U.S. Department of Agriculture | Agricultural Research Service | March 2011

Agricultural Research

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Recipe for Pest Control

Agricultural Research Service • *Solving Problems for the Growing World*

Conservation Grazing Uses Livestock as Ecosystem Engineers

Livestock are proven ecosystem engineers in the Great Plains and in other rangelands around the world.

The trick is to manage them accordingly.

Historically, the prairies of the western Great Plains east of the Rocky Mountains had a diverse mix of vegetation both in plant species and plant heights, ranging from barely an inch to 2½ feet. For this rain-deprived area, that's about as diverse as you're going to get.

Buffalo, prairie dogs, and wildfires helped maintain this mosaic. But humans changed it by converting rangelands to croplands in the early 20th century and, more recently, by converting rangelands to residential ranchettes.

Rangeland management practices implemented over the past 50 years—such as evenly distributing livestock and water sources and using moderate stocking rates—mainly focused on livestock production. These practices, while very successful in terms of sustainable livestock production, have led to more homogeneous landscapes. This is opposite of the historical heterogeneity that resulted from the disturbances caused by grazing, fire, and prairie dogs.

The result has been declines in the numbers of wildlife species, from grassland birds to black-tailed ferrets, the only ferret native to North America. The "management to the middle" practices leave few areas on the landscape that are either intensively disturbed—having very short vegetation and a lot of bare soil—or relatively undisturbed, from a rest in grazing. Unfortunately, the vast majority of "species of concern" in these rangeland ecosystems are those with habitats that are associated with either highly disturbed or minimally disturbed areas. This issue creates conflicts between ranchers and environmentalists.

As a result, there is an emerging need to manage these rangelands for a variety of ecosystem goods and services—including carbon storage, aesthetic beauty, biodiversity, recreation, wildlife habitat, and water—through an understanding of the tradeoffs involved.

Realistically, livestock are the primary practical tools for altering vegetation on rangelands because of environmental concerns about herbicides and the high costs of treating vast acreages of rangeland. This management style, called "conservation grazing," balances the tradeoffs between livestock production and other ecosystem services. Conservation grazing allows this by recreating and maintaining the historical mosaic of vegetation through various techniques, including varying levels of grazing.

Conservation grazing is a recent development and has resulted in a marked shift in the once negative views of cattle grazing held by many environmentalists and conservationists.

As described in the article on page 4 of this issue, one way that conservation grazing can be accomplished is with controlled late-fall burns. Burning patches of pastures creates habitats that have large areas of bare ground and vegetation less than 2 inches high. These conditions are favorable for prairie dogs and mountain plovers, and the burned areas provide green, nutritious forage for livestock and antelope and other wildlife the following spring. The ARS Rangeland Resources Research Unit (RRRU) did its fourth controlled burn in early October 2010 at one of its long-term field sites in Colorado. The fire and conservation grazing research is a joint effort of the RRRU and other Agricultural Research Service labs in Miles City, Montana, and Woodward, Oklahoma.

Other conservation grazing techniques include varying the seasons and the areas in which cattle graze, adding sheep and goats to the livestock mix, and varying livestock numbers and animal densities. Cattle can be encouraged to graze certain parts of a pasture by placement of water troughs, supplemental feed locations, and herding. Livestock will tend to congregate in areas around water and supplemental feed, and the trampling of their hooves creates patches of bare ground. The management practice of leaving a pasture ungrazed for a season to create a temporary "grass bank" fits in well with conservation grazing and also provides management flexibility to deal with drought.

The growing number of ranching coalitions offers more opportunities for regional planning. The RRRU works with one of the oldest groups, the Crow Valley Livestock Cooperative, which has worked with the U.S. Department of Agriculture since 1937. The list of authors of a conservation grazing paper published in 2010 illustrates the RRRU's breadth of cooperation: Besides two ARS researchers from the lab, there are representatives from the Environmental Defense Fund and the Rocky Mountain Bird Observatory and a prairie ecologist with the Wyoming Game and Fish Department.

We rangeland scientists cannot work by ourselves anymore. We share the natural resources arena with a diverse group of interests. But we all have the same goal: providing a sustainable flow of ecosystem goods and services from rangelands that meet the needs of society. It is also time to fully acknowledge the role of livestock as engineers of entire ecosystems, with positive implications for a wide variety of wildlife, from insects to grassland birds, hawks, owls, prairie dogs, ferrets, foxes, and coyotes.

Then we can manage that role to blend production and conservation goals.

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PEGGY GREB (D2106-1)

Steer fitted with a global positioning system (GPS) collar to examine cattle responses to prescribed burns at the Central Plains Experimental Range in northeastern Colorado. Story begins on page 4.

Cover: Microbiologist Erin Rosskopf (right) and technician Kate Rotindo collect plant tissue samples and data on eggplant growth in an anaerobic soil disinfestation (ASD) trial. ASD can be used as an alternative to methyl bromide fumigation for control of soilborne fungal plant pathogens, weeds, and other pests. Story begins on page 12. Photo by Peggy Greb. (D2130-1)

PEGGY GREB (D2105-1)

Can Livestock, Prairie Dogs, and Fire Coexist?

PEGGY GREB (D2111-1)

In a study to evaluate the effects of cattle grazing, prairie dogs (inset), and fire on biodiversity in the western Great Plains, ARS technician Jeff Thomas (right) and Troy Smith, a technician with the Crow Valley Livestock Cooperative, observe the behavior of the steer in response to prescribed burns. The cattle are fitted with GPS (global positioning system) collars that help track their movements.

PEGGY GREB (D2104-1)

Ecologist David Augustine (left) and technician Reanna Moore collect forage samples from a black-tailed prairie dog colony in eastern Colorado in a study of grazing competition between prairie dogs and cattle.

Historically, research at the Agricultural Research Service's Rangeland Resources Research Unit (RRRU) focused on how to manage rangelands of the western Great Plains for sustainable beef production. Wildfires and prairie dogs were considered disturbances to be suppressed. But the unit's studies in recent years are showing that fire and prairie dogs may be key players in sustaining the biodiversity of the western Great Plains.

As grazers, cattle now perform the historical role of bison on the Great Plains. David Augustine, an ARS ecologist at the RRRU laboratory in Fort Collins, Colorado, and colleagues—in collaboration with state, federal, and university researchers—have results from several studies over the past 13 years showing that fire, prairie dogs, and cattle together maintain a mosaic of diverse vegetation, with varying heights, that supports a variety of wildlife as well as beefing up cattle.

The RRRU is a three-location unit that spans two states—Wyoming and Colorado—and two major native grassland ecosystems of the western Great Plains: northern mixed-grass prairie, where the unit headquarters (High Plains Grasslands Research Station) is located on 2,870 acres near Cheyenne, Wyoming, and shortgrass steppe, where the unit has its 15,500-acre Central Plains Experimental Range (CPER). The CPER is the site of the National Science Foundation's (NSF) Shortgrass Steppe Long-Term Ecological Research, and NSF grants support part of the ARS research done there. The third location, the Crops Research Laboratory, is in Fort Collins, near Colorado State University (CSU).

Plovers Found on Prairie Dog and Fire Landscapes

Mountain plovers and many other declining populations of grassland wildlife thrive best among low plants, possibly because this enables them to see coyotes,

hawks, and other predators. Black-tailed prairie dogs live in the same places, probably because of the same survival instinct. Fortunately, unlike plovers, prairie dogs modify their environment to their benefit: They eat the grasses, making the plants short. And, as they graze, prairie dogs create lots of bare soil, which is key to plover nesting success. The bare soil helps camouflage the brown-colored birds.

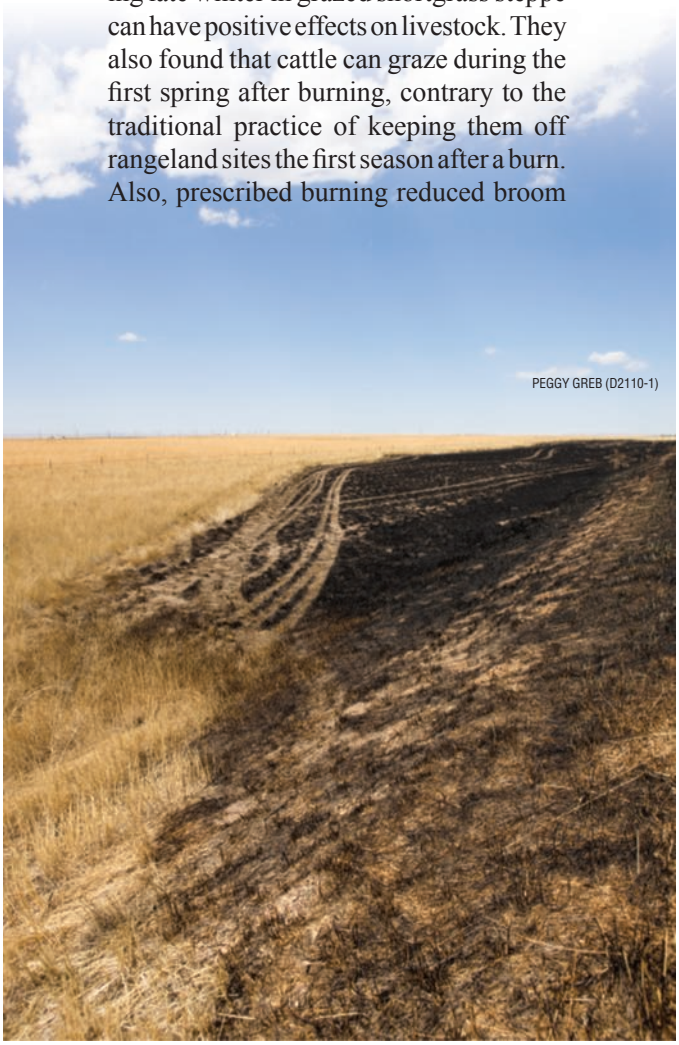
But both plovers and prairie dogs can use some help from fire.

Prescribed burns are carefully controlled fires designed to burn safely in a limited area at temperatures that do not damage future plant growth. The burns remove standing dead plant material and increase the exposure of bare soil.

From 2008 to 2009, Augustine surveyed mountain plovers during nesting season in four shortgrass steppe habitats on the USDA Forest Service's 30-by-60-mile Pawnee National Grasslands in northeastern Colorado. Cattle grazed all four sites, and three of the sites had other disturbances—either by fires or by prairie dogs. Augustine found the highest densities of plovers were on the burned sites and among prairie dog colonies.

"We found no plovers on sites lacking recent disturbance by prairie dogs or fire. It turns out that we may need to restore these disturbances because they are an essential part of the grassland's history and future," he says.

From 1993 to 2004, Augustine did a broader study with a state agency and two universities that provided more evidence of a link between mountain plovers and grasslands colonized by prairie dogs. The researchers found that when prairie dogs are killed by periodic disease, the number of mountain plover nests goes down quickly. The sites in that study included the Comanche National Grassland, the Central Plains Experimental Range, and mixed-grass prairie on U.S. Bureau of Land Management lands in Montana.



Contrast between burned and unburned shortgrass steppe after a fall wildfire in northeastern Colorado.

Cows and Ranchers Benefit From Fire Effects as Well

From 1997 to 2002, a period that included dry, intermediate, and wet years, Augustine and CSU researcher Daniel Milchunas studied prescribed burns by the Forest Service on the Pawnee National Grassland. They found that, except after severe drought, prescribed burns done during late winter in grazed shortgrass steppe can have positive effects on livestock. They also found that cattle can graze during the first spring after burning, contrary to the traditional practice of keeping them off rangeland sites the first season after a burn. Also, prescribed burning reduced broom snakeweed infestations for a short time and suppressed prickly pear cactus for one or two seasons. Broom snakeweed is toxic to cattle, and prickly pear can keep cattle from eating forage near it.

In a 2007 to 2008 Pawnee study, Augustine, Milchunas, and Justin Derner, rangeland scientist and research leader for the unit, found that prescribed burning substantially increased soil nitrogen availability to plants in the first summer after burning. Augustine says, "It also significantly enhanced the digestibility of blue grama in late May, when cattle typically begin summer grazing on shortgrass steppe."

Both studies indicate that under most weather conditions, late-winter burns in previously grazed shortgrass steppe do not reduce forage growth.

"It has long been thought that burning is harmful to rangeland during dry years," Augustine says, "and that may be true for sagebrush steppe found farther west. But we did not find that true for the shortgrass steppe found in Colorado."

Worldwide, shortgrass steppe is one of the rangeland types most resistant to grazing and fire disturbances. Derner says, "This may be due in large part to the traits of the dominant perennial shortgrasses: blue grama and buffalo grass. Blue grama's abundant underground growth and buffalo grass's prostrate growth make them very resistant to aboveground disturbances. The combination of resistant plants and a conservative stocking rate in our study may be why we didn't find any negative effects."

All of this goes to show that science can help ranchers determine the best course of action to achieve their goals, especially in regard to sensitive issues.—By **Don Comis,** ARS.

This research is part of Pasture, Forage, and Range Land Systems, an ARS national program (#215) described at www.nps.ars.usda.gov.

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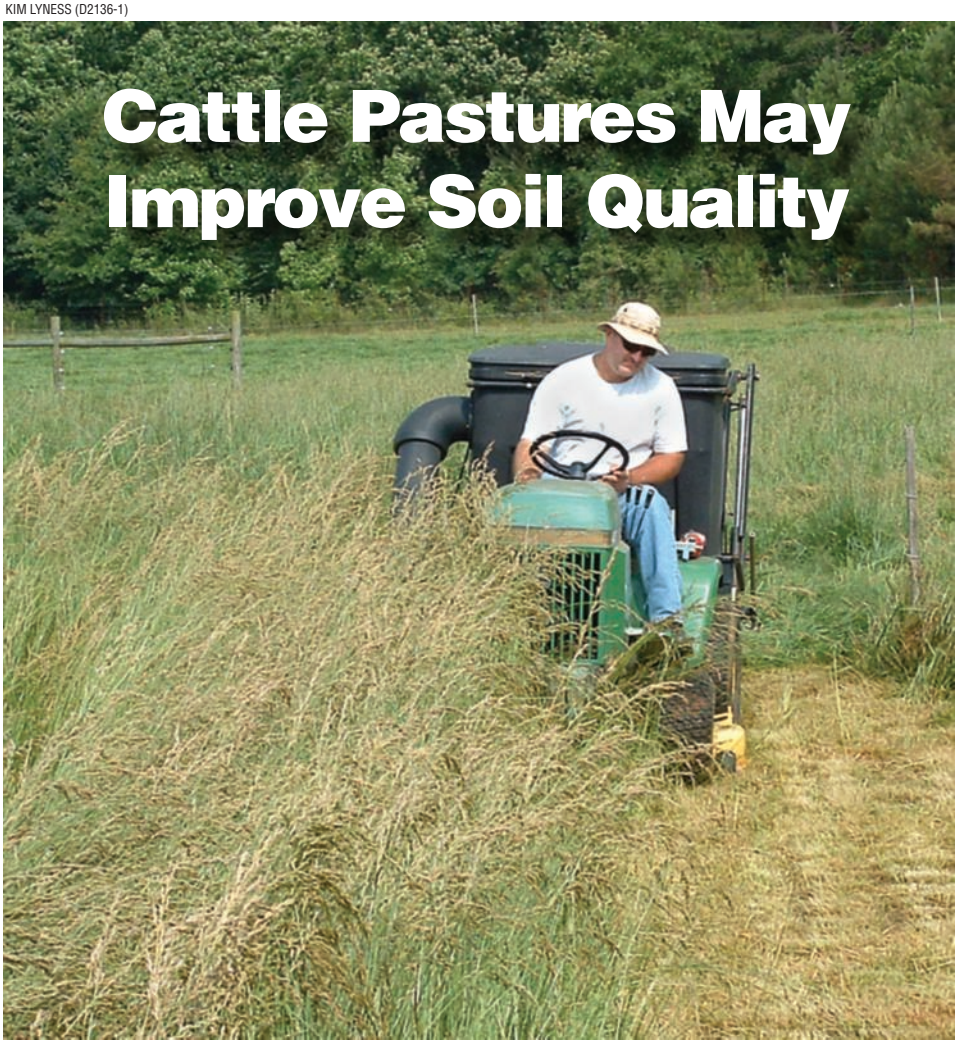
KIM LYNESS (D2136-1)

Cattle Pastures May Improve Soil Quality



At an experimental field site in Oconee County, Georgia, technician Steven Knapp cuts a test plot to determine hay yield.

Decades of plowing throughout the Piedmont region of the United States have degraded the soil, allowing much of it to be washed away and robbing what is left of nutrients and organic matter. Sorghum, cotton, soybean, and wheat are still widely grown in the region, which stretches all the way from Alabama to New Jersey. But because the soil is so degraded, growers have allowed much of the land to revert to forests and pastures.

"Growers need guidance on whether keeping the land unused is the best way to restore degraded soils or whether allowing cattle to graze on it is a viable option," says Alan Franzluebbers, an Agricultural Research Service ecologist at the J. Phil Campbell, Sr., Natural Resource Conservation Center in Watkinsville, Georgia. The center was started in 1937 to look for ways of improving soil quality for farmers in the southeastern United States.

Franzluebbers led a project where researchers planted grasses on 37 acres of rolling, eroded land in northeastern Georgia and allowed beef cattle to graze there to assess the effects on soil quality. Coastal bermudagrass was planted initially, and after 5 years, tall fescue was drilled into it, when the bermudagrass was in a dormant winter stage, to extend the grazing season from 5 months to 10 months of the year.

The research team, which included retired ARS scientists John Stuedemann and Stan Wilkinson, varied the number of cattle per acre, and over 12 years they assessed how the soils would respond to four different scenarios: moderate grazing (average of 23 steers for every 10 acres), intensive or heavy grazing (35 steers per 10 acres), no grazing and letting the grass grow, and no grazing but cutting the grass for hay. Under each scenario they looked at the amount of soil compaction that occurred, the amounts of soil organic carbon and nitrogen found in the soils, and the amounts of surface plant residues, which help prevent erosion. Soil compaction makes it harder to grow crops. They also looked at the effects on the soil of three different fertilizer treatments (inorganic fertilizer alone, organic broiler litter alone, and a mix of inorganic fertilizer and organic broiler litter).

The team found that fertilizer type made little difference, but different grazing scenarios produced dramatically different effects. Land that was grazed produced more grass than ungrazed land, and grazing led to the most carbon and nitrogen being sequestered in soil. Sequestering carbon and nitrogen in the soil has become a major goal for agriculture because it reduces greenhouse gas emissions. Whether grass was grazed moderately or intensely made little difference on sequestration rates.

Cutting grass for hay reduced the amount of surface residue and increased soil compaction but didn't change the amounts of organic carbon and nitrogen in the soil. Land left unused had the highest surface residue and least soil compaction and was better at sequestering carbon in the soil than haying.

From an environmental standpoint, grazing has traditionally been viewed as less desirable than leaving the land unused. But the results, published in the *Soil Science Society of America Journal,* demonstrate that if growers manage cattle so that pastures are grazed moderately, they're restoring soil quality and cutting greenhouse gases by keeping carbon in the soil as organic matter rather than releasing it into the atmosphere as carbon dioxide.—By **Dennis O'Brien,** ARS.

This research is part of Climate Change, Soils, and Emissions, an ARS national program (#212) described at www.nps.ars.usda.gov.

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Dairy Farmer Finds Unusual Forage Grass

An unusual forage grass reported by a farmer 10 years ago led to its identification as meadow fescue *(Schedonorus pratensis),* a long-forgotten grass that seems just right for today's intensive rotational grazing.

Nontoxic fungi called "endophytes" live inside meadow fescue, helping it survive heat, drought, and pests. Unlike the toxic endophytes that inhabit many commercial varieties of tall fescue and ryegrass, meadow fescue's endophytes do not poison.

Meadow fescue is also highly adaptable, very winter hardy, and persistent, having survived decades of farming. It has gradually emerged from oak-savanna refuges to dominate many pastures in the Midwest's Driftless Region, named for its lack of glacial drift, material left behind by retreating continental glaciers.

Charles Opitz found the grass growing in the deep shade of a remnant oak savanna on his dairy farm near Mineral Point, Wisconsin. "The cows love it and produce more milk when they eat it," Opitz says.

Michael Casler, an Agricultural Research Service geneticist, used DNA markers to identify Opitz's find as meadow fescue—a once popular forage grass introduced to the United States about 50-60 years before tall fescue. Casler is at the U.S. Dairy Forage Research Center in Madison, Wisconsin.

Casler and colleagues have since found the plant on more than 300 farms in the Driftless Region of Wisconsin, Iowa, and Minnesota. Geoffrey Brink, an ARS agronomist working with Casler, was the first to thoroughly examine the digestibility of the fiber in meadow fescue's cell walls. Brink says they "discovered that fiber of meadow fescue is 4-7 percent more digestible than other cool-season grasses dominant in the United States. A traditional evaluation of total digestibility didn't reveal this difference."

Brink and Casler have conducted a number of other studies on meadow fescue.

"Meadow fescue yields are equal to other grasses in the Driftless Region," Brink says, "but as you go further north in the Midwest, the yields tend to be slightly lower, although the gap begins to close with the frequent harvesting involved in intensive grazing."

In Brink's test of three meadow fescue varieties against one orchardgrass and one tall fescue variety, meadow fescue had a nutritional forage quality advantage that may compensate for its slightly lower annual yield.

Brink found that applying nitrogen fertilizer above 120 pounds an acre per year was economically counterproductive, because the efficiency of production, or the amount of yield produced per unit of nitrogen applied, begins to decline.

The results of their studies would also apply to farmers who might want to raise sheep and beef cattle on pastures of meadow fescue.

ARS has developed a new variety of meadow fescue, and its seed is being grown for future release.—By **Don Comis,** ARS.

This research is part of Pasture, Forage, and Range Land Systems (#215), an ARS national program described at www.nps.ars.usda.gov.

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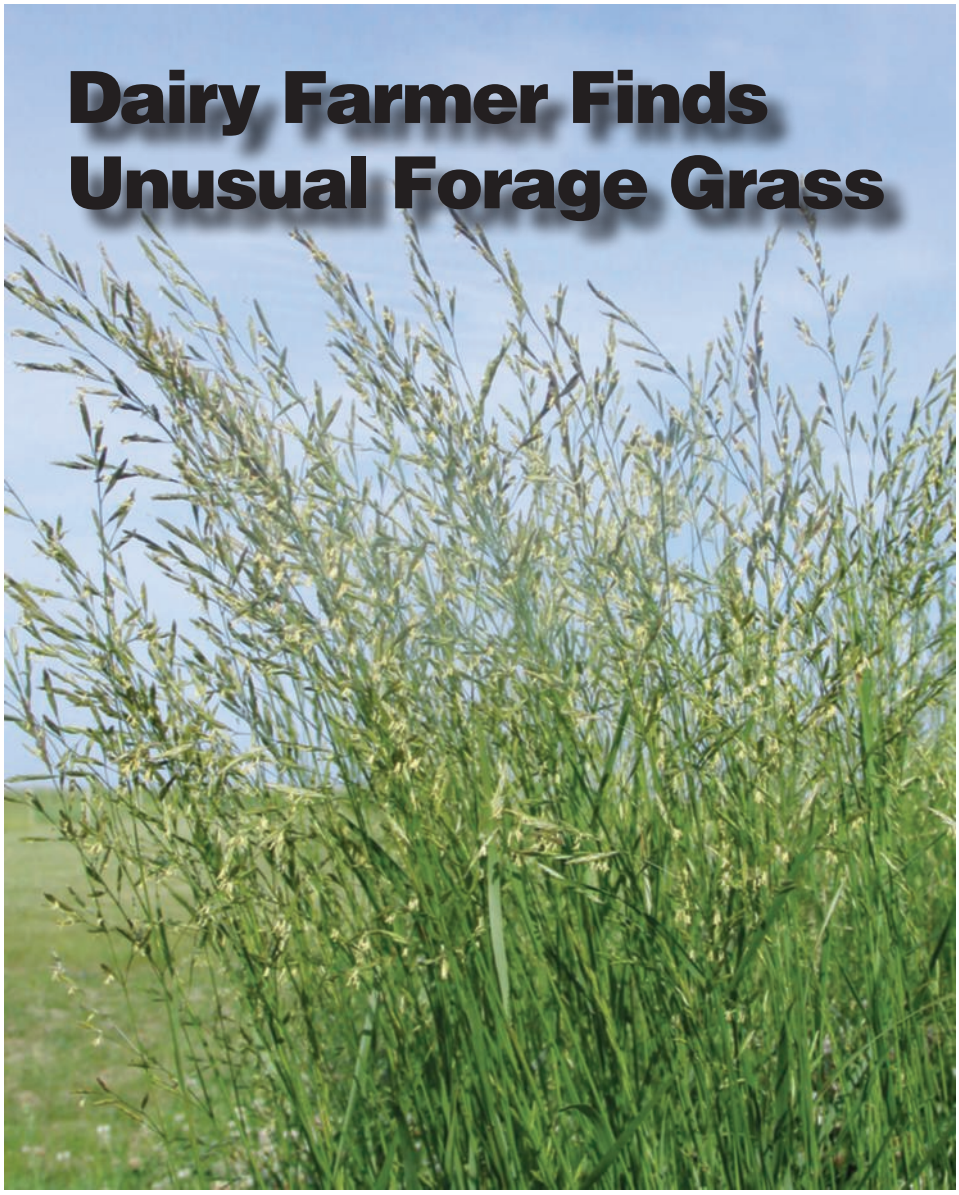
Meadow fescue, *Schedonorus pratensis.*



MICHAEL CASLER (D2119-1)

JOHN WILLIAMS (D2127-1)

Testing No-Till Winter Wheat in the Pacific Northwest

A winter storm covers a road bed with soil runoff from an adjoining hill slope on a conventionally tilled field.

Pacific Northwest farmers plant around 2.2 million acres of winter wheat every year. And every year, between 1.3 to 22.3 tons of silt-loam soil erode from each acre in production.

"Sometimes the roads around our lab are covered with eroded soils that are a foot deep," says Dan Long, who is the research leader at the Agricultural Research Service Columbia Plateau Conservation Research Center in Pendleton, Oregon. "But there hasn't been much measurement of regional soil-erosion rates at a production scale—only in small square-meter study plots."

Despite the obvious soil losses due to erosion, Pacific Northwest farmers generally use conventional tillage in their winter wheat production. There was no real data available on how different tillage practices might reduce soil erosion—until ARS hydrologist John Williams began a watershed-scale study to see whether no-till production might help stem soil losses.

"No-till production for wheat has been studied in the Midwest and the Southeast, but we have different issues in the Pacific Northwest," Williams says. "We have multiple freeze-thaw events every year, and our farmers are working on 20- to 45-degree slopes."

Two Years of Conventional Till, Four Years of No-Till

At Pendleton, Williams, Long, and soil scientists Hero Gollany and Stewart Wuest compared runoff, soil erosion, and crop yields in a conventional, intensively tilled winter wheat-fallow system and a no-till 4-year cropping rotation system. The scientists set up research plots in two small neighboring ephemeral drainages in the Wildhorse Creek Watershed in northeast Oregon and measured runoff and sediment loads at the mouth of each drainage channel in the study area.

The scientists discovered that 70 percent more runoff and 52 times more eroded material escaped from the conventional-till fields than from the no-till fields. These findings convinced them that if wheat producers in eastern Oregon and Washington used no-till systems, they could substantially stem soil erosion and enhance water quality and conservation.

"We looked at almost every rainfall event from 2001 to 2004," Williams said. "Of those, we saw that 13 events generated erosion from conventionally tilled fields, but only 3 events resulted in erosion from no-till fields. This alone says a lot about how effective no-till can be in the Pacific Northwest. It doesn't disturb the soil surface and it leaves behind crop residue—and it leaves pore space in the soil so that water can infiltrate. Any runoff that does take place occurs over soil that's protected by organic material, so the soil doesn't erode."

"In this case study, there was no significant difference in yields between the two systems," Long adds. "And from a cost-benefit perspective, direct seeding in no-till production minimizes the trips across a field that a farmer needs to make, which saves fuel and time in the long run."

Keeping an Eye on Subtle Soil Creep

The researchers also found that the no-till soils eroding downslope moved much more slowly over time, unlike more sudden and severe erosion events that are typical of regions with heavy rainfall.

Gollany studied the difference in soil organic matter between conventional-till and no-till systems, and part of her work involved looking at how this difference affected the movement of nutrients from the top of the slope to the bottom. No-till production improved levels of soil organic carbon. These higher soil carbon levels increase soil aggregation—which in turn increases soil stability.

"I expected to see big differences in erosion rates between no-till and convention till, but the magnitude surprised me," Gollany says. "Until we actually measured it, I didn't realize how much soil was going down the hill in the conventionally tilled field."

Wuest shared her surprise, as did local producers. "I presented these findings to farmers in the area, and there were a lot of raised eyebrows when we talked about how much soil and water was moving downhill in conventionally tilled fields," Wuest says.

Williams used data from his watershed-scale project to evaluate the applicability of the USDA Water Erosion Prediction Project (WEPP) model for measuring hydrological and erosion processes in the semiarid croplands of the Columbia Plateau. WEPP was developed by ARS scientists as a tool that resource managers could use in soil and water conservation and environmental planning and assessment. The WEPP model simulates many of the physical processes important in soil erosion, including infiltration, runoff, raindrop and overland-flow detachment of soil particles, sediment transport, deposition, plant growth, and residue decomposition.

Williams found that when the field data they collected was used to run WEPP simulations, the program produced good estimates for soil water volume and crop yields in no-till and conventional-till systems and for aboveground biomass in no-till production. WEPP simulations of runoff and erosion also aligned with field observations.

JOHN WILLIAMS (D2124-1)

A research watershed near Pendleton, Oregon, shows the amount of residue left after October no-till seeding, with a glimpse of a traditionally tilled field without surface residue in the far right.

As a result of his findings, Williams concluded that during years with below-normal precipitation, mild weather, and little runoff, the WEPP model was able to successfully estimate hydrology dynamics, sediment transport, and crop growth for northeast Oregon's no-till and conventional-till cropping systems.

"This gave us a good start towards finding out how well WEPP did with minor tweaking to replicate field erosion," Williams observes. "Getting models developed elsewhere to work in the Pacific Northwest has been a challenge, but we were able to calibrate it using the best data set in the Pacific Northwest."

"Both these projects go a long way in helping wheat growers in eastern Oregon balance their immediate economic returns with the need for sustainable crop management," Long notes. "Farmers here really appreciate this work because, for the first time, it measures the environmental differences in no-till and conventional-till production."—By **Ann Perry,** ARS.

This research is part of Climate Change, Soils, and Emissions (#212), Agricultural System Competitiveness and Sustainability (#216), and Water Availability and Watershed Management (#211), three ARS national programs described at www.nps.ars.usda.gov.

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JOHN WILLIAMS (D2125-1)

A traditionally farmed field at a research watershed in Pendleton, Oregon, with no residue, 7 months before it was seeded.

ARS Scientists Strategize To Save a Desert River

STEPHEN AUSMUS (D2115-7)

Technician Jim Riley (left) and hydraulic engineer Dave Goodrich download water-level data from the Rostrin Basin, a flood detention pond in Sierra Vista, Arizona, which will aid in calculating the recharge rate to the ground-water aquifer.

"The landscape is pretty fantastic," says Agricultural Research Service hydraulic engineer Dave Goodrich, who has been conducting research in Arizona's upper San Pedro River basin for years. "It starts with sky islands with ponderosa pines at the higher elevations and traverses down and across four major vegetation types to desert shrub land. Then there's an emerald-green ribbon in the middle of the desert—all within about 15 miles."

In 1988, Congress designated parts of that emerald green ribbon as the San Pedro Riparian National Conservation Area. It's where around 400 species of birds, 80 species of mammals, and 40 species of reptiles and amphibians make their home. It is also a primary flyway for birds migrating between North, Central, and South America.

In 1998, 21 federal, state, and local agencies and groups formed the Upper San Pedro Partnership (USPP) and began looking at ways to meet the region's long-term water needs. Goodrich and hydrologist Russ Scott, who both work at the ARS Southwest Watershed Research Center in Tucson, Arizona, have been part of the partnership since it started.

MAP COURTESY OF U.S. GEOLOGICAL SURVEY

"The problem is that the ground water that sustains all the riparian vegetation in the upper San Pedro River valley—and all the people and animals who live there—is being pumped out faster than it's being replenished," explains Scott. "Fortunately, we haven't seen any serious harm to the river yet. So there's still time to translate our improved scientific understanding of the ground-water system into management actions that will ensure the long-term health of the river."

"We want to better measure water uses in the basin," Goodrich adds. "How much water does the riparian vegetation use? How can we harness the storm-water runoff that comes from urbanization to enhance ground-water recharge?"

Rural River Meets Urban Demands

Managing water resources in the upper San Pedro River valley isn't just about plants and animals. The primary economic engine of the area is the U.S. Army's Fort Huachuca, which depends on the same ground water that sustains the river and its diverse ecosystem. In 2004, Congress directed the U.S. Department of the Interior to work with the U.S. Departments of Agriculture (USDA) and Defense and the USPP to develop water-use management and conservation measures for restoring and maintaining the sustainable yield of the regional aquifer by and after September 30, 2011.

The ARS scientists had a bit of a head start. For more than 50 years, USDA scientists have been monitoring watershed dynamics at the Walnut Gulch Experimental Watershed, which drains into the San Pedro River.

"Our studies in Walnut Gulch were critical in helping us determine that ephemeral streams, which flow for a short time after heavy rains, make significant contributions to ground-water replenishment. This changed our understanding of ground-water recharge mechanisms in arid regions," Goodrich says.

As more rural land is given over to urban ventures—along with the associated construction of impervious areas like parking lots and roads—these findings will help improve estimates of how the increased storm-water runoff contributes to regional ground-water supplies.

Goodrich also used a computer program called "KINEROS2," which models a range of hydrological processes from small agricultural and urban watersheds, to quantify how the switch from rural to urban land use affected runoff. He added calculations for assessing how variations in channel infiltration and detention-pond design affected surface runoff for subsequent ground-water recharge.

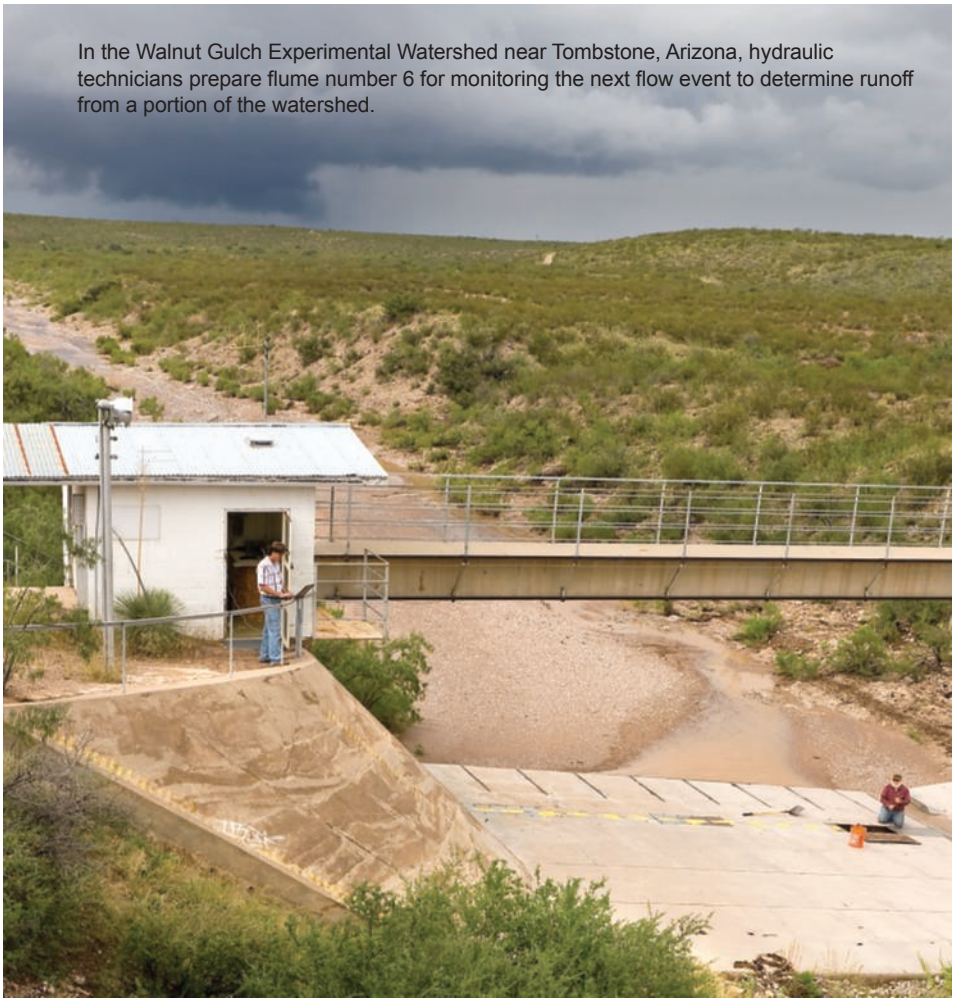
To obtain data for modeling, Goodrich, U.S. Geological Survey scientists, and University of Arizona graduate students set up stream gauges, rain gauges, and other monitoring equipment in two different basins. One was located on undeveloped land at the edge of Fort Huachuca, and the other was in a newly developed area just outside the military installation.

The group was surprised to find that a third of the increase in runoff from the developed site resulted from the compaction of surface soils during construction. "This finding is a little unexpected," Goodrich says. "We've usually looked only at manmade impervious surfaces, like roads and roofs, as the places that generate extra runoff after development."

Spending Down the Water Budget

Scott, meanwhile, remains focused on learning more about plant demands on the regional ground water. He ran into some surprises as well. For instance, he found that mesquite thickets use much more water than cottonwood and willow trees growing along the riverbanks.

"Even though mesquite woodlands don't grow right along the riverbank, they have good access to ground water because their roots can go 30 feet deep," Scott says. "And since they've been expanding, there are more of them that can tap into the ground-water supply." Using this work, Scott and others developed a geographic information system-based riparian evaporation and transpiration tool that regional land managers can use to estimate water savings by replacing mesquite with native desert grasses.



In the Walnut Gulch Experimental Watershed near Tombstone, Arizona, hydraulic technicians prepare flume number 6 for monitoring the next flow event to determine runoff from a portion of the watershed.

STEPHEN AUSMUS (D2113-1)

Scott also determined that cottonwoods, which flank both perennial and intermittent stream channels, vary their water use according to fluctuations in the water table. "The trees that grow along an intermittent stretch use half as much water as the trees growing along a perennial stretch," he says. "It's interesting that even in a riparian environment, they strongly regulate their water use."

Scott and Goodrich are pleased with how their research has gone. And they're just as pleased at how well they've been able to work with other USPP members. A 2003 survey of the USPP members and participants found that 90 percent of them considered scientific studies to be among the most important projects undertaken by the partnership.

"We've been working directly with elected officials and decisionmakers and helping them understand the uncertainty and variability in our research," Goodrich says. "And we've been able to design research that addresses their planning needs."

"People have become educated about the whole hydrologic cycle in the basin," Scott agrees. "They know there's a problem, and they want to know which tools can address the problem. Our work as ARS scientists explains how to fill these gaps in hydrologic understanding."

"This is a great example of how ARS research can be directly used to provide advice on policy decisions," notes ARS national program leader Mark Walbridge. "It can be a challenge to communicate scientific findings, but we've been able to successfully work with groups of people who, even though they have very different goals and values, have become knowledgeable about issues involved in ground-water management."—By **Ann Perry,** ARS.

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

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

PEGGY GREB (D2132-1)

Technician Amanda Rinehart (foreground) and ecologist Nancy Kokalis-Burelle study eggplant roots for nematode damage and root health.

Investigating T to Replacing M

As they search for soil treatments to replace methyl bromide, Agricultural Research Service scientists in Fort Pierce, Florida, are using one technique that sounds as if it were borrowed from a family recipe—taking molasses and heating it up.

Farmers have been using methyl bromide since the 1930s, but these days it is subject to strict environmental controls because it depletes Earth's ozone layer. As part of an international agreement, growers worldwide are being required to find a replacement, a tall order because methyl bromide eliminates a broad spectrum of pests, including weeds, nematodes, and plant pathogens. The mandate is particularly challenging in Florida, where sandy soils limit organic alternatives and the mild winters serve as a safe harbor for many of nature's most pernicious pests. Nutsedge is a particular weed problem in Florida and is a major reason methyl bromide is still used there.

"We don't usually see the cold winter temperatures that you have in other places, so pests aren't killed off here by Mother Nature the way they might be elsewhere," says Erin Rosskopf, a microbiologist at the U.S. Horticultural Research Laboratory in Fort Pierce.

For Florida growers, the stakes are enormous. Fresh-market tomatoes and bell peppers, both raised in Florida with methyl bromide, netted growers there a combined $889 million in 2008. Caladiums, an ornamental also produced largely with methyl bromide, are a $15 million crop in Florida.

In their search for alternatives, ARS researchers are studying two approaches: a biologically based cropping system that builds on success overseas, and two recently developed fumigants. Similar approaches have had some success elsewhere, but the question is whether they will be effective in Florida, with its unique soils, climate, and pest pressures. Preliminary results are promising, but the researchers still need to evaluate whether the biologically based treatments can sufficiently control nutsedge.

A Biological Alternative

At the Fort Pierce lab, Rosskopf, ecologist Nancy Kokalis-Burelle, and soil scientist David Butler are raising bell peppers followed by eggplant in a field to test a biological approach that uses a combination of composted broiler litter, molasses, and anaerobic soil disinfestation (ASD). Lab colleagues Gregory T. McCollum and Joseph Albano are evaluating fruit quality and soil nutrients.

In ASD, a carbon source—in this case molasses—is added to stimulate microbial activity, and the soil is covered with a clear plastic tarp. The topsoil is saturated with water and allowed to heat. The sun-drenched tarp "cooks" the weed seeds in the soil, and the carbon and water increase microbial activity and create anaerobic conditions conducive to pest control.

In this study, before heating the soil, the researchers treated plots with different levels of organic amendments: with and without poultry litter; with and without molasses; and with 2 inches of water per acre, 4 inches per acre, or no water at all. The poultry litter increased soil moisture and added organic matter, and the molasses provided a readily available carbon source for soil microbes. The molasses they used is a waste product of the sugarcane processing industry. The researchers are also conducting studies to evaluate mustard meal, sorghum, and cowpeas as possible alternatives to molasses.

They planted peppers in the fall and eggplant in the spring for 2 years, using the type of raised-bed production system common in Florida. Before planting, the researchers introduced *Phytophthora capsici* to the fields, an oomycete that causes crown rot and root rot, so they could track control rates. They buried packets of it 6

In an anaerobic soil disinfestation trial for growing eggpla nutrient analysis and plant pathogen population assessn

Two Pathways Methyl Bromide

DAVID BUTLER (D2133-1)

Bell peppers and a wide variety of other vegetables and fruits may benefit from anaerobic soil disinfestation, a potential alternative to methyl bromide fumigation for pest control.

inches deep in the soil and retrieved them after 3 weeks of ASD to evaluate the effects. They also sampled the soil for nematodes, counted the number of nematodes extracted from crop roots, assessed weed populations and soil properties throughout the trials, and measured crop yields.

They found that at depths of 6 inches, the ASD treatments heated the soil temperature to about 113˚F, which was at or just below lethal levels for many soil pathogens. They also found that nematode populations were reduced when treated with molasses and poultry litter, that molasses and poultry litter controlled grass weeds just as well as methyl bromide did, and that the ASD treatments controlled *P. capsici* in the buried packets as well as methyl bromide did, regardless of how much water, poultry litter, or molasses was applied.

ant, soil scientist David Butler collects a soil sample for ment.

PEGGY GREB (D2131-1)

"The nutsedge pressure at the test location wasn't really adequate to show treatment differences, so we are still investigating that component," Rosskopf says.

Evaluating New Commercial Products

Rosskopf and Kokalis-Burelle completed large-scale demonstration field trials comparing the effectiveness of two recently developed fumigants with methyl bromide at two Florida sites, one where they are raising delphiniums and the other caladiums. Both dimethyl disulfide, approved for experimental use under the trade name "Paladin," and methyl iodide, being marketed as "Midas," have shown promise at controlling weeds, nematodes, and plant diseases.

The researchers combined each treatment with chloropicrin, a pesticide that kills fungi and is often used in combination with methyl bromide. They applied each treatment to about a half-acre of delphiniums in a field in Hobe Sound and 2 acres of caladiums at another site in Zolfo Springs. They raised two varieties of delphiniums and four varieties of caladiums.

In the caladium trials, where the pest pressure was much higher than in the delphinium trial location, their grower cooperator also applied a soil treatment often used on caladiums known as "Telone II" (1,3-dichloropropene). They measured weed density, weeding time required, and nematode and fungal populations in the soil. They also examined roots for disease and compared the sizes and numbers of flowers produced under each treatment.

Preliminary results show the alternative fumigants were just as effective as methyl bromide at suppressing grass weeds and at controlling nematodes, but that the effectiveness of Paladin was reduced when it was used year after year.

In the delphinium trial, there were no significant differences in weed density and total weeding time or in total flower yields. In the caladium trial, they found no significant differences among methyl bromide, Paladin, and Midas in terms of total weeds, "rogue" or off-variety plants produced, or in total hours of labor for weeding, but yields were dependent on the combination of fumigant and cultivar.

"This interaction indicates that growers will have harder decisions to make, because their choice of cultivar is often market-driven. They may have to choose a fumigant that provides the greatest return for that specific cultivar, making it much more difficult than when they could use methyl bromide with everything they grew," said Rosskopf.

The fumigant field trials are attracting widespread interest. A recent field day organized to explain the project at Zolfo Springs attracted dozens of cut-flower and caladium growers.—By **Dennis O'Brien,** ARS.

This research is part of Methyl Bromide Alternatives (#308), an ARS national program described at www.nps.ars.usda.gov.

To reach scientists mentioned in this article, contact Dennis O'Brien, USDA-ARS Information Staff, 5601 Sunnyside Ave., Beltsville, MD 20705-5129; (301) 504-1624, dennis.obrien@ars.usda.gov.

ARS and Russian Scientists Develop "AgroAtlas" With Worldwide Benefits

MICHAEL THOMPSON (K7394-6)

AgroAtlas provides maps, photos, and descriptions of crops such as wheat (shown above) and important diseases, insect pests, and weeds that affect production.

AgroAtlas, an interactive Russian/English website (**www.agroatlas.ru**) created by a team of Russian scientists backed by the Agricultural Research Service, shows the geographic distributions of 100 crops; 640 species of crop diseases, pests, and weeds; and 560 wild crop relatives growing in Russia and neighboring countries. The atlas also includes 200 maps that illustrate the environmental variables that affect crop production in that part of the world. In addition to the maps, the Internet-based atlas provides free geographic information system (GIS) software and offers color photos and a wealth of useful information about each species.

Although maps and information can be printed individually, once the free GIS software and atlas data are downloaded, users can build layers of information to, for example, determine the locations of the heaviest concentrations of insect pests, like Russian wheat aphids, in relation to the geographic distribution of wheat in the former Soviet Union.

"The ability to layer information from such a comprehensive atlas enables researchers to answer a huge array of agricultural questions," says Stephanie Greene, an ARS plant geneticist who leads the AgroAtlas project with Alexandr N. Afonin, a senior scientist with St. Petersburg State University-St. Petersburg.

"For example, when we demonstrated AgroAtlas in Crimea, a major wine-producing region, we showed where along its coast U.S. wine grapes can be successfully grown," says Greene. "In Petrozavodsk, a group that coordinates activities for more than 70 Russian botanical gardens was excited to see how the atlas and GIS software can be used to support plant-introduction activities. In the North Caucasus region, they were interested in using the atlas to understand the distribution of major wheat diseases according to agroclimatic zones."

An Idea Takes Shape

AgroAtlas is the successful result of a proposal that Greene and Afonin submitted in 2003 for funding under a program coordinated by ARS's Office of International Research Programs (OIRP) in Beltsville, Maryland, with funds from the U.S. Department of State. Known officially as the "Interactive Agricultural Ecological Atlas of Russia and Neighboring Countries," AgroAtlas is administered by the International Science and Technology Center, an intergovernmental organization headquartered in Moscow and comprising 13 member countries, including the United States.

Portions of AgroAtlas are managed by Nikolay I. Dzyubenko, with the N.I. Vavilov All-Russian Institute of Plant Industry in St. Petersburg; and by Andrei N. Frolov, with the All-Russian Institute of Plant Protection, Pushkin. To date, more than 60 scientists from 3 Russian research institutes have contributed their knowledge and time to the 7-year project.

"The impetus behind developing AgroAtlas was to promote food security, particularly in the NIS (Newly Independent States) countries, which are challenged with broadening their agricultural base after the Soviet years," says Greene, who is with ARS's Plant Germplasm Introduction and Testing in Prosser, Washington. "We wanted to bring together a wealth of agricultural information in a format that was useful to scientists, policymakers, and farmers and to provide tools that would enable the information to be combined and analyzed so it could support agricultural decisionmaking."

In September 2010, Greene and Afonin collaborated with their colleagues to host the first of a series of 10-day workshops in St. Petersburg to teach the use of AgroAtlas's GIS software to scientists and students from former Soviet states. In addition, OIRP awarded scholarships to support travel and lodging expenses for 20 students who learned about GIS using the AgroAtlas software. They were then to return to their institutes to train others. To receive university certificates, students also completed a research project using

AgroAtlas GIS. Sometime in summer 2011, the students with the best projects will publish their research results in *BioGIS,* a new, peer-reviewed journal that will be accessible from the AgroAtlas website.

Global Uses

The bilingual atlas is also generating interest in the United States and other countries. Greene says an official with USDA's Animal and Plant Health Inspection Service who contacted her about AgroAtlas remarked on its potential to aid in detecting and identifying species of insect pests, disease organisms, or weeds that have entered—or could enter—the United States from Russia or neighboring countries.

The USDA Cooperative Agricultural Pest Survey program has also used AgroAtlas in developing the Grape Commodity Survey Reference Data Sheet. There have been requests from the United Kingdom and India to use images of various species in other publications. A scientist in the United Kingdom found the information on black currants valuable in writing a global review on black currant production, markets, and products, Greene adds.

On another front, AgroAtlas maps of climate, environmental, and other data could be integrated with computer models to assess the potential impact of global climate change on the future distribution of crops, pests, and crop wild relatives, particularly in the former Soviet Union. Another potential application is improved conservation of genetic resources.

According to Greene, no other resource gathers together the geographic distribution of the many native crop wild relatives that are found in Eastern Europe and central Asia. Although the atlas has only recently been published, the website receives more than 30,000 hits per month, she reports.

The project, while drawing to a close, has forged stronger personal and professional ties—both among Russian scientists and colleagues in other countries, all of which bodes well for future collaborations. "Because AgroAtlas showcases the work of such a diverse array of Russian scientists, it's a great place to identify potential collaborators. And international partnerships promote global food security," says Greene.—By **Jan Suszkiw,** ARS.

This research supports the USDA priority of promoting international food security and 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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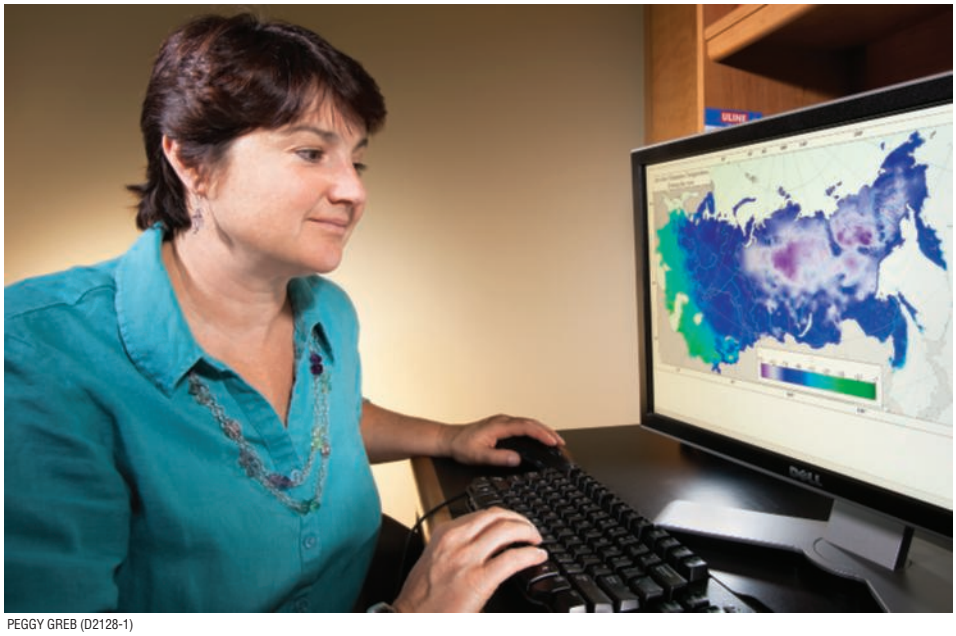
ALEXANDR N. AFONIN (D2129-1)

Tamara Smekalova (right), head of the Agrobotany Department, shows Stephanie Greene, ARS plant geneticist, herbarium specimens at the N.I. Vavilov Institute of Plant Industry in St. Petersburg, Russia. For the AgroAtlas project, scientists at the Vavilov Institute used herbarium specimens to help describe and pinpoint where crops and wild relative species grow throughout the area of the former Soviet Union.

Plant geneticist Stephanie Greene examines a digital map of absolute minimal temperature. AgroAtlas contains 1,500 maps that illustrate the distribution of crops, wild crop relatives, diseases, pests, weeds, and more. Maps are in an open-source geographic information system format and can be downloaded from the AgroAtlas website.



PEGGY GREB (D2128-1)

"FasTracking" Plum Breeding

Plum, peach, cherry, apricot, and almond trees—what do they have in common? Well, they are all members of the genus *Prunus,* and their fruits are well loved among American consumers. But perhaps the most significant similarity is that the trees take a very long time to mature and produce fruit.

The time it takes for these fruit trees to reach maturity from seed has a considerable effect on the development of new varieties with desired traits, such as an improved mix of sugars or resistance to disease. "Fruit tree breeding still remains a slow, arduous process that has changed little over the centuries," explains horticulturist Ralph Scorza. "In addition to the long juvenile period (3 to 10 or more years during which trees do not fruit), other limitations include the need for large land areas with significant field costs and yearly limitations on flowering and fruiting related to chill and heat requirements. Temperate fruit tree crops require a period of dormancy to induce flowering and to bear fruit."

But what if there were a way to get around those limitations?

That's exactly what Scorza and his colleagues at the USDA-ARS Appalachian Fruit Research Station in Kearneysville, West Virginia, aimed to do when they started "FasTrack," an advanced fruit tree breeding system. Plant physiologist Chinnathambi Srinivasan, molecular biologist Christopher Dardick, and geneticist Ann Callahan join Scorza on this project.

The team is focused on improving the breeding system for plum, a fruit the scientists have spent many years working on. With FasTrack, they have found a way to lessen the time it takes to create new, improved plums. Instead of taking 15-20 years to breed trees with a combination of desired traits, such as disease resistance and high-quality fruit, the scientists can now accomplish this task in just 3-5 years.

CHINNATHAMBI SRINIVASAN (D2142-1)

Rather than the 3 to 10 years normally required for a seedling plum to produce fruit, FasTrack plum lines carrying the early-flowering gene produce fruit in less than a year after being planted from seed.

Inducing Early Flowering

Genes for early flowering have been previously reported in several plants. By over-expressing certain flowering genes, scientists were able to induce early flowering in the model species *Arabidopsis* as well as in poplar and citrus. "But this early-flowering construct was never developed into a practical system for breeding," says Dardick. "Our research represents one of the first efforts to implement this technology in fruit trees."

Unlike conventional breeding, FasTrack uses plum lines that have been transformed with a special gene called *"PtFT1"* that induces early flowering. The scientists inserted this gene, previously discovered in California poplar *(Populus trichocarpa),* into the plum cultivar Bluebyrd to stimulate early and continual flowering.

The research team, spearheaded by the genetic engineering work of Srinivasan, produced 196 transgenic plum plants in total, many of which flowered and set fruits within 1 year. These plants don't look like trees, but rather like shrubs. And instead of single flowers, some buds produced flower clusters.

"Because of their growth habit, these transgenic trees aren't suitable for standard orchard practices," explains Dardick. "So we keep them in the greenhouse, which provides a controlled environment where we can continually makes crosses all year long and produce offspring at a faster rate. By coupling FasTrack technology with new molecular marker technologies, we will ultimately be able to produce a new variety in less than half the time it would take with conventional breeding practices."

At the very last step of breeding in the greenhouse, the scientists select trees that don't have the *PtFT1* gene but still possess traits of interest, such as sweet fruit, resistance to a certain disease, or higher nutrient levels. In this way, FasTrack technology uses genetic modification during the breeding process, but in the final step, the trees that are selected for use as cultivars are not genetically modified; that is,

STEPHEN AUSMUS (D2117-3)

At the Appalachian Fruit Research Station, Kearneysville, West Virginia, plant physiologist Chinnathambi Srinivasan evaluates developing transgenic plum shoots for evidence of the expression of the early-flowering gene. These will be transferred to the greenhouse for use in FasTrack breeding.

they don't have the *PtFT1* gene, do flower normally, and are no different than if they had been produced through traditional breeding practices.

The scientists are the only group in the country conducting this kind of research at the moment. According to the researchers, FasTrack can be adapted for any plant, but it is more useful for plants that take a long time to mature.

The technology can also be used to produce fruit in new ways, especially considering the challenges we face in dealing with climate change. The transgenic tree's shrublike stature could make it possible to grow fruit in greenhouses or high tunnels. And because it doesn't require a chilling period, it could be adapted for growing in tropical climes and could be used to produce fruit year round. It might also be appealing to home gardeners as an ornamental plant that continually flowers and fruits.

Building a Better California Plum

Funded by the Specialty Crop Research Initiative, the Kearneysville scientists are now using FasTrack to improve trait quality for the California dried plum industry. They are collaborating with researchers at the University of California (UC) at Davis, Clemson University, and Pennsylvania State University.

One cultivar, Improved French, is currently planted on more than 98 percent of the total dried-plum acreage in California. This monoculture situation makes the industry vulnerable to disease and pest outbreaks and statewide yield decline. Using one cultivar also means the industry must harvest and dehydrate the crop within the span of a few weeks.

"Because of the long generation time, only two plum varieties have been released for the dried-plum industry since 1985," explains Scorza. "Developing new cultivars will increase the efficiency of California dried-plum production and ensure the two top traits of interest—improved sugar content and resistance to plum pox virus, a devastating disease of plum and other stone fruits—are incorporated into the germplasm."

The research team will use FasTrack to cross dried-plum germplasm developed at UC-Davis by Ted DeJong with Kearneysville-developed breeding stock possessing improved sugar content and resistance to plum pox virus. The improved germplasm will then be sent back to UC-Davis and used by breeders to develop new varieties.

With ARS and university partnerships, California will continue to be the world leader in dried-plum production.—By **Stephanie Yao,** formerly with 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.

Ralph Scorza, Chinnathambi Srinivasan, Christopher Dardick, and Ann Callahan are with the USDA-ARS Appalachian Fruit Research Station, 2217 Wiltshire Rd., Kearneysville, WV 35430; (304) 725-3451, ralph.scorza@ars.usda.gov.

FasTrack allows scientists to pollinate flowers and evaluate fruit from the same plants in the greenhouse year round. In the background, geneticist Ann Callahan measures sugar content of plum fruit as plant molecular biologist/pathologist Chris Dardick measures fruit size. In the foreground, horticulturist Ralph Scorza pollinates plum flowers.

STEPHEN AUSMUS (D2116-10)

Livestock Numbers by Weather and Climate

PEGGY GREB (D2135-1)

In the semi-arid Great Plains, a good forecast of forage growth can guide the rancher in planning the right herd size for the coming season. Here, soil scientist Gale Dunn checks the validity of model-forecasted forage growth against actual growth in late summer.

Ranchers in the central Great Plains may soon be using some of their winter downtime to rehearse the growing season, all from the warmth of their homes.

Ranchers would use a computer model known as "GPFARM-Range" to see which stocking rates are sustainable on their rangelands. The scenarios include forage yields and weight gains of beef cattle and calves and other livestock under various stocking rates and weather conditions.

Looking at National Weather Service seasonal weather predictions, ranchers would judge whether precipitation in the coming season would likely be normal or above or below normal. The ranchers would then choose a stocking rate based on this.

"The high variability of precipitation in the semi-arid Great Plains makes it difficult for ranchers to choose a stocking rate that is the best balance between economic and rangeland sustainability," says Sam Adiku, a visiting soil scientist from Colorado State University who is working in the Agricultural Research Service's Agricultural Systems Research Unit at Fort Collins, Colorado.

Throughout the season, ranchers would keep an eye on changing weather conditions to see if adjustments in the stocking rate would be wise. GPFARM-Range is one of a few range models that can also factor in the effects of climate change on stocking rates. "We can predict the response of forage plants to increased CO_2 and higher temperatures," Adiku says.

GPFARM-Range was originally developed by ARS and tested on rangeland at Cheyenne, Wyoming, in 2003. The acronym stands for "Great Plains Framework for Agricultural Resource Management."

Adiku works with ARS soil scientist Gale Dunn and research leader Laj Ahuja to test GPFARM-Range in enough locations to make the model fully usable throughout the central Great Plains. They recently tested GPFARM-Range on sheep pastures in Miles City, Montana, and beef cattle pastures at Fort Supply, Oklahoma.

At Fort Supply, Adiku and colleagues recalibrated and enhanced the model to simulate the effects of soil compaction on native sand bluestem grass. Soil compaction increases as the number of cattle per acre goes up.

With this adjustment, the model accurately predicted forage yields as stocking rates increased. Previously, the model was overestimating forage yields with high stocking rates, because it wasn't accounting for soil compaction.

GPFARM-Range guides researchers as well as ranchers by pinpointing areas requiring further research and development. "This is an evolutionary process that ties research and technology transfer closely together," Ahuja says. "It brings scientists together with farmers, ranchers, consultants, and land managers in a joint search for solutions."—By **Don Comis,** ARS.

This research is part of Agricultural System Competitiveness and Sustainability, an ARS national program (#216) described at www.nps.ars.usda.gov.

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GPFARM, the range model's parent, can be downloaded at **www.tinyurl.com/farmrange**.

A CD is available on request by e-mailing **GPSR_Email@ars.usda.gov**.

GPFARM-Range is not yet online, but a CD is available from Gale Dunn, **gale.dunn@ars.usda.gov**.

PEGGY GREB (D2034-1)

Reading Herbal Tea Leaves: Benefits and Lore

These days, there is a lot of talk about health benefits from drinking teas.

Green, black, and oolong are considered the three major classes, and each comes from the age-old *Camellia sinensis* tea bush. But there is an even wider variety of herbal teas—infusions derived from anything other than *C. sinensis*.

According to folklore, some herbal teas also provide benefits. But there is little clinical evidence on the effects of drinking these teas. Now, Diane McKay and Jeffrey Blumberg have looked into science-based evidence of health benefits from drinking three of the most popular herbals in America. McKay and Blumberg are with the Jean Mayer USDA Human Nutrition Research Center on Aging at Tufts University in Boston, Massachusetts. Both work at the center's Antioxidants Research Laboratory, which Blumberg directs.

One popular herbal, chamomile tea, has long been considered a soothing brew. In the early 20th century, it was mentioned in a classic children's book about a little rabbit named Peter. At the end of a rough day, Peter's mom served him some chamomile tea. Interestingly, when Blumberg and McKay reviewed scientific literature on the bioactivity of chamomile, they found no human clinical trials that examined this calming effect.

They did, however, publish a review article on findings far beyond sedation—describing test-tube evidence that chamomile tea has moderate antioxidant and antimicrobial activities and significant antiplatelet-clumping activity. Also, animal feeding studies have shown potent anti-inflammatory action and some cholesterol-lowering activity.

The researchers also published a review article describing evidence of bioactivity of peppermint tea. In test tubes, peppermint has been found to have significant antimicrobial and antiviral activities, strong antioxidant and antitumor actions, and some antiallergenic potential. When animals were fed either moderate amounts of ground leaves or leaf extracts, researchers also noted a relaxation effect on gastrointestinal tissue and an analgesic and anesthetic effect in the nervous system.

The researchers found several human studies involving peppermint oil, but they found no data from human clinical trials involving peppermint tea. McKay and Blumberg have concluded that the available research on herbal teas is compelling enough to suggest clinical studies.

McKay has led a human clinical trial to test whether drinking hibiscus tea affects blood pressure. She tested 65 volunteers, aged 30 to 70 years, who were pre- or mildly hypertensive. Blood pressure readings of 120/80 or greater are considered a risk factor for heart disease, stroke, and kidney disease.

For 6 weeks, about half the group was randomly selected to drink 3 cups of hibiscus tea daily. The others drank a placebo beverage containing artificial hibiscus flavoring and color. All participants were advised to follow their usual diet and maintain their normal level of activity. Before the start of the study, blood pressure was measured twice—1 week apart—and at weekly intervals thereafter.

The findings show that the volunteers who drank hibiscus tea had a 7.2-point drop in their systolic blood pressure (the top number), and those who drank the placebo beverage had a 1.3-point drop.

In a subgroup analysis of 30 volunteers who had the highest systolic blood pressure readings (129 or above) overall at the start of the study, those assigned to drink hibiscus tea showed the greatest response to hibiscus tea drinking. Their systolic blood pressure went down by 13.2 points, diastolic blood pressure went down by 6.4 points, and mean arterial pressure went down by 8.7 points.

The 2010 study was published in the *Journal of Nutrition.*

"This data supports the idea that drinking hibiscus tea in an amount readily incorporated into the diet may play a role in controlling blood pressure, although more research is required," says McKay.—By **Rosalie Marion Bliss,** ARS.

This research is part of Human Nutrition, an ARS national program (#107) described at www.nps.ars.usda.gov.

Diane L. McKay is with the Jean Mayer USDA Human Nutrition Research Center on Aging at Tufts University, 711 Washington St., Boston, MA 02111-1524; (781) 608-7183, diane.mckay@tufts.edu.

Antioxidants Research Laboratory scientists Diane McKay and Oliver Chen discuss the results of their hibiscus tea study, which showed the effectiveness of this beverage in reducing blood pressure.

STEPHEN AUSMUS (D-1814-8)

Protecting Our Melons

JAMES MCCREIGHT (D2122-1)

Sweetpotato whiteflies covering melon leaves even after numerous insecticide treatments.

Combating Cucurbit Yellow Stunting Disorder Virus

Much of our country's popular cucurbit crops, like cantaloupe and honeydew, are grown in California's Imperial Valley and nearby Yuma, Arizona. But a few years ago, growers in the area noticed a new disease spreading through their fields.

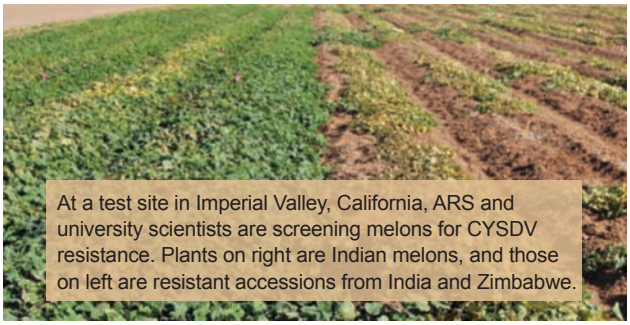
Agricultural Research Service plant pathologist Bill Wintermantel, with the U.S. Agricultural Research Station in Salinas, California, and university colleagues were asked to help identify the disease. The diagnosis: cucurbit yellow stunting disorder virus, or CYSDV.

CYSDV, a "crinivirus" originally from the Middle East, was identified by Wintermantel and colleagues in the melon-production regions of California, Arizona, and Sonora, Mexico, in the fall of 2006. Wintermantel and Florida colleagues also identified CYSDV a year later in that state.

"It's difficult to determine exactly how the virus spread to California and Florida, but it's clearly the same virus in both locations," says Wintermantel. "Virus samples from both regions indicate they are essentially genetically identical to one another."

Melons from plants infected with CYSDV may appear normal but often have reduced sugar levels, resulting in poor marketability. The virus is spread by the whitefly, *Bemisia tabaci,* a small sap-sucking insect.

JAMES D. MCCREIGHT (D2121-1)



At a test site in Imperial Valley, California, ARS and university scientists are screening melons for CYSDV resistance. Plants on right are Indian melons, and those on left are resistant accessions from India and Zimbabwe.

Melon plant with early symptoms of cucurbit yellow stunting disease.

WILLIAM WINTERMANTEL (D2120-1)

Wintermantel and colleagues identified several local weeds and important alternate crops, such as alfalfa, lettuce, and snap beans, as hosts of CYSDV. They found that the virus is capable of infecting plants in seven plant families besides the Cucurbitaceae family. The scientists are now trying to determine which of the new host plants are most important for virus survival during noncropping seasons and to better understand how the virus is moving throughout the region.

Meanwhile, horticulturist Jim McCreight, research leader of the Salinas laboratory, is working to develop CYSDV-resistant melons. In 2006, when the disease first appeared in California, McCreight observed resistance in a salad melon (a nonsweet melon similar to a cucumber) from India that was being grown for research purposes in Yuma and in the Imperial Valley. McCreight also determined that a salad melon from Africa—first reported by Spanish investigators as resistant to a strain of CYSDV present in southern Spain—was resistant to CYSDV in California and Arizona. After field screening of more than 300 melon accessions from India, McCreight found a few plants among them showing promise of resistance to the virus. He continues to evaluate these lines and additional material sent from overseas.

McCreight's field tests showed that disease resistance can only be effective when whitefly populations are controlled. "The whiteflies and the virus are like a severe one-two punch to the plant," says McCreight. "Hundreds of whiteflies constantly feeding on the plants assure high frequency of infection by the virus. Continued heavy feeding by the whiteflies, particularly in summer-planted melons grown in high temperatures, further weakens the plants. The result is often complete loss of fruit yield and quality or plant death."

For genetic resistance to be truly effective for preventing crop losses, it will be necessary to combine it with effective pest-management practices. With further research, the scientists hope to develop a plan to combat this devastating disease.—By **Stephanie Yao,** formerly with ARS.

This research is part of Plant Genetic Resources, Genomics, and Genetic Improvement (#301) and Plant Diseases (#303), two ARS national programs described at www.nps.ars.usda.gov.

Bill Wintermantel and Jim McCreight are with the USDA-ARS U.S. Agricultural Research Station, 1636 East Alisal St., Salinas, CA 93905; (831) 755-2824 [Wintermantel], (831) 755-2864 [McCreight], bill.wintermantel@ars.usda.gov, jim.mccreight@ars.usda.gov.

Getting Closer to Better Biocontrol for Garden Pests

Agricultural Research Service scientists are moving closer to developing an environmentally friendly bacteria-based biocontrol agent that offers long-lasting protection against caterpillars and other pests in a garden or cultivated field.

Bacillus thuringiensis (Bt) is now used to control gypsy moths, tent caterpillars, leaf rollers, canker worms, and other pests that attack garden plants, corn, and other crops. But the commonly used strain, *B. thuringiensis kurstaki,* doesn't survive more than one generation. After an initial round of pests is killed, the biocontrol dies out and the pests return.

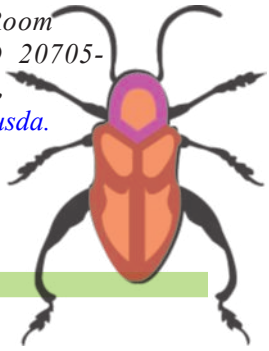
Michael Blackburn, an entomologist at the Invasive Insect Biocontrol and Behavior Laboratory in Beltsville, has been searching among the 3,500 characterized *Bt* strains in the ARS Beltsville Bacterial Collection for a strain that will not only kill an initial generation of pests, but will also survive to kill later generations.

Blackburn and his colleagues are classifying strains in the collection based on the compounds the bacteria metabolize and produce. As part of that effort, they tested 50 strains of *Bt* known to be toxic to gypsy moths, including *kurstaki,* and found they could be divided into two groups: those that produce an enzyme called "urease" and those that don't. They fed the 50 strains to gypsy moth larvae, and when those caterpillars died, they ground them up and applied them to pellets of artificial diet. They then fed the pellets to another cycle of caterpillars.

The researchers looked at survival rates of the bacteria over several generations of caterpillars and found that urease-producing phenotypes survived better when repeatedly fed to gypsy moths. Of 26 urease-producing *Bt* strains, 23 survived 5 passages through gypsy moth larvae, while none of the 24 strains that don't produce urease survived them.

The results, published in *Biological Control,* bring scientists a step closer to finding a *Bt* strain that will be more effective at combating gypsy moths and possibly other insect pests. The efforts should also lead to the discovery of *Bt* strains with other desirable traits, such as the ability to grow on mulch, multiply on specific crops, or thrive in gardens and other sites favored by a targeted pest.—By **Dennis O'Brien,** ARS.

Michael Blackburn is with the USDA-ARS Invasive Insect Biocontrol and Behavior Laboratory, 10300 Baltimore Ave., Bldg. 011A, Room 281, Beltsville, MD 20705-2350; (301) 504-9396, mike.blackburn@ars.usda.gov.



Vaccine for Anaplasmosis Under Development

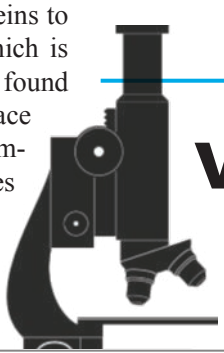
Molecular biologist Susan Noh, at the Agricultural Research Service's Animal Disease Research Unit in Pullman, Washington, is working to develop a vaccine to protect against anaplasmosis, a tick-transmitted disease of cattle. Caused by the microbe *Anaplasma marginale,* anaplasmosis affects cattle health, well-being, and production in many parts of the world and is characterized by severe anemia, fever, and weight loss. Despite this threat, there is no widely accepted vaccine for anaplasmosis.

Through their studies, Noh and her colleagues at Washington State University have identified important proteins to include in a potential vaccine, which is now being tested on animals. They found that small groups of the outer surface proteins of *A. marginale* induce an immune response that not only reduces symptoms, but can also prevent *A. marginale* infection in some animals. Some of the more promising vaccines being tested have protected 80 to 90 percent of the animals from clinical disease and have prevented infection in up to 40 percent of the animals.

"This is significant because infected animals may have no clinical evidence of infection, yet serve as sources of infection for others," says Noh. "No vaccine has ever prevented infection from *A. marginale* in cattle." Other countries have used an attenuated (weakened) strain (usually *A. centrale*) as a vaccine, and that vaccine protects against clinical disease, but not infection. Attenuated vaccines are prepared from live microorganisms or viruses that are cultured in the lab in such a way that they lose their virulence, but still confer disease immunity.

"To date we have only tested the vaccine against one strain of *Anaplasma*. In the field, many strains coexist. The next step is to determine whether this particular group of surface proteins will protect cattle from multiple strains of *Anaplasma,"* says Noh.—By **Sharon Durham,** ARS.

Susan Noh is with the USDA-ARS Animal Diseases Research Unit, 441 Bustad Hall, Washington State University, Pullman, WA 99164-6630; (509) 335-6162, susan.noh@ars.usda.gov.



PEGGY GREB (D2123-1)

New Device Eavesdrops on Insect Pests

Entomologist Richard Mankin examines signals collected by an inexpensive prototype system (on the bench, at his fingertips) for automated insect detection and identification.

Grain elevators, warehouses, and food-processing facilities are a hungry insect's delight, thanks to ample food and climate-controlled conditions. Fortunately, there are many effective strategies for keeping stored-product insects in check—including targeting of problem areas with extra sanitation measures and baits. But determining pest whereabouts and numbers in order to effectively implement these strategies can be challenging.

Now, after 8 years of research, Agricultural Research Service entomologist Richard Mankin and colleagues may have some inexpensive help. Using commercially available parts, they've built a monitoring device that detects insects by the sounds they make.

Collaborating with Mankin are North Carolina State University researchers Ryan Hodges, Troy Nagel, and Coby Schal, all in Raleigh; and Roberto Pereira and Philip Koehler, both at the University of Florida in Gainesville.

The most likely application will be to automate routine monitoring of industrial-scale traps, especially those placed in hard-to-reach areas like crawl spaces or near food-processing equipment. "Automation could be useful in a situation where you have a trap in place for a long time and you don't want to have to check it every week or two," says Mankin, at the ARS Center for Medical, Agricultural, and Veterinary Entomology in Gainesville.

Armed with automated traps, managers could improve the timing and placement of control measures or even avoid using them when there's no need. The researchers' insect intelligence gathering isn't restricted to stored-product pests, though. They're also targeting home intruders like *Blattella germanica* (the German cockroach) and *Cimex lectularius,* better known as the "bed bug."

Mankin says their objective was to create a device that would make automated insect monitoring not only affordable, but also easy to use and reliable. Toward that end, they integrated commercially available sensors (LEDs, microphones, and piezoelectric film) with high-gain amplifiers and laptop-run software for analyzing digital signals.

Their system uses the sensors to collect infrared, acoustic, and vibrational signals generated by three kinds of insect movements: wriggling, crawling, and scraping. The software analyzes the signals to create a profile of the target insect that distinguishes it from other species.

The researchers tested their device on three stored-product pests (rice weevil, red flour beetle, and drugstore beetle) and two household pests (German cockroach and bed bug). Individuals of each pest were placed inside small arenas where their signals could be collected and analyzed for differences in profile, magnitude, and duration. Although all five species generated all types of signals, red flour beetles mostly wriggled, German cockroaches typically ran or crawled, and bed bugs mostly scraped.

Mankin envisions users placing the devices in traps in or near infested structures and monitoring them remotely via laptop computer. "You would probably receive an alarm when a potential target insect was detected," he says. "The information could also be saved in a spreadsheet, with the time of occurrence and probability that this was a target insect."—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.

Richard Mankin is in the USDA-ARS Insect Behavior and Biocontrol Research Unit, Center for Medical, Agricultural, and Veterinary Entomology, 1700 S.W. 23rd Dr., Gainesville, FL 32608; (352) 374-5774, richard.mankin@ars.usda.gov.

The Agricultural Research Service has about 100 labs all over the country.

Locations Featured in This Magazine Issue

The Vegetable and Forage Crop Research Unit, Prosser, Washington
1 research unit ■ 34 employees

Pullman, Washington
6 research units ■ 144 employees

Columbia Plateau Conservation Research Center, Pendleton, Oregon
1 research unit ■ 23 employees

U.S. Agricultural Research Station, Salinas, California
1 research unit ■ 54 employees

Tucson, Arizona
2 research units ■ 52 employees

Fort Keogh Livestock and Range Research Laboratory, Miles City, Montana
1 research unit ■ 27 employees

Rangeland Resources Research Unit, Cheyenne, Wyoming (including Nunn, Colorado)
1 research unit ■ 30 employees

Fort Collins, Colorado
5 research units ■ 143 employees

Madison, Wisconsin
5 research units ■ 140 employees

Southern Plains Range Research Station, Woodward, Oklahoma
1 research unit ■ 17 employees

USDA Jean Mayer Human Nutrition Research Center on Aging, Boston, Massachusetts
1 research unit ■ 14 employees

Appalachian Fruit Research Station, Kearneysville, West Virginia
1 research unit ■ 71 employees

Henry A. Wallace Beltsville Agricultural Research Center, Beltsville, Maryland
30 research units ■ 953 employees

J. Phil Campbell Sr. Natural Resource Conservation Center, Watkinsville, Georgia
1 research unit ■ 24 employees

Center for Medical, Agricultural, and Veterinary Entomology, Gainesville, Florida
4 research units ■ 144 employees

U.S. Horticultural Research Laboratory, Fort Pierce, Florida
3 research units ■ 133 employees

Continental U.S. map courtesy of Tom Patterson, U.S. National Park Service

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