration and voluntary codes of conduct for groups whose actions affect the spread of invasive plant species — nursery professionals, landscape architects, the gardening public, botanic gardens and arboreta and government. The second workshop, in Chicago in 2002, focused on exploring the role "regionality" plays in addressing the invasive plant species problem and developing guidelines for selecting alternative plant species that could be used in place of horticultural species recognized as invasive.

HIGHLIGHTS FROM THE ST. LOUIS DECLARATION ON INVASIVE SPECIES AND VOLUNTARY CODE OF CONDUCT

- Efforts to address invasive plant species prevention and management should be consistent with national goals or standards, while considering regional differences.
- Prevention and early detection are the most cost-effective techniques that can be used against invasive plants.
- Research, public education and professional training are needed to more fully understand the invasive plant issue and develop non-invasive alternatives and other solutions.
- A broad-based, collaborative effort is needed to address the challenge and should include leaders in horticulture, retail and wholesale nurseries, weed science, ecology, conservation groups, botanical gardens, garden clubs, garden writers, educational institutions, landscape architects, foundations and government.
- Invasive potential must be assessed before a new plant species is introduced and marketed in North America.

"These gatherings provided the foundation needed to begin the development of an invasive plant game plan for Michigan," Schutzki said.

Batter Up: The Invasive Plant Lineup

Michigan bases its invasive plant list on the executive order, which defines an alien invasive species as non-native to an ecosystem and one whose introduction causes or is likely to cause economic or environmental harm or harm to human health.

"In Michigan, as is the case with every other state, we have an invasive plant council," said David MacKenzie, owner of Hortech, Inc., a wholesale nursery in Spring Lake, Mich. and MIPC member. "But we also have every other entity you can imagine publishing its own list of invasive plants and, in some cases, with absolutely no criteria for a scientific evaluation of them.

"A couple years ago, we had an instance in Michigan where a list of invasive plants was developed and then banned by virtue of law," MacKenzie continued. "Though there were plants on the list that were invasive from everyone's perspective, there were a number that were there simply because someone observed them in a natural setting without investigating their characteristics and scientifically verifying their invasiveness. As a result, an inaccurate conclusion was made."

One of the plants on the list was *Iris pseudacorus*, the yellow flag iris. Although this plant can be found in natural areas, MacKenzie explained that even the ecologists familiar with it don't really consider it an invasive plant in Michigan.

"Once that plant was banned, any variety of the plant also became

THE MICHIGAN PLANT INVASIVENESS ASSESSMENT SYSTEM

The purpose of the assessment system is to identify relevant biological, ecological, management and economic information that help evaluate the impact a plant may have on Michigan ecosystems. Assessment results become the foundation of the Michigan Invasive Plant Council recommended plan of action.

The assessment system has seven sections:

- Biological character: includes reproduction and dispersal characteristics.
- Impact: assesses the plant's impact on natural systems, managed landscapes, production systems and constructed habitats.
- Distribution: assesses the plant's current range in Michigan and beyond as well as the extent of its distribution in Michigan's four ecological regions – eastern and western Upper Peninsula, and northern and southern Lower Peninsula.
- Control methods: includes information on known methods of control.
- Control effort: includes known efforts that are under way.
- Value within Michigan: summarizes the plant's aesthetic, economic and conservation value.
- Summary: includes invasiveness ranks, supporting information and the plan of action.

Rating Criteria for the MIPC Assessment System

- impacts on natural areas
- impacts on managed areas (focus is on production systems and managed landscapes)
- biological characteristics and dispersal ability
- distribution and abundance in Michigan
- management potential
- value

banned," he said. "Although *Iris pseudacorus* isn't of particular interest economically as a garden plant, some of the cultivars with variegated or striped leaves are quite valuable to the nursery and gardening communities."

When the horticultural community protested, the plant was reexamined and it was concluded its inclusion on the list was a mistake.

"But here's the problem," MacKenzie said. "Nurseries that stocked this plant have already lost their sales and dumped their inventory, and the public now perceives the plant as invasive. Once something like this occurs, it's very hard to change the impact or reverse the momentum. This is an extreme example of what can happen if there isn't a proactive, judicious sourcing of information from all involved stakeholders."

"What we want to see are lists based on science and research," said MNLA executive director and MIPC chair Amy Frankmann. "It's critical that these lists are credible and accurate from the beginning so people are well-informed and aren't confused. If I'm told something, act on it and six months or a year later, I'm told something else, I stop listening to the source. We have to be able to come out and be right, otherwise we're never going to fix the problem."

"Alternative and invasive plant species lists are useful and worth developing provided all stakeholders participate in their development, there are clear and accepted criteria for listing invasive plants and alternatives for them, the needs of different audiences are considered and addressed, and regional considerations are given a priority," Schutzki said.

Hitting the Strike Zone: Regionality

Experts agree that the potential for a particular plant to behave invasively depends on the region in which it exists.

"This is the case with many plant species and means that any effort to address the invasive species problem must include credible information on plant behavior in a given location," Frankmann said. "One of the concerns the landscape and nursery industry has is that information is posted on the Internet and then used by many people, often without an examination of whether it is valid for the geographic area being referenced."

Although many people think of non-native plants as coming from Europe, Asia or somewhere off the North American continent, a native plant from Pennsylvania or Ohio or Illinois can also be considered invasive in Michigan.

"We've had instances where information comes from other states outside our region in which the plants being talked about do not behave the same way in Michigan," Schutzki said. "People also borrow images from national databases to use as examples of what is happening in Michigan when, in fact, that's not the case."

Japanese honeysuckle provides a good example of the importance of regional considerations, Schutzki said.

In the northeast and southeast United States, Japanese honeysuckle poses a significant problem. Its thick growth blocks sunlight and gradually smothers other plants. Native shrubs and small trees can also be killed or stunted by girdling when honeysuckle vines wrap tightly around the stems.

"But Japanese honeysuckle doesn't grow like that in Michigan," Schutzki explained. "It's controlled and you don't see the aggressive growth here that you see elsewhere, yet it is cited as an example of a Michigan invasive plant."

In addition, Michigan is classified according to four ecological regions, and variations in plant behaviors can and do occur across and within these areas.

"Invasiveness ratings and rankings in Michigan need to be established for each of these areas as well," Schutzki said. "The bottom

line is that the factors that affect invasiveness vary regionally and should be assessed on a regional basis to be most useful."

Using Designated Hitters: Alternative Plants

Another concern for the horticulture industry is that most plants are evaluated at the species level and all subgroups are included in the results. Schutzki observed that this is especially troublesome when species are identified on regulatory lists with no provisions for acceptable varieties, cultivars, hybrids or other subgroups.

"WE NEED TO BUILD AND SUPPORT A NETWORK OF WELL-INFORMED PLANT PROFESSIONALS WHO HAVE THE CONTACTS, INFORMATION AND RESOURCES NECESSARY TO DEAL EFFECTIVELY WITH THE PREVENTION AND MANAGEMENT OF INVASIVE PLANTS."

"The nursery industry has grown species for 10, 20, 30 years and has demonstrated through trials that cultivars can be developed that don't produce as much seed and have different vegetative growth," he said. "But these trials haven't been published in scientific publications, so this information is typically considered anecdotal. This has been an issue especially when it comes to cultivars — intentionally created cultivated varieties of plant species."

Because most people don't understand the difference between a species of plant and a cultivar, Frankmann uses a parent-child analogy to explain the distinction.

"When I talk with folks, I ask them to think of a species as the mom and dad," she said. "And just because the mom and dad are bad doesn't mean all of the kids are bad. With education and different influences, children can behave and act differently. They don't have to be the same as their parents. In the same way, by taking an invasive species and changing certain traits that elicit different behaviors than the parent plants, we can create cultivars that are non-invasive."

Schutzki added that there are numerous examples of reproductive and growth habits differing among species and their cultivar selections.

"All of the ornamental plants we work with have cultivar selections with different ornamental traits not only in terms of color, but seed sets, seed production and growth rates," he said. "Cultivars provide acceptable alternatives and are already produced in the trades. There are also several non-invasive alternatives to some of the species that have been labeled as invasive. Research is under way to document and verify these selections."

Amy Frankmann, executive director of the Michigan Nursery and Landscape Association, wants to see lists of invasive ornamental plant species based on science and research. She'd also like to see a standard definition of invasive species.

Similar research is taking place at the national level to develop non-invasive nursery plants by combining infertility with other desirable traits using traditional breeding approaches. The 5-year project, started in 2003, is part of a national program on plant genome characterization and genetic improvement that includes research on amur maple, Norway maple, mimosa, trumpet vine, Scotch broom, St. Johns-wort, privet, callery pear and lacebark elm.

"Focus at the national level on programs to breed non-invasive characteristics such as sterility will help us develop better behaved cultivars," Schutzki said.

Who's on First? The Science of Plant Assessment

A conference held in conjunction with the Seventh International Conference on Ecology and Management of Alien Plant Invasions in 2003 addressed invasive plant list development, assessment systems and invasive plant ranking protocols.

The results of this meeting, combined with the key findings and recommendations from the St. Louis and Chicago symposia formed the basis of MIPC's Michigan Plant Invasiveness Assessment System (MPIAS) (see box on page 38).

"FOCUS AT THE NATIONAL LEVEL ON PROGRAMS TO BREED NON-INVASIVE CHARACTERISTICS SUCH AS STERILITY WILL HELP US DEVELOP BETTER BEHAVED CULTIVARS."

Plant invasiveness assessments are divided into two categories: predictive models for first-time introductions and systems that deal with plants already present in a given region.

"Predictive risk/benefit assessment models are in the developmental stage and not yet effective in predicting the possible impacts of newly introduced species," said Schutzki, who chairs the MIPC assessment committee. "Currently, there are no broadly accepted scientific principles or reliable procedures for identifying the invasive potential of plants in new geographic areas. Work will continue on developing a sound methodology and, at some point, there may be a credible predictive model."

Most of the plant invasiveness assessment systems being employed today, including Michigan's, evaluate plants already present. The MPIAS seeks to provide in-depth information on biological characteristics, impact, plant distribution, control methods and efforts, and plant value within Michigan. It also includes a final assessment of invasiveness, a plan of action and a list of documents supporting the assessment.

"The goal is to make the process of assessing and listing invasive plants objective and systematic and to incorporate scientific documentation of the information used to determine each species' rank," Schutzki said.

To date, about two dozen plants have been assessed, and MIPC is in the process of developing a plan of action for each.

"A judicious evaluation of plants that includes the assessment of a plant's biology and reproductive characteristics, the impact it causes and what value exists for the public at large is essential," said MacKenzie, who is also an MIPC assessment committee member. "Such an approach gives us the opportunity to make decisions and recommendations that are sensible and scientifically sound."

"Scientific research and economic and environmental risk assessment models need to be further developed to provide a stronger foundation for identifying and listing plant species as invasive or non-invasive alternatives," Schutzki said. "Invasive plant assessments that do not consider regionality and subclasses of plants as individuals when evaluating for invasiveness are not scientifically complete."

Teaming Up to Manage Invasives

Although there have been numerous attempts over the past several years to clarify the term invasive species, including an invasive species definition clarification and guidance white paper issued by the National Invasive Species Council in 2006, there continues to be uncertainty concerning the use and perceived meaning of the term and, consequently, over the prospective scope of actions needed to effectively address the problem.

Frankmann said she attended a USDA meeting on invasive plants in March where participants got to the point that they had to ask each presenter which definition of invasiveness he/she was using.

"If we can't even agree on the definition, how are we ultimately going to solve the problem?" she said. "You can't have good results unless you are all starting from the same place. What we're doing right now is like having 50 people in the same room trying to make the same cake using different recipes and expecting to have the same cake at the end. It's not going to happen."

Another challenge is securing the necessary funds for research and outreach efforts.

"Unfortunately, with the executive order there were no funding provisions, so the MIPC has largely been supported through donations and membership," MacKenzie said. "The bottom line is that there's not enough money to accomplish a lot of testing, assessing overall impact or distributing literature. A regular, predictable income stream would change that. I think that people currently out there doing things freelance would be a lot more supportive of the MIPC if it had the ability to function from an economic standpoint."

Despite continued challenges, Schutzki feels progress is being made.

"The guidance developed at the St. Louis and Chicago meetings is making a difference," he said. "The codes of conduct have been endorsed by the major national societies for botanic gardens and arboreta, the nursery industry, garden clubs and landscape architecture, and steps are being taken to encourage their members to adopt and implement them.

"The focus for the horticulture industry moving forward will be to evaluate existing and potential new ornamental plant introductions for potential invasiveness, develop ornamental plants that do not reproduce and spread in the landscape, and promote plants that are non-invasive alternatives to current ornamental invasives," Schutzki continued.

"We need to build and support a network of well-informed plant professionals who have the contacts, information and resources necessary to deal effectively with the prevention and management of invasive plants," MacKenzie added. "In the meantime, the whole issue could do with a little less finger pointing and a whole lot more collaboration and sharing of information."

::: Val Osowski

Research *in the news*

New Technique Puts DNA Profiling of *E. coli* on Fast Track

Thomas Whittam

Using new genetic techniques, MAES scientists are unlocking the secrets of how *E. coli* bacteria contaminate food and make people sick.

MSU has developed a new technique to test the DNA of *E. coli* bacteria by examining very small genetic changes called single nucleotide polymorphisms or SNPs (pronounced "snips"). Using SNPs, scientists were able to genetically analyze 96 markers — a rate never before accomplished in pathogenic bacteria.

"It used to take three months to score one gene individually," said Thomas Whittam, MAES scientist and Hannah distinguished professor at the National Food Safety and Toxicology Center at MSU. "Now, we are working on a new, more rapid system that can do thousands of genes per day."

In a new study released in the March 10 edition of the Proceedings of the National Academy of Sciences, "Variation in Virulence Among Clades of *Escherichia coli* O157:H7 Associated With Disease Outbreaks," Whittam and his co-authors looked at the DNA of more than 500 strains of a particularly dangerous member of the *E. coli* family, O157:H7. In collaboration with David Alland of the University of Medicine and Dentistry of New Jersey, Whittam discovered that individual bacteria could be separated into nine major groups, called clades.

E. coli makes people sick because the bacteria produce toxins, called Shiga toxins, which block protein synthesis, an essential cellular function, particularly in the kidneys. What Whittam found was that the various clades produced different kinds of Shiga toxins in varying amounts on the basis of their DNA.

"For the first time, we know why some outbreaks cause serious infections and diseases and others don't," Whittam said. "The different *E. coli* groups produce different toxins."

Rapid genetic characterization also opens up a new world of possibilities for identifying the bacterial culprits in outbreaks and finding out where they originated.

E. coli bacteria usually come from animal waste contaminating sources of human food or water. Finding out how the bacteria entered the food source always has been a challenge, but now food safety experts can use DNA just as police use DNA at crime scenes. Scientists will be able to identify those bacteria making people sick, find out where they entered the food source and then use this information to reduce contamination.

"This is the first time anyone has been able to classify very closely related groups," Whittam said. "This is also the first time we can tell the differences in how they cause disease."

Whittam also has plans to use this methodology to study other bacterial strains, such as *Shigella*, a major cause of diarrhea around the world.

"This new equipment can be used to identify hundreds of thousands of pathogenic bacteria," Whittam said.

The research is supported by the National Institute of Allergy and Infectious Diseases of the National Institutes of Health through the Food and Waterborne Diseases Integrated Research Network.

Chicken Genome Leads to New Vaccine to Fight Poultry Disease

Researchers in Michigan, Delaware and Texas are using the chicken genome sequence to develop vaccines to combat Marek's disease, a highly contagious, cancer-causing viral disease that costs the poultry industry $1 billion a year worldwide.

MAES scientist Jerry Dodgson and colleagues at MSU, the USDA Agricultural Research Service Avian Disease and Oncology Lab, the University of Delaware and Texas A&M University began by assembling the physical map of the chicken genome using DNA clones that describe all or nearly all of the genes in the chicken. The researchers then began to identify individual genes whose levels went up or down after infection by Marek's disease virus (MDV). To do this, they used a "gene chip" with approximately 13,000 gene sequences (about half the chicken genes) to test levels of gene products before and after MDV infection, and in chicken lines that were highly susceptible versus lines that were more resistant.

In the field, MDV spreads from bird to bird via inhaled feather dander. Any infected tissue is a mixture of uninfected and infected cells that are closely intermingled, making it difficult to distinguish differences between them. Using a laser to microdissect a clump of infected cells from uninfected ones, the group discovered a suite of genes in the chicken genome that influence the course of viral infection. This new understanding of the interaction between the virus and the genes was used to develop new ways to identify genes in the chicken that are turned on or modified by MDV infection.

A new recombinant vaccine was developed by cloning one of the identified genes, called chicken MIP-1, into the vaccine strain of the virus. The protection this vaccine provides is comparable to that afforded by the best commercially available vaccines.

The chicken genome sequence developed during this project is now available to scientists working on MDV worldwide. The data generated by this project are also available on two Web sites, one at Michigan State University and one at the University of Delaware, to provide other scientists instantaneous access to the data prior to publication.

The project was funded by the U.S. Department of Agriculture Cooperative State Research, Education and Extension Service through the Initiative for Future Agricultural and Food Systems program.

MAES Scientists Are First Recipients of Elwood Kirkpatrick Dairy Science Research Fund

Two dairy science research projects led by MAES scientists were selected to receive the first funds awarded from the Elwood Kirkpatrick Dairy Science Research Endowment, established in honor of Elwood Kirkpatrick, former president of the Michigan Milk

Producers Association (MMPA).

The endowment, with matching support from the MSU Department of Animal Science, the MSU College of Agriculture and Natural Resources, MSU Extension, the Michigan Agricultural Experiment Station and the MMPA, awarded $10,000 in competitive research dollars for 2008.

Robert Tempelman, MAES biostatistician and geneticist, and Nora Bello, MSU animal science doctoral student, were awarded funding for their project, "Modeling the role of herd management on the relationship between production and reproduction in dairy cows." Lorraine Sordillo and Ronald Erskine, MAES large animal clinical sciences researchers, received funding for their project, "Bovine leukosis virus and vaccine responsiveness in dairy cattle."

Researchers were encouraged to submit proposals addressing dairy industry-identified priorities: animal waste recycling, nutrient management/utilization, and manure handling and storage; animal comfort and well-being, health and reproduction; business, financial management skills, management information systems and profitability; labor and management skills; or planned growth and profit strategies.

The MMPA board of directors established the Elwood Kirkpatrick Dairy Science Research Endowment at MSU in 2007 upon Kirkpatrick's retirement from the MMPA, which he served as president for 26 years. Numerous industry organizations and individuals have also contributed to the endowment fund in support of dairy and dairy-related research and education programs.

Project GREEEN Awards Dollars for 2008 Projects

More than 100 plant agriculture research projects will share nearly $2.5 million in grant funding from Project GREEEN, Michigan's plant agriculture initiative at MSU, for fiscal year 2008.

Project GREEEN (Generating Research and Extension to meet Economic and Environmental Needs) is a cooperative effort between plant-based commodities and businesses together with the Michigan Agricultural Experiment Station, MSU Extension and the Michigan Department of Agriculture to advance Michigan's economy through its plant-based agriculture. Its mission is to develop research and educational programs in response to industry needs, ensure and improve food safety, and protect and preserve the quality of the environment.

A total of 92 new project proposals requesting approximately $2.5 million were received for consideration in this year's selection process. Forty-six continuation proposals seeking more than $1 million in available funds were received for projects that started in 2006 or 2007.

"Now is a time of rapid growth and development in plant agriculture despite economic challenges on the state and national levels," said Doug Buhler, coordinator of Project GREEEN and associate director of the Michigan Agricultural Experiment Station. "Project GREEEN is privileged to administer these funds to target the most pressing issues in agricultural research and Extension."

Projects were funded in the categories of basic research, applied research and Extension/education/demonstration. New projects were funded across the spectrum of Michigan's plant agriculture industries, on topics ranging from estimating the carbon footprint of Michigan apple and cherry orchards and developing pest and nutrient management guidelines for landscape trees and shrubs to translating the national pesticide applicator manual into Spanish and designing farm financial record systems.

"Project GREEEN is uniquely positioned to stay at the forefront of plant agricultural research and Extension," Buhler said. "We are able to continue funding important advances in crop production and pest management strategies while also addressing emerging markets such as organic production and the bioeconomy."

The main criteria used to evaluate proposals for funding were their relationship to the Project GREEEN mission and Michigan plant agriculture priorities, scientific soundness and appropriateness of methodology and multidisciplinary linkages, leverage of funds, potential for future external funding and the feasibility of completing the objectives within the proposed time frame. All proposals are reviewed by a diverse panel of industry, government and university experts.

"The research and outreach projects selected for Project GREEEN funding address industry-identified priorities and have met the rigors of scientific peer review," Buhler said. "These research and outreach projects reflect the partnership and cooperative relationship that exist between the plant industry groups, agribusiness, the Michigan Department of Agriculture and Michigan State University."

"These grants offer continued growth and development opportunities for Michigan's nearly $64 billion agribusiness sector, which is essential to the diversification of the state's economy," said Don Koivisto, MDA director. "It's this type of collaboration between private industries, government and universities that provides a vital link addressing the changing needs and challenges of Michigan's agriculture industry."

A complete listing of 2008 newly funded and continuing Project GREEEN research projects can be found at the Project GREEEN Web site: www.greeen.msu.edu.

Pot-in-Pot Offers Alternative Growing System for Christmas Tree Farms, Nurseries

Bert Cregg

Potted evergreen trees are the hottest trend going in the Christmas tree market, and nurseries and Christmas tree farms are poised to take advantage of this budding niche market.

Potted evergreens are ideal for consumers looking for an environmentally friendly alternative to artificial trees, and container-grown table-top evergreens provide Christmas tree growers and nurseries with a profitable specialty line. They're also the tree of choice for those who prefer a live tree but don't have room in their home or apartment

for a large tree, or for those who like the option of planting their tree after the holidays.

"Consumers can purchase a live potted conifer between 2 and 4 feet tall, use the small tree for their holiday celebrations, and then plant the tree in their yard to watch it grow and enjoy for years to come," said Bert Cregg, MAES horticulture and forestry scientist.

Cregg and graduate student Wendy Klooster are in the second year of a project to refine a production system for container-grown trees known as pot-in-pot. In pot-in-pot production, growers first place a "socket pot" in the ground. A second pot, containing the crop tree, is then placed inside the socket pot.

"Pot-in-pot production combines the benefits of container growing with standard field production techniques," Klooster said.

"The system eliminates problems with trees blowing over in the wind, and placing the tree container in the socket pot in the ground insulates the roots and prevents cold damage during the winter," Cregg said.

Cregg and Klooster's research is focused on improving fertilization practices for conifers used for living Christmas trees and for deciduous shade trees.

"Identifying the types and amounts of soil, nutrients and other resources that various tree species need to thrive when they're grown in the pot-in-pot system will help us develop management guidelines to help growers avoid common missteps such as overfertilizing or over- or underwatering," Cregg said.

Christmas tree farms and nurseries across Michigan are already experimenting with pot-in-pot growing. Cregg said he has received a good response from growers who have seen the system in operation and producers who are interested in expanding their markets to include living trees.

The largest barriers for growers interested in the pot-in-pot system are the start-up costs and the need for a suitable production site. The costs of installing socket pots and irrigation occur up front, though these can be used for multiple crop cycles. If the production area does not drain well naturally, growers must install drainage, which adds to growers' initial costs.

Despite the initial costs, Cregg expects the use of pot-in-pot production to continue to increase for both nursery stock and living Christmas trees.

"The general trend in the nursery industry is toward container production," he said, "but for Michigan growing conditions, pot-in-pot is a great option to produce high-quality container-grown trees."

This research is supported by Project GREEEN, J. Frank Schmidt and Sons Nursery, Boring, Ore.; Nursery Supplies, Inc., Chambersburg, Pa.; Renewed Earth, Inc., Kalamazoo, Mich.; Peterson's Riverview Nursery, Allegan, Mich.; Fairplains Nursery, Greenville, Mich.; Scotts, Inc., Marysville, Ohio; the Michigan Nursery and Landscape Association; the Michigan Department of Agriculture; the Michigan Christmas Tree Association; and the Michigan Forestry and Parks Association.

MAES Turf Experts Answer Homeowners' Questions in New 'Lawncare University' DVD

Ron Calhoun

The temperature is climbing and the snow has melted — time to dust off the weed whacker, slip on some gardening gloves and usher in spring with a freshly manicured lawn. Before you start the mower, however, take a few notes from MAES lawn care experts at MSU.

The MSU Turf Team, with funding support from Project GREEEN, has created a new resource to answer many common lawn care questions: a DVD package called "Lawncare University."

The DVD includes 16 videotaped lessons presented by Ron Calhoun and Kevin Frank, MAES crop and soil sciences researchers. Topics are divided into spring, summer and fall turf tips, with an extra section on turfgrass pests.

Featured lesson topics include mowing, dealing with problem weeds, selecting turfgrass varieties, managing waterfront turf, soil testing, dealing with leaves, managing thatch and controlling white grubs (including European chafer) in lawns. Other segments focus on spring cleanup, irrigation, renovation, fertilization, fall weed control and crabgrass.

Most video segments also have a complementary written bulletin available free for download at www.turf.msu.edu.

The DVD package also includes a copy of the "I've Got Moles!" video. In the video, Calhoun and mole expert Brian Yost demonstrate the proper use of four simple traps to help rid a lawn of the destructive pests.

"I think homeowners are going to love the 'I've Got Moles!' segment," Calhoun said. "We get hundreds of calls every year about mole damage in yards, and video is the perfect medium to show someone proper trapping techniques."

The Lawncare University, DVD-300, can be purchased from the MSU Extension bulletin office. Call (517) 353-6740 or visit http://www.emdc.msue.msu.edu.

MAES Scientist Selected as 2008 Leopold Leadership Fellow

Scott Swinton

MAES scientist Scott Swinton, professor in the Department of Agricultural, Food and Resource Economics, is one of 19 environmental researchers from across North America selected as Leopold leadership fellows for 2008.

Pamela Matson, scientific director of the Aldo Leopold Leadership Program, said the members of the group were selected

through a highly competitive process on the basis of their exceptional scientific qualifications, demonstrated leadership ability and strong interest in communicating science beyond traditional academic audiences.

Each of the fellows will participate in two weeklong intensive training seminars in June and September to learn to become stronger communicators with audiences outside of academia, including journalists and policymakers.

"Like many MSU professors, I've learned how to reach academic audiences via classroom teaching, journal article publications and conference presentations," Swinton said. "But making scientific learning accessible to the general public and to policymakers is a greater challenge."

Swinton's areas of research include environmental economics, ecosystem services, pest management, sustainable agriculture, natural capital and agricultural issues. He studies how farmers make management decisions about agricultural systems, and he has a special interest in how farmers' attitudes combine with price and policy incentives to influence their technology choices.

His current research with the National Science Foundation Long-Term Ecological Research (LTER) agroecological site in Michigan focuses on management decisions to enhance the provision of ecosystem services from row-crop agriculture and explores farmers' awareness, attitudes and incentives to adopt low-input cropping practices.

"My work with MSU's LTER site at the Kellogg Biological Station has persuaded me that the greatest ecological challenge today is to create incentives for humans to make more ecologically sustainable choices," Swinton said. "I am an economist, and incentive design is central to what economists think about."

The Aldo Leopold Leadership Program, located at the Woods Institute for the Environment at Stanford University, was founded in 1998 to fill a gap in environmental decision making: getting the best scientific knowledge into the hands of government, nonprofit and business leaders to further the development of sustainable policies and practices. The program recognizes the fact that environmental scientists are increasingly called upon to explain their research, provide comments on public policy and give advice within the public sector and helps build their communication skills. The fellows also become part of a network of Leopold leadership alumni and program advisers who are leaders in conducting scientific outreach beyond traditional academic and scientific circles.

"Aldo Leopold was committed to science that informs policy and makes a difference. I look forward to learning more about how to do that," Swinton said. "The Leopold program draws from leading researchers with interests in ecology and associated policy. So, it looks like a promising chance to build the kind of professional ties that will enable both better research and research that makes a difference for society."

A list of 2008 fellows and more information about the Aldo Leopold Leadership Program are available online at www.leopoldleadership.org.

Research Team Has High Asparagus Aspirations

STOCK PHOTO

Michigan is a big player in the asparagus field, ranking second nationwide only to California in total planting — about 12,000 acres, valued at more than $15 million.

That may be a lot, but it's 30 percent less than the 18,000 acres the state boasted in 1997.

After the first crop, asparagus farmers face declining yields over time because pathogens such as *Fusarium* and *Phytophthora* build up in asparagus fields.

To regain some lost asparagus yields, a team of MSU experts funded in part by Project GREEEN will explore ways to reduce soil disease and increase plant vigor by finding the best possible soil fumigants, fungicides, herbicides and planting methods.

"Because of the complexity of asparagus replant suppression, we have adopted a multidisciplinary approach to fighting the problem," said Mathieu Ngouajio, MAES horticulture researcher. "If nothing is done in the short term, the decline in asparagus acreage will likely continue as more and more growers are forced to abandon unproductive fields."

Others on the research team are Mary Hausbeck, MAES plant pathology scientist; Darryl Warncke, MAES crop and soil sciences researcher; Norm Myers, Oceana County Extension director; Bernard Zandstra, MAES horticulture scientist; John Bakker, executive director of the Michigan Asparagus Advisory Board; and several farmers.

Through extensive research, the team hopes to find a fumigant that cleanses the soil of toxic diseases, a nutrient management program that strengthens asparagus plants' vigor, an appropriate herbicide to control weeds, disease-free planting methods to reduce the spread of disease and new cultivars with improved replant performance.

MAES Forest Entomologist Goes Prime Time with EAB Awareness

As the only forest entomologist on campus, MAES scientist Deb McCullough is used to being the point person for all manner of insects that attack trees. So when the folks at The Weather Channel were looking for information on the emerald ash borer, McCullough was one of the first people they called.

McCullough, along with former graduate student Andrea Anulewicz, current graduate student Andrew Tluzcek and EAB communications manager Robin Usborne, are featured in the Forecast Earth show that aired on The Weather Channel at 5 p.m. June 7. Watch the segment online: http://climate.weather.com/video/?clip=11005

McCullough and her colleagues discuss what EAB is doing to communities, the research she and others are doing to combat the pest, and what the loss of ash trees will mean for Michigan and the United States.

"People are beginning to realize that this pest could wipe out an entire species of tree in North America," McCullough said. "The ramifications of this are widespread. This was a good opportunity to get information out to the public, even in areas that currently are not infested."

Research *in the news*

Since its first identification near Detroit in 2002, the EAB has killed about 30 million ash trees in southeastern Michigan alone and cost municipalities, property owners, nursery operators and forest product industries tens of millions of dollars. The bug also has been found in Indiana, Illinois, Maryland, Ohio, Pennsylvania, West Virginia and Ontario, and quarantines and fines have been imposed to prevent people from moving ash trees, logs or firewood out of infested areas.

MAES Scientist Discusses Food and Fuel with Renewable Fuels Commission

STOCK PHOTO

The Michigan Renewable Fuels Commission (RFC) heard from an MAES expert on factors affecting the current food versus fuel debate at its May 13 meeting.

"Having both food and fuel are possible, but it hinges on the resolution of several critical issues such as continued global population growth and subsequent diet transformation, the capacity of the agribusiness sector to improve its productivity, water and land use, and carbon impact," said H. Christopher Peterson, MAES agricultural economics scientist, who holds the Homer Nowlin Chair of Consumer-Responsive Agriculture and serves as the director of the MSU Product Center for Agriculture and Natural Resources. "The fact that Michigan has a Renewable Fuels Commission dedicated to tackling these tough issues offers tremendous opportunity."

At its meeting, the RFC outlined issues related to the expansion of biobased fuels, including the need to evaluate Michigan's supply and production chains to determine the long-term sustainability of biofuels.

"The production and supply inventory underscores the need to see where we've been and where we are in order to help pave the way for the future of biofuels in Michigan," said Don Koivisto, Michigan Department of Agriculture director and RFC chair. "Creating a baseline will help us evaluate the long-term sustainability of present and post-corn ethanol while utilizing our vast natural resources to advance other biofuel technologies such as cellulosic ethanol, which is made from non-food feedstocks."

At the meeting, Peterson presented information on biofuels' impacts on food prices. Ethanol production is only one of many factors contributing to higher food prices, he pointed out. Others include skyrocketing fuel costs (which increases the cost of transporting food), increased food demand due to population and income growth, worldwide weather conditions and dwindling carryover stocks of agricultural commodities.

Two of the most important factors affecting food prices are:

- The growing middle class in China and India. With more disposable income, this group is now able to afford to buy more protein-based foods, including meat and milk. Producing those foods is boosting demand for feed.
- The declining value of the U.S. dollar. The fluctuations in the value of the dollar create a twofold issue: increasing worldwide demand for U.S. exports while simultaneously making food and fuel imports more expensive. The United States now spends $1.4 billion a day on imported oil.

"At MSU, our research and development emphasis is on making renewable fuels from cellulose — trees, stems and stalks that aren't food products," said Steve Pueppke, director of the MSU Office of Biobased Technologies and RFC member. "If the cellulose comes from crops that we're already growing, we can increase the amount of fuel we make from crop residues without affecting food prices any further. Developing a strong cellulosic biofuel industry also would allow the state to tap forestland — land that isn't in the food system — to make fuel."

The Renewable Fuels Commission, appointed by Gov. Jennifer M. Granholm, is charged with promoting the use of alternative fuels and vehicles, encouraging the production and use of biodiesel and ethanol products in the state, increasing the viability of Michigan's agribusiness industry and advancing alternative fuel research.

MAES Scientist Edits Special Journal Issue on Biofuels

Christoph Benning

Sustainably harnessing plant biomass for use as biofuels and other bioproducts is the focus of a special issue of The Plant Journal, co-edited by MAES biochemistry and molecular biology researcher Christoph Benning.

The issue, published in May, features three articles written by MAES scientists and is available online at http://www.blackwell-synergy.com/toc/tpj/54/4.

"The special issue contains a series of reviews that describe the multiple biochemical processes that plants can or could use to convert their fixed carbon into fuels and other useful products," Benning explained. "Rather than advocate a specific process or compound, these invited peer-reviewed articles by leading plant biologists and biochemists focus on the scientific facts behind the production of plant biofuels such as ethanol or biodiesel, as well as other important chemicals that are often unique to plants."

Papers by MSU scientists in the special issue are:

- "Cell-wall carbohydrates and their modification as a resource for biofuels," by Markus Pauly, associate professor of biochemistry and molecular biology, and Ken Keegstra, MAES scientist and university distinguished professor of biochemistry and molecular biology and plant biology.

Research *in the news*

- "Plant triacylglycerols as feedstocks for the production of biofuels," by Tim Durrett, plant biology postdoctoral researcher; Benning; and John Ohlrogge, MAES scientist and university distinguished professor of plant biology.
- "Harnessing plant trichome biochemistry for the production of useful compounds," by Anthony Schilmiller, biochemistry and molecular biology postdoctoral researcher; Rob Last, MAES plant biology and biochemistry and molecular biology scientist; and Eran Pichersky, from the University of Michigan.

Pichersky also served as co-editor with Benning.

To go along with the special issue, The Plant Journal also produced a podcast with Benning, which is available online at http://www.gabcast.com/casts/1696/episodes/1210588423.mp3.

New Faculty Members

The MAES is pleased to welcome two new faculty members.

Richard Hula, professor and chairperson of the Department of Political Science, became affiliated with the MAES in May. His work will include development of a set of questions around the issue of brownfield redevelopment in Michigan. These questions will probe public awareness and attitudes toward contamination and redevelopment efforts in the state and will be included in the annual State of the State survey. Survey results will be used to assess current public perspectives and positions on the issue and will be compared with the results of a similar survey conducted five years ago.

Before coming to MSU in 1991, Hula taught at the University of Texas at Dallas and the University of Maryland. His current research and teaching interests focus on urban politics and policy. He has projects exploring state/local environmental policy, the impact of faith-based organizations on social service delivery and state-level interventions into local policy arenas. Hula received his doctorate in from Northwestern University in 1975.

Jennifer Owen, assistant professor of wildlife disease ecology, became affiliated with the MAES in June. Her current research focuses on the role migrating birds play in the spread of zoonotic disease — illnesses that can be transmitted from other vertebrate animals to humans — particularly viruses borne by arthropods (mosquitoes, ticks, etc.). Owen is interested in how environmental and physiological stressors affect an animal's ability to mount effective immune responses and how that reduced immune response influences both their susceptibility to disease and their ability to serve as carriers and dispersers for zoonotic pathogens. Her research program is beginning to explore the role of wild birds in the spread of avian influenza both at a local and global scale.

Before coming to MSU, Owen spent four years as a postdoctoral research associate at University of Southern Mississippi (USM) on an NSF-funded project investigating the role of birds in the overwintering of both West Nile and eastern equine encephalitis viruses. She received her doctorate at USM in biological sciences in 2004 and her bachelor's in wildlife biology from University of Montana, Missoula in 1993.

MSU Part of First Michigan Center of Energy Excellence

Michigan State University is partnering with the Mascoma Corporation and Michigan Technological University in the state's first Center of Energy Excellence, Gov. Granholm announced on June 27.

Michigan State, Mascoma and Michigan Tech will be working with the Michigan Economic Development Corporation and J.M. Longyear, a Marquette company that owns more than 65,000 acres of forestland in the Upper Peninsula, to develop the state's first cellulosic ethanol plant. The plant will be in Chippewa County, south of Sault Ste. Marie.

"Long before the current run-up in petroleum prices, we declared Michigan's intention to lead the nation in alternative energy production and help reduce our dependence on foreign oil," Granholm said. "Mascoma's next generation biomass-to-ethanol technologies are integral to wide-scale ethanol production, and this plant will put Michigan on the leading edge of technology that will create good-paying jobs for Michigan citizens."

"At MSU, our research and development emphasis is on making renewable fuels from cellulose — trees, stems and stalks that aren't food products," said Steve Pueppke, director of the MAES and MSU Office of Biobased Technologies. "Michigan State is delighted to collaborate with our colleagues at Michigan Tech and Mascoma to help create a bioeconomy that is based on the state's vast forest resources and develop a strong cellulosic biofuel industry."

Michigan State will provide expertise in pretreatment technology for cellulosic ethanol production and assistance with renewable energy crops that can be used by the plant's biorefinery. Michigan Tech will contribute its knowledge of sustainable forestry management practices and access to its automotive engineering labs for analysis of the biofuels produced.

Michigan is in a race with a firm in Georgia to open the first commercial-scale cellulosic ethanol plant. The Massachusetts-based Mascoma Corporation announced its decision to locate a plant in Michigan last July.

Mascoma chose Michigan because of its vast, sustainable forests and other non-food agricultural materials, as well as the research expertise available at Michigan State and Michigan Tech.

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