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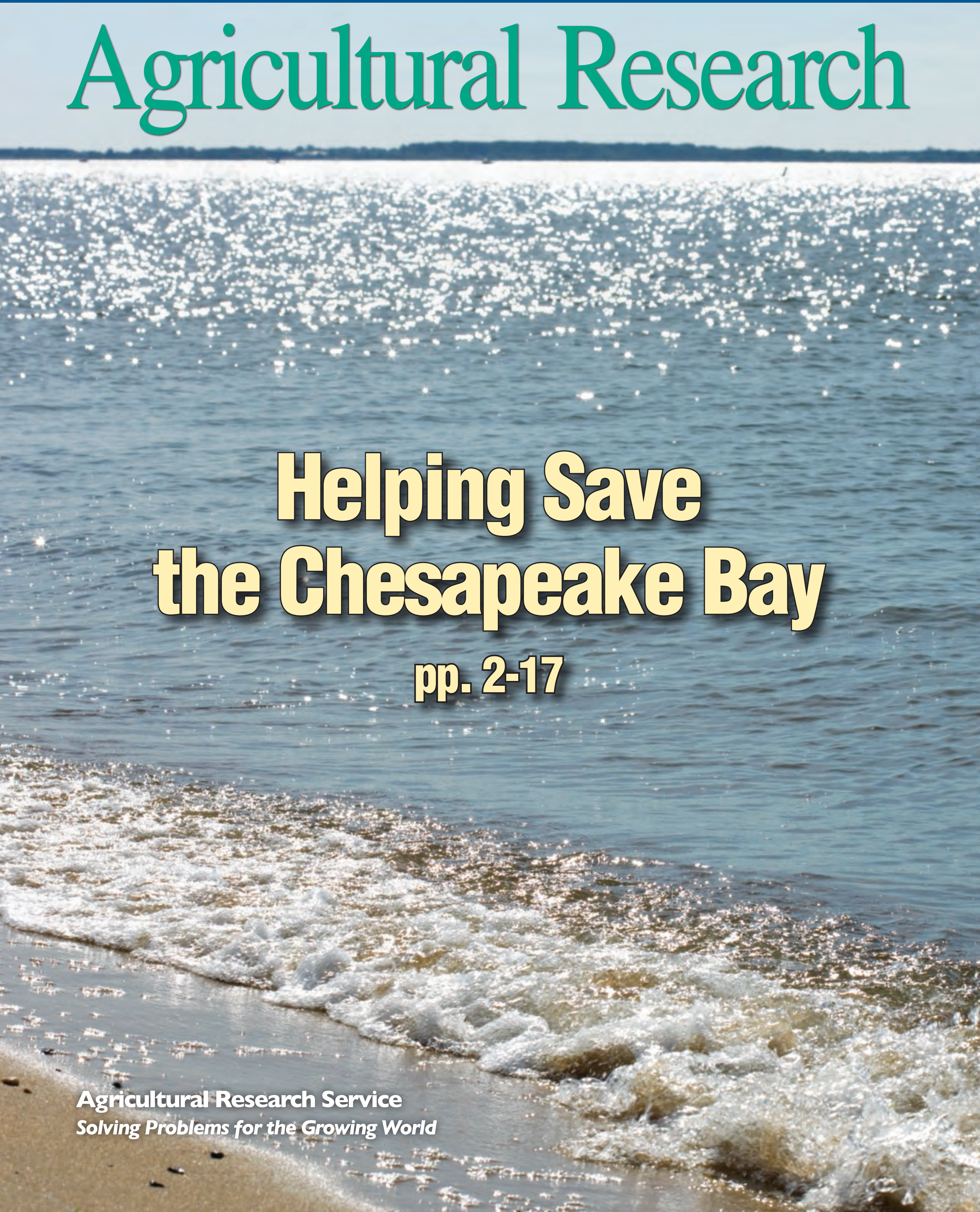
Agricultural Research



Helping Save the Chesapeake Bay

pp. 2-17

Agricultural Research Service

Solving Problems for the Growing World

Saving the Bay: It's One of the Things ARS Does Best

Some locals measure water quality in the Chesapeake Bay using the "sneaker index." In the 1950s, Maryland resident Bernie Fowler waded into the Patuxent River to his shoulders and could see his white sneakers on the riverbed. But in 1988, when Fowler, who by then was a state senator, ventured back into the Patuxent, he could not see his nice white sneakers once he waded beyond 10 inches of water. It was better in 2009, when he could see his sneakers in 25.5 inches of water—but it's still not good enough.

Agricultural Research Service scientists haven't been watching over the Chesapeake Bay quite as long as Fowler has, but they are committed to restoring water quality in the bay. This is where bald eagles patrol the marshes, American oystercatchers pace the beaches and tidal flats, bottlenose dolphins cruise offshore waters, and crabs with bright blue claws swim sideways through the shallows. And the famed eastern oysters that cluster in massive aquatic reefs double as water-treatment plants—an individual bivalve can filter sediments, algae, and pollutants from as much as 50 gallons of water every day.

But the oysters can't keep up with current challenges. In 2006, about 16.6 million people lived in the bay watershed (see map of watershed on page 5), where the demand for surface- and ground-water supplies continues to grow. At the same time, water sources are contaminated by sewage, sediment, fertilizer runoff from suburban lawns, and expired medications that are poured down drains throughout the six states in the Chesapeake Bay Watershed.

Agriculture is another major factor in the bay's health. Poultry production on the Eastern Shore is an economic mainstay, but nutrient-rich runoff from poultry litter flows into the creeks and drainage ditches that feed the bay. The runoff prompts growth of algae and other plants, and when the vegetation dies, its decomposition robs those waters of oxygen essential to other aquatic life. Sediment and excess fertilizer from crop fields can also eventually migrate into waterways that feed into the bay.

None of this is news. Over the years, a range of state, federal, local, and nonprofit groups have put their best efforts toward stemming water pollution and restoring bay habitats. There's been some progress, but not enough.

So what happens now? And how will ARS be involved?

On May 12, 2009, President Barack Obama signed Executive Order No. 13508 for the Chesapeake Bay Protection and Restoration, which directed federal agencies to increase their cooperation and collaboration in a concerted effort to clean up the bay. ARS scientists will carry out the President's mandate by strengthening their current research and continuing to forge new collaborative efforts with other federal agencies. These partnerships will allow ARS to more fully address the environmental issues presented by the bay's complex landscape—a mix of crop fields, pastures, forests, wetlands, and urban and suburban areas.

For instance, since 2004, ARS scientists in Beltsville, Maryland, have been leading the Conservation Effects Assessment Project's Watershed Assessment Study of Maryland's Choptank River Watershed (see article beginning on page 10). Their long list of county, state, federal, university, and local partners reflects just how vital these studies are to understanding the watershed processes that affect water quality in the bay.

ARS scientist Greg McCarty and USDA Forest Service ecologist Megan Lang are using remote sensing to map forested wetlands in the Chesapeake Bay Watershed (see page 13). They've increased the accuracy of wetland maps by around 30 percent and developed techniques to track temporal variations in wetland flooding and soil moisture. McCarty is also working with U.S. Geological Survey physical scientist Dean Hively to use remote sensing to monitor the effectiveness of winter cover crops in sequestering nitrogen, which will support Maryland's cover crop cost-share programs (see page 16).

ARS scientists Laura McConnell and Cathleen Hapeman are partnering with the U.S. Environmental Protection Agency to examine atmospheric, agricultural, and urban sources of bay pollutants. A few hours up the road, ARS scientists at the Pasture Systems and Watershed Management Research Unit in University Park, Pennsylvania, are making their own contributions to cleaning up the Chesapeake Bay Watershed. Researchers Peter Kleinman, Ray Bryant, John Schmidt, Tony Buda, Curt Dell, and Clinton Church have teamed up with regional partners on a range of water-quality projects that start in New York and end up on a former chicken farm on Maryland's Eastern Shore (see page 4).

At ARS, we'll continue to do what we've been doing all along: partnering with experts throughout the public and private sectors to find new technologies and improve existing tools for cleaning up the bay one crop field, stream, wetland, and drainage ditch at a time.

Mike Shannon, Mark Walbridge, Matt Smith,
and **Charles Walthall**
ARS National Program Leaders
Natural Resources and Sustainable Agricultural Systems
Beltsville, Maryland

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Solving Problems for the Growing World

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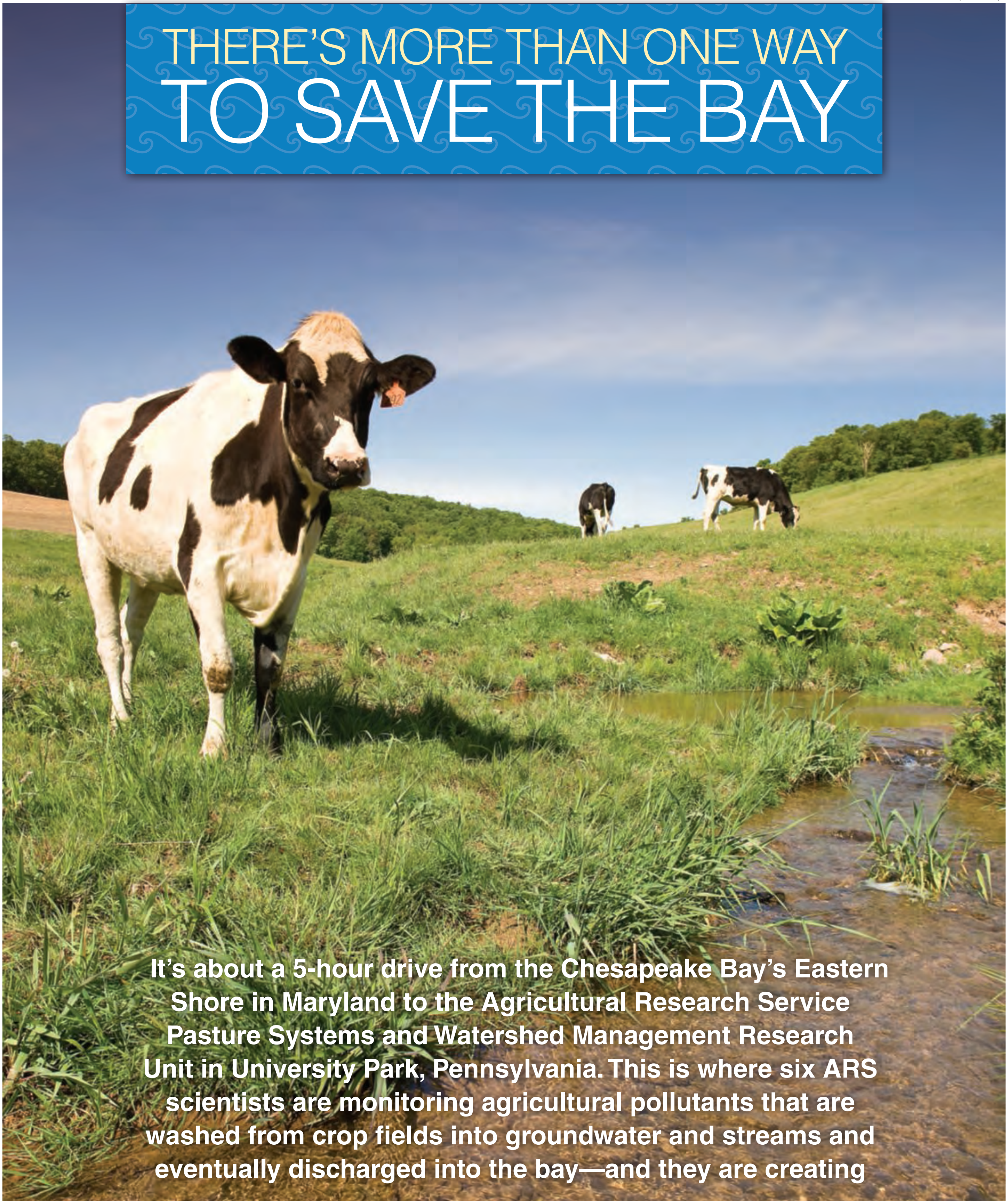
PEGGY GREB (D1834-2)

Cover: The Chesapeake Bay's health is in jeopardy from sediment, fertilizers, pharmaceuticals, and other contaminants coming from its 65,000-square-mile watershed. A recent Executive Order emphasized the importance of protecting and restoring the bay. ARS is partnering with experts throughout the public and private sectors to find new technologies and improve existing tools for cleaning up this national treasure. See Forum (opposite page) and stories on pages 4-17.

STEPHEN AUSMUS (D1862-22)

THERE'S MORE THAN ONE WAY TO SAVE THE BAY



It's about a 5-hour drive from the Chesapeake Bay's Eastern Shore in Maryland to the Agricultural Research Service Pasture Systems and Watershed Management Research Unit in University Park, Pennsylvania. This is where six ARS scientists are monitoring agricultural pollutants that are washed from crop fields into groundwater and streams and eventually discharged into the bay—and they are creating

An ARS team of scientists determined that the equivalent of 12 percent of the phosphorus load in the Town Brook Watershed—a major source of drinking water for New York City—came from dairy cow dung deposited directly in streams.

all the roadblocks they can along the way. The ARS team has been able to work in all the major physical and geographic regions of the Chesapeake Bay Watershed by developing a six-state network of collaborators.

"Some of our research is quantifying how farming contributes to nutrient runoff," says ARS soil scientist Peter Kleinman. "But we're also testing and developing new practices and strategies for improving the odds that plant nutrients like nitrogen and phosphorus are taken up by crops and don't escape to the bay."

Please Step Away From the Streambank

Kleinman's work started in New York's Allegheny Plateau (see map), a forested expanse broken up by small dairy farms, where the University Park team oversees activities in the Town Brook Watershed as part of the Conservation Effects Assessment Project (see story on page 10). Although the area is just outside of the Chesapeake Bay Watershed, farming practices in the Town Brook Watershed closely resemble those across the Allegheny Plateau—the headwater region of the the Chesapeake's watershed.

Kleinman's team determined that the equivalent of 12 percent of the phosphorus load in the Town Brook Watershed—a major source of drinking water for New York City—came from dairy cow dung deposited directly in streams. The findings helped convince local farmers to install more streambank fencing to keep cows away from streambeds and to improve water quality.

Testing Apps in Appalachia

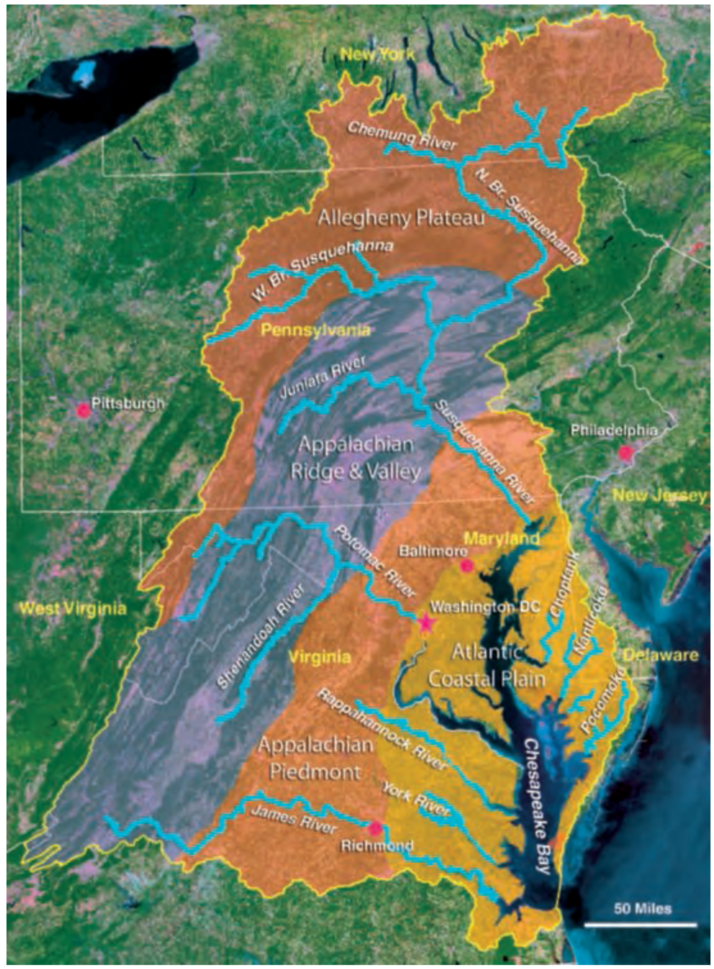
The ARS team often test-drives their practices and procedures in the Mahantango Watershed, a long-term experimental watershed 2 hours southeast of University Park that is part of the Appalachian Ridge and Valley Region.

This is where soil scientist John Schmidt has been testing a sensor system to help farmers fine-tune applications of nitrogen to knee-high corn crops. The small sensors are mounted in front of a tractor and measure yellow-amber and near-infrared light waves from the corn plants. A computer uses the data to calculate the amount of nitrogen that should be added to the soil and transmits this information to the applicator, which amends the field with the appropriate levels of nitrogen.

"If we match the amount of nitrogen that's applied with the amount that the crop needs, then less nitrogen will be leached out of the field—and the yields should be greater," Schmidt says. "It's also a way to get on-the-go recommendations for nitrogen applications, instead of sending soil samples off for testing."

Schmidt and University Park research leader Ray Bryant are also testing a proprietary nitrogen fertilizer formulation developed in the United Kingdom. "When nitrogen is added to soil, it's often converted to nitrate, which is easily leached out," Bryant explains. "But the nitrogen in the U.K. fertilizer is in a form that is available for plant uptake and can resist the microbial breakdown that results in the conversion to nitrate."

ARS (D1890-1)



Chesapeake Bay Watershed map created from a satellite image.

Bryant and Penn State colleague Max Schlossberg ran a trial of this fertilizer on bentgrass—a type of turfgrass used in golf courses and residential lawns—and found they could reduce fertilizer use by 25 percent and still obtain optimum growth and performance. They now plan to test the new fertilizer on corn and other crops.

It's All in the Timing

Farmers who add manure to their fields don't have to pay for fertilizer and don't have to pay to have manure hauled away. But when it rains, the nitrogen and phosphorus in freshly applied manure can run off and pollute nearby water sources.

So ARS hydrologist Tony Buda has been working in the Appalachian Ridge and Valley Region to build a Web-based "fertilizer forecast" for agricultural fields. Kleinman, Pennsylvania State climatologist Paul Knight, and Doug Miller, who oversees Penn State's Center for Environmental Informatics, are also part of the effort. Another team member is ARS agricultural engineer Gary Feyereisen, who works at the ARS Soil and Water Management Research Unit in St. Paul, Minnesota. The scientists want to create a tool that produces 24-hour and 5-day runoff forecasts that are as user-friendly as Web-based weather forecasts.

"We want to develop a simple hydrologic model that indicates the probability of field runoff occurrence using National Weather Service (NWS) probabilities for precipitation, soil moisture, and other data," Buda says. "And we want something that runs pretty quickly."

The researchers are analyzing how runoff measurements for different regions in Pennsylvania correlate with different NWS data sets for the same areas. For instance, they've found that soil moisture levels are a strong indicator of nutrient runoff potential from field soils that have relatively impermeable subsurface soil layers. But at sites with other soil characteristics, runoff potential is much more strongly associated with rainfall amount and intensity.

The Right Tools for the Job

The University Park scientists are also helping farmers in the Conewago Creek Watershed implement best management practices for manure and fertilizers, including the use of cutting-edge technology like manure injectors. The watershed is located in the Appalachian Piedmont, which stretches from the eastern slopes of the mountains to the Atlantic Coastal Plain and includes some of the most populated areas in the Chesapeake Bay Watershed.

As part of this work, soil scientist Curt Dell is testing techniques for amending soils with manure from swine and cattle. He's trying to strike a fine balance between tilling manure into soils to minimize nutrient runoff and maintaining the environmental benefits of no-till farming, which leaves the soil surface undisturbed and more resilient to erosive forces.

Dell thinks manure disk injectors (see sidebar on page 9) show the most promise for meeting these dual goals. A single disk cuts into the soil to a maximum depth of 4 inches, and then a tube attached to the

STEPHEN AUSMUS (D1859-16)

ARS hydrologist Tony Buda (far left) and Penn State University climatologist Paul Knight examine regional data they are using to develop a Web-based "fertilizer forecast," which will help farmers limit nutrient runoff by avoiding fertilizer applications before precipitation events. The program will use a range of weather variables, including the type of meteorological data Penn State associate professor Doug Miller and ARS soil scientist Peter Kleinman (far right) are studying in the background.

STEPHEN AUSMUS (D1861-12)

ARS hydraulic technician Terry Troutman collects a routine water sample in the Mahantango Creek Experimental Watershed, Klingerstown, Pennsylvania.

STEPHEN AUSMUS (D1871-21)

University of Maryland-Eastern Shore (UMES) scientist Eric May (right) retrieves a plankton net from the water while Penn State graduate student Sarah Gustafson and ARS hydrologist Tony Buda conduct water-quality sampling in a tributary of Maryland's Manokin River. These samples will be used in studies that examine whether urea pollution in the watershed is linked to periodic blooms of phytoplankton known as *Pseudo nitzschia* species.

STEPHEN AUSMUS (D1864-12)

Tony Buda (right) and laboratory worker David Otto collect runoff water samples from a hillslope trench that is being used to monitor lateral subsurface flow pathways during and after storms.

disk injects the manure into the cut. This ensures that there is minimal disturbance to the soil surface, and odor emissions drop because the manure is added below the soil surface.

"Up to half of the plant-available nitrogen is typically lost through ammonia emissions within a few days after dairy manure is applied to fields," Dell explains. "But when we use a disk injection system to add manure to the fields, we can cut those emissions by 80 percent."

Litter's Legacy

Large-scale poultry farming started up on the Chesapeake Bay's Eastern Shore in the 1920s, and now over 750,000 tons of poultry litter and manure are produced each year. Farmers on the Eastern Shore—part of the Chesapeake Bay's Coastal Plain—have amended the region's sandy soils with poultry manure and litter for years. Nutrient levels have accumulated in the soils, and some of the nutrients find their way to the bay.

"Even if we stopped fertilizing some soils, it wouldn't really affect how much phosphorus is lost from them because they contain so much already," says Bryant. "We need to deal with the legacy of past management—and that means we're attacking a very difficult part of the problem."

Bryant and colleague Arthur Allen from the University of Maryland-Eastern Shore (UMES) have developed a way to trap the "legacy phosphorus" from the region's poultry farms that leaches from soils to drainage ditches. Working at an experimental farm owned by UMES—the site of a former chicken farm—they dug a trench alongside an existing drainage ditch. Then they filled the trench with synthetic gypsum, a product of scrubbing the smokestacks of coal-fired power plants to remove sulfur emissions.

When the groundwater passed out of the field and through the gypsum-filled trench on its way to the drainage ditch, the soluble calcium in the gypsum "captured" the soluble phosphorus in the water by

STEPHEN AUSMUS (D-1868-10)

ARS chemist Clinton Church (center) works with UMES student Betty Chumbe-Kitur (left) and other UMES students to measure arsenic levels in water samples from Princess Anne, Maryland.

STEPHEN AUSMUS (D1870-18)

ARS soil scientist Ray Bryant (left) and UMES associate professor Arthur Allen collect samples of groundwater before and after it is filtered through an underground "curtain" of gypsum. The low-cost gypsum curtains remove phosphorus from the groundwater before it flows into a drainage ditch, preventing the phosphorus from reaching the Chesapeake Bay.

combining with it and forming calcium phosphate. Calcium phosphate is similar to rock phosphate, which is the source of phosphates used to make fertilizer. Bryant found that the gypsum trench could treat all the water draining from a field and reduce soluble phosphorus in subsurface drainage by about 50 percent.

"These gypsum 'curtains' are good for 10 years," Bryant says. "Then they can be dug up, and the trapped phosphorus can be used again for fertilizer. And the power plants don't have to pay to haul the gypsum to a landfill."

ARS chemist Clinton Church is also dealing with a legacy: arsenic.

"Although the practice is falling out of favor, historically arsenic was routinely added to poultry feed to control parasites and help the birds gain weight. But 90 percent of the arsenic is excreted, and when the litter is used to amend the soil, the arsenic ends up in the fields," Church explains.

Church, Allen, and others conducted a comprehensive survey of soils around the UMES Research and Teaching Farm and in forested areas around the farm and found that virtually all of the samples contained some arsenic. Levels were low in the forested soils and notably higher in the soils that were closer to the source of the litter, such as the shed where the litter was stored.

"Arsenic can occur naturally in soils, so this study is a first step to find out where the arsenic is and how much is there," Church says. "But since its chemical structure is very similar to the chemical structure of phosphorus, we know it has to be ending up in the region's estuaries." He is hopeful that some of the filtration methods Bryant is testing will also work to remove arsenic.

The Big Picture

Kleinman thinks the University Park research helps provide a broader perspective on the effort that will be needed to clean up a 65,000-square-mile watershed.

"There's a real risk of focusing on local issues to derive conclusions about what is best for the Chesapeake Bay," Kleinman says. "For instance, the Eastern Shore is only 6 percent of the Chesapeake Bay Watershed, but for many people, it's the biggest part of the story. We need to look at agricultural practices throughout the watershed, because the entire watershed contributes to the health of the bay."—By **Ann Perry,** ARS.

This research is part of Water Availability and Watershed Management (#211), Global Change (#204), and Manure and Byproduct Utilization (#206), three ARS national programs described at www.nps.ars.usda.gov.

To reach scientists mentioned in this article, contact Ann Perry, USDA-ARS Information Staff, 5601 Sunnyside Ave., Beltsville, MD 20705-5129; (301) 504-1628, ann.perry@ars.usda.gov. *

New Poultry Litter Applicator Offers Hope for Chesapeake Bay Area

It isn't even fully patented yet, but the Poultry Litter Subsurfer prototype invented by Agricultural Research Service soil scientist Dan Pote is on order by a research coalition across five Chesapeake Bay states: Delaware, Maryland, Virginia, Pennsylvania, and New York.

The coalition, led by ARS's Peter Kleinman and counterparts at Pennsylvania State University at University Park and Virginia Polytechnic Institute and State University at Blacksburg, recently received a $786,000 Chesapeake Stewardship Fund grant to test four prototypes of Pote's Subsurfer in applying poultry litter and composted cattle manure to no-till fields and pastures across the Chesapeake Bay Watershed.

Pote is at the ARS Dale Bumpers Small Farms Research Center in Booneville, Arkansas.

ARS is applying for U.S. and international patents on the equipment. One company has applied for a license to commercialize it.

The Subsurfer can carry up to 5 tons of litter for application below the surface of pastures without damaging the grass, much as a no-till planter places seeds. It can also apply poultry litter below no-till fields before planting.

In prior tests on Arkansas pastures, Pote found that subsurface application of litter lowers nutrient runoff and ammonia emissions at least 90 percent, while increasing forage yields. Kleinman and colleagues at the University of Maryland-Eastern Shore tested several versions of ARS subsurface litter applicators on no-till fields and pastures in Maryland and Pennsylvania, documenting lower phosphorus runoff and ammonia loss and greater corn yields. Jack Meisinger, soil scientist at the ARS Henry A. Wallace Beltsville Agricultural Research Center in Beltsville, Maryland, also reports lower ammonia losses from corn plots.

In 2009, Pote demonstrated the Subsurfer at a Soil Conservation District/USDA Natural Resources Conservation Service meeting in southern Maryland as well as at the 31st Southern Agricultural Systems Conference on Virginia's Eastern Shore.

In spring 2010, Pote teamed up with Karamat Sistani of the ARS Animal Waste Management Research Unit in Bowling Green, Kentucky, to test the Subsurfer on a farmer's corn field near Owensboro, Kentucky. "This is the largest scale test we've done on corn fields," Pote says. "We are comparing the Subsurfer to the traditional method of surface-broadcast application under field-scale conditions."

As a collaborative project, Pote led development of the Subsurfer for pastures and no-till fields, while ARS agricultural engineer Tom Way's team at the ARS National Soil Dynamics Laboratory in Auburn, Alabama, focused on developing a different prototype with adjustable row spacing for litter application in row-crop systems and pastures.

The two machines have such different delivery systems that Pote and Way sought different patents. Pote's Subsurfer uses a unique auger system that crushes litter and distributes it to soil trenches, allowing precise control, including very low rates not previously feasible. His tractor-drawn Subsurfer simultaneously opens eight trenches (2 inches wide and 3 inches deep), each 1 foot apart.

Throughout the southeastern and Middle Atlantic states, poultry production is the primary source of income for many small family farms. Poultry litter is an excellent source of crop nutrients, but the common practice of spreading it on the soil surface promotes odor emissions, exacerbates nutrient runoff to nearby waterways—most notably the Chesapeake Bay, and allows ammonia nitrogen to evaporate. By minimizing nutrient losses, farmers can improve air and water quality and increase crop productivity.—By **Don Comis,** ARS.

This research is part of Pasture, Forage, and Range Land Systems (#215) and Water Availability and Watershed Management (#211), two ARS national programs described at www.nps.ars.usda.gov.

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STEPHEN AUSMUS (D1510-11)

ARS soil scientist Dan Pote observes as ARS technician Stephen Haller operates their invention, the Poultry Litter Subsurfer—the first commercially viable machine for applying dry poultry litter below ground.

ARS CHESAPEAKE BAY RESEARCH INTENSIFIES

PEGGY GREB (D1884-1)

PEGGY GREB (D1886-1)

USDA Forest Service ecologist Megan Lang and herpetologist Joseph Mitchell (Mitchell Ecological Research Services, LLC) carefully search a wetland debris sample for amphibians. Frog tadpoles are often hidden in the sample material. **Inset:** This adult male green frog *(Rana clamitans)* is a common inhabitant of natural and restored wetlands. Biometric assessments (weight and length) of captured amphibians are recorded, then they are released back into the wetlands.

The Chesapeake Bay faces many threats—from the pesticides and fertilizers used to grow corn, soybeans, and other crops, to pollution from wastewater-treatment plants, cars and boats, and poultry production.

Agricultural Research Service scientists have contributed to the effort to clean up the bay for more than two decades. Most recently, ARS scientists in Beltsville, Maryland, conducted a comprehensive study of pollutants at seven spots in the Choptank River, a major bay tributary that faces the same threats.

Traveling in a research vessel, they collected water samples at each stop. They later analyzed these samples for salinity, temperature, dissolved oxygen, chlorophyll, phosphorus, nitrogen, arsenic, copper, and the herbicides atrazine, simazine, and metolachlor and their degradation products.

Sampling a Bay Tributary

The U.S. Geological Survey (USGS) established some of these sampling sites in 1975, providing long-term data for reference. The U.S. Environmental Protection Agency (EPA) also has water-quality monitoring stations in the Choptank that date back even earlier.

This study was done as part of the Conservation Effects Assessment Project (CEAP) for the Choptank River Watershed. CEAP began in 2004 and now involves 37 watersheds nationally. CEAP focuses on the effects of USDA conservation practices and Farm Bill conservation programs.

The long-standing regional goal of cleaning the bay is an additional incentive for success in the CEAP Choptank program, resulting in a network of organizations ready to use ARS's research results. (See list of organizations on page 12 in this issue.) It also provides an established scientific infrastructure, such as the USGS and EPA samplings sites, to support research.

Monitoring the Choptank provides needed information on the dynamics of the bay watershed. This information helps develop new conservation practices or refine existing ones.

Sampling every 2 months from March 2005 through April 2008, the ARS scientists and their colleagues found that nitrate concentrations, which were highest in winter, often exceeded levels that can cause algal blooms. Algal blooms can deplete dissolved oxygen concentrations in the river, killing aquatic organisms such as fish and shellfish. Nitrate levels were highest at the headwaters where farming is concentrated, suggesting that agricultural fertilizers, including manure and poultry litter, are the primary sources of the nitrate.

In contrast, phosphorus concentrations were similar throughout the length of the river, suggesting multiple sources of this nutrient. While some evidence points to wastewater treatment plants as a likely primary source, agriculture is also a major contributor of phosphorus to the bay.

Elevated copper concentrations were found in almost all samples at the lower reaches of the Choptank, but not in the upstream areas.

"This suggests that copper loss from antifouling boat paint is the primary source of the copper, rather than agriculture," says Dean Hively, a visiting physical scientist from the USGS Eastern Geographic Science Center. "The levels were high enough to be toxic to clams and other aquatic invertebrates that help feed and filter the bay."

To the Bay: Above- and Below-Ground Routes

Herbicides and their breakdown products were present year-round throughout the study, says Cathleen Hapeman, a chemist at the ARS Environmental Management and Byproducts Utilization Laboratory (EMBUL) in Beltsville, Maryland. Herbicide concentrations peaked after springtime applications. While herbicides and phosphorus travel to the Choptank mainly via surface water flow, herbicide breakdown products and nitrates flow mainly via groundwater.

"The concentrations of herbicides we observed did not approach established levels of concern for aquatic organisms," Hapeman says. "Still, this research shows the importance of agricultural practices that reduce herbicide losses from springtime applications in particular."

A Clear View of the Bay

"The Choptank water sampling gives us a baseline against which to compare future changes in water quality," Hapeman says. "It may also be used to design programs to monitor the effectiveness of restoration efforts. Simultaneous measurement of multiple water-quality variables and contaminant concentrations is important to creating a clear picture of the main water-quality problems and dynamics within Chesapeake Bay tributaries."

ARS soil scientist Greg McCarty says that the overall goal of the Choptank CEAP research is to "develop a set of measurement and modeling tools for assessing the effectiveness of commonly used conservation practices at a watershed scale. We use remote-sensing techniques

PEGGY GREB (D1878-1)

University of Maryland PhD student Gabriela Niño de Guzmán collects water samples for pesticide and antibiotics analyses in a stream within the Choptank River Watershed.

PEGGY GREB (D1880-1)

ARS agronomist Peter Downey (left) and soil scientist Greg McCarty collect a water sample on the Choptank River for pesticide and nutrient analyses.

to broaden measurements of the effectiveness of practices from one field to the entire watershed. We also do this with another technique we developed to evaluate winter cover crop effectiveness." (See story on page 16 of this issue.)

In another CEAP Choptank study, McCarty, Hapeman, and colleagues monitored levels of nitrogen, phosphorus, atrazine, and metolachlor within 15 small agricultural and forested subwatersheds of the Choptank to gain a more detailed assessment of land use and conservation practices on water quality. For comparison, they periodically sampled lower portions of the river that are not bordered primarily by agricultural land.

McCarty and ARS chemist Laura McConnell are the principal investigators for the Choptank project, working with Hapeman, ARS soil physicist Ali Sadeghi, Hively, USDA Forest Service ecologist Megan Lang, ARS agronomist Eton Codling, and ARS chemists Clifford Rice and Krystyna Bialek.

McCarty, Sadeghi, Hively, and Lang are at the ARS Hydrology and Remote Sensing Laboratory in Beltsville, Maryland. McConnell, Hapeman, Rice, Bialek, and Codling are with EMBUL.

Forests, Wetlands Vital to Bay's Health

In studying nutrient and herbicide flows from the 15 subwatersheds, McCarty says, "We have discovered that watersheds with more forests or wetlands export less

Chemists Cathleen Hapeman (left) and Laura McConnell use air and rain sample collection devices to study the fate of atmospheric pollutants in the Chesapeake Bay region.

nitrate to the river." Forests and wetlands naturally slow the movement of water on the land, allowing nature to process nitrate. "This area of the bay has historically been drained by ditches, which short-circuit these natural filters within the landscape," McCarty says. "Farmers can use drainage-control strategies to slow the movement of water from their fields, thereby restoring some of the filtering capacity of the land. A combination of riparian buffers, wetlands, and controlled drainage management are needed to mitigate nutrient pollution."

Nation's Testing Ground

ARS is also working on CEAP's recently developed Mid-Atlantic wetlands study, which incorporates ARS research on wetlands in the Choptank's watershed. The effort involves ARS laboratories in Beltsville; University Park, Pennsylvania; and Florence, South Carolina. It focuses on wetland benefits in the New Jersey, Delaware, Maryland, Virginia, and North Carolina Coastal Plain. The Mid-Atlantic project provides a testing ground for a national program of monitoring wetlands to evaluate and sustain or improve their benefits to society and the environment.

"Like all CEAP projects," Lang says, "one goal of the wetlands study is to develop collaborations to deliver research results for better practices. The results inform conservation decisions affecting wetland ecosystems and the services they provide, such as pollution control," she says.

Through the Choptank wetland study, Lang found that using radar sensors aboard satellites provided a way to detect water flows in forested wetlands. (See article on page 13 of this issue.) Through this CEAP wetland study, new techniques have been developed to map and monitor wetlands. These techniques are currently being explored for possible incorporation into operational programs by multiple federal and state agencies. Lang is now working with the Maryland Natural Resources Conservation Service to use these techniques to monitor the success of large forested wetland restorations and encourage the restoration of more wetlands.

To the Bay: By Air

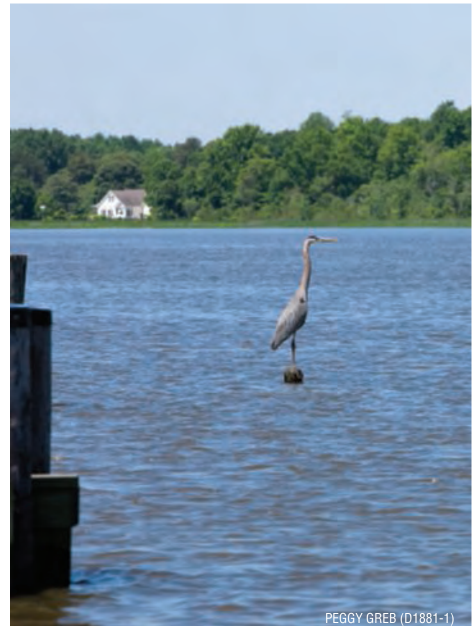
Newer CEAP Choptank studies are looking at how the interplay of agriculture and urban areas affects carbon storage, wildlife habitat, and air quality.

For example, McConnell leads a new air-quality study that is the first to examine several types of farm emissions—ammonia; active ingredients in pesticides; volatile organic compounds from crops, solvents, and other pesticide ingredients; and dust—and their interactions with urban pollutants across the bay watershed.

McConnell, Hapeman, Rice, and colleagues at the University of Maryland-College Park are developing new techniques for tracking agricultural airborne particles by their chemical fingerprints.

The vastness of the bay's watershed makes the task of halting the bay's decline even more of a challenge. Growing urbanization makes it essential to implement practices in coming years that ensure that urban and rural communities work together to lower rather than increase pollution risks.—By **Don Comis,** ARS.

This research is part of Manure and By-product Utilization (#206), Soil Resource Management (#202), Water Availability and Watershed Management (#211), and Climate Change, Soils, and Emissions (#212) four ARS national programs described at www.nps.ars.usda.gov.



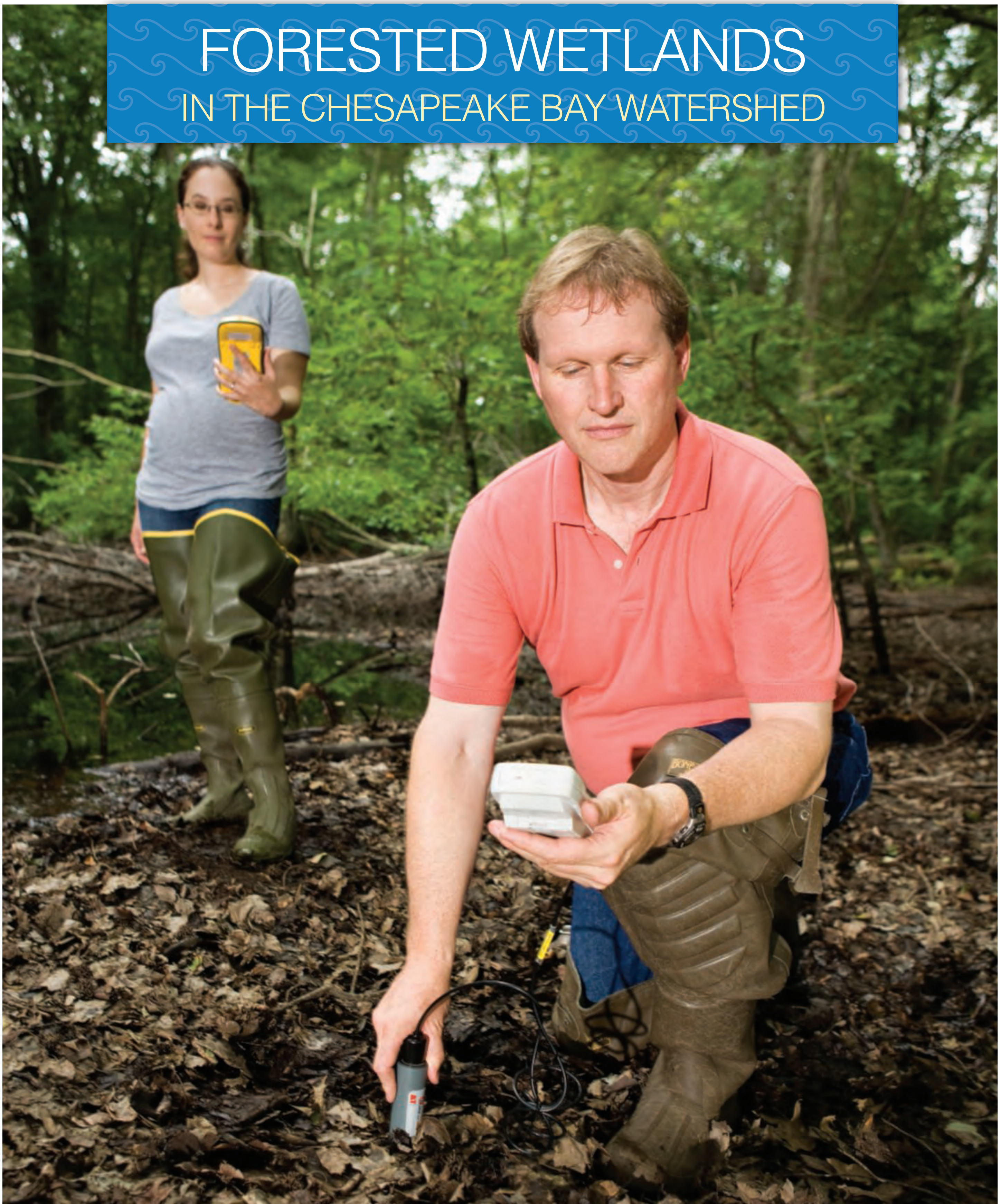
A blue heron on the Choptank River.

To reach scientists mentioned in this article, contact Don Comis, USDA-ARS Information Staff, 5601 Sunnyside Ave., Beltsville, MD 20705-5129; (301) 504-1625, donald.comis@ars.usda.gov. *

CEAP Chesapeake Bay Partners

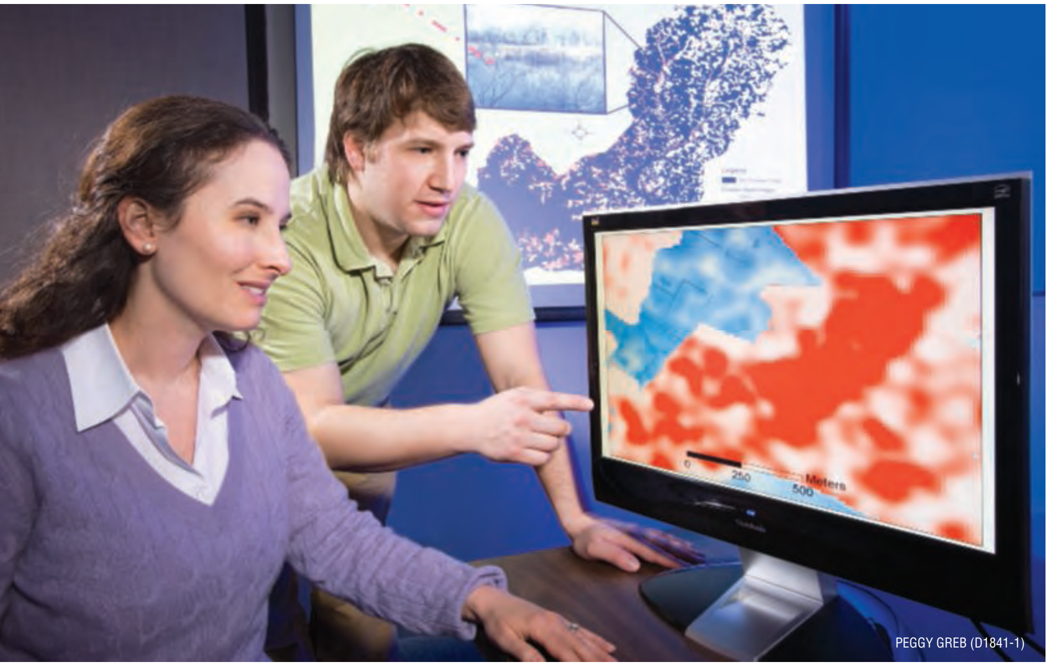
- Maryland Department of Agriculture
- University of Maryland-Wye Research and Education Center
- University of Maryland Center for Environmental Science
- Smithsonian Environmental Research Center
- USDA's Natural Resources Conservation Service
- National Oceanic and Atmospheric Administration
- USGS Eastern Geographic Science Center
- USDA's Forest Service
- Queen Anne's, Talbot, and Caroline County Soil Conservation District Offices
- Local farmers

FORESTED WETLANDS
IN THE CHESAPEAKE BAY WATERSHED



PEGGY GREB (D1745-1)

USDA Forest Service ecologist Megan Lang uses a global positioning system to determine an area's exact location while ARS soil scientist Greg McCarty measures soil moisture at the location. Information on soil moisture is used to determine the accuracy of wetland maps produced using LiDAR and radar.



Megan Lang and University of Maryland graduate student Robert Oesterling compare forested wetland maps for relationships between low (blue) and higher (white) elevations on one map and wet (red) and drier (white) spots on the other map. The maps were created with two remote-sensing technologies, one using laser light (LiDAR, or light detection and ranging), the other radio waves (SAR, or synthetic aperture radar).

A clear view through the trees. That's what soil scientist Greg McCarty and USDA Forest Service ecologist Megan Lang have been working towards as they pioneer the merging of two remote sensing technologies to map forested wetlands in the Chesapeake Bay Watershed.

McCarty and Lang are based at the ARS Henry A. Wallace Beltsville Agricultural Research Center in Maryland, and they conduct research on the bay's Eastern Shore, which is located on the Delmarva Peninsula that juts between the bay and the Atlantic Ocean. Delmarva is an acronym for Delaware, Maryland, and Virginia—the three states that make up the peninsula.

The two scientists are the first to apply LiDAR (light detection and ranging) to forested wetland mapping. They are also among the few researchers to report combining the laser technology with a similar technology, a form of radar (radio detection and ranging) that relies on advanced technology called a "synthetic aperture radar" (SAR) sensor.

A Tale of Two Sensors

Both SAR and LiDAR are active sensors in that they transmit their own energy. Long-wavelength microwave energy is used by SAR, while shorter wavelength laser energy is used by LiDAR. Both sensors use the time it takes for the signals to travel to the wetlands and the strength of the returning signal to help detect the presence, extent, and, in some cases, depth of water.

SAR is currently collected by satellite-mounted sensors, allowing for more frequent image collections over large areas. LiDAR sensors are usually flown on airplanes, so the imagery is collected much less frequently, but it has greater spatial resolution.

SAR is best for spotting short-term changes in water levels, such as flooding or short-lived pools of water, while LiDAR is better for producing highly accurate maps of flooding and understanding the surface-water flow paths in landscapes or recording changes over long time periods.

SAR sensors are not restricted by clouds or even most rainstorms. That is important when collecting data during rainy periods, when wetlands really show up. The imagery also makes it practical to monitor wetlands year-round, day or night.

Both LiDAR and SAR can literally see the wetlands through a forest canopy. Most bay-area wetlands are forested, as are half of the wetlands in the United States.

The sensitivity of radar's microwaves to water makes SAR ideal for detection of hydrologic patterns in wetlands, although this research demonstrates that LiDAR is also up to the task—and with even greater spatial resolution.

More Accurate Wetland Maps

With the synergy between the two sensors, McCarty and Lang have created wetland maps that are about 30 percent more accurate than existing maps that use aerial photographs, a standard method for wetland mapping. This synergy also made it possible for them to develop new techniques to monitor wetland flooding and soil moisture as it varies through time. This information can be used to map wetlands and estimate the ecosystem services that wetlands provide society—such as filtering out pollutants, controlling floods, cycling nitrogen and other nutrients, storing carbon, and providing wildlife habitat.

"The combined sensors can greatly improve understanding of ecological services that wetlands provide and will likely have bearing on the management and conservation of wetland ecosystems in agricultural landscapes nationally," McCarty says.

Together, the two sensors can detect wetlands and identify their ecological benefits. As one example, Lang points to combined LiDAR/SAR maps that show water flow: In one part of the map, the surface water is flowing into a ditch and then into the Choptank River—a major Chesapeake Bay tributary—with little filtering of pollutants. To the right of that area, water flows into a forested wetland, where nutrients, sediments, and pesticides

Using a global positioning system, ARS soil scientist Greg McCarty locates a wetland study site.

may be removed before entering the river. Lang can even track how well these forested wetlands can remove pollutants through time. This information would not have been available from less advanced images, like aerial photography.

Wetlands Not Separate After All

Combining SAR and LiDAR gives such a clear view of wetlands that McCarty and Lang have found that many depressional wetlands on the Delmarva Peninsula are often connected to each other, to waterways, and to the bay by an intricate network of other wetlands, drainage ditches, intermittent streams, and ponds. Lang and McCarty have mapped networks that carry water and possibly pollutants to the Choptank River.

Many of these depressional wetlands were thought to be hydrologically isolated from each other, from perennial streams and rivers, and from the bay, so the Clean Water Act did not offer them the same regulatory protections as other wetlands.

The advent of new technology has made this work possible. LiDAR topographic mapping is spreading from state to state. New LiDAR and SAR sensors are being developed, along with advanced computer software and models to process data. The fine-resolution LiDAR data that is used by McCarty and Lang was provided by the Canaan Valley Institute in Morgantown, West Virginia, in partnership with the ARS Pasture Systems and Watershed Management Research Unit in University Park, Pennsylvania. These two organizations are currently working with McCarty and Lang to extend LiDAR to other applications, including the prediction of in-field soil moisture variations.

Chesapeake Bay Watershed Is Test-Bed for Improved Wetland Monitoring

The scientists are working with USDA's Natural Resources Conservation Service in the Choptank River Watershed as part of the Mid-Atlantic USDA Wetland Conservation Effects Assessment Project. This project is a test-bed for new landscape-monitoring tools and technologies that will be used for national applications. It partly funds Lang's and McCarty's research.

The flat topography of the Choptank River Watershed causes poor drainage, so farmers have built an extensive network of drainage ditches.

Lang says, "Until recently, people have not fully appreciated the valuable services wetlands provide to society, and this has led to the loss of vast areas of wetlands. Maryland has lost about 75 percent of its wetlands, and we estimate that the Choptank Watershed has lost well over half of its historic inland wetlands. But the wetlands that remain serve critical roles in maintaining water quality, regulating greenhouse gases, and providing habitat. The information that SAR and LiDAR provide can be used to best manage the native wetlands that remain and reduce the impact of agriculture on the bay."

The maps created by McCarty and Lang show changes in wetlands caused by ditches, other construction, farming, and weather. By tracking the impact of extreme weather on wetland water levels, they can predict how climate change will affect wetlands and their ability to provide vital services, like improving water quality, in the future. In this way, the maps also help identify how these changes may affect the health of the bay.

LiDAR can also be used to create digital elevation models. These maps have a three-dimensional-like effect, showing likely flow paths and where water may pool. The maps are accurate for elevation differences as small as 6 inches. These small differences can add up to big changes in flat landscapes like the Delmarva.

Even Bare Trees Block Aerial Views

"With aerial photography, it's almost impossible to see wetlands when deciduous trees have leaves, and it's very difficult to see many types of wetlands even when the leaves are gone. The tree branches and their shadows are often enough to hide wet soil, ditches, and ephemeral streams," Lang says.

With the combined sensors, the "view" through the trees is so thorough that it even "sees" wildlife habitat, such as small pools that form each spring where many invertebrates spawn, including endangered species. These vernal pools serve as refuges for other animals, such as frogs and toads. The pools also help maintain unique vegetation—even endangered plants—by providing moisture for seed germination.

The research adds vital information to the Chesapeake Bay cleanup and state and national wetland regulation debates.—By **Don Comis,** ARS.

This research is part of Water Availability and Watershed Management, an ARS national program (#211) described at www.nps.ars.usda.gov.

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CHESAPEAKE BAY CLEANUP REVS UP!

STEPHEN AUSMUS (D1368-4)

ARS soil scientist Greg McCarty (right) and Dean Hively, a physical scientist with the U.S. Geological Survey, sample plant biomass and soil nitrogen on a cover crop field in the Choptank River Watershed.

President Barack Obama's May 12, 2009, Executive Order on Chesapeake Bay Protection and Restoration directed federal agencies to clean up the bay and to promote reliance on adaptive management to increase environmental benefits.

This management approach means using ecosystem monitoring, with rapid feedback, for improved decisionmaking in managing land to reduce pollution of the bay.

The Agricultural Research Service's merging of remote-sensing, field-sampling, and farm-program records to judge the effectiveness of winter cover crops in controlling nitrogen losses from fields fits the bill in several ways. It is the type of use of advanced monitoring tools the order calls for, with many rapid feedback loops to allow adjustments each fall, when winter cover crops are planted in the bay area. Winter cover crops are an important practice for capturing nitrogen left over from fall-harvested crops before it can pollute the bay.

Promoting Successful Cover Crop Solutions

In a 4-year study using this combination of remote-sensing tools, Greg McCarty, a soil scientist at the ARS Hydrology and Remote Sensing Laboratory (HRSL) in Beltsville, Maryland, and Dean Hively, now a visiting physical scientist from the U.S. Geological Survey Eastern Geographic Science Center, showed that, of the predominant winter cover crop species planted in Maryland—rye, barley, and wheat—wheat is by far the least efficient at taking up nitrogen because of its slow fall growth. Yet 60 percent of the land planted to cover crops is in winter wheat. The State of Maryland pays farmers to plant cover crops, with a premium for early-planted and nonwheat crops.

McCarty and Hively also used the tools to calculate that it costs taxpayers about $9 for each pound of nitrogen sequestered by winter wheat, while it only costs $2.50 per pound of nitrogen for rye and $3.50 for barley. These calculations will be

PEGGY GREB (D1876-1)

Greg McCarty (left), Royden Powell (center), assistant secretary, Maryland Department of Agriculture, and Dean Hively review fields in the Choptank River watershed that are enrolled in the winter cover crop program.

made each year on a field-by-field basis, and will also include analysis of planting techniques and time of planting.

Every year, the ARS scientists look at cost-share program enrollment records to locate all cover crop fields in their Eastern Shore study area. In late December, the scientists acquire satellite imagery of the fields to measure fall cover crop growth and again in March to measure spring growth. Simultaneous with satellite imagery acquisition, the scientists hand-sample 30 cover crop fields to calibrate the satellite-derived measurements.

Pilot Project for Cover Crop Monitoring

The scientists are developing GIS (geographic information system) software to automate cover crop monitoring and management reporting. A prototype package goes operational this year with a pilot project in Talbot County, Maryland. Every participating farmer will receive a field-by-field report of cover crop performance, as well as a county summary report. Soil conservation district offices will then be able to evaluate underperforming fields to strategize for improved implementation in the coming year. With success, the project will be scaled up to each of Maryland's 24 soil conservation districts.

The scientists are also developing software to summarize the data by county and watershed and produce reports to the Maryland Department of Agriculture (MDA). This is part of the feedback system, leading to potential adjustments in federal and state conservation program implementation strategies.

"This represents a shift from modeling to actual measurement of conservation practice performance, with tabular summaries of cover crop nitrogen uptake and associated costs made available at county and watershed levels, in a timely fashion," McCarty says.

In the past, scientists and managers had to rely on cover crop performance data derived from plot-scale research. The new technique allows performance monitoring on a watershed scale, with analysis pertaining to all farms participating in the cost-share program for winter cover crops.

Farm Records Give Realistic View

"Another unique feature of this program is that, unlike most remote-sensing specialists and computer modelers, we have access to on-the-ground agronomic management data on a field-by-field basis," says Hively. "For example, the farm cost-share records tell us what variety of crop was planted, on what date, using what method, following what summer crop. This information can be combined with remote sensing to evaluate the outcomes of various management strategies used by farmers, while maintaining farm privacy."

The interagency research team, led by McCarty and Hively, works closely with the MDA Office of Resource Conservation Operations, which manages the cover crop cost-share program.

Says Royden Powell, MDA assistant secretary, "Cover crops are our top priority for controlling nitrogen and phosphorus flows to the bay. The remote-sensing technology to identify crops and their growth progress from space has been developed and perfected over the past 5 years. Combining remote sensing with farm records and field sampling gives us more exact inputs for the Chesapeake Bay model."

The cover crop project is an outcome of the Choptank River Conservation Effects Assessment Project. (See story, page 10.)

In addition to ARS funds, the cover crop project is also supported by $1.3 million in Chesapeake Bay program watershed grants administered by the National Fish and Wildlife Foundation. These funds are used for research and to increase cost-share funding, accounting for the planting and evaluation of 13,000 acres of cover crops.

"Business as usual" meant judging bay cleanup progress through water-quality measurements of the bay and its tributaries, such as the Choptank River. But water-quality measurements often reflect past management, because it can take 30 years or more for nitrogen and other pollutants to filter through the soil to groundwater and resurface in a stream on the way to a river and the bay.

Faster Feedback

"The ARS program provides rapid—rather than decades-old—feedback so that the annual effects of practices such as crop choice, planting technique, and timing can be seen and corrected the next season, if needed," Hively says.

Participating scientists also include HRSL soil scientist Ali Sadeghi, USDA Forest Service ecologist Megan Lang, and chemist Laura McConnell, from the ARS Environmental Management and Byproduct Utilization Laboratory in Beltsville.

Maryland doubled its budget for its cover crop cost-share program to $18 million in 2008-2009 and budgeted $12 million for 2009-2010. This year, farmers enrolled 330,500 acres in the program.

But how much nitrogen loss do these cover crops prevent? The answer will be provided annually on a local basis using this project's innovative combination of remote sensing, farm-management records, and field sampling.—By **Don Comis,** ARS.

This research is part of Water Availability and Watershed Management (#211), an ARS national program described at www.nps.ars.usda.gov.

To reach scientists mentioned in this article, contact Don Comis, USDA-ARS Information Staff, 5601 Sunnyside Ave., Beltsville, MD 20705-5129; (301) 504-1625, donald.comis@ars.usda.gov. ✻

Anti-pest Aeration: A New Twist on an Old Concept

Aeration—blowing ambient air through storage bins using low airflow rates—has been used in commercial and on-farm storage since the 1950s to maintain the quality of grain by keeping it cool. In Kansas and other south-central states, aeration is also used to manage insects in stored wheat. This is achieved by cooling the grain to 60°F or below, a temperature range that slows the activity of most stored-product insect pests.

But few recent studies have been performed to examine whether it's better to direct air from above or below as a means of using temperature to control insects, according to entomologist Frank Arthur and agricultural engineer Mark Casada, both with ARS's Center for Grain and Animal Health Research in Manhattan, Kansas.

To find out, they used bins located at the ARS center to compare "pressure aeration"—which uses fans to push ambient air from the bottom of grain storage bins upwards, and "suction aeration," which involves reversing the fans to pull air from the top downward. They conducted two 8-month trials using 6 metal storage bins with perforated floors and grain-storage capacities of 1,250 bushels of wheat.

Three bins used pressure aeration, and three used suction aeration. Devices called "anemometers" measured airflow rates, while temperature readings were taken with data loggers attached to special sensor cables pushed to various depths and locations within the stored wheat. Eighteen-inch-long pitfall probe traps monitored the number, location, and species of grain-infesting insects in the top surface of the wheat mass. These included rusty grain beetles, foreign grain beetles, hairy fungus beetles, red flour beetles, sawtoothed grain beetles, rice weevils, and lesser grain borers.

Data analysis showed that, during summer months, suction aeration cooled the stored wheat's upper portion—dubbed the "surface zone"—more quickly than pressure aeration and that this difference correlated to fewer insects in the surface zone. For example, pitfall trap data for rusty grain beetles collected over 5 sampling dates revealed 3,290 in pressure-aeration bins versus 662 in suction-aeration ones. Fewer red flour beetles were observed too: 8,210 trapped in pressure-aeration bins versus 722 in suction-aeration bins. With a few exceptions, these reductions also held true for other species.

Suction aeration's rapid cooling of the grain's surface zone (about 1 foot deep) is advantageous, the researchers note, because that's where insects initially infest the grain after flying in from outside.

The studies reaffirm earlier Manhattan research that aerating bins using three temperature cycles—75°F in the summer, 60°F in early autumn, and 45°F in late autumn—reduced insect populations in experimental bins compared to using two autumn aeration cycles at 60°F and 45°F— the standard practice in south-central states where wheat is harvested in June or July.

Though larger-scale aeration studies are needed, "One benefit could be reduced reliance on the fumigant phosphine for control of insect pest populations," Arthur and Casada write in a paper currently in press in *Applied Engineering and Agriculture.*—By **Jan Suszkiw,** ARS.

This research is part of Crop Protection and Quarantine, an ARS national program (#304) described at www.nps.ars.usda.gov.

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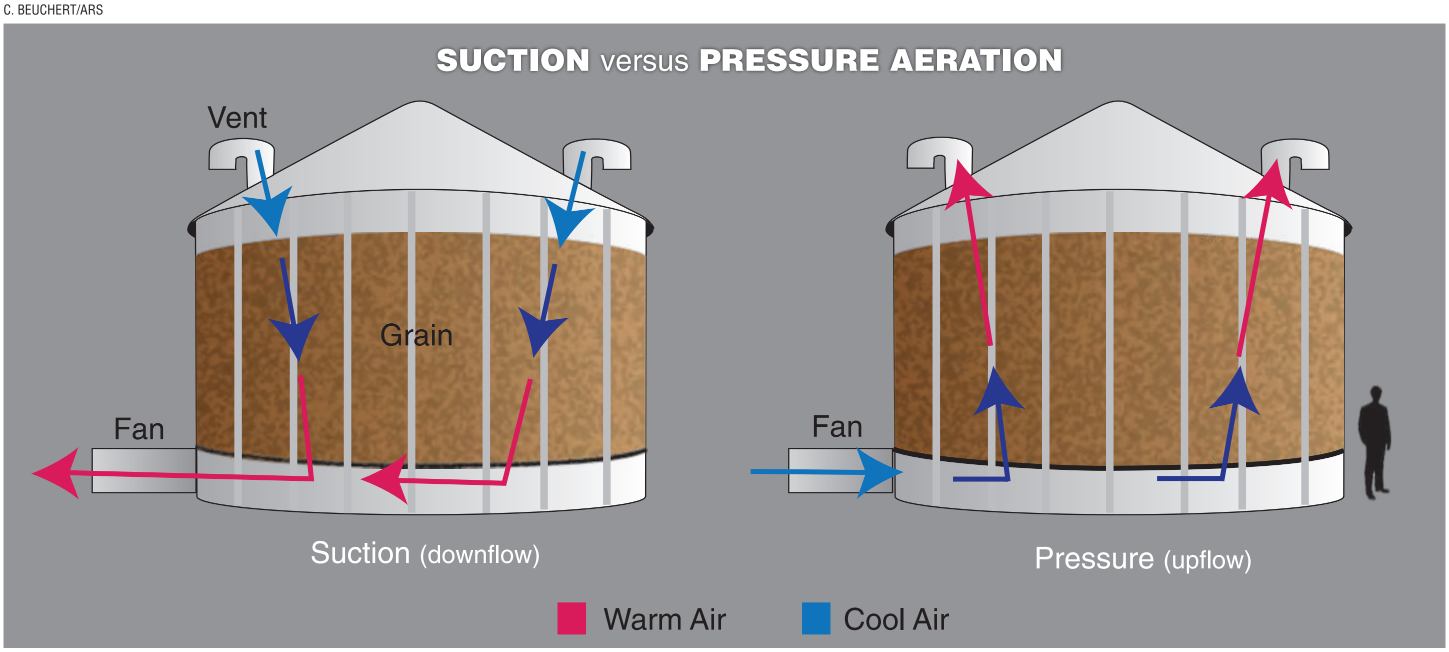
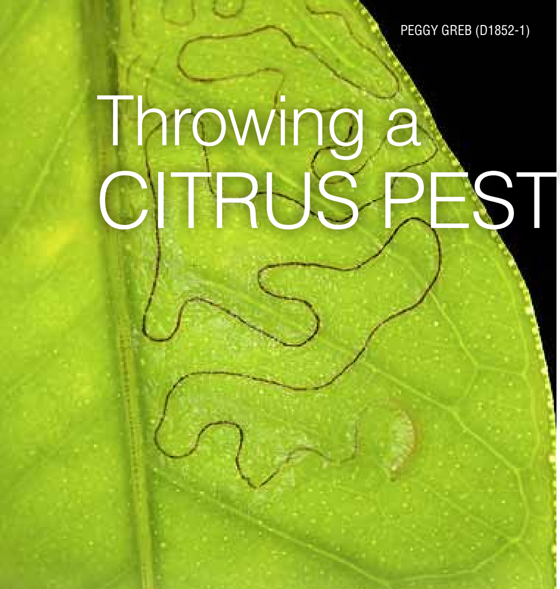
C. BEUCHERT/ARS





PEGGY GREB (D1852-1)

Throwing a CITRUS PEST Off Its Scent

A citrus leafminer larva creates a gallery, or mine, within a citrus leaf, thereby gaining protection from externally applied pesticides and leaving behind a fecal trail. The wound created by the larva also makes the plant more susceptible to citrus canker disease.

PEGGY GREB (D1851-1)

A 1-gram dollop of SPLAT containing the sex pheromone to disrupt citrus leafminer mating.

Agricultural Research Service scientists are working on controlling a pest that poses an increasing threat to Florida citrus groves by exploiting the insect's own reproductive habits.

The leafminer moth, *Phyllocnistis citrella,* forms channels as it feeds inside citrus leaves and, as a result, often makes the plant more susceptible to canker disease. Further exacerbating the leafminer problem is the spraying of more insecticide to combat another pest—the Asian citrus psyllid. The insecticide is killing off the leafminers' natural enemies, allowing the pest to increase in numbers.

Commercial traps can sometimes help, but Stephen Lapointe, an ARS entomologist with the U.S. Horticultural Research Laboratory in Fort Pierce, is exploring a control strategy that has proved effective with other pests: mating disruption. He is collaborating on the project with geneticist Randall P. Niedz and ecologist Terence J. Evens, ARS researchers at the Fort Pierce lab, and with Lukasz Stelinksi of the University of Florida's Citrus Research and Education Center. The experimental design and data analysis were handled by Niedz and Evens, who applied advanced statistical approaches that they have been developing for resolving the effects of different kinds of mixtures in complex biological systems.

Many insects release pheromones to attract mates. In some cases, scientists have synthesized those pheromones and developed treatments that throw males off the scent of fertile females in orchards and fields. The technique has been used to control gypsy moths, codling moths, and several other pests that attack fruit and vegetable crops. These treatments are considered environmentally friendly because they reduce the need for insecticides and are designed to target specific pests. "In all of them, we are basically just interfering with the male's ability to receive the signal from the female," Lapointe says.

Lapointe is working with Lukasz Stelinksi of the University of Florida's Citrus Research and Education Center to see whether they can disrupt leafminer mating by manipulating either of two compounds—a triene and a diene—used by female leafminers to attract mates.

The researchers are trying to see whether they can disrupt leafminer mating by manipulating either of two compounds-a triene and a diene-used by female leafminers to attract mates. They also wanted to see what formulations would be most effective at confusing males and disrupting their ability to pick up the female scent.

The researchers created synthetic female-scented traps, placed them in a citrus grove, and counted the number of males caught. They confirmed that the three-to-one ratio of triene to diene worked better than triene or diene alone as an attractant. In 2.5 months, more than 48,000 males were captured in traps baited with the 3:1 blend compared with around 3,500 males captured in traps baited with the triene and only 70 in traps baited with the diene.

PEGGY GREB (D1853-1)

ARS research leader David Hall (left) observes as entomologist Stephen Lapointe applies a formulation of SPLAT containing the sex pheromone of the citrus leafminer.

In a second phase of the project, the researchers surrounded the female-scented traps with 17 different combinations of the two synthetic compounds—as well as each compound on its own—to see which would be most effective at preventing males from finding the traps. They placed the experimental treatments around female-scented traps at different points inside a 59-acre grove of grapefruit trees. If the experimental treatments prevented the males from reaching the female-scented traps, the males theoretically would be unable to find females in natural settings, the researchers say. They used a waxy substance known as "SPLAT" that slowly released the experimental treatments over time, and they checked once a week over several months to see which treatments were most effective at keeping leafminers out of the female-scented traps.

Results showed that either compound used alone was as effective as the 3:1 blend at keeping male leafminers away from the female-scented traps. The diene-only treatment resulted in an 89-percent reduction in moth catches, and the triene-only treatment resulted in an 83-percent reduction. Greater amounts of diene are required to disrupt the moths, but diene is also much cheaper to synthesize, Lapointe says.

The work was recently published in the *Journal of Chemical Ecology.* Lapointe is also working with ISCA Technologies, Inc., of Riverside, California, a manufacturer of the SPLAT technology, to use these results to develop a marketable leafminer mating-disruption technology.—By **Dennis O'Brien,** ARS.

The research is part of Crop Protection and Quarantine, an ARS national program (#304) described at www.nps.ars.usda.gov.

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Bee Pastures: Floral Havens Where Pollinators

Chinese houses *(Collinsia heterophylla)*

California bluebell *(Phacelia campanularia)*

Blue orchard bee on a California five-spot flower *(Nemophila maculata)*

Baby blue eyes *(Nemophila menziesii)*

Lacy (or tansy) phacelia *(Phacelia tanacetifolia)*

Beautiful wildflowers, perhaps as alluring to bees as they are to people, might someday be planted in "bee pastures." These floral havens would be created to help propagate larger generations of healthy, hard-working bees.

Pesticide-free bee pastures can be "simple to establish and—at perhaps only a half-acre each—easy to tend," says entomologist James H. Cane. He's with the Agricultural Research Service's Pollinating Insects Biology, Management, and Systematics Research Unit in Logan, Utah, about 80 miles north of Salt Lake City.

Cane has conducted bee-pasture-related experiments for about 4 years, working both in a research greenhouse and at outdoor sites in Utah and California. He says species of pastured pollinators could include, for example, the blue orchard bee, *Osmia lignaria.* This gentle bee helps with pollination tasks handled mainly by the nation's premier pollinator, the European honey bee, *Apis mellifera.*

Today, millions of bees are needed, every year, to pollinate orchards and fields. Planting pastures for native blue orchard bees, for instance, could help meet that need. Cane estimates that, under good conditions, blue orchard bee populations could "increase by as much as four- to fivefold a year" in a well-designed, well-managed bee pasture.

Cane gives this brief explanation of how the pasture idea would work: Blue orchard bees would be taken out of a bee manager's winter storage and brought to the pasture, where they would emerge from their cocoons, mate, and, if female, lay eggs, before dying.

The following year, some of the new generation of bees that developed from those eggs would be brought to commercial almond orchards to pollinate the trees' cream-white blooms. But most of that generation would be returned to their parents' pasture to produce yet another, hopefully larger, generation.

Ideally, this cycle would continue year after year, with each year's new generation larger than the one it replaced.

Best Bets for a Bountiful Bee Pasture

In their experiments, Cane and colleagues have studied wildflowers that might be ideal for planting at bee pastures in California. In particular, the team was interested in early-flowering annuals that could help bolster populations of blue orchard bees needed for pollinating California's vast almond orchards. The research resulted in a first-ever list of five top-choice, bee-friendly wildflowers for tomorrow's bee pastures in almond-growing regions.

These native California plants are: Chinese houses *(Collinsia heterophylla),* California five-spot *(Nemophila maculata),* baby blue eyes *(N. menziesii),* lacy or tansy phacelia *(Phacelia tanacetifolia),* and California bluebell *(P. campanularia).*

Though blue orchard bees gathered nectar and pollen from all of these species—a key requirement for wildflowers on the list—the bees' obvious favorite was the bright-pink blossoms of the Chinese houses plants.

Wildflower species had to have more attributes than merely appealing to bees, however. Cane's team made sure that each of the select species flourishes in the same climate and soil as that of almond orchards, and that the wildflowers bloom at about the same time of year as those trees.

These features help make it feasible and practical for bee managers who are busy fulfilling a commercial almond pollination contract to—at the same time—manage a bee pasture.

The wildflowers also met other criteria: They are rich in pollen and nectar and are reasonably easy to grow. And their seed is commercially available.

There was yet more that the researchers determined before deciding that the wildflowers were pasture-perfect. For example, the scientists either newly determined or confirmed the amount of pollen and nectar produced by the plants, and they noted the timing and duration of the bloom. They estimated how many flowers were produced per acre, then calculated the "carrying capacity" of each species, that is, the number of blue orchard bees that these plants could nourish.

Cane estimates that every 10 square yards of pasture that is planted with a mix of these five attractive flowers could provide enough pollen and nectar to support 400 mother bees. In turn, these pastured parents could produce enough progeny to—the following year—pollinate 3 acres of almond trees.

Two bee businesses in California are already using the findings to propagate more bees, Cane notes. He collaborated in the research with support scientist Glen Trostle at Logan; former Logan technician Stephanie Miller; AgPollen LLC colleague Steve Peterson, and others. ARS and the Modesto-based Almond Board of California funded the studies.

Cane notes that the bee-pasturing approach could perhaps be developed for other regions where other tree crops that blue orchard bees pollinate are grown, such as the cherry, apple, or pear orchards of the Pacific Northwest.

Bee pasturing isn't a new idea. But the studies by Cane and his collaborators are likely the most extensive to date.

For the foreseeable future, bees will remain in great demand. And the bee pastures that Cane proposes are in perfect harmony with the pollination needs of almond blossoms and wildflowers alike.

"Bee pasturing," he says, "is an efficient, practical, environmentally friendly, and economically sound way for bee managers to produce successive generations of healthy young bees."—By **Marcia Wood,** ARS.

This research is part of Crop Production, an ARS national program (#305) described at www.nps.ars.usda.gov.

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PEGGY GREB (D1044-1)

Entomologist James Cane examines wildflowers in a Logan, Utah, test plot.

Producers and Pigs Profit From Manure

PEGGY GREB (D1774-1)

ARS soil scientists Matias Vanotti (left) and Ariel Szogi (right) and Lewis Fetterman, the CEO of Terra Blue, Inc., examine swine wastewater before (dark liquid) and after (clear liquid) treatment in the second-generation system they invented.

For almost 10 years, Agricultural Research Service (ARS) soil scientists Matias Vanotti and Ariel Szogi have worked with farmers, state agencies, and businesses to improve swine manure management practices. Now the scientists have developed a streamlined system that delivers a winning trifecta—healthier pigs, healthier profits, and a healthier environment.

A key factor in this success? "We paid lots of attention to what farmers and industry were telling us," says Vanotti, who works with Szogi at the ARS Coastal Plains Soil, Water, and Plant Research Center in Florence, South Carolina.

Manure can be used to fertilize crops, but excess nitrogen and phosphorus that is not taken up by plants can be carried away by water and end up polluting nearby streams, lakes, and groundwater. Controlling pathogens, odors, and emissions of ammonia and greenhouse gases is also a concern with livestock production. So swine producers in North Carolina—who in 2008 sent close to 20 million pigs to market—are always on the lookout for ways to reduce the environmental impact of their facilities.

Vanotti and Szogi have been essential partners in this search. In 2005 they unveiled a first-generation swine manure management system created in partnership with Terra Blue, Inc., a private business based in Clinton, North Carolina. (See "Blue Lagoons on Pig Farms?" *Agricultural Research,* March 2005.)

Taking It to the Next Level

When Vanotti and Szogi started out, the technology available to them resulted in a highly effective first-generation treatment system. But the results from their farm-scale trials and new discoveries suggested that they could design an even more economical and simple process.

An added incentive: In 2007, the State of North Carolina started a statewide Lagoon Conversion Program (LCP) that provided financial support to livestock farmers who installed new manure management technologies that improved water and air quality. The LCP set clearly defined targets for techniques that would meet their criteria of an Environmentally Superior Technology (EST) for manure management.

An EST needed to eliminate discharge of animal waste to surface waters and groundwater. It also needed to "substantially eliminate" emissions of ammonia and odors detectable beyond the production facility. An EST would also substantially eliminate the release of disease-transmitting vectors and pathogens as well as nutrient and heavy metal contamination of soil and groundwater. And an EST would need to run economically and efficiently.

The scientists' system already met the environmental targets. "We needed to demonstrate that we could cut costs while maintaining the efficiency of the first-generation system," Szogi says.

So Vanotti and Szogi went back to the drawing table and worked with Lewis Fetterman, the chief executive officer of Terra Blue, Inc., to redesign and fine-tune the process. In the end, the team made 24 changes to the first-generation system to lower its installation and operating costs and improve its reliability.

A U.S. Patent was granted for this new system (U.S. Patent 7,674,379, March 9, 2010).

The on-farm system used solid-liquid separation and nitrogen and phosphorus removal processes. In the right combination, these systems replaced traditional anaerobic lagoon systems with a process that produced clean, deodorized, and disinfected effluent.

After processing, the nutrient-rich solids were transported off-site to a central composting facility that produced class A composted materials for making organic plant fertilizer and plant growth media.

The team reduced the solid-liquid separation operation from 7 days a week to just 2. Several other adjustments were also made to this process, including simplifying the equipment used in the dewatering process and the production of drier solids. This improved solids handling, lowered transportation costs, and made the solids more suitable for composting. It also increased their potential for use as fuel for on-farm energy generation by thermal technologies.

To cut costs further, Vanotti and Szogi removed two tanks from the biological nitrogen removal process and incorporated a high-performing nitrifying bacterial sludge (HPNS), which they developed over 10 years in the laboratory. The new HPNS was well adapted to operate efficiently in both high-ammonia wastewater and cold temperatures, which translated into a smaller plant footprint. It also reduced the cost of ammonia removal.

A U.S. Patent Application was filed for the HPNS (Serial No. 12/495,958, July 1, 2009).

Finally, the scientists invented a simplified process to simultaneously separate the phosphorus and the manure solids. This innovation required fewer polymers than the previous separation system and also reduced equipment costs.

The revamped system was tested for 15 months on a 5,145-head swine farm over 4 growing cycles. For this full-scale project, they collaborated with microbiologist Patricia Millner, who works at the ARS Environmental Microbial and Food Safety Laboratory in Beltsville, Maryland, and chemist John Loughrin, who works at the ARS Animal Waste Management Research Unit in Bowling Green, Kentucky.

The results: the revamped system met EST standards at one-third the cost of the previous version. In cleaning up manure wastewater, the system removed almost 100 percent of pathogens and odor-causing components, 95 percent of total phosphorus, 97 percent of ammonia, and more than 99 percent of heavy metals copper and zinc.

The new system also cut emissions of methane and nitrous oxide—powerful greenhouse gases—by 97 percent. In addition, the system transformed the old lagoon into an aerobic reservoir that reduced 90 percent of the ammonia emissions.

The second-generation system used less energy to boot—power consumption dropped by 44 percent. The newer system was also more labor efficient and easier to operate than the first system, in part because of the development of operation practices that integrated automation with simple operator input.

SCOTT BAUER (K7623-1)

Close-up of piglet and sow.

PEGGY GREB (D1777-1)

Using a deep sampling probe, Ariel Szogi inspects the amount of calcium phosphate produced in a phosphorus-separation module that is part of the new system.

After processing, the nutrient-rich solids are transported off-site to a centralized composting facility. The composting process results in materials with an earthy scent and rich texture that can be used in organic fertilizers, soil amendments, and potting soils.

Matias Vanotti and C. Ray Campbell, vice president of research and development, Terra Blue, Inc., examine a compost sample.

Payback Time

All told, the second-generation technology was two-thirds less expensive to build and operate than the first system. What Vanotti and Szogi didn't anticipate is how well the animals would respond.

But Billy Tyndall, the farmer who owned the facility where the second-generation system was being tested, began to notice an improvement in his pigs immediately after the system was installed. "The animals were heavier," Szogi says. "And they were showing a better conversion of feed."

The scientists and Tyndall were so impressed that they extended the project—originally planned for 5 months—to run for another year and a half to see if the results stayed consistent over five growing cycles. At the end of the study, the scientists tallied up the surprising results.

Daily weight gain increased 6.1 percent, and feed conversion improved 5.1 percent. Animal mortality decreased 47 percent, and cull weight was reduced 80 percent. The farmer sold an average of 5,265 pigs per growing cycle, which resulted in a 1,138,247-pound net gain per cycle. Using the second-generation system instead of the lagoon system, the farmer sold 61,400 pounds more hogs—a 5.8 percent increase—per growing cycle.

"Participating in the program took my average farm to the top of the field," Tyndall declares.

The scientists attribute the productivity improvement in part to the improved air quality and health conditions in the barns. Since the recycled wastewater was mostly ammonia free, ambient ammonia levels in the barns dropped an average of 75 percent.

"Improvement in animal production is important to farmers because that's their bottom line," Vanotti says.

Fetterman, their Terra Blue, Inc., partner, sees it from another angle. "If you treat the pigs well, they will pay you back," he says.

Sharing the Success

The second-generation system was discussed in a chapter of "Manufacturing Climate Solutions: Carbon-Reducing Technologies and U.S. Jobs," published in 2008 by Duke University. The report was commissioned by the AFL-CIO and the Environmental Defense Fund and featured technologies that could help reduce greenhouse gas emissions and create green jobs in the United States.

The authors concluded that the second-generation system could help swine-producing states protect existing jobs and keep the door open for future job expansion.

In 2009, the USDA Natural Resources Conservation Service's Environmental Quality Incentives Program began a 5-year initiative with additional funding for North Carolina livestock farmers who participate in the LCP. At the time the program was established, only the second-generation system met all the LCP qualifications for funding, which will pay for up to 90 percent of the costs involved in installing an EST for manure management.

"When one considers the many direct and indirect benefits of the cleaner hog-waste technology, farmers and society may not be able to afford not to convert to the new technologies," Fetterman observes.

"We learned our lessons and tried to make a new system as simple to operate and economical as possible," Vanotti adds. "Now we need to install these systems in a sufficient number of farms to confirm their environmental benefits at a regional scale and to facilitate the development of markets for co-products from recovered manure nutrients."—By **Ann Perry,** ARS.

This research is part of Manure and Byproduct Utilization (#206), Water Availability and Watershed Management (211), and Food Safety (#108), three ARS national programs described at www.nps.ars.usda.gov.

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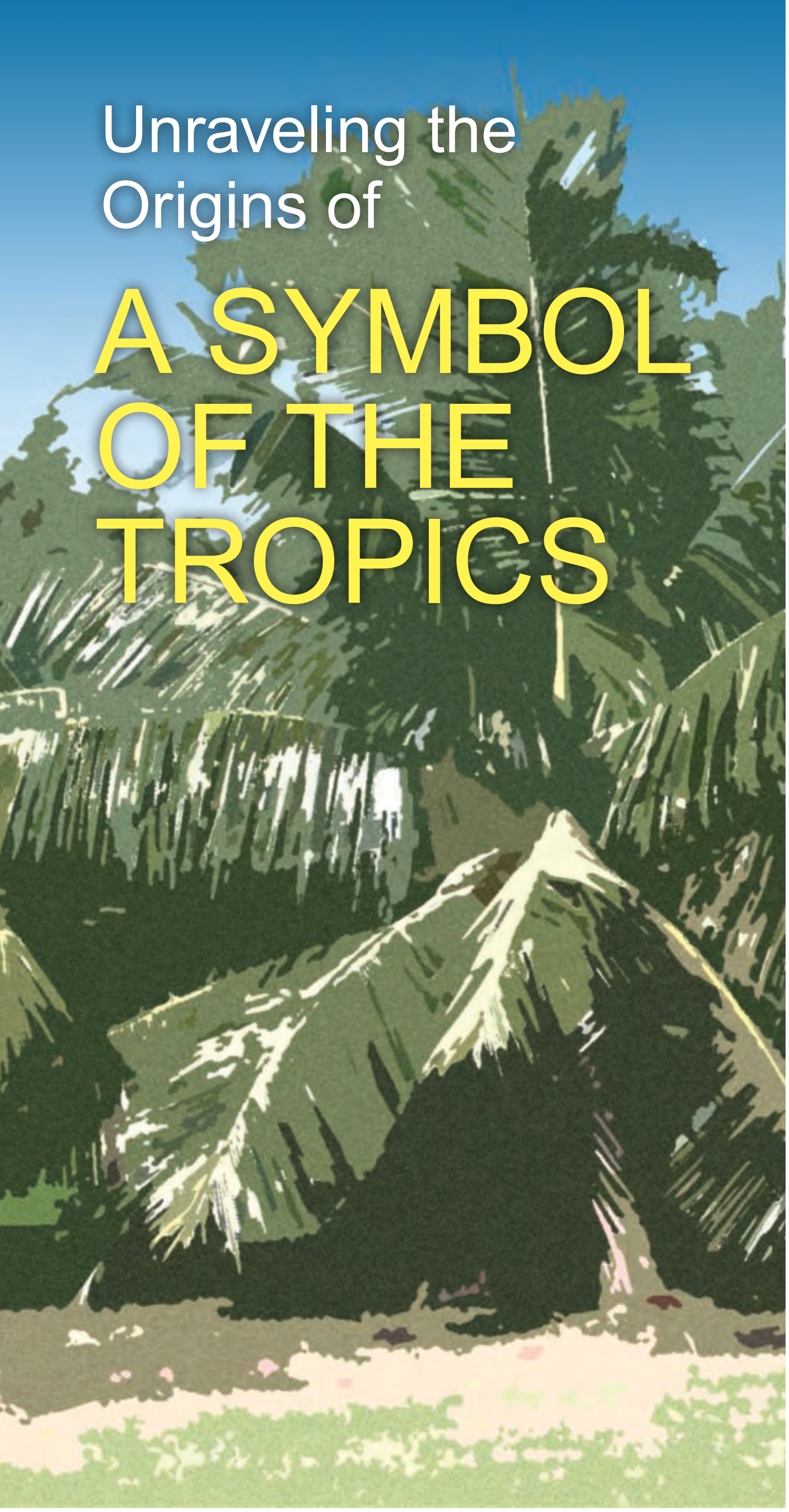
Unraveling the Origins of

A SYMBOL OF THE TROPICS



The coconut variety Niu Leka, or Fiji Dwarf (see back cover), from the South Pacific may represent the earliest lineage in the coconut's domestication.

The coconut tree is a symbol of the Tropics, and as a source of fiber, food, fuel, soap, and cooking oil, it is sometimes called "the tree of life." But one aspect of the tree has remained a mystery—its origins. Scientists have debated the tree's genealogical roots for decades.

Using genetic markers found in coconuts and other palm trees from around the world, Alan Meerow, a geneticist with the USDA-ARS Subtropical Horticulture Research Station in Miami, Florida, has completed a phylogenetic analysis of a large group of palm species (the Attaleinae subtribe) that provides the most comprehensive look yet at the coconut tree's family history. The results suggest that the ancestors of the coconut tree originated in South America, that the tree's closest living relatives are a modern genus of American palms (the genus *Syagrus*), and that it diverged from them about 35 million years ago. The genus *Syagrus* includes another popular Florida ornamental, the queen palm.

Meerow and colleagues also found that the modern coconut tree probably evolved about 11 million years ago, perhaps in the South Pacific. The Fiji Dwarf, a variety of coconut tree now grown in the United States, shares its South Pacific ancestry with many of today's other coconut varieties, according to Meerow. "The Fiji Dwarf is more distantly related to all these other varieties," he says.

The work, published in *PLoS One,* is more than an academic exercise. Five of the 80 known varieties of coconut tree are major ornamentals in Florida. Identifying their closest relatives will help in the search for genes with traits capable of resisting diseases, insect pests, and other threats. An epidemic of lethal yellowing phytoplasma in the early 1980s destroyed an estimated 100,000 coconut palms in South Florida. Bud rot, caused by several fungal pathogens, threatens coconut production around the world.

"The more we know about it, the easier it will be to address future threats," Meerow says.

Patterns of differences in DNA can open a window into a plant's evolutionary past, revealing when it diverged from its ancestors. Meerow and colleagues looked for patterns among a family of genes developed as markers by ARS researchers studying cacao (chocolate) plants. Known as "WRKY genes," they are valuable "clocks" for dating the occurrence of important evolutionary events.

With these molecular clocks and evidence from fossil palms, Meerow traced the coconut tree's ancestry back more than 40 million years to palms that grew in both Madagascar and eastern Brazil. He also found that milestones in the coconut's early "family tree" coincide with major geological events in South America, making it likely they played a role in how these palms evolved. A group of palm species in southern Brazil, for example, split off from a relative in Chile about 14 million years ago, around the time when geological events gave rise to the Andes Mountains. The extensions of oceans into the western Amazon region that lasted from 25 to 30 million years turned dry areas into wetlands and probably altered the evolution of coconut ancestors growing at the time across South America, Meerow says.—By **Dennis O'Brien,** ARS.

This research is part of Plant Genetic Resources, Genomics, and Genetic Improvement, an ARS national program (#301) described at www.nps.ars.usda.gov.

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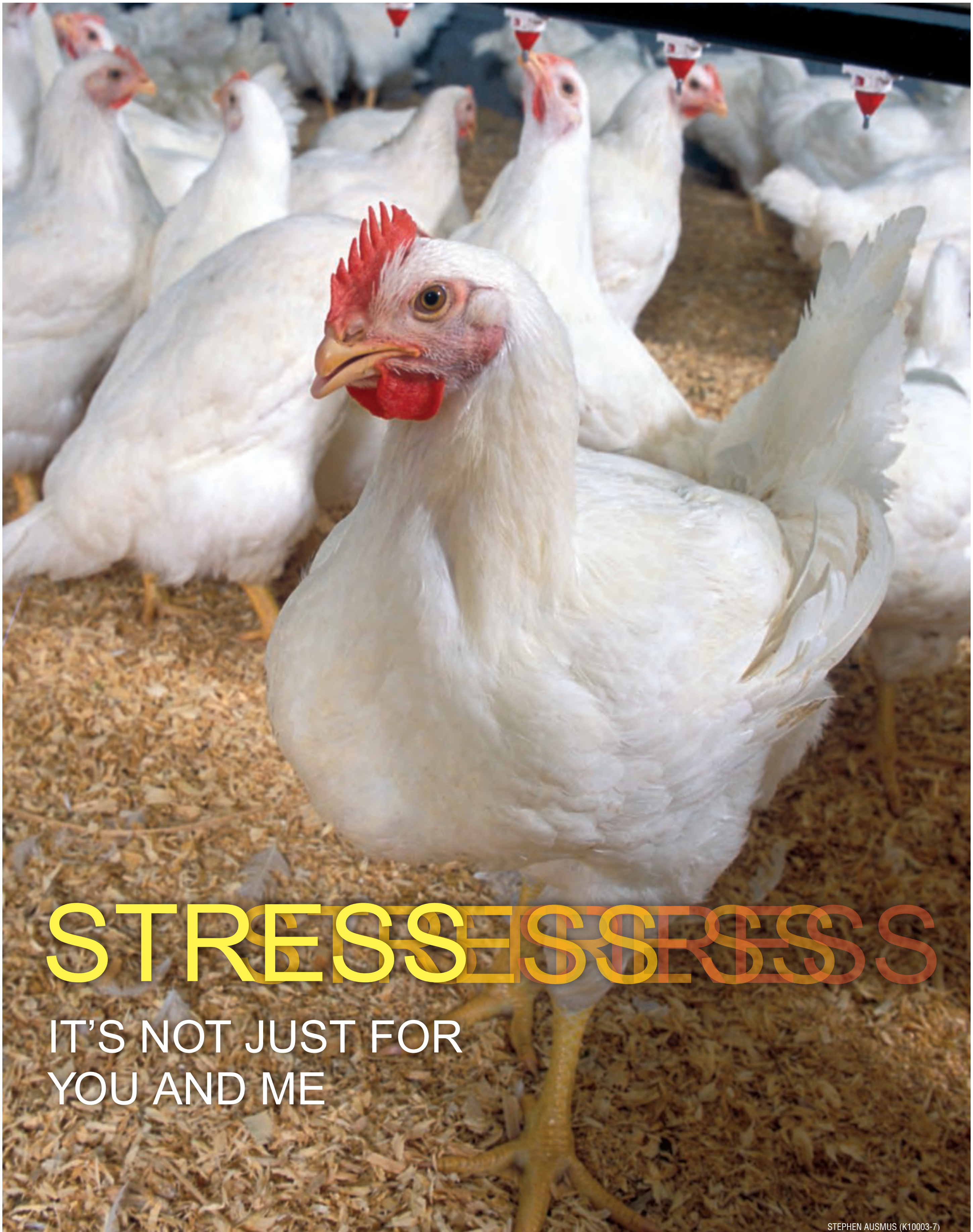

STRESS

IT'S NOT JUST FOR YOU AND ME

STEPHEN AUSMUS (K10003-7)

Vitamin C and beta-glucan supplements can help piglets gain weight after weaning.

Whenever we feel stress—like falling off a ladder—our bodies react in predictable ways—increased heart rate, rapid and shallow breathing, and an adrenaline rush. Animals feel stress too, and it can compromise their health and ability to thrive. That, in turn, can cost producers money.

Researchers in the Livestock Behavior Research Unit in West Lafayette, Indiana, study stress in poultry, swine, and cattle.

In one study, research leader Donald C. Lay, Jr., used animal restraint and stress-inducing hormone injections of sows as stressors. He found that prenatal stress, the stress imposed on a pregnant animal, resulted in widespread effects on the offspring.

"Prenatal stress has been shown to have effects on the behavior and physiology of many species, including monkeys, rats, guinea pigs, goats, humans, and swine," says Lay. "Research in our lab has shown that prenatal stress, from restraint and stress hormone injection of sows, caused offspring to have increased plasma cortisol levels in response to stress and less ability to heal a wound when subjected to stress."

Cortisol is a glucocorticoid—a class of steroid hormones that suppress the immune system. Cortisol can also raise blood pressure and blood sugar levels.

"Prenatal stress has been shown to cause an increase in fetal cortisol, which may in turn impair immune function and increase the maximum binding capacity of glucocorticoid receptors in the central nervous system immediately after birth."

Pigs in social groups are known to form hierarchies. Sows at the bottom of the hierarchy may produce litters of prenatally stressed piglets. Lay and his colleagues have shown that the effects associated with prenatal stress in swine, however, are not caused by cortisol alone. They are continuing research to identify the other factors involved.

Treating Farm Animal Stress from the Inside Out

Animal well-being can be improved and stress counteracted in farm animals by enhancing their enteric health and immunity through dietary supplements. In studies to reduce the negative health effects of a known stressor—such as animal transport and handling—animal physiologist Susan Eicher has shown that beta-glucan (a yeast cell-wall product) and vitamin C supplements, fed together, can improve piglet health by enhancing the animals' growth and immune function after transport.

In Eicher's studies, piglets received diets supplemented with beta-glucan alone, vitamin C alone, or both beta-glucan and vitamin C. An unsupplemented diet was fed to piglets as a control.

"Piglets receiving both vitamin C and beta-glucan had a greater weight gain after weaning," says Eicher. "We also detected changes in the expression of immune-system communication molecules called 'cytokines' in intestinal and liver tissues." Other animal species may also benefit from this combination diet during stressful times, such as transport.

This ARS nutritional supplemental combination was patented in 2005 and is licensed. The marketed product is presently used by calf producers in Idaho, and they report a lower incidence of respiratory problems.

Reducing Stress—and Pain—of Birds' Beak Trimming

Beak trimming is a routine husbandry procedure used in the commercial poultry industry—particularly in broiler breeders and laying hens—to reduce injuries during confinement.

During conventional beak trimming, one-third to one-half of the beak is removed. A hot blade is normally used to cut and cauterize the beaks of chicks. But the process can be painful to the birds, so alternative methods are needed.

Biologist Heng Wei Cheng has identified a better technique—infrared laser—that can reduce pain and tissue damage.

"Infrared lasers have been widely used for noninvasive surgical procedures in human medicine and their results are reliable, predictable, and reproducible," says Cheng. "Infrared lasers have recently been designed with the purpose of providing a less painful, more precise beak-trimming method compared with conventional beak trimming."

Infrared laser was compared to conventional beak trimming, and the results are promising. "Our results indicate that while there was no statistical difference in egg production or bird body weight between the two beak-trim treatments, those birds treated with the infrared method displayed superior feather condition and reduced aggression, even though they had less of the beak removed," says Cheng. "The data show that infrared beak treatment may reduce the damage done by feather pecking and provides a better alternative to conventional beak trimming. Indeed, infrared trimming may provide a less invasive alternative to conventional beak trimming without compromising productivity."

These research efforts are just some of many projects of the Livestock Behavior Research Unit that are aimed at improving existing practices and inventing new practices that enhance animal well-being and increase animal productivity.—By **Sharon Durham,** ARS.

This research is part of Food Animal Production (#101) and Animal Health (#103), two ARS national programs described at www.nps.ars.usda.gov.

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WHOLE TREE A More Sustainable,

GLENN FAIN (D1873-1)

Fresh WholeTree chips being processed into a substrate component at Young's Plant Farm.

GLENN FAIN (D1872-1)

A worker at Young's Plant Farm transplants seedlings into containers filled with an experimental substrate containing WholeTree.

At Young's Plant Farm in Auburn, Alabama, rows of southern pine trees *(Pinus taeda)* stretch as far as the eye can see. But these trees won't be used to decorate landscapes and parks or to provide shade on a hot day. Instead, these pine trees—commonly known as "loblolly pine"—will be used to grow the vibrant, healthy potted plants we see in nurseries and garden centers.

Nursery plants are grown in containers filled with a soil-less potting media, formally called "substrate," which typically consists of Canadian peat moss, perlite (heat-expanded volcanic rock), vermiculite (heat-expanded silicate mineral), and pine bark. But the process of harvesting, preparing, and shipping peat moss, perlite, and vermiculite requires tremendous energy inputs. Also, the availability of pine bark has been tenuous because it depends on the stability of various other industries from which pine bark is derived.

Seeing this predicament, horticulturist Glenn Fain, formerly with the ARS Thad Cochran Southern Horticultural Laboratory in Poplarville, Mississippi, and Charles Gilliam, a professor at Auburn University, began looking for an alternative material to use as a substrate or substrate component. Fain continues to collaborate with Jim Spiers, research leader of the Poplarville laboratory; Anthony Witcher, a doctoral student and horticulturist at Poplarville; and Greg Young, owner of Young's Plant Farm. In 2005 and 2006, ARS, Auburn University, and Young's Plant Farm entered into specific cooperative agreements to develop a new substrate they call "WholeTree."

Locally Produced, Completely Self-Sustainable

As its name suggests, WholeTree is made from all parts of the loblolly pine—bark, needles, wood, and cones. The word "loblolly" means "low, wet place," but these trees aren't limited to that environment. Loblolly pines grow well in acidic clay soil, which is commonly found in the South, and can be found in large

Environmentally Friendly Substrate

groups in rural areas. But trees used to make WholeTree aren't taken from natural areas; they're farmed at tree plantations across the southeastern United States.

The pine trees used are those that are harvested from pine plantations at the thinning stage. "Thinning" is when some trees are removed to achieve a density the site can support. The trees are then chipped and further processed to achieve the desired physical properties needed for a substrate component. Similar products have been available in Europe for several years, but WholeTree could be one of the first available products for the United States made from locally grown materials.

"We've taken a locally available product that's native to this region and that's already being farmed, and we've used it to make a more environmentally friendly product," says Fain, now an assistant professor at Auburn University. "It's completely self-sustainable and would cost less than other substrates on the market."

Glenn Fain evaluates garden chrysanthemums grown in WholeTree at the ARS Thad Cochran Southern Horticultural Laboratory in Poplarville, Mississippi.

Field and laboratory studies have demonstrated the successful use of WholeTree, even at 100 percent for some nursery plants. In one study, Fain and colleagues compared chrysanthemums grown in WholeTree with those grown in a WholeTree-and-peat moss mix and a peat moss-and-perlite mix. The scientists collected data on plant growth, flower bud number, leaf chlorophyll content, root rating, shoot dry weight, and nutrient content of plant tissue. In the end, they found minimal differences between the plants, all of which were considered marketable at the conclusion of the study. Other studies have produced similar results with only minor changes in cultural practices.

Results from the studies have been so promising that in 2008, Young's Plant Farm, a supplier to retail outlets such as Lowe's and Wal-Mart, made a significant investment in order to adopt this technology and further the research on a larger scale. They are now producing their own substrate component, farming and harvesting pine trees produced at one of their farms to make WholeTree. In fact, Wal-Mart recently recognized Young's Plant Farm for their efforts with a supplier sustainability award for using the product.

"Other plant suppliers can adopt this technology, although some cultural practices will have to be altered," says Fain. "WholeTree has the potential to be an economically sustainable substrate component that could be available in close proximity to major horticultural production areas throughout the Southeast."

Further Testing and Future Applications

Witcher, Fain, Spiers, and Eugene Blythe, an assistant research professor at Mississippi State University's South Mississippi Branch Experiment Station in Poplarville, are currently conducting further studies evaluating WholeTree's use in cutting and seedling propagation of herbaceous perennial and woody ornamental crops. So far, they have conducted tests on plants popular to the ornamental and landscaping industries, such as the garden mum, perennial salvia, climbing rose, and Leyland cypress.

"We've had promising results, but we need to further examine the physical properties of WholeTree," says Witcher. "We want to create an optimal mix of air space and water-holding capacity in the substrate to enhance root development in these plants. We also want to create a particle size that works well for a wide range of crops."

Researchers are planning to conduct trials using WholeTree as a landscape soil amendment. According to Fain, it is typical practice to add an organic amendment to the soil, especially in heavy clay soils. In the southeast, aged pine bark and peat moss are standard soil amendments. WholeTree will be compared with these standards to determine its potential use in the landscape industry.

Scientists are also planning to conduct plant-growth-response trials at other producer locations in the southeast. And they are looking into the possibility of using other species of trees growing in southern forests as standalone substrates or substrate components.

"We've taken a locally available product that's native to this region and that's already being farmed, and we've used it to make a more environmentally friendly product."
—Glenn Fain

If all goes well, you may soon see plants grown in WholeTree in a nursery near you.—By **Stephanie Yao,** ARS.

This research is part of Crop Production, an ARS national program (#305) described at www.nps.ars.usda.gov.

To reach scientists mentioned in this article, contact Stephanie Yao, USDA-ARS Information Staff, 5601 Sunnyside Ave., Beltsville, MD 20705-5129; (301) 504-1619, stephanie.yao@ars.usda.gov. ✻

Power Needs and *Wind Power* as Different as Day and Night

Brian Vick found that, in parts of Texas and California, an almost perfect match between wind-power production and peak energy demands can be obtained by combining wind power with solar power, and by proper storage of excess energy when power supply exceeds demand.

Vick is an agricultural engineer at the Agricultural Research Service's Renewable Energy and Manure Management Research Unit in Bushland, Texas.

Vick found that in both the Texas Panhandle and California, there is almost an exact mismatch between wind-power production and peak energy demands over a 24-hour period. In these locations, at the tops of modern wind turbines, winds are lowest at midday, when power demands are greatest. In Texas, there is a seasonal mismatch as well: The winds are weakest in the summer, when power demands peak. But adding solar power helps because the sun's rays are most intense at midday and in summer months.


SCOTT BAUER (K5474-12)

Wind turbines for electricity production.

When wind or sun power generated exceeds demand, it's important to capture the energy and store it. The most efficient storage system is one being used in solar thermal power plants, where the sun's energy is used to heat water or other fluids. The fluids are kept hot long after the sun goes down and can be used later to produce steam to generate electricity. The excess electricity generated by wind in the late night and early morning hours could be pumped into the grid and stored to supply power when wind and solar power are insufficient.

Vick and colleagues at Bushland design and test wind/solar/biodiesel hybrid systems running on an experimental electric grid. They also operate modern turbines for wind-farm research for the U.S. Department of Energy.

Vick expects that a better blending of solar and wind power will increase the use of renewable energy for California, Texas, and the rest of the nation. Texas is the top state for wind-generated electricity production, with Iowa second and California third. California is the leader in solar-generated electricity production.—By **Don Comis,** ARS.

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Torching Invasive Trees Revives Rangeland Perennials

Western juniper trees have thrived in Oregon's high desert for about 6,000 years, but in the past century, the aggressive conifer has begun to dominate some of the region's sagebrush grasslands. In Burns, Oregon, Agricultural Research Service rangeland scientists Jon Bates and Tony Svejcar are finding ways to manage this arboreal invasion and prompt the recovery of perennial grasses and forbs.

Although rangeland managers use controlled burns to keep ahead of the juniper, they also just cut down the problem trees and leave them where they fall. This protects the soil, but the dead trees pose an increased fire risk—and may also create conditions that encourage establishment of cheatgrass, an invasive annual that fuels fierce wildfires.

Bates and Svejcar conducted a study at a site dominated by a 90-year-old western juniper woodland—a site once vegetated with basin big sagebrush and associated perennial grasses and forbs—to determine whether burning the cut junipers would help reestablish the perennials. Burning was done during two consecutive winters after cutting. A control group of felled trees at the site was left unburned.

Results indicate that burning the trees when soils were frozen prompted a more successful recovery of perennials and helped keep cheatgrass establishment at bay. Ten years after burning, total perennial grass cover was 1.5 to 2 times greater in the areas where trees had been burned than in the areas where they were not burned. Perennial grass density was 60 percent greater in the burned areas than in the unburned areas, and cheatgrass was twice as dense in the control area as in the two burned areas.

The scientists concluded that native perennial communities could recover from juniper invasions most effectively when the felled junipers were burned rather than cut and left. Burning in winter, when soils were wet or frozen, helped limit damage to existing perennials at the site and gave them a head start in their growth the following spring, when they needed an edge against invasive annuals.—By **Ann Perry,** ARS.

Jon Bates and Tony Svejcar are with the USDA-ARS Range and Meadow Forage Management Research Unit, Eastern Oregon Agricultural Research Center, 67826-A, Hwy. 205, Burns, OR 67826; (541) 573-8932 [Bates], (541) 573-8901 [Svejcar], jon.bates@ars.usda.gov, tony.svejcar@ars.usda.gov.

Sustainable Corn Production Supports Advanced Biofuel Feedstocks

Researchers have found a cost-effective, energy-efficient, and environmentally sustainable method to use corn stover for generating an energy-rich oil called "bio-oil" and for making biochar to enrich soils and sequester carbon. The team used fast pyrolysis to transform corn stover and cobs into bio-oil and biochar. They found that the bio-oil captured 70 percent of the total energy input, and the energy density of the bio-oil was 5 to 16 times that of the feedstock. This suggests it could be more cost effective to produce bio-oil through a distributed network of small pyrolyzers and then transport the crude bio-oil to central refining plants to make "green gasoline" or "green diesel," rather than transporting bulky stover to a large centralized cellulosic ethanol plant. About 18 percent of the feedstock was also converted into biochar, which contains most of the mineral nutrients in the corn residues. Amending soils with this biochar would return those nutrients to the soil, reduce leaching of other nutrients, help build soil organic matter, and sequester carbon. *Charles Mullen, USDA-ARS Crop Conversion Science and Engineering Research Unit, Wyndmoor, Pennsylvania; (215) 836-6916, charles.mullen@ars.usda.gov.*

Plant Hormone Increases Cotton Yields in Drought Conditions

A naturally occurring class of plant hormones called "cytokinins" has been found to boost yields from cotton crops that receive little or no irrigation during drought conditions. Young cotton seedlings have difficulty reaching available soil water because they have small root systems. By tricking water-stress defenses in the young plants, cytokinins prompt the plant to quickly build a bigger root system that can access deep soil moisture. They also stimulate the growth of a protective wax on the surface of the plant that helps reduce water loss. Test results indicated that one application of cytokinins produced a 5- to 10-percent increase in yields under water-reduced conditions. In addition, the hormones didn't help or hinder yields under fully irrigated or rainy conditions, which makes them safe to use in all weather environments. There is also no extra work involved for the grower, because cytokinins can be applied when conducting normal weed-management practices early in the season. *John Burke, USDA-ARS Cropping Systems Research Laboratory, Lubbock, Texas; (806) 749-5560, ext. 5216, john.burke@ars.usda.gov.*

Fungi May Hold Key to Reducing Grapefruit Juice Interactions with Medications

Grapefruit juice can interfere with the effectiveness of some medications because it contains furanocomarins, which are one of many types of phytochemicals commonly found in plants. Furanocomarins inhibit the enzymatic activities responsible for metabolizing certain medications and facilitating their release into the bloodstream. Researchers have found that the fungus *Aspergillus niger* either binds with grapefruit furanocomarins or enzymatically breaks them down. Studies are continuing to identify the enzymes in *A. niger* that prompt the breakdown of furanocomarins to see if these enzymes could be used to eliminate the compounds from grapefruit juice.

In another study, when edible mushrooms that are related to *A. niger*—including morels and oyster and button mushrooms—were dried, pulverized, and added to grapefruit juice, they also removed furanocomarins. These findings provide additional evidence that proteins from *A. niger* and other fungi might someday lead to new methods for removing furanocomarins from grapefruit juice. *Jan Narciso, USDA-ARS Citrus and Subtropical Products Laboratory, Winter Haven, Florida; (863) 293-4133, ext. 119, jan.narciso@ars.usda.gov.*

Tough New Spuds Take on Double Trouble

Powdery scab and black dot can cause yield losses of up to 25 percent in potato crops and prevent tubers from reaching the sizes needed by the French-fry and fast-food industries. Now, five new potato breeding lines could lead to development of cultivars that are resistant to the fungal pathogens that cause both diseases. After screening a collection of wild and cultivated potatoes for sources of natural resistance to powdery scab and black dot, researchers developed the five advanced potato breeding lines from a wild species from Mexico, *Solanum hougasii,* and a recent commercial release, Summit Russet. In 3 years of field trials, the potato breeding lines consistently showed fewer disease symptoms—root galling for powdery scab and sclerotia-infected stems for black dot—than other lines and varieties tested. These new lines will be made available as seed for potato breeding programs working to develop the first commercial varieties with dual resistance to the fungal diseases. *Chuck Brown, USDA-ARS Vegetable and Forage Crops Research Laboratory, Prosser, Washington; (509) 786-9252, chuck.brown@ars.usda.gov.*

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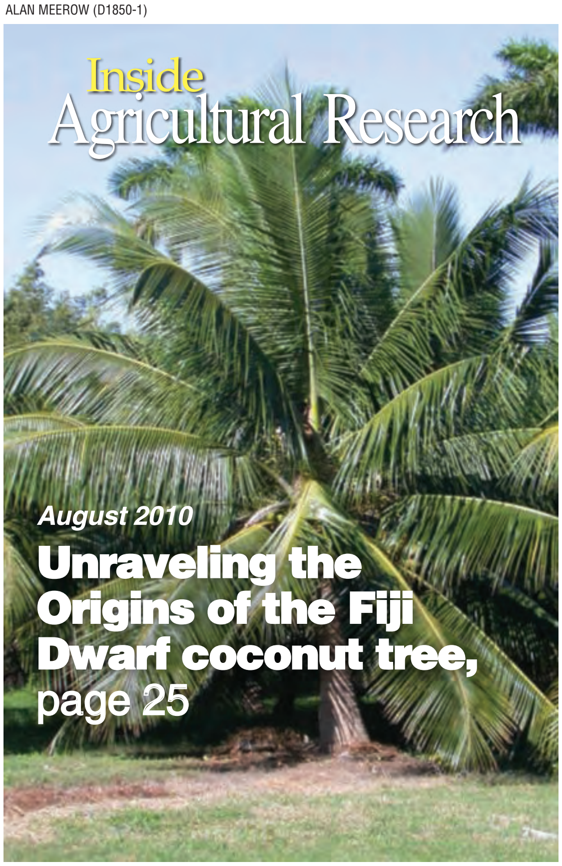

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