USDA

United States Department of Agriculture

Agricultural Research Service

IMPACTS

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Selected Accomplishments Under Research, Education, and Economics Mission Area Goals

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Low-Fat
Milk

Introduction

The Agricultural Research Service (ARS), U.S. Department of Agriculture's (USDA) chief in-house scientific research agency, exemplifies the mandate expressed in President Abraham Lincoln's 1862 Executive Order establishing the USDA to conduct "practical and scientific experiments" to improve the quality and security of agriculture in the United States. Today, with more than 2,000 scientists at 90 laboratories throughout the country, ARS continues to seek solutions to agricultural problems that affect Americans every day—on the farm, in the production of products from agricultural resources, and in the food we eat. ARS's institutional capacity makes it one of the world's premier scientific organizations and allows for coordinated and integrated research targeting national and regional agricultural priorities.

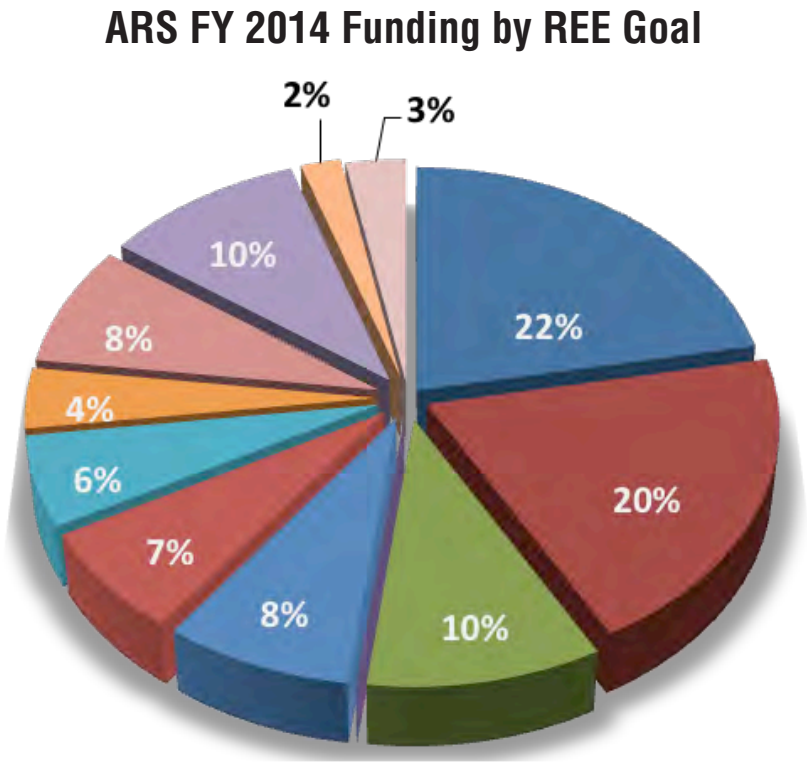
ARS's mission, vision, and research plans are directly linked to the strategic goals and priorities of USDA and the Research, Education, and Economics (REE) Mission Area Action Plan. With more than $1 billion in annual congressional appropriations, ARS routinely collaborates and shares research findings with research partners from universities, private companies, non-profit organizations, other Federal agencies, and other countries. This leadership on a wide range of agricultural issues helps to ensure the timely transfer of new knowledge and technologies to potential users—a key element of the ARS mission.

The following sections illustrate the significant recent achievements of ARS research in crop and animal production, disease and pest protection, bioenergy, natural resources, food safety, and human nutrition.

ARS FY 2014 Funding by REE Goal

Goal 1.	**Local and Global Food Supply and Security**	
1.A.	Crop and Animal Production	22%
1.B.	Crop and Animal Health	20%
1.C.	Crop and Animal Genetics, Genomics, Genetic Resources, and Biotechnology	10%
1.D.	Consumer and Industry Outreach, Policy, Markets, and Trade	--
Goal 2.	**Responding to Climate and Energy Needs**	
2.A.	Responding to Climate Variability	8%
2.B.	Bioenergy/Biofuels and Biobased Products	7%
Goal 3.	**Sustainable Use of Natural Resources**	
3.A.	Water Availability: Quality and Quantity	6%
3.B.	Landscape-Scale Conservation and Management	4%
Goal 4.	**Nutrition and Childhood Obesity**	8%
Goal 5.	**Food Safety**	10%
Goal 6.	**Education and Science Literacy**	2%
Goal 7.	**Rural Prosperity/Rural-Urban Interdependence**	3%

Total : 100%



Local and Global Food Supply and Security

Curbing a major threat to wheat

Ug99 is the first stem rust to threaten world wheat and barley in 50 years, and almost all U.S. varieties are susceptible. While Ug99 is not yet in the United States, it is spreading in Africa and the Middle East, and it is considered a risk to 90 percent of the world's wheat. ARS scientists have identified Sr35 and other genes that could provide resistance to Ug99, which are now being used by wheat breeders to develop new Ug99-resistant varieties. ARS researchers have also developed a new assay that can distinguish Ug99 from other rust strains—an important tool needed to combat the spread of Ug99. An important leader in the global cooperative response to Ug99, ARS is working with the U.S. Agency for International Development and other U.S. and international partners as part of the Borlaug Global Rust Initiative.

Releasing new rootstocks with tolerance to citrus greening

Citrus greening (Huanglongbing, HLB), the most serious worldwide threat to citrus production, has already reduced Florida citrus production by 50 percent. Now, ARS scientists have released nine new citrus rootstocks on which grafted tree stocks have displayed much higher sweet orange fruit productivity and tree health than standard rootstocks in field trials in areas severely affected by citrus greening, when no inherent genetic protection has previously been available. In addition, ARS researchers have released a new hybrid sweet orange with high-quality fruit with excellent tolerance to citrus greening. Release of these rootstocks and tolerant hybrid is offering citrus growers new options for production in the presence of this disease.

Enhancing milk production with improved fertility

ARS computer modeling is helping the dairy industry put a halt to declining fertility rates in Holstein cattle, the primary breed for milk production in the United States. Dropping fertility has led to increases in the cost of milk. ARS scientists used extensive datasets going back to the 1960s to develop a computer model

that incorporates information about multiple production traits for multiple breeds and crossbreds and the environment to more accurately predict the impact of genetic backgrounds associated with fertility. The new model and data are being used by ARS and the Council on Dairy Cattle Breeding to improve genetic evaluations for selecting animals for improved fertility.

Producing high-protein fish feed from barley

To help control high feed costs, a significant production expense in commercial aquaculture, ARS scientists have developed and patented a process to turn barley that is too high in protein for use in malting into a protein concentrate that can be incorporated into aquaculture feeds. Rainbow trout and Atlantic salmon showed rapid growth on the highly digestible concentrate, which replaced more expensive ingredients such as fishmeal. A pilot plant for barley concentrate production has been built and is delivering product to commercial fish farms in Idaho. Two more plants are in the development phase.

Improving pollinator health

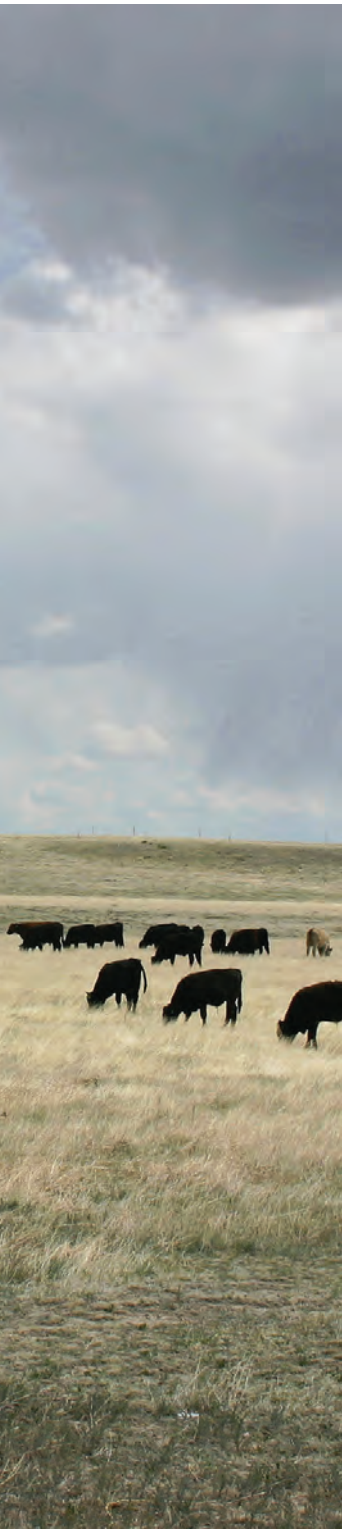
The health of American pollinators, especially honey bees, is of critical importance to farmers and other agricultural producers, especially in light of the high rate of winter deaths in managed colonies in recent years. ARS scientists are conducting extensive research to identify and mitigate the serious threats to the health and well-being of honey bees and other pollinators such as pathogens, parasites, predators, nutritional deficiencies, and pesticide exposure. ARS researchers have discovered genes and molecular markers in honey bees for resistance to tracheal and *Varroa* mites and chalkbrood disease that are proving useful in breeding bees that are better able to resist their adverse effects. ARS scientists are conducting area-wide projects in Arizona, Maryland, and Mississippi to precisely examine the effect of neonicotinoid pesticides on honey bee health when they are applied to row crops under realistic conditions. This research also includes developing application technologies and strategies to help reduce exposure of honey bees to pesticides.

Leading efforts for global food security

ARS scientists are working as part of the President's Feed the Future Initiative under the U.S. Agency for International Development to address chronic food insecurity in developing countries, principally in Africa and the Middle East. ARS scientists are helping researchers and growers in those regions build a foundation of cutting-edge technical skills and knowledge that will have a lasting and sustainable impact beyond addressing problems of immediate concern. These collaborative efforts have already spawned a goat improvement program that applies modern genomics tools to improve food animal health, breeding, and production in Africa; a program to develop improved peanut and maize lines with resistance to aflatoxin contamination and the use of biological control agents for control of aflatoxin; and a project to develop highly productive pulse crops (dry beans, peas, and lentils) with heat, drought, and disease resistance, with the goal of increasing dry-bean productivity for low-input agriculture systems.

Safekeeping and distributing the genetic foundation for new crops

ARS maintains one of the world's oldest and largest plant genetic resource collections at 19 locations around the United States. These genebanks, which hold material from cultivated plants and their wild relatives, currently safeguard 218 plant families, 2,378 genera, 14,851 species, and more than 569,000 individual accessions. ARS offers access to these genetic resources, free of charge and without restriction, to researchers and breeders from all over the world. During the past 5 years, ARS genebanks distributed more than 1 million samples to researchers and breeders. While most of these samples were supplied to requesters in the United States, more than 200,000 were sent to foreign researchers and breeders. In addition, in 2014, ARS plant breeders and researchers developed and released 398 new plant varieties and enhanced germplasm lines with desirable new traits such as extended pest tolerance, greater disease resistance, new flavor possibilities, increased growing range, and enhanced nutrition, as part of an effort to help create new markets and enhance economic opportunities for rural America.



Developing a better vaccine for deadly foot-and-mouth disease

Foot-and-mouth disease, which affects cattle, sheep, goats, pigs, deer, and bison, is caused by one of the most contagious viruses. The disease is not in the United States at this time, but were it to re-appear, it would result in extensive animal quarantines and disruptive restrictions on U.S. trade with other countries. Given the seriousness of the disease, ARS scientists' development of a next-generation "leaderless" vaccine that does not use the live virus to produce is a major advancement. This new vaccine is safer than current foot-and-mouth disease vaccine technologies, which depend on naturally occurring viruses. This is a major enhancement in vaccine technologies. A patent has been filed for this new technology, which is currently being developed in partnership with a multinational pharmaceutical company.

Responding to Climate and Energy Needs

Boosting cultivated rice yields with weedy rice traits

Carbon dioxide (CO_2) is increasing globally, and researchers already know that plants, which convert CO_2 to sugars as part of the photosynthesis process, are likely to react to rising CO_2 in undetermined ways that could affect crop yield, disease susceptibility, and growth. As ARS scientists evaluated the specific effects of increased CO_2 on plants in both greenhouse tests and field studies, they determined that existing plant varieties could benefit from traits found in their more "weedy" and resilient relatives. A recent study of several varieties of commercial rice and weedy red rice showed that red rice had higher seed yields than cultivated rice when both were grown under elevated CO_2 levels. Crop breeders are using this weedy rice trait to develop commercial rice cultivars with a greater ability to take advantage of rising CO_2 levels to produce higher seed yields.

Making fuels from forages

ARS scientists have developed a new variety of switchgrass, named "Liberty," specifically for biofuel production that can increase yield by as much as 75 to 160 more gallons of ethanol per acre than previously possible. Research has shown that farmers can expect current varieties of switchgrass to yield enough biomass to produce 100 to 400 gallons of ethanol per acre. Switchgrass, a native prairie grass long used for conservation plantings and cattle feed in the United States, has recently been seen as a potential feedstock for bioenergy production. As a perennial plant, switchgrass has the advantage of not needing annual planting and tillage, which also saves on planting costs and energy. Liberty has been made available to the public for use in new plantings for bioenergy.

Keeping soil in place despite extreme weather

A computer model developed by ARS researchers to evaluate the effectiveness of various tillage and cropping systems in controlling soil erosion under climatic changes has provided a scientific basis for adopting conservation tillage to combat soil erosion in regions expected to experience an increase in precipitation intensity under changing weather conditions. In Oklahoma, yearly precipitation

is expected to drop, but the number of extreme rainfall events is expected to increase as the climate changes with global warming. Soil erosion there could be expected to increase because of the increased occurrence and intensity of heavy storms. Results of the modeling showed that conservation tillage, especially no-till, offered the best option for keeping soil loss within acceptable levels.

Producing biodiesel without the messy oil

ARS researchers have developed an alternate method, called "in situ transesterification," to convert vegetable oils and animal fats into biodiesel that converts the lipid portions directly while they are still part of the raw agricultural material. In the conventional method, it is necessary to first isolate and purify the lipids from the rest of the plant and animal matter. The technologies for doing so increase production costs and involve the use of chemicals not legally permitted everywhere. ARS researchers have optimized the in situ transesterification reaction and demonstrated the ability of this process to produce biodiesel from a wide variety of feedstocks at any scale and in any location. The research has influenced a number of groups outside USDA to use the process to successfully create small amounts of biodiesel from algae, cottonseed meal, oil palm pulp, Jatropha, and municipal sewage sludge.

Turning garbage into fuel

To demonstrate the flexibility of biorefineries in handling and processing a wide variety of feedstocks and biomass sources, ARS researchers developed a large-scale pilot biorefinery at the Crazy Horse Landfill in Salinas, CA. Between growing seasons, the biorefinery converts rural and urban solid waste into ethanol, biogas, compost, and other value-added recyclables. Each ton of food-processing waste at the landfill currently can be converted into 65 gallons of ethanol. If the same biomass source were to be converted to liquefied natural biogas (which has the same burn rate as 100 percent ethanol), the biomass could yield about 100 gallons of transportation fuel, which can be used to power diesel turbines. Together, ARS and the City of Salinas have created an "energy park" that converts both agricultural biomass and curb-collected garbage into bioenergy in the same biorefinery.

Sustainable Use of Natural Resources

Creating an ecosystem research network

A unique and important contribution that ARS makes in climate change and sustainability research is the opportunity to collect data over long periods of time that document changes across local areas, regions, and even continental gradients. ARS, in partnership with several universities, has organized 18 existing experimental watersheds, ranges, and research farms into a Long-Term Agro-ecosystem Research (LTAR) network (www.ltar.ars.usda.gov) for the collection and sharing of compatible data across sites. This will facilitate cross-site data analysis and synthesis to make the most effective use of the data. The LTAR network provides the infrastructure to enhance research on agricultural processes at a variety of scales, including how key agricultural system components interact at larger scales, create common data sets using shared research protocols, and support long-term investigations into the sustainable intensification of agricultural production across multiple locations and ecosystems. The LTAR network has now grown to a collaboration among more than 60 colleges and universities, as well as Federal and State agencies, nongovernmental organizations, private industry, and international researchers.

Stretching groundwater supplies

ARS works to improve water conservation for the Ogallala Aquifer with a consortium of several universities in Kansas and Texas to help agricultural producers use this resource as cost-effectively as possible. The Ogallala Aquifer covers around 225,000 square miles in 8 States from South Dakota to Texas and supplies 30 percent of all groundwater used for irrigation. But increasing demands from agricultural, municipal, and industrial development on the Great Plains has led to water being pumped out of a large portion of the aquifer much more quickly than can be replenished. By helping producers determine how to maximize returns for each acre-foot of water used, the Ogallala Aquifer Program helps not only to conserve this irreplaceable natural resource but also to preserve the agricultural community that depends on the Ogallala Aquifer as a catalyst for economic activity, since every dollar of farm income has a substantial multiplier effect in the rural community.

Improving tillage management for sustainable production

ARS scientists found that cover crops and no-till production systems led to desirable increases in carbon, nitrogen, and enzyme activity in the soil in a 6-year evaluation of Mississippi cotton fields. Such conservation practices are an increasingly important component of sustainable management systems, and information is needed about how these practices affect soil quality. Farmers who use conservation tillage management and cover crops may increase the sustainability of their production systems, although overall soil quality improved in all tillage systems.

Cleaning up the Chesapeake Bay

To help producers reduce nutrient loss from farm fields into the Chesapeake Bay, ARS scientists used soil maps and weather forecast data to develop simple models that predict the likelihood of runoff on agricultural soils. These models give producers another tool for determining when and where to apply fertilizers and manure, which will help reduce nutrient runoff into local watersheds and the Chesapeake Bay. Mid-Atlantic States are making significant efforts to reduce nutrient runoff from farm fields and other sources into the Chesapeake Bay, and ARS is helping to make that happen.

Developing new seeding method to restore rangelands

ARS researchers have developed protective “seed pillows” as a new way to reseed western rangelands damaged by fires, invasive grasses, or other problems. In early spring, seeds protected by these pillows can be planted in wet or frozen soils. The pillows provide stability to help seedling roots penetrate the soil and reduce seed loss from erosion. The pillows can be adapted with fertilizers, beneficial organisms, water-absorbent material, and other amendments according to the individual needs of a wide variety of seeds.

Developing a new biocontrol for Canada thistle

ARS scientists have developed a new way to use a pathogenic fungus to kill Canada thistle, a non-native invasive weed that is difficult to eradicate. The fungus, which is a natural enemy of Canada thistle, kills the weed but does not attack other plants, notably crops. This new approach calls for grinding leaves from thistle plants already infected by the fungus and adding the ground leaves to newly emerged thistle rosettes in the fall. The diseased leaves contain millions of spores that spread the fungus to new plants. Once the spores germinate, the fungus infects the weed's roots and kills the weed. This initial infection triggers an epidemic among other thistle plants, and the disease spreads naturally without further input. The approach has already been highly successful in field trials conducted at 13 sites in 4 countries. Some fields were completely rid of the noxious weed.

Taming cover crops with a new tool

ARS scientists have patented a new tool that flattens stubborn cover crops so that farmers can plant their cash crops through them more easily. The cover crop "residue manager" firmly flattens cover crop stalks to keep them from obstructing machinery used to plant seeds. The device also prevents "hair pinning" or plant residue from interfering with contact between seed and soil. Cover crop residue can also become tangled in commercial rotary row cleaners, but the new residue manager doesn't have any rotating parts. The residue manager can be attached to a standard planter or seed drill and adjusted to accommodate a number of different cover crops, seed drills, and planters. It even adjusts to hills, valleys, or depressions as the implement runs through a field.

Developing a smarter way to spray

Orchardists and nursery operations could reduce their pesticide use by more than 50 percent with costs as low as one-third those of conventional sprayers by making use of a high-tech spraying system developed by ARS scientists. The system centers around an automated variable-rate, air-assisted precision sprayer that gauges the presence, size, shape, and foliage density of target trees and applies an optimum amount of pesticide accordingly. The pest control efficacies of the new sprayer are comparable to those of conventional sprayers but without most of the airborne spray drift. Users could save an average of $230 per acre in annual pesticide costs.

Using cover crops for cattle forage

Cover crops are known to improve carbon sequestration, soil water retention, and erosion control when cash crops are not being grown. ARS scientists determined that growing cover crops provides an additional benefit as cattle forage in Southern Piedmont cotton production management. Cover crops can provide cattle with about a ton of forage per acre per year. The value of rye forage (based on its hay equivalent) on which cattle were grazed returned an additional $33 per acre, compared to fields where only cotton lint and seed had been harvested. In addition, approximately one-third of the forage consumed by the cattle was returned to the fields as manure, which helped maintain soil organic matter.

Nutrition and Childhood Obesity

Making the latest nutritional data available

ARS scientists compiled nutritional information for a 2014 update of the USDA National Nutrient Database for Standard Reference, which now includes data for more than 8,600 food items. Nutrient profiles have been updated using data generated by ARS and through collaborations with the food industry and other researchers. The Internet "dashboard" that users see after launching the online version of the database has been reorganized so that users can more easily select and view food-nutrient profiles from individual food groups. Another new consumer-oriented upgrade allows users to look up the amount of a specific nutrient within any of the food items in the database.

Determining more accurate calorie requirements for kids

ARS-funded research has determined that Dietary Reference Intake (DRI) standards overestimate the calories required to meet the energy needs of preschool children. Current DRI standards are based on previous studies in which preschoolers were under-represented and which did not address how substantial differences in physical activity level might affect their energy needs. The new studies included 97 children, whose total energy expenditure, short-term metabolic needs, and long-term metabolic needs were measured. Not only did the new studies show that current DRI standards for energy often overestimate caloric need for young children, but that physical activity sometimes can increase caloric demand by almost 600 calories per day. This research will support nutritionists in providing guidance on the appropriate caloric intake levels for children, which may help stem the increase in childhood obesity that has been taking place over the past 30 years.

Getting the calories right for nuts

After conducting precise energy-balance studies with volunteers, ARS researchers found that almonds provide one-third fewer calories than the value listed on nutrition labels, and pistachios provide about 5 percent fewer calories than the listed amount. People trying to watch their weight often avoid eating nuts, which are high in fat and calories. However, in observational studies, people who eat the most nuts generally have normal body weights. The discrepancy between actual calories and the listed value may be part of the reason. These results could be used by the U.S. Food and Drug Administration to update calorie information on food labels. All types of nuts are good sources of nutrients like fiber and magnesium and are already recommended in the Dietary Guidelines for Americans.

Food Safety

Confirming that our food supply is safe

ARS researchers collected more than 500 samples of fat from U.S. slaughter facilities over a period of 13 months and analyzed the samples for dioxins and dioxin-like compounds, which are common organic impurities, as part of an every-5-year effort to ensure the quality of the U.S. food supply. USDA's Food Safety and Inspection Service oversees the overall effort to assess background levels of a range of persistent organic pollutants in U.S. beef, pork, turkey, and chicken to determine if background levels of these contaminants are increasing or decreasing in food animals. Dioxin and dioxin-like compound levels are consistently low in the U.S. meat supply and have been continually declining—findings that help confirm that U.S. producers are increasingly successful in their efforts to enhance the quality and safety of the U.S. meat supply.

Reducing pathogen levels in refrigerated poultry

Refrigerated chicken sold in grocery stores is often contaminated with low levels of *Salmonella*, a pathogen that can cause foodborne illness unless it is destroyed by cooking. Based on studies that assessed the growth of *Salmonella* bacteria in chicken meat in cold storage, ARS researchers determined that at 54 to 61 degrees F, *Salmonella* growth was highest on dark meat, intermediate on skin, and lowest on white meat. The researchers used these findings to develop and validate a computer model that predicts *Salmonell*a growth and survival on chicken stored at temperatures up to 61 degrees F. The new model will help the chicken industry, regulatory agencies, and consumers improve food handling and storage processes and lower the risk of developing foodborne illness from consuming chicken contaminated with *Salmonella*.

Education and Science Literacy

Paying it forward: ARS scientists and the next generation of scientists

ARS is as involved in developing the scientists of tomorrow as it is in solving the problems facing agriculture today. Each year, ARS scientists bring hundreds of students, from high schoolers to those seeking postgraduate degrees, into their laboratories to conduct experiments, feed and care for animals, help with field work, and provide substantive support to ARS research. These students learn the research methods, procedures, and discipline needed for their future in scientific discovery. While mentoring students and young scientists is not the primary function of ARS researchers, it is an important measure of the leadership and community stewardship ARS scientists have always demonstrated toward agriculture and related sciences. Additionally, more than half of ARS scientists hold adjunct appointments at the land-grant universities where they are co-located, which provides them opportunities to serve as academic advisors to students and maintain strong research relationships with other faculty members.

Building a diverse workforce

ARS is committed to increasing the diversity of its workforce. The agency has several ongoing programs to provide workplace training and experience for students from underserved communities. In cooperation with the Hispanic Association of Colleges and Universities (HACU), ARS hosted 41 HACU students during 2014 who received on-the-job training and gained experience in information technology, real and personal property management, budget processes, human resources, and general management. In addition, ARS continues outreach activities at kindergarden through grade 12 (K-12) schools, land-grant colleges and universities, and minority-serving institutions to educate students about ARS career opportunities. ARS has partnered with a number of organizations including the Society for Advancement of Chicanos/Latinos and Native Americans in Science; Minorities in Agriculture, Natural Resources, and Related Sciences; Federal Asian Pacific American Council; the League of United Latin American Citizens; and the Thurgood Marshall College Fund to provide opportunities for minority and under-represented groups.

ARS Involvement in Training and Mentoring – 2014	
Pathways interns/graduates	270
Graduate students	628
Undergraduate students	1,093
Post-doctoral appointments	306
ARS adjunct appointments	1,094
Academic advisors	667

Rural Prosperity/Rural-Urban Interdependence

Testing assumptions about recycled wastewater

Despite assumptions to the contrary, ARS studies showed that using reclaimed municipal wastewater for irrigation does not cause antibiotic resistance in soil microbes, even though the wastewater often contains pharmaceutical compounds. Reclaiming wastewater for irrigation is an increasingly attractive option for extending water supplies, but high levels of antibiotic resistance have been appearing in soil microbes exposed to recycled wastewater. Whether the antibiotic resistance is coincidental to exposure to antibiotics in wastewater or a result of such exposure has been unclear. ARS scientists compared antibiotic resistance levels in soil microbes from two water-supply facilities: a "control" facility that is recharged by groundwater and a facility that processed wastewater. The scientists found that water from the two facilities contained microbes that had similar levels of resistance, but resistance to four antibiotics was higher in microbes from the "control" facility than in those from the facility that processed wastewater. These findings demonstrate the importance of challenging assumptions about the effect of recycled wastewater on soil microbial antibiotic resistance and help expand options for increasing water supplies for irrigation from recycled wastewater.

Improving air quality for our neighbors

ARS scientists have determined that just three compounds are responsible for generating over two-thirds of detectable odors in beef manure, and most of these odors are released within 24 hours after manure is applied to the soil. Identifying and targeting the compounds responsible for manure odors can help control emission of gases and aerosols that cause objectionable odors from manure used to amend crop fields. ARS scientists evaluated how land application practices, diet, soil moisture, and application procedures affect emissions of odor-causing chemicals. Incorporating the manure into the soil and irrigating afterwards reduced most of the odor compounds measured. These findings can help livestock producers manage air quality issues associated with concentrated feedlots.

Luring stink bugs to their fate

Two new brown marmorated stink bug (BMSB) pheromone attractants have been identified and synthesized by ARS researchers. They could be used in commercial lures and traps to help keep this invasive pest out of backyards, gardens, homes, and agricultural operations. This pest has devastated U.S. orchards, crops, and fields and has spread to more than 40 States and parts of Canada. Traps baited with the attractants were effective throughout the summer in capturing BMSB males, females, and nymphs, and they were three times more effective when combined in one trap than when used individually.

Cleaning up Lake Erie

ARS scientists are figuring out how some agricultural pollutants are most likely to be carried off from crop fields with prairie potholes in northeast Indiana's St. Joseph River Watershed. Farmers often install tile risers to drain away excess water from these fields because they are prone to ponding. But this excess water is discharged via subsurface drains into the nearest field ditch without any filtration or processing, and the water eventually reaches Lake Erie. ARS scientists determined that water quality differed between pothole drainage that passed through tile risers and drainage that passed through blind inlets, which are similar to a French drain that channels excess water away from a building foundation. Water samples collected from drainage channeled through tile risers consistently showed the highest levels of total phosphorus lost from the fields, while phosphorus loads of water from the blind inlets were 78 percent lower on average. This information gives farmers another option for draining their fields in a way that helps to reduce agricultural pollutants in the Lake Erie Watershed.

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