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Rescuing Rambutan

Story on pages 16-17

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

Current Challenges Can Help Fuel Future Opportunities

Rapidly spreading western junipers present a challenge to keeping rangelands healthy. Harvesting them in a sustainable manner for potential renewable fuel production can help us meet multiple national goals.

KIRK DAVIES (2900-2)

Native juniper trees and invasive plants pose an expanding threat to the survival of the sagebrush ecosystem in arid western rangelands. As the trees mature, they compete with other native plants that are valuable food sources for wildlife and cattle. After these plants die back, the bare patches of soil that remain are vulnerable to erosion and encroachment from other species like cheatgrass, an invasive nonnative annual that fuels wildfires.

Wildfires threaten livestock ranches, are suppressed in large part by efforts funded with taxpayer dollars, and increase the probability that invasive plants will spread and thrive in the postfire landscape. So while western juniper, pinyon pine, and other similar native trees have a role to play in this ecosystem, the thickets that are rapidly spreading across the rangelands need to be brought under control.

Fortunately, the challenge these trees present to healthy rangelands also creates an opportunity for using them as a feedstock for renewable jet fuel production. And this new opportunity means that western states could significantly contribute to meeting national goals for the production of renewable bioenergy in the United States—and help the U.S. military develop homegrown and sustainable sources of alternative biofuels for powering its assortment of vehicles, planes, and ships.

Agricultural Research Service researchers already have a framework in place for tackling the many issues that need to be resolved before turning a tree into a gallon of renewable fuel. In 2010, U.S. Department of Agriculture Secretary Tom Vilsack created five Regional Biomass Research Centers to maximize existing USDA research resources for bioenergy development. The goal of this effort is to develop sustainable, regional approaches for producing feedstocks so that rural communities across the country have opportunities to participate in the emerging biofuels and biobased-products economy. (See "ARS and the Regional Biomass Research Centers," *Agricultural Research,* September 2012.)

One of the main challenges in producing domestic sources of bioenergy feedstocks is ensuring that we don't interfere with production of food and feed crops grown on prime farmland. We must also develop cost-effective production systems that not only protect soil resources and conserve water but also sequester carbon. Carbon dioxide is a greenhouse gas that contributes to long-term global warming but boosts crop productivity when accumulated in the soil as organic matter. Achieving these multiple beneficial outcomes is complicated by the fact that extreme weather events such as droughts and heat waves are already necessitating adjustments in current U.S. agricultural production systems.

ARS conducts ongoing research to identify management strategies to protect arid rangeland ecosystems and maintain their value for wildlife, livestock, and recreation. Looking for additional sustainable ways to manage and utilize invasive trees is simply introducing a new—and potentially lucrative—value-added component to land managers' toolboxes.

In a new initiative supported in part by the USDA Regional Biomass Research Centers, ARS scientists are working with colleagues at universities and other research and commercial institutions to develop biofuel production facilities that will use juniper's woody biomass (see page 4 of this issue). This partnership encompasses biofuel production from the outset, including locating the best regions where the trees could be sustainably harvested (see page 8) and evaluating different methods for restoring the rangelands after the trees have been removed (see page 10).

An important component of this interdisciplinary teamwork is providing information about various economic, social, business, and environmental indicators to help guide the regional development of sustainable renewable jet fuel industries. These studies will show how this use of invasive trees can also benefit production of grazing livestock and food products—and increase local, regional, and state tax revenue, economic growth, and job creation. Examining options for expanding supply-chain networks and aligning the different participant and stakeholder interests to promote effective partnerships will help ensure that new rural economic development opportunities centered on renewable jet fuel production can be brought to reality.

Using invasive junipers to make cost-competitive biofuels can help reduce wildfires and improve grazing for cattle and habitat for wildlife—including the sage grouse, which depends on the fragrant sagebrush to provide food, shelter, and a suitable backdrop for its legendary mating call and dance. With careful planning and cooperation, we can turn an arid rangeland challenge into a resource that will help us meet multiple national goals well into the new century.

Jeffrey J. Steiner
Former ARS National Program Leader
Biomass Production Systems
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Solving Problems for the Growing World

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TIM GOTTWALD (D2259-1)

Orange tree leaves with symptoms of Huanglongbing, also known as "citrus greening disease." ARS scientists have developed a shoot-tip cryopreservation method to store and preserve citrus germplasm, safeguarding it for the future. Story begins on page 20.

Cover: The tasty and nutritious flesh of rambutan makes it an important crop in many tropical areas. So when rambutan trees in Honduras were threatened by a serious canker disease called "corky bark," ARS scientists stepped in to determine which fungus was causing the disease. Story begins on page 16. Photo by Peggy Greb. (D959-1)

LACY CARPENTER (D2370-1)

Turning Trees Into *Fighter Fuels*

After junipers were removed on this field near Burns, Oregon, rangeland scientist Tony Svejcar (left), technician Lori Ziegenhagen, and plant physiologist Jeremy James examine the establishment of bluebunch wheatgrass as part of research to improve range restoration.

In western U.S. rangelands, native juniper and pinyon pine trees are spreading beyond their historical ecological niches and disrupting the environmental balance of their expanded range. Meanwhile, Agricultural Research Service scientists are teaming with university and industry colleagues to turn this problem into a source of fuel for U.S. Navy fighter jets.

"Juniper competes with grass and forbs for water and nutrients, and this leaves bare soil that is vulnerable to erosion," says ARS scientist Mark Weltz, who works at the Great Basin Rangelands Research Unit in Reno, Nevada. "We have also lost habitat for sage grouse and mule deer, and the amount of forage available for cattle has declined as well."

"Our options for controlling juniper expansion are limited," adds ARS rangeland scientist Tony Svejcar, who is the research leader at the Eastern Oregon Agricultural Research Center in Burns, Oregon. "There's not much of a market for cut juniper, so we usually just cut the trees and leave them where they fall."

Pinyon pine trees, which in the western United States often grow alongside juniper, present similar management problems. The good news is that some preliminary estimates suggest that harvesting a percentage of these hardy trees every year could supply enough biomass to produce millions of gallons of renewable jet fuel. Removing the trees would help restore productive rangeland for livestock and protect critical sagebrush habitat for threatened species such as the western sage grouse. The time is right to develop a comprehensive strategy for harvesting the trees and using the woody biomass to jumpstart a regional biofuel industry.

This project, called "Accelerated Renewable Jet Fuel Supplies from Western Woody Species," is headed up by rangeland ecologist Tamzen Stringham at the University of Nevada-Reno. The effort

STEPHEN AUSMUS (D552-18)

An adult male sage grouse. On western U.S. rangeland, removing excessive junipers and pinyon pine trees for biofuel production can help restore land for livestock and protect sagebrush habitat critical to the survival of the sage grouse.

In 1973, this area in central Nevada had little juniper tree coverage, and the junipers were mostly at the higher elevations (top photo). By 2005, at the same area, the junipers had expanded substantially (middle photo).

ROBIN TAUSCH (D2904-1)

ROBIN TAUSCH (D2905-1)

includes numerous public and private collaborators and is part of the U.S. Department of Agriculture's Regional Biomass Research Centers initiative, which supports research on and development of dependable feedstock supplies to promote advanced biofuels production throughout the United States. (See box on page 7.)

"The arid west has traditionally been overlooked as a source of biomass for bioenergy," says Dallas Hanks, director of Utah State University's Extension Center for Agronomic and Woody Biofuels. "With new technology and the knowledge from cooperating organizations, we've learned that this region has tremendous opportunity to contribute significant quantities of biomass that can be used to meet the nation's growing need for renewable fuels."

Taking Stock

The first step in the process is taking an inventory of how many trees could be harvested for use as biofuel feedstocks. Current remote-sensing work by ARS rangeland scientists—using satellite data to identify juniper and pinyon pine trees and estimate the density of mature trees—has given the process a head start. (See story on page 8).

"This will help us locate where trees can be harvested and figure out how many trees are actually available to use for biofuel development," says Svejcar. "We can also use this information to determine where wildlife habitat would be best restored and avoid harvesting in areas where it could harm existing wildlife populations."

The next task will be to devise plans for harvesting the trees in a sustainable manner, a process dictated in part by environmental characteristics that differ across the vast western rangelands. ARS scientists have already conducted considerable research

STEPHEN AUSMUS (D2115-7)

In Arizona, hydraulic engineer David Goodrich (right) and technician Jim Riley are working to improve modeling estimates of watershed-level rainfall runoff and erosion—information that will help guide decisions on where, and how many, juniper trees can be harvested without having an adverse effect on runoff and erosion.

that will help determine how harvesting the trees could affect the ecological health of this region.

For instance, ARS scientist Fred Pierson is using watershed data gathered over the past 50 years from the Reynolds Creek Experimental Watershed in Idaho to simulate how tree harvests would affect water runoff from the surrounding terrain. His previous work involved studying hillslope erosion processes across the Great Basin. Now he plans to conduct experimental juniper harvests on a variety of sites to observe how the removal affects soil erosion from snow runoff water. He'll use the information to model the environmental impacts of large-scale tree harvests.

Pierson will also be monitoring how juniper removal affects large-scale water cycles. "Junipers draw a great deal of water from the soil," says Pierson, research leader at the ARS Northwest Watershed Research Center in Boise, Idaho. "Up to this point, we've only looked at the water demand of individual trees. But now we're looking at how whole juniper forests affect water cycles in entire watersheds, which is important for calculating how much more water could be available after the trees are removed."

Pierson's preliminary findings suggest that invasive juniper stands have affected long-term patterns of snowpack formation and snowmelt schedules—two essential processes in the availability and delivery of irrigation water to farmers. Harvesting trees will allow him to observe any shifts in water supplies that result from clearing juniper trees from the landscape.

Models for Management

Much of the harvest planning will be conducted with computer models that have been developed by ARS scientists and their colleagues. One of these models, the Rangeland Hydrology and Erosion Model (RHEM), was developed in 2009 and produces estimates for storm-water runoff and soil erosion for hillslopes. Another ARS program, called "KINEROS2," incorporates RHEM to provide estimates of watershed-level rainfall runoff and erosion as well.

The newest modeling program is the Automated Geospatial Watershed Assessment tool, known as "AGWA." It fine-tunes watershed delineations by incorporating layers of GIS data, such as soils and land-cover data, into KINEROS2 watershed models. David Goodrich, a hydraulic engineer at the ARS Southwest Watershed Research Center in Tucson, Arizona, will work with the team to improve modeling estimates of watershed-level rainfall runoff and erosion, which will help guide decisions on where to harvest trees.

Stringham and Keirith Snyder, an ARS scientist with the Reno unit, will also design site-restoration plans so landowners and those who utilize the biomass can ensure that the harvests are conducted sustainably from beginning to end. One of the tools that can help with this process is an ARS decisionmaking model called "Ecologically Based Invasive-Plant Management" (EBIPM), which can be used to develop plans for restoring native plants on terrain previously overrun by invasive vegetation. (See "Step-by-Step Strategies for Restoring Western Rangelands," *Agricultural Research,* February 2012.)

In addition, using state-and-transition model mapping techniques to obtain information about soils and other site characteristics that affect restoration plans could make EBIPM assessments even more effective. (See story on p. 10.) Carefully integrating plans that include tree inventory, harvest, and site-restoration methods will be essential to ensuring that an emergent biofuel industry leaves the landscape in better shape than before.

End of the Line

While ARS scientists are figuring out how to assess and harvest the woody biomass, other partners in the project will be developing feedstock logistics plans and strategies for transporting the harvested trees and processing the biomass into fuel. Part of this effort will include finding coproduct market possibilities for the materials generated during the fuel-conversion process. Honeywell UOP, a developer and licenser of technologies that produces aviation and other biofuels, will conduct tests of the biofuels produced from the rangeland tree biomass. Amaron Energy will contribute work on methods for preprocessing woody biomass into a bio-oil to reduce transportation costs of the harvested trees.

"All of this work is part of an overall plan to ensure that regional biomass businesses for jet fuel enhance regional business and environmental conditions," says former ARS national program leader Jeffrey Steiner, who has helped lead the project. "We want to align participant and

A slash bundler harvesting device being used to harvest a whole juniper tree. ARS scientists are working with collaborators to use this invasive tree as a potential renewable source, or feedstock, for producing biofuels.

RANDY PARKS, BURNS TIME-HERALD (D2908-1) stakeholder interests to form effective partnerships along supply chains to create new rural job opportunities based on renewable jet fuel production."

"The federal government is already spending millions of dollars every year to remove these trees that could be used to make jet fuel," says Weltz, who will be assisting in some of the modeling work. "Development of a biofuel industry would add new job opportunities in rural areas that need new businesses. It could be a win-win-win for everyone."—By **Ann Perry,** ARS.

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

"Development of a biofuel industry would add new job opportunities in rural areas that need new businesses."

— Mark Weltz

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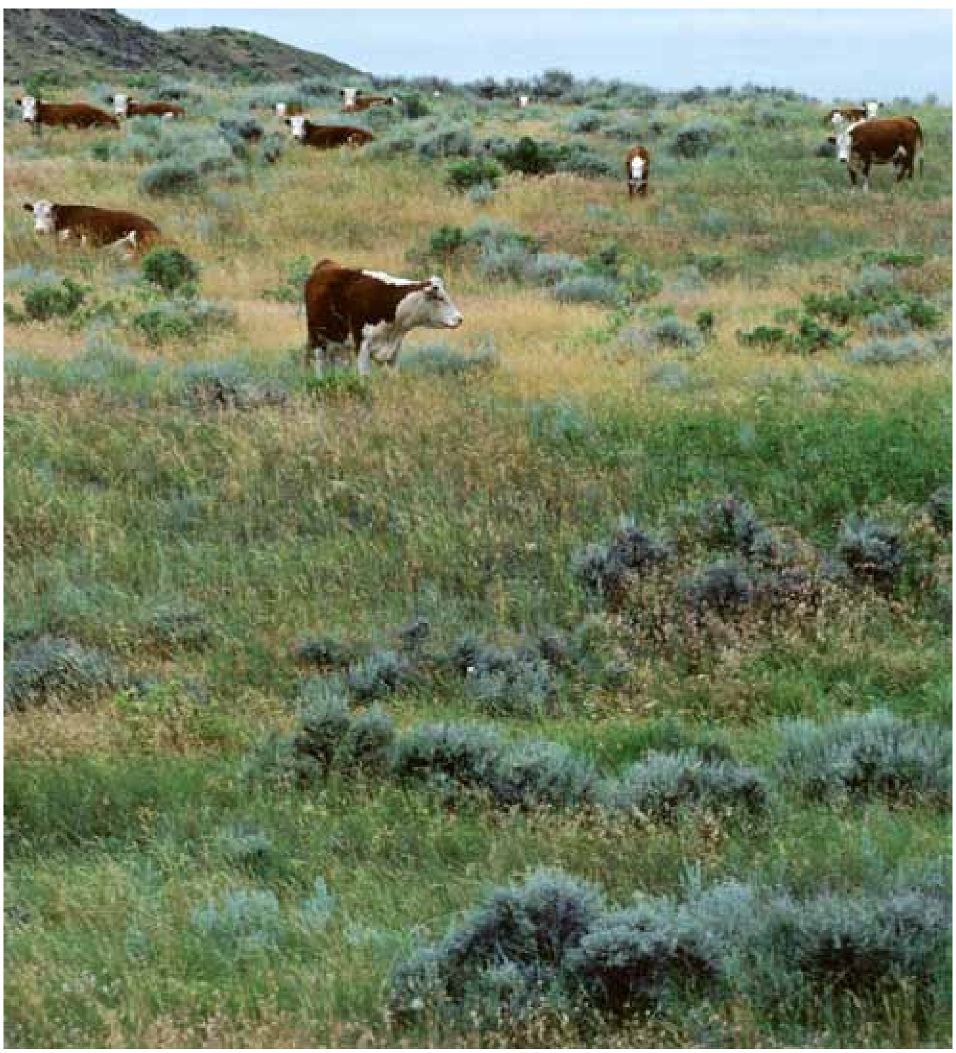
DOUG WILSON (K1223-19)



This healthy pasture provides a variety of plants for livestock and wildlife. Pastures covered with invasive juniper could be restored to look something like this after the excessive juniper cover is removed for biofuel production.

The ARS Network of Biomass Centers

The **Agricultural Research Service** locations included in this story are parts of the U.S. Department of Agriculture's Western and Northwestern Regional Biomass Research Centers network. The network is made up of five national centers whose mission is to help accelerate the establishment and production of sustainable commercial biomass from farms and forests without disrupting the production and marketing of food, feed, and fiber.

Collaborators on the research covered in this story include: Amaron Energy, Brigham Young University, Honeywell UOP, Michigan Technological University, Montana State University, National Aeronautics and Space Administration, Oregon State University, Resource Concepts Incorporated, USDA Forest Service, USDA National Agricultural Library, USDA Rural Development, Utah State University, and Vermont and Nevada Extension.*

KIRK DAVIES (D2898-1)

Tools for Tracking Troublesome Trees

Near Burns, Oregon, rangeland scientist Kirk Davies (left) and ecologist Matt Madsen use a GPS device to obtain their exact location. Next, they will verify the accuracy of juniper population data obtained from remote-sensing equipment compared to field observations.

In Oregon, western juniper trees are expanding their range, pushing out other plant species, reducing sagebrush habitat and livestock forage, and at times fueling catastrophic wildfires. During some of these conflagrations, fires burn even hotter because more wood is available to feed the flames—a cause-and-effect that in turn lengthens the time that temperatures remain elevated at fire-stricken sites.

To help streamline efforts to manage invasive trees, Agricultural Research Service rangeland scientists Kirk Davies and Matt Madsen are investigating ways of combining aerial photography and computer programs to quickly identify and measure affected areas. These tools could save time and money for land managers tasked with protecting sagebrush ecosystems and controlling invasive vegetation.

Scouting for Western Juniper

Davies and Madsen, who work at the Eastern Oregon Agricultural Research Center in Burns, Oregon, led studies on using National Agricultural Imagery Program (NAIP) high-resolution aerial images to estimate western juniper cover. A related part of the project included exploring the relationships between cover of mature stands of juniper and site characteristics that influence soil moisture and temperature.

Working at a 30,500-acre site in Idaho, they collected information about juniper distribution and then used this data for "training" image software to identify juniper on the NAIP images. Using this calibrated approach—called "feature extraction"—the team identified juniper with an overall accuracy rate of 92 percent. For instance, the NAIP/software combination calculated that 26.8 percent of one site was covered with juniper; initial ground scouting had determined the coverage to be 24.7 percent.

Imagery analysis indicated that the maximum juniper cover in the study area was 82 percent—a figure the scientists validated with ground-truth surveys, which indicated that the maximum juniper cover was 78.7 percent. They found that the western juniper stands with greater cover were more likely to be found at higher elevations and on steeper, more northerly facing slopes.

"Feature extraction gives us a fast-and-easy way to survey a large area and

Right: (A) High-resolution aerial photograph of Utah juniper and pinyon trees. (B) Tree cover extracted using feature-extraction software (red outlines). (C) Individual trees converted to data points (blue X's); trees that were clustered had a negative buffer technique applied (yellow areas). (D) A second negative buffer applied (yellow). (E) Final tree-density extraction results, showing all individual trees.

know how much juniper is out there," says Davies.

Picking Out Pinyon Pine Trees

In collaboration with Brigham Young University, Madsen also led another project that examined the use of high-resolution aerial imagery from the Utah Automated Geographic Reference Center to study the expanse of pinyon-juniper forests in Utah.

"Pinyon-juniper woodlands create the same problems that western juniper woodlands do," Madsen says. "Lack of resources and extensive and rugged terrain limit a land manager's ability to monitor pinyon-juniper woodland expansion using traditional field-based methods. The geospatial techniques we developed give land managers the ability to map woodland expansion across large land areas."

Photographs used by Madsen had been obtained in the fall of 2006—a time when there were distinct differences on the images between the evergreen pinyon-juniper vegetation and seasonally dormant trees, such as gambel oak and bigtooth maple. Madsen "trained" his feature-extraction software to identify pinyon and juniper trees within aerial photographs and then used this data to estimate pinyon-juniper tree cover and density. This method yielded a 93-percent accuracy rate for tree cover.

Madsen's research was the first to estimate tree density from aerial photographs by using what he calls a "negative buffer post-processing technique." This method involves reclassifying data from the tree-cover file to generate a unique data point for each tree (see photos below). He then added up the total number of unique data points to obtain an estimate of tree density. With this method, he obtained a 95-percent accuracy rate in estimating the density of trees that were at least 4½ feet wide.

Ground data indicated that smaller trees that were not identified—primarily juvenile trees—made up only around 1 percent of the total tree cover. But these overlooked trees made up 39 percent of the total number of trees at the site. Madsen showed how ground-based data could be used to develop additional calibrations to the feature-extraction model to account for missing juvenile trees.

The researchers also compared feature-extraction data to ground data for 35 different locations obtained by the Utah Division of Wildlife Resources Range Trend Project (DWR-RTP), which has collected rangeland trend data across the state since 1983.

Madsen's group was pleased with how well the feature-extracted data correlated with measurements by DWR-RTP. But without calibration, the DWR-RTP data had a higher success rate than the feature-extracted model in detecting juvenile trees. After the feature-extraction program was calibrated to account for juvenile trees, it had almost a 1-to-1 ratio with the DWR-RTP—additional evidence that the process can provide accurate information about tree cover and density.

KIRK DAVIES (D2900-1)

A view from Juniper Mountain, looking toward South Mountain, shows a landscape heavily populated with invasive western juniper trees.

Madsen says, "This technique could let land managers monitor woodland change over large land areas for a range of things, including woodland encroachment, fuel loads, timber value, wildlife habitat, and grazing suitability."

Findings from the two studies were published in *Rangeland Ecology and Management* and *Environmental Management*.—By **Ann Perry,** ARS.

This research is part of Pasture, Forage, and Rangeland Systems (#215) and Crop Protection and Quarantine (#304), two ARS national programs described at www.nps.ars.usda.gov.

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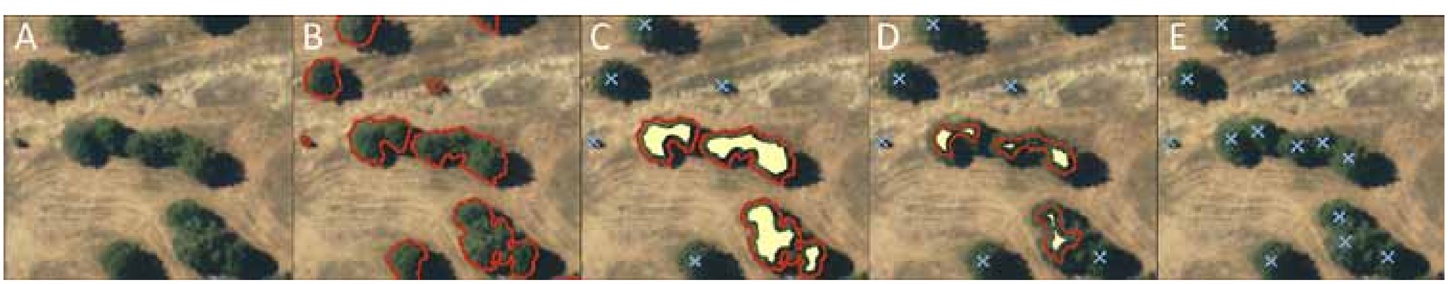
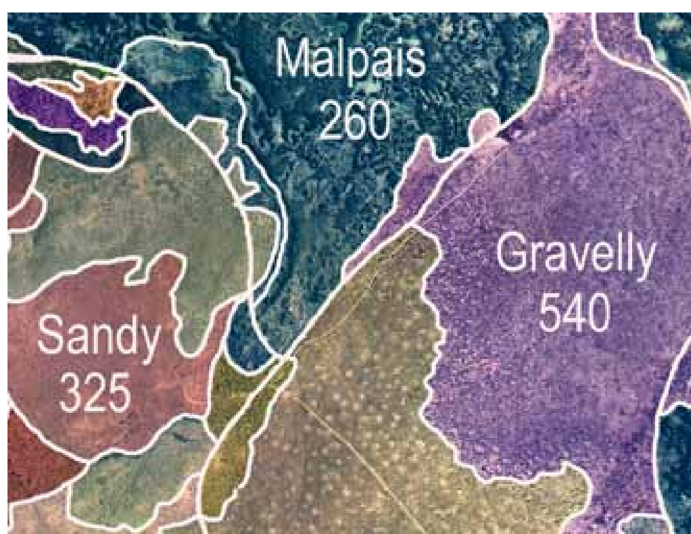


(D2899-1)

Better Maps Mean Better Rangeland Management


LAURA M. BURKETT (D2932-1)


LAURA M. BURKETT (D2933-1)



LAURA M. BURKETT (D2934-1)

Land managers are always hoping for the next best thing to help them figure out where they should spend their time and money restoring and maintaining healthy rangelands. Now Agricultural Research Service rangeland ecologist Brandon Bestelmeyer has one of the answers—an ecological-state map that identifies where rangeland is holding its own, where it could respond to restoration efforts, or where it's already past the point of no return.

"We wanted to find a way to turn existing field-level rangeland assessments into broader tools for comprehensively managing larger landscapes," says Bestelmeyer, who works at the ARS Jornada Experimental Range in Las Cruces, New Mexico. Working with U.S. Bureau of Land Management (BLM) rangeland specialist Philip Smith and others, Bestelmeyer began pairing time-tested soil data and vegetation maps with state-and-transition models (STMs) to generate science-based assessments of rangeland conditions across landscapes.

STMs describe the types of plant communities that can occur on a specific soil type and the shifts that occur among plant communities. Sometimes, beneficial plant communities have persisted through past events. Other times these plant communities have been so altered by invasive plants, soil degradation, or other processes that they require management interventions—reseeding, herbicide treatments, changes to grazing, or other approaches—to be restored, if they can be restored at all.

A Worksite in the West

The team used around 6 million acres in southwestern New Mexico for the study. This area features large expanses of public and private land with desert grassland, savanna, and shrubland. Native shrubs have been encroaching on areas previously covered by perennial grasses, and erosion has degraded soils throughout much of the region.

The researchers started developing three ecological-state categories for plant communities by defining how woody-cover density varies among different soils. They determined this by identifying the vegetation they believed had historically dominated a particular soil. The categories were "little woody cover," "significant woody plant cover within a grassland matrix," and "dominated by woody plants."

Then the team developed ecological-state descriptors for different soils. They assessed factors such as USDA's Natural Resources Conservation Service (NRCS) soil data, STM soil characteristics, plant functional groups, responses to disturbance, and soil erosion patterns. Through this process, the scientists

Top map: Original soil survey map from the Soil Survey Geographic Database.

Middle map: Ecological-state map units delineated on the soil survey base map above.

Bottom map: Final ecological-state map designations with an example of coding. The three-number code within an ecological-state area means that there is more than one ecological state within that area. Each number represents one ecological state, and the numbers are listed in order of the extent of the ecological state within that area. For instance, “Gravelly 540” means that the area is characterized by a gravelly ecological state, 5 means that much of the site is covered with expanded shrublands/woodlands, 4 means that some of the site is shrub-dominated, and 0 indicates that this site does not have a third ecological state category.

“We already knew that shrub encroachment on grasslands was a significant management problem, but now we also know where it’s a fixable problem, based on how soils affect ecological potential and restoration likelihoods.”

—Brandon Bestelmeyer

identified eight distinct ecological-state categories that could be used to evaluate the overall condition of a specific site and decide whether restoration efforts could be successful.

Before the team mapped these ecological states, they paired soil-map boundaries with other site data and overlaid this information on fine-resolution photographic imagery. Geographic Information System analysts who were familiar with STMs and the regional terrain used this information to map ecological-state areas throughout southwestern New Mexico. Mapping at a range of sizes resulted in ecological-state areas that ranged from a few acres to 10,000 acres.

A Good Map Makes All the Difference

The result? “Pretty good—on a scale of 1 to 10, we’re at a 7,” says Bestelmeyer. “For instance, we already knew that shrub encroachment on grasslands was a significant management problem, but now we also know where it’s a fixable problem, based on how soils affect ecological potential and restoration likelihoods. We can see that grass recovery after shrub removal is happening at different rates on different soils, and we can use soil and ecological state maps to represent those differences. And these differences can be important when rangeland managers are trying to decide whether to remove shrubs as part of grassland restoration, whether the shrubs are elements of the historical plant community, or whether they are now the only plants that can exist in a site.”

In its current form, says Bestelmeyer, the map is a good tool that can be used to guide range-management fieldwork—and information gathered during fieldwork can then be used to update map information. “The map can become more accurate the more it’s used. We’re also hoping to develop applications for mobile devices that will allow us to automatically upload field observations to verify or correct the map.”

So far, the map has been used by resource managers working in BLM’s “Restore New Mexico” grasslands program to target herbicide applications on shrubs in areas where the remaining grass cover is sufficient to support restoration efforts once the shrubs are gone.

BLM managers have also used the map to locate large areas of severely degraded rangeland that would probably not respond to plant restoration efforts but could be suitable for solar energy installations—part of a federal effort to encourage the development of the solar grid.

The team published their results in 2012 in *Rangeland Ecology and Management*.

“Rangeland managers like what we’ve done,” says Bestelmeyer, particularly ranchers associated with the Malpai Borderlands Group in the “boot heel” of southwest New Mexico and southeast Arizona. “In fact, it’s a challenge to keep up with the demand. In the future, we’d like to include a greater range of information in the maps, like variations in ecological states relevant to management needs. For instance, we think the map could be developed to identify NRCS land-management practices, like where to focus carbon sequestration efforts or to sustain wildlife habitat.”—By **Ann Perry,** ARS.

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

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New, Improved Codling Moth Lures Available

New lures that entice codling moths with the scent of food and a possible mate are available for use in monitoring this orchard pest and controlling it with carefully timed applications of insecticide. The research related to the development and use of the lures involved scientists Alan Knight and Peter Landolt at the Agricultural Research Service's Yakima Agricultural Research Laboratory in Wapato, Washington, and Douglas Light at the ARS Western Regional Research Center in Albany, California.

As larvae, codling moths are major pests of apples, pears, and walnuts. Historically, growers have sprayed their orchards with insecticide to prevent the pinkish-white, 3/4-inch-long larvae from holing up inside the fruit to feed, damaging it and ruining its marketability—both domestically and abroad.

ESTOBAN BASOALTO (D2876-1)

A trap baited with sex pheromone, pear ester, and acetic acid. ARS researchers and collaborators found that the combination of all three ingredients provides the best attractant for codling moths.

Lures baited with synthetic versions of the adult female moth's chemical sex attractant, or sex pheromone, have helped growers refine their timing of insecticide and reduce the amount applied. As part of research to improve the technology further, a team of ARS and collaborating scientists has identified and synthesized new compounds to add with the sex pheromone. Among these are pear ester and acetic acid.

Pear ester is the characteristic aroma of ripe pears and acetic acid is what makes vinegar tangy.

Pear ester alone is a potent attractant for both sexes of codling moth. Adding acetic acid significantly increases the number caught. But the most powerful lure resulted from combining pear ester, sex pheromone, and acetic acid, the researchers found. Indeed, studies indicate that the combined lure can capture 8 to 10 times more female moths than the pear ester-pheromone combination alone can.

Using lure-based monitoring tools, the researchers developed action thresholds (based on both female and total moth catches) for growers that have enabled insecticide reductions of 30 to 70 percent.

Orchard trials conducted with Washington State University entomologist Jay Brunner over 2 years found that combining the pear ester-pheromone lures with acetic acid can also be used effectively to monitor apple leafrollers—considered important secondary pests. This will allow growers to more easily establish management thresholds for leafrollers concurrently with codling moths.—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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SCOTT BAUER (K9205-1)

Codling moths lured to sticky paper by an attractant contained in the blue plastic device. Better attractants can help growers refine their timing of insecticide sprays and reduce the amount applied.

New Strawberry Species Found in Oregon

KIM HUMMER (D2878-1)

The Cascade strawberry *(Fragaria cascadensis)*. The length of the flower stalk for this species is variable. These stalks were collected near Waldo Lake, Oregon.

A recently discovered wild strawberry species provides new genetic material for plant research and, in the future, might also provide a new class of commercial strawberries.

Agricultural Research Service scientist Kim Hummer, with the USDA-ARS National Clonal Germplasm Repository at Corvallis, Oregon, found the new species during several plant collection expeditions in the high peaks of Oregon's Cascade Mountains. She named it *Fragaria cascadensis.*

The find was reported in the *Journal of the Botanical Research Institute of Texas*.

The new strawberry is endemic to the Oregon Cascades, hence its specific name, *F. cascadensis.* It is perennial, with white flowers and green leaves, and it differs from other strawberry species of the region by having hairs on the upper side of its leaves; a different-shaped middle leaflet; comma-shaped, small brown fruits (called "achenes") on the strawberry surface; and 10 sets of chromosomes, unlike the 8 sets of chromosomes of the commercial strawberry, according to Hummer.

"The new strawberry species begins growing after snowmelt in late May or early June and flowers in early July. Runner production begins after flowering, and fruit ripens during August for about 2 weeks," says Hummer. "The fruits of plants at about 5,000 feet elevation ripen 1 to 2 weeks later than those at 3,280 feet."

The strawberry's distribution in the Oregon Cascades stretches from the Columbia River in the north to the vicinity of Crater Lake in the south, at elevations of about 3,000 feet up to tree line. It grows in sandy-clay loam soil of volcanic origin located in forest clearings and open alpine meadows. The northern distribution range of *F. cascadensis* has an average annual precipitation of 12-15 inches, but the southern range receives only about 6 inches of precipitation annually.

This new strawberry is now included in the living collections of the Corvallis repository, which is a genebank that preserves invaluable plant genetic resources of temperate fruit, nut, and agronomic crops. This genebank maintains collections representing global diversity of blackberries, blueberries, cranberries, currants, gooseberries, hazelnuts, hops, pears, raspberries, and strawberries.

"*Fragaria cascadensis* presents the possibility for developing and breeding a new class of cultivated strawberries. This wild Oregon strawberry, if crossed with the commercial strawberry, would likely result in hybrid offspring with lower fertility," says Hummer. "However, crossing this new species with other strawberries having the same number of chromosomes, such as the cultivated *F. vescana* or the wild Russian species *F. iturupensis,* should produce fertile offspring, which may reveal new flavors or genetic disease resistance. In the future, consumers could benefit from the knowledge gained and genes provided by this new wild strawberry."—By **Sharon Durham,** 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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KIM HUMMER (D2877-1)

Wild fruiting plants of *Fragaria cascadensis* near Hoodoo Mountain, located in Oregon's Cascade Mountains.

Measuring the Feeding Behavior of Livestock

Determining how much time animals spend eating could help animal caretakers identify sick livestock, improve management, and establish genetic differences within a herd. But first, a system is needed to monitor animal feeding behavior.

Scientists at the Agricultural Research Service's Roman L. Hruska U.S. Meat Animal Research Center in Clay Center, Nebraska, have developed a new system to monitor feeding behavior of feedlot cattle and grow-finish swine in a livestock industry setting.

The system, created by agricultural engineers Tami Brown-Brandl and Roger Eigenberg in the center's Environmental Management Research Unit, uses standard radio-frequency identification technology designed around a commercial reader. The technology includes an ear tag applied to each animal, monitoring equipment at the feeders, and data recording and storage.

Eigenberg designed the hardware for the system, including a "multiplexer." Instead of a single unit that connects to a single antenna, the multiplexer functions as multiple switches—connecting the signal from the reader to the correct antenna. Software designed by Brown-Brandl controls the hardware, timing, and data recording and storage.

"We can check antennas at a quick pace to determine if there is or isn't an animal at each feeder space," Brown-Brandl says. "This allows us to measure individual animal feeding behavior without influencing it. Once data is gathered and summarized, we can tell how much time each animal spent at the feeder."

The system was originally designed for cattle and has been adapted to grow-finish swine. Antennas were encased in a PVC panel mounted on the front face of the standard swine feeders in 6 pens, each holding 40 pigs. Both systems were evaluated using video cameras and proved rugged and reliable.

"The relatively low-cost system has provided a wealth of feeding-behavior data," says Brown-Brandl. "We're reading every single antenna every 20 seconds in the swine area, and we are working on ways to summarize the data into information that could prove to be very useful for producers."

The system will also provide valuable management information to aid in animal care. Scientists are working to determine the normal day-to-day variation in feeding behavior—time spent eating, number of eating events in a day, and timing of the events for each animal.

"If we could determine a pig's normal eating behavior, we might be able to use this system to detect illness when a pig decreases its time spent eating," Brown-Brandl says. "Sick pigs don't always appear sick. If we could identify pigs as they become sick, we may be able to treat them earlier, preventing severe illness."

Scientists are using the monitoring system's data to examine feeding behavior as it relates to age, gender, weight gain, and health of animals. They also plan to determine the number of feeder spaces needed in each pen and whether additional feeder spaces would result in a more equal distribution of pig weights across the pen.—By **Sandra Avant,** ARS.

This research is part of Food Animal Production, an ARS national program (#101) described at www.nps.ars.usda.gov.

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Agricultural engineer Tami Brown-Brandl evaluates a pig's feeding behavior with a new monitoring system that has been installed on the feeder in the background. Each pig receives an electronic ear tag that allows the system to identify it and record its presence at the feeder.

PEGGY GREB (D2909-1)

Savvy Seed Sorter Gains New Fans

Simple, swift, and comparatively inexpensive, a color-image-based seed sorter is helping plant breeders and others separate the seeds they want from those they don't—with an impressive degree of accuracy.

Agricultural Research Service agricultural engineer Thomas C. Pearson, based at the agency's Center for Grain and Animal Health Research in Manhattan, Kansas, developed the sorter in collaboration with National Manufacturing in Lincoln, Nebraska. The company has marketed the device to customers in the United States and abroad since 2010.

In tests, the compact, portable sorter—a simpler and faster version of other machine-vision equipment that Pearson developed in 2009—speedily differentiated kernels of hard red wheat from kernels of hard white winter wheat with 98.6 percent accuracy. Says Pearson, "Breeders cross red and white varieties of these breadmaking wheats to transfer desirable traits from one to another. Test fields are planted with both hard red and hard white wheat. At harvest, the seeds have to be separated."

The sorter is also skilled at separating yellow from brown flax and barley from durum wheat.

Pearson explains that yellow flax is used somewhat like sesame seeds as a tasty, nut-flavored garnish for breads and other baked goods, while brown flax is harvested for its oil. The sorter was accurate 94 percent of the time in detecting yellow flax seeds from brown ones in Pearson's tests.

Barley plants can sometimes turn up as unwanted "rogues" or "volunteers" in neighboring test rows of candidate durum wheats. The sorter system detected durum kernels with 93 percent accuracy, Pearson reports.

The device is handling other important tasks, as well. For instance, seed from native grass plants, needed for revegetating publicly owned lands in the western United States, is being sorted to rid it of seeds of unwanted plant species. A major breeder of peas and beans for vegetable farms uses the sorter to remove damaged seeds. Some university plant breeders rely on the machine to discern and discard spotty peas or to reject wheat kernels that show coloration associated with *Fusarium* head blight, a costly disease of wheat and barley.

THOMAS PEARSON (D2906-1)

The sorter assembly, which measures 3 feet by 1 foot by 3 feet, sits snugly on a wheeled base, making it easy to move from one worksite to another. Unsorted seeds are placed in a vibrating hopper and begin sliding down any of three adjacent chutes. After a seed falls off the end of its chute, a color camera equipped with an image sensor (a complementary metal-oxide semiconductor) snaps an image and sends it, via a circuit board, to a chip for processing.

The chip (a field programmable gate array) uses preprogrammed data to determine whether the seed's surface texture and red, green, and blue color values more closely match those of an "accept" seed than those of a "reject." Seeds that appear similar to "rejects" are quickly directed, via a puff of air from an air valve, into the "reject" container, while the desirable seeds fall neatly into the "accept" bucket.

Pearson's research is documented in peer-reviewed articles published in *Applied Engineering in Agriculture, Computers and Electronics in Agriculture*, and the *Journal of Food Measurement and Characterization*.—By **Marcia Wood,** ARS.

This research is part of Quality and Utilization of Agricultural Products, an ARS national program (#306) described at www.nps.ars.usda.gov.

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Biological science aide Anne Berry puts wheat in the hopper of a color-image sorter. The ARS-developed camera behind her takes and processes a color image of each kernel as it falls off the end of the chute. The kernels are then sorted based on visual features and deposited into either of two separate buckets at the base of the sorter.

Fungi Can Be Friends or Foes

PEGGY GREB (D2914-1)

PEGGY GREB (D2915-1)

Left: Research leader Amy Rossman (left) and collections manager Shannon Dominick pull some of the million-plus specimens in the U.S. National Fungus Collections. The fungi in the foreground include specimens of reishi *(Ganoderma lucidum)* and corn smut *(Ustilago maydis)*.

Above: Dried specimen of the mushroom *Amanita daucipes* retrieved from the fungus collections and ready to be sent on loan for mycologists to study.

Fungi are a large and diverse group of organisms. Some fungi, like mushrooms, are edible and considered crops. Others, however, can cause serious diseases of crop and forest plants, and those diseases can have negative effects on local and international economies as well as on the supply of food and other materials that agriculture provides.

The Agricultural Research Service maintains a unique resource—the U.S. National Fungus Collections—for helpful and detailed information about fungi. Accurate knowledge of fungi is critical for controlling the diseases they cause.

North America's Largest Fungarium

In 1869, the Smithsonian Institution transferred its fungal collection to the U.S. Department of Agriculture. It later became the Mycological Collections and finally the U.S. National Fungus Collections.

"The collection had fewer than 3,000 specimens in 1885. It has grown to more than 1 million collected specimens and is the largest fungarium in North America today," says Amy Rossman, research leader of the Systematic Mycology and Microbiology Laboratory (SMML) in Beltsville, Maryland. "It is important that this long-standing resource be available because species and science are not static, and you can never go back in time and space. Many fungal species can be lost either through competition or habitat loss, so having this collection will become increasingly important."

When producers are faced with a fungus problem in their crops, the U.S. National Fungus Collections, its curator, and the scientists who work most directly with the collection are often the first contacts made. SMML biologist Shannon Dominick serves as the collection manager, receiving, cataloging, maintaining, and providing samples of fungi.

"When this collection was started more than 100 years ago, no one had an inkling of how DNA worked or its scientific importance," says Dominick. "Now, DNA is extracted to definitively identify fungal species that may be new or those that have been sitting in the collection for years. It is imperative that this collection be available for future scientific technologies that may help agricultural scientists and producers maintain health of a crop."

Protecting Turf Grass

The U.S. National Fungus Collections has come in handy for determining the fungus responsible for anthracnose disease in a turf grass used in the southern United States. Molecular biologist Jo Anne Crouch was asked to identify the fungal culprit of anthracnose disease in centipedegrass in that region of the country. While many suspected one fungus, *Colletotrichum sublineola,* Crouch ultimately found that a different, related fungal species, *C. eremochloae,* was the cause. She reported this finding in the journal *Mycologia* in 2012.

"DNA sequence data from modern cultures and archival fungarium specimens in this study were used to determine the identity of the fungus responsible for

PEGGY GREB (D2916-1)

Leaf-inhabiting fungus *Phyllachora concentrica* preserved as the standard reference or type specimen in the U.S. National Fungus Collections. This fungus is used by the Kuna Indians of Panama for medicinal purposes.

PEGGY GREB (D959-1)

The white, fleshy pulp surrounding the large seed of the fruit of rambutan is quite delicious. The plant that produces this fruit is susceptible to a serious fungal canker disease called "corky bark." ARS scientists used specimens in the U.S. National Fungus Collections to determine that a little-known fungus was the cause.

centipedegrass anthracnose disease and to provide confirmation of its pathogenicity," says Crouch. "We investigated *C. eremochloae* based on the genetic evolutionary tree analysis and found that the isolates we obtained from centipedegrass had some physical characteristics in common with *C. sublineola,* but there were also distinct genetic differences."

Indeed, there were fixed nucleotide differences between the species in collections spanning 105 years, including a specimen of *C. sublineola* from 1904. *C. eremochloae* was identified from a fungarium specimen of centipedegrass in the U.S. National Fungus Collections. "Centipedegrass was first introduced to the United States in 1916 from China," says Crouch, "and the fungus came with it."

Now that the correct suspect has been identified, the proper fungicide can be applied to control the disease.

Fungus Invades Tropical Fruits

Another fungus has caused problems for two tropical plants—rambutan and pulasan—new crops in Honduras. Rambutan and pulasan produce edible fruits encased in coverings that have nubby or hairlike projections. A little-known fungus, *Dolabra nepheliae,* was discovered to cause a stem canker disease known as "corky bark" of rambutan and pulasan in Honduras.

The fungus causing this disease was identified using both microscopic structures and molecular sequence data by Rossman and her colleagues in the lab and in Honduras.

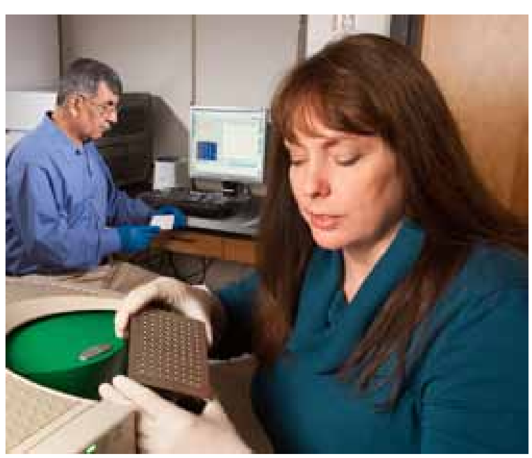
"This research will help plant pathologists to accurately identify the cause of this disease of specialty crops," says Rossman. "It will also be used by plant pathologists and plant quarantine officials to identify the fungi that cause diseases on these woody plants, thus helping control the spread of this disease and prevent its introduction into the United States."

This finding was reported in the journal *Plant Disease* in May 2012.

Earlier research helped pave the way for this discovery. *D. nepheliae* belongs to a group of fungal species that cause canker diseases on woody plants such as cherry and apple trees, as well as rambutan and pulasan. Rossman and her colleagues examined hundreds of specimens and living cultures of another three genera of canker-causing fungi from around the world to determine both their macroscopic and microscopic appearance. Molecular sequence data were analyzed to evaluate the relationships among the species in the three genera. Of the 56 species included, 13 are new to science, and all are described and illustrated with a key for their identification.

"Scientists of the past documented their research with specimens and cultures. Today, these specimens and cultures are used in ways they could not have imagined," says Rossman.—By **Sharon Durham,** ARS.

Molecular biologist Jo Anne Crouch and microbiologist Ed Ismaiel perform genotypic analysis on DNA from the pathogen that causes downy mildew of *Impatiens.*



PEGGY GREB (D2912-1)

This research is part of Plant Genetic Resources, Genomics, and Genetic Improvement (#301), Plant Diseases (#303), and Crop Protection and Quarantine (#304), three ARS national programs described at www.nps.ars.usda.gov.

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Detecting Deadly Colonies of E. coli

PEGGY GREB (D2921-1)

Six different serogroups of Shiga-toxin producing *E. coli* can be detected on this test card. A sample is placed on each test area on the card, followed by a drop of latex chemical agent bound to a specific antibody for that serogroup. The results are visible within a few minutes.

Shiga-toxin-producing *Escherichia coli* (STEC) serogroup O157:H7 has long been associated with severe forms of foodborne illnesses. But these bacterial bad guys have many cousins, and six other STEC groups have also been linked to serious illnesses and outbreaks of disease.

In 2011, the U.S. Department of Agriculture's Food Safety and Inspection Service (FSIS) announced a regulation that, as of June 2012, certain beef products that test positive for any of these six groups, nicknamed the "Big Six," would be banned from being sold for public consumption. As USDA's regulatory arm, FSIS employs inspectors who collect meat samples on the front lines of meat-processing facilities. Those samples are then tested at FSIS laboratories for the presence of foodborne pathogens to help ensure that consumers' food is safe before it is sold.

Identifying proven analytical methods to detect other types of STEC besides O157:H7 in meat samples has always been a government priority. But in 2011, most of the existing detection methods for the Big Six were in the research stage and were not commercially available.

"Early laboratory methods to detect the Big Six were time-consuming and cost prohibitive," says William Cray, chief of the microbiology branch of the USDA-FSIS Eastern Laboratory in Athens, Georgia. "Improved, validated methods were needed, and fast."

FSIS scientists have long collaborated with researchers at the ARS Eastern Regional Research Center (ERRC) at Wyndmoor, Pennsylvania, so working together to produce a fast, accurate detection method for the Big Six was a natural progression.

ARS chemist Marjorie Medina and colleagues developed an analytical method that screened for all six non-O157 STEC groups. Medina—who is lead author of a published study about the method—recently retired from ERRC's Residue Chemistry and Predictive Microbiology Unit. Coauthors include colleagues in ERRC's Molecular Characterization and Foodborne Pathogens Unit; the ARS Biosciences Research Laboratory in Fargo, North Dakota; FSIS in Athens; and Pennsylvania State University in University Park.

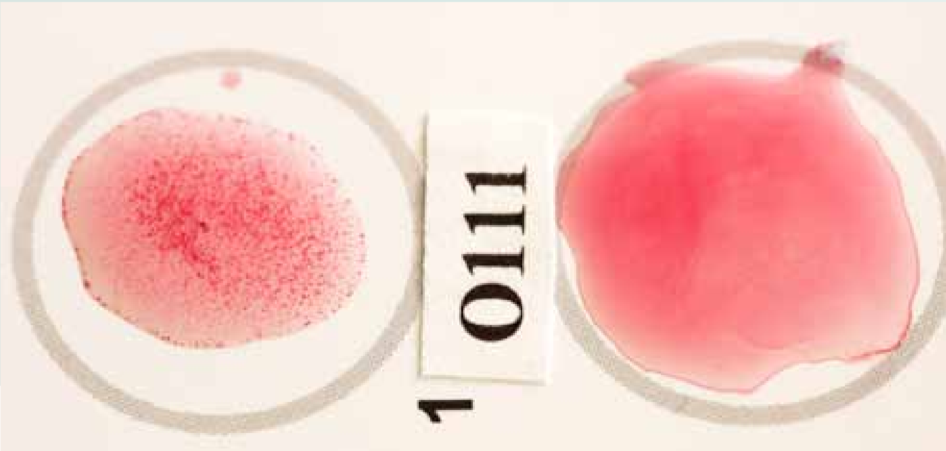
Medina and colleagues developed a method to make a latex chemical agent that hooks, or binds, to bacterial cells in the presence of antibodies against any of the Big Six pathogens. This binding lets food safety scientists verify the presence of any one of the six major non-O157 STECs individually.

To produce antibodies against the STECs, the ERRC researchers injected dead bacteria of individual types into laboratory animals. This activated the animals' immune systems, which produced the antibodies (IgG) that were collected, purified, and then linked to plastic (polystyrene latex) particles, resulting in a latex-IgG complex.

When the researchers mixed a fresh colony of *E. coli* onto a slide or test card laden with the latex-IgG complex, clumping of the STEC colony was observed instantly. Clumping indicated that the STEC cells were binding to the antibodies, giving a positive result. Flaking, or suspension, indicated bacteria would not bind to the antibodies, giving a negative result.

Through a cooperative partnership with Abraxis LLC, Warminster, Pennsylvania, the technology was tested and validated. In July 2012, commercial test kits based on the ERRC latex-IgG complex and manufactured by Abraxis were rolled out at the International Association for Food Protection conference.

PEGGY GREB (D2922-1)



In this test for STEC serogroup O111 bacteria, the sample on the left tested positive, whereas the one on the right was negative. The red clumps that formed in the sample on the left indicate that the O111 bacteria have bound with the O111 antibody-coated latex beads on the card.

Below: Research leader Pina Fratamico (right) and retired chemist Marjorie Medina perform an assay on a sample from an agar medium presumed to contain STEC bacteria.

“The IgG is uniformly attached to the surface of microbeads, forming a latex-IgG complex used for test kits,” says Medina. “The IgG on the microbeads acts like a molecular hook, and when the beads bump into the bacteria, they capture the bacteria.”

The ERRC technology is a key component of commercialized test kits, which are now being used by FSIS laboratories that receive meat samples collected from meat processing plants for analysis, according to Cray, a coauthor of the study.

Diagnostic polymerase chain reaction-based tests are first used for preliminary identification of individual STEC groups in the meat samples. Then the test kits are used to confirm the presence of live colonies of STECs belonging to the specific group. The published method for making the latex-IgG complex is available on the FSIS website.

Thanks to the collaboration of FSIS and ARS, and a prompt response from ERRC scientists, a fast, effective detection method for identifying the top six non-O157 STECs on meat samples is available for food safety efforts that help protect consumers.—By **Rosalie Marion Bliss,** ARS.

This research is part of Food Safety, an ARS national program (#108) described at www.nps.ars.usda.gov.

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PEGGY GREB (D2919-1)

STEPHEN AUSMUS (D055-16)

STEPHEN AUSMUS (D056-58)

Storage Technique Preserves Citrus, Kills Pathogens

Left: Technician Remi Bonnart (foreground) flash-freezes plant shoot tips while plant physiologist Christina Walters places cryopreserved materials into cryovats for long-term storage.

Above: Plant shoot tips are frozen within droplets of cryoprotection solutions on foil strips. The strips are plunged into liquid nitrogen slush that is formed by placing liquid nitrogen in a vacuum.

Americans consume about 84 pounds of fresh and processed citrus per person each year, with oranges topping the list at 61 pounds annually. The availability of these favored fruits in grocery stores, fresh markets, and other consumer outlets is a testament to growers' success in managing the ever-present threat of pests and diseases to the nation's $3.4 billion citrus crop (2011-12), most of which is produced in Florida and California.

A major threat is citrus greening disease, also known as "Huanglongbing." First detected in Florida in August 2005, citrus greening today is the target of a multi-faceted effort by federal, state, university, and industry partners to control this costly bacterial disease and the insect responsible for spreading it, the Asian citrus psyllid. The most visible symptoms include stunted growth of citrus trees; poor flowering; blotchy, mottled leaves; and off-flavored, misshapen fruit. A diseased tree cannot be cured and starts to decline in 5 to 12 years.

Other hazards, such as droughts, freezes, hurricanes, and earthquakes, can be just as devastating to the citrus industry. Globally, human encroachment on the natural habitat of potentially valuable wild citrus genetic resources is also a concern.

Ensuring Citrus's Future

Fort Collins, Colorado, is the home of the "Fort Knox" of plant and animal germplasm preservation, the National Center for Genetic Resources Preservation (NCGRP). There, Agricultural Research Service plant physiologist Gayle Volk is spearheading a program to develop methods to back up U.S. citrus cultivars in the form of shoot-tip cuttings that have been cryopreserved—kept in frozen storage via immersion in liquid nitrogen.

The Fort Knox comparison reflects the value of the center's germplasm collections, which are crucial to research and to food security of current and future generations. The analogy also reflects the structural strength of its large storage vaults, which can withstand flooding, tornado-strength winds, and the impact from a 2,500-pound object hurtled at 125 miles an hour.

In addition to state-of-the-art equipment, NCGRP has a staff of scientific personnel renowned for expertise in the storage and evaluation of germplasm acquired from around the world—whether it be seed, pollen, and vegetative tissues (buds and stems) from endangered plants and cultivars; or blood, semen, and embryos from prized livestock breeds.

For example, Volk's laboratory, part of the center's Plant Germplasm Preservation Research Unit, is the only one in the United States that's adapted cryopreservation methods to safeguard citrus cultivars. "Once cryopreserved, citrus genetic resources are safe from biological or physical threats, and their associated maintenance costs are very low," she says. Cryopreserving shoot tips also offers a way to ensure pathogen-free germplasm for restoring lost or imperiled cultivars.

To date, Volk and her colleagues have cryopreserved shoot tips for 30 cultivars, including mandarin and navel oranges, from collections maintained by the ARS National Clonal Germplasm Repository for Citrus and Dates, located at the University of California-Riverside. The collections, among others there, contain nearly 900 accessions (specimens) and represent 132 taxonomic groups of *Citrus, Fortunella* (kumquat), and wild citrus species, whose rich genetic diversity can be tapped to improve economically important traits like yield, nutrient content, and pest and disease resistance.

"The citrus collection at Riverside is our current source of material, and we have been strategically selecting high-priority materials for the California industry from that collection as some of the first to be cryopreserved here at NCGRP," says Volk. "Riverside's citrus collection doesn't contain some of the key cultivars grown in Florida or Texas, and we will be working with people from those states to obtain a greater diversity of germplasm."

The cryopreservation process begins with removing a 1-millimeter-long shoot-tip segment from new citrus growth, called "flush," and immersing the tissue in a solution containing glycerol, sugar, and other cryoprotectants. This preparatory step is critical because it displaces water in shoot tip cells and prevents lethal ice crystals from forming during the next phase—immersion in liquid nitrogen at -196˚C (-321˚F). As they are needed, the cryopreserved tips can be removed from the vials in which they are stored and carefully thawed for rootstock grafting procedures that lead to whole, young citrus plants.

Initial results showed that, on average, 53 percent of shoot tips survive cryopreservation, and they have now refined the technique to achieve average regrowth levels of 83 percent. A paper reporting the detailed methods has been published in the journal *CryoLetters*. Long-term experiments are under way to confirm the viability of the regenerated plants and make sure that they are identical, or true-to-type, to the plants from which they were originally derived.

Putting Pathogens on Ice

Cryopreservation has an added benefit of eliminating bacteria, viruses, and viroids to ensure disease-free germplasm for citrus research, breeding, and commercial operations. Volk's team has used the approach—dubbed "cryotherapy" by the Chinese researcher who first investigated it—to eliminate pathogens from citrus shoot tips, which are composed of meristem cells.

These cells are important to cryotherapy because they are especially small, densely packed, and often not infected with pathogens that reside in the more mature, vascular tissues. Most importantly, meristem cells survive being frozen in liquid nitrogen, unlike larger cells in the shoot-tips, especially those cells harboring pathogens. Additionally, the procedure leaves much of the shoot-tip intact, which expedites regeneration of whole plants.

"If cryotherapy proves to be an effective way to clean up diseased material, then it will facilitate movement of breeding lines and cultivars among the states where quarantines are in effect to restrict the spread of citrus greening," says Volk.—By **Jan Suszkiw,** 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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Citrus shoot tips were cryopreserved and then micrografted onto seedling rootstocks. This recovered plant is about 2 months old.

RICHARD LEE MARCH (D2881-1)

At ARS's National Clonal Germplasm Repository for Citrus and Dates in Riverside, California, technician Brittany Moreland selects citrus shoot tips for cryopreservation at the ARS germplasm repository in Fort Collins, Colorado.

RICHARD LEE MARCH (D2883-1)

Better French Fries: Technique Helps Lower Fat

STEPHEN AUSMUS (D1529-1)

Americans love French fries, and ARS scientists at Albany, California, are working to make this favorite food more healthful.

No doubt about it. Americans love French fries.

But fries soak up a lot of oil while they're turning a perfect golden brown in the deep-fat fryer.

Agricultural Research Service scientist Zhongli Pan and colleagues have tackled the challenge of lowering some of the fat from this favorite side order without skimping on the fries' delicious taste and texture or their pleasing appearance and aroma.

Their idea?

After potatoes are peeled and sliced into strips, and just before the raw strips are dunked in the fryer, prep them with 3 minutes of infrared (IR) heat—just like that created in home or commercial IR ovens or grills.

The IR prep "forms a nice, microscopic crust on the fries, which helps reduce oil uptake," says Pan, an agricultural engineer at the ARS Western Regional Research Center in Albany, California.

His team has made hundreds of fries—about 20 pounds in all—to determine the best combination of IR heating times and intensities, and deep-frying times and temps, to produce appetizing fries with less oil.

In these experiments, Pan's group used an IR unit with emitters that heated the top and underside of the fries, each a square-cut strip about 3/8-inch by 4 inches.

Fries that were prepped with 3 minutes of infrared at 120 kilowatts per square foot, then deep-fried at about 295°F for 7 minutes, had about one-third (37.1 percent) less oil than fresh-cut fries that were not prepped with IR heat.

What's more, an IR unit that heats all surfaces of the fries—not just the top and bottom—might lower the fries' fat content even further, according to Pan.

Of the 77 volunteer taste-testers who sampled the fries, more than half said they found the taste and color of the IR-prepped fries to be no different from that of the conventionally prepared fries. More than half of the panelists said they preferred the IR fries' crunchier texture.

"Fresh fries" are prepared from start to finish while you wait, instead of being prepared from a frozen product. Though the team has only published oil uptake comparisons for IR-prepped vs. non-IR-prepped fresh fries, the IR prep is also suitable for fries that are partially processed at a potato-processing plant, says Pan.

Typically, partially processed fries are blanched with steam or hot water for about 14 minutes to inactivate enzymes—like polyphenol oxidase—that might otherwise cause unwanted browning.

After that, the fries are air-dried for about 5 minutes, then partially fried, called "par-frying," for about 1 minute, before they are packed, frozen, stored, and then shipped for finish-frying at restaurants, cafeterias, and other eating places.

IR heating can make this process simpler, faster, more environmentally friendly, and perhaps less expensive, as well, notes Pan. That's because IR blanches the potato strips, and clobbers those enzymes, without using water. So there's no need for air-drying. Processors who opt for IR prep may be able to reduce water use and cost—and perhaps lower their energy bills, too.

The idea of prepping fries to help reduce oil uptake isn't new. But the experiments that Pan led are apparently the first to as extensively explore IR as a prepping option for fresh or finish-frying of French fries.

The team's findings are documented in a peer-reviewed scientific article published in 2012 in *Food Chemistry.* Pan collaborated in the work with Tara H. McHugh, food technologist and leader of the Processed Foods Research Unit, to which Pan belongs; Gokhan Bingol, formerly at the Albany center; and Ang Zhang of Northwest A&F University, Yangling, Shaanxi, China.

ARS and the Washington State Potato Commission funded the research.—By **Marcia Wood,** ARS.

This research is part of Quality and Utilization of Agricultural Products, an ARS national program (#306) described at www.nps.ars.usda.gov.

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PEGGY GREB (D2907-1)

Fries prepped with infrared heat before frying have less fat than conventionally prepared fries, ARS scientists have shown.

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

Locations Featured in This Magazine Issue

Locations listed west to east.

Map courtesy of Tom Patterson, U.S. National Park Service

Albany, California
9 research units ■ 241 employees

Corvallis, Oregon
3 research units ■ 127 employees

Great Basin Rangelands Research Unit, Reno, Nevada
1 research unit ■ 19 employees

U.S. Salinity Laboratory, Riverside, California
2 research units ■ 39 employees

Yakima Agricultural Research Laboratory, Wapato, Washington
1 research unit ■ 57 employees

Eastern Oregon Agricultural Research Center, Burns, Oregon
1 research unit ■ 27 employees

Northwest Watershed Research Center, Boise, Idaho
1 research unit ■ 18 employees

Tucson, Arizona
2 research units ■ 54 employees

Las Cruces, New Mexico
2 research units ■ 49 employees

Fort Collins, Colorado
7 research units ■ 141 employees

Roman L. Hruska U.S. Meat Animal Research Center, Clay Center, Nebraska
6 research units ■ 117 employees

Red River Valley Agricultural Research Center, Fargo, North Dakota
5 research units ■ 140 employees

Center for Grain and Animal Health Research, Manhattan, Kansas
5 research units ■ 125 employees

Henry A. Wallace Beltsville Agricultural Research Center, Beltsville, Maryland
30 research units ■ 707 employees

Eastern Regional Research Center, Wyndmoor, Pennsylvania
6 research units ■ 190 employees

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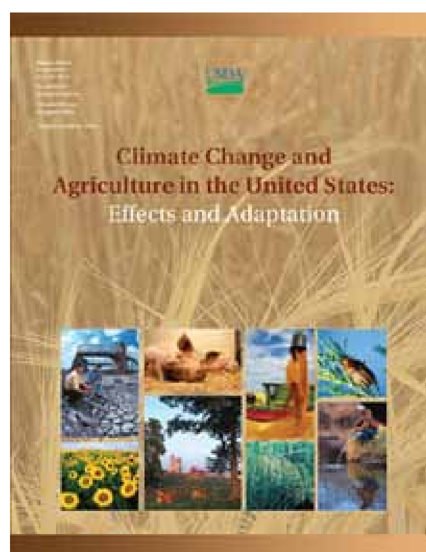

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