



United States Department of Agriculture

FY 2017 Annual Report on Technology Transfer



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INTRODUCTION

President Abraham Lincoln coined the phrase “the People’s Department,” acknowledging the role of the U.S. Department of Agriculture in solving problems—a service that benefits all people every day. Thus, well before the coining of the modern day phrase of “technology transfer,” it was the culture of USDA to deliver solutions to the people of the United States. Today, USDA broadly defines technology transfer as the adoption of research outcomes (i.e., solutions) for public benefit. A seemingly simple statement, the process of adoption is complicated, requiring integration of many assets from disparate sources in the successful delivery of solutions. “Public benefit” is achieved through many mechanisms including public release of information, tools, and solutions (e.g., germplasm, plants, and other materials; adoption and enhancement of research outcomes by partners through collaborative research; formal cooperative research and development agreements (CRADA) authorized by the Federal Technology Transfer Act (1986); direct Federal, State, or local technical assistance; or through licensing of biological materials or protected intellectual property directly to not-for-profit entities and for-profit private-sector firms). Additionally, successful adoption of USDA knowledge and research outcomes typically requires complementary assets and services provided by multiple agencies in USDA, including agencies that are not primarily engaged in direct research in the physical and life science arenas.

Private-sector involvement in technology transfer adds the benefits of creating new or expanded businesses, jobs, and economic prosperity. Science-based innovations from USDA intramural research, often developed through public-private partnerships (PPPs), create new or improved technologies, processes, products, and services that benefit the Nation by increasing productivity, increasing efficiency (keeping costs low), and enhancing global competitiveness for the U.S. agriculture sector.

Thus, technology-transfer functions are critical to accelerating utility of public research and

development investments, creating economic activity, and in job creation and sustainable economic development.

The Agricultural Research Service (ARS) has been delegated authority by the U.S. Secretary of Agriculture to administer the patent program for ARS and to review CRADAs and administer technology licensing programs for all intramural research conducted by USDA. These activities are housed in the Office of Technology Transfer.

On October 28, 2011, following a series of reports identifying the status of technology transfer from Federal funds and Federal laboratories, the White House issued the Presidential Memorandum – “Accelerating Technology Transfer and Commercialization of Federal Research in Support of High-Growth Businesses.” Issuance of this Memorandum provided an unprecedented opportunity for unifying technology transfer across USDA science and technology agencies as the mechanism to deliver these outcomes for public good. In the USDA’s response to the Presidential Memorandum (<http://www.nist.gov/tpo/publications/upload/USDA-Tech-Transfer-Plan.pdf>), several initiatives were identified to promote technology transfer and commercialization. These initiatives ushered in a new era of unprecedented collaboration among USDA agencies to enhance services and opportunities to the customers and stakeholders of the Department. This report describes progress in implementing these initiatives.

This report also covers technology-transfer activities and metrics for the USDA, Agricultural Marketing Service (AMS), Animal and Plant Health Inspection Service (APHIS), Agricultural Research Service (ARS), Economic Research Service (ERS), Foreign Agricultural Service (FAS), Food Safety and

Inspection Service (FSIS), Forest Service (FS), Grain Inspection, Packers and Stockyards Administration (GIPSA), National Agricultural Statistics Service (NASS), National Institute of Food and Agriculture (NIFA), Natural Resources Conservation Service (NRCS), and Rural Development (RD).

COMBINED METRIC TABLES FOR ALL USDA AGENCIES

Table 1: Invention Disclosures and Patents from Animal and Plant Health Inspection Service, Agricultural Research Service, and Forest Service.

| | FY 2013 | FY 2014 | FY 2015 | FY 2016 | FY 2017 |
|-------------------------------------|---------|---------|---------|---------|---------|
| Invention Disclosures | | | | | |
| Number of new inventions disclosed | 191 | 117 | 222 | 244 | 166 |
| | | | | | |
| Patents | | | | | |
| Number of patent applications filed | 157 | 119 | 125 | 109 | 111 |
| Number of patents received | 65 | 83 | 94 | 60 | 68 |

Table 2: Active Licenses from Animal and Plant Health Inspection Service, Agricultural Research Service, and Forest Service.

| | FY 2013 | FY 2014 | FY 2015 | FY 2016 | FY 2017 |
|---------------------------------------|---------|---------|---------|---------|---------|
| Total Active Licenses | 400 | 414 | 424 | 441 | 438 |
| To small business | 139 | 154 | 150 | 152 | 155 |
| To startups | 13 | 13 | 13 | 7 | 6 |
| Invention licenses | 351 | 363 | 359 | 370 | 363 |
| | | | | | |
| Total New Licenses | 25 | 30 | 35 | 33 | 38 |
| Invention licenses | 19 | 28 | 20 | 27 | 29 |
| | | | | | |
| Income-Bearing Licenses, Total | 397 | 412 | 421 | 439 | 437 |
| Exclusive licenses | 291 | 299 | 292 | 307 | 302 |
| Partially exclusive licenses | 13 | 15 | 11 | 9 | 6 |
| Non-exclusive licenses | 93 | 98 | 118 | 120 | 129 |

Table 3: Elapsed Amount of Time for Granting Licenses and Licensing Income from Agricultural Research Service*.

| | FY 2013 | FY 2014 | FY 2015 | FY 2016 | FY 2017 |
|---|-------------|-------------|-------------|-------------|-------------|
| Elapsed Amount of Time for Granting Licenses | | | | | |
| Average (months) | 3.5 | 5.9 | 2.8 | 4.9 | 6.1 |
| Minimum (months) | 0.4 | 0.9 | 0.5 | 0.9 | 1.3 |
| Maximum (months) | 12.5 | 21.5 | 10.0 | 16.0 | 13.7 |
| | | | | | |
| License income | | | | | |
| Total active licenses | \$4,385,952 | \$4,927,938 | \$5,066,988 | \$4,784,466 | \$5,703,475 |
| Total invention license | \$4,053,931 | \$4,733,200 | \$4,842,256 | \$4,456,054 | \$5,377,909 |
| | | | | | |
| Earned Royalty Income | \$3,353,876 | \$3,610,774 | \$3,509,904 | \$3,633,239 | \$3,503,866 |

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|--|-------------|-------------|-------------|-------------|-------------|
| Earned Royalty Income from top 1% of licenses | N/R | N/R | N/R | N/R | N/R |
| Earned Royalty Income from top 5% of licenses | \$1,969,155 | \$2,048,317 | \$1,756,460 | \$1,811,637 | \$1,639,557 |
| Earned Royalty Income from top 20% of licenses | \$2,892,796 | \$3,103,143 | \$2,856,924 | \$3,043,395 | \$2,933,342 |
| Minimum Earned Royalty Income | \$5 | \$32 | \$13 | \$5 | \$15 |
| Maximum Earned Royalty Income | \$856,987 | \$575,753 | \$728,017 | \$818,537 | \$769,167 |
| Median Earned Royalty Income | \$3,609 | \$3,232 | \$3,525 | \$3,966 | \$3,698 |
| | | | | | |
| Disposition of Earned Royalty Income | | | | | |
| Percent of Earned Royalty Income distributed to inventors | 25% | 25% | 25% | 25% | 25% |
| Percent of Earned Royalty Income distributed to the agency or laboratory | 0% | 0% | 0% | 0% | 0% |
| | | | | | |
| Licenses terminated for cause | 0 | 0 | 0 | 0 | 0 |

*Only Agricultural Research Service numbers are reported due to the low numbers of Animal and Plant Health Inspection Service and Forest Service licenses and their generated income.

N/R, data is not reported due to its proprietary nature.

Table 4: Collaborative research agreements from Animal and Plant Health Inspection Service, Agricultural Research Service, and Forest Service. CRADA = Cooperative Research and Development Agreement.

| | FY 2013 | FY 2014 | FY 2015 | FY 2016 | FY 2017 |
|---|---------|---------|---------|---------|---------|
| Total Active CRADAs | 259 | 267 | 301 | 238 | 330 |
| With small businesses | 117 | 102 | 106 | 76 | 68 |
| Traditional CRADAs | 211 | 193 | 188 | 161 | 296 |
| Non-traditional CRADAs | 48 | 74 | 113 | 77 | 34 |
| | | | | | |
| Total Newly Executed CRADAs | 86 | 60 | 80 | 79 | 91 |
| With small businesses | | | 32 | 14 | 17 |
| Traditional CRADAs | 54 | 39 | 52 | 43 | 77 |
| Non-traditional CRADAs | 21 | 21 | 28 | 36 | 14 |
| | | | | | |
| Total other collaborative R&D Agreements¹ | 5,408 | 5,629 | 4,730 | 5,628 | 6,125 |
| Newly executed other collaborative R&D Agreements | 2,088 | 1,535 | 1,383 | 2,316 | 1,968 |

¹Includes Trust Fund Cooperative Agreements, Reimbursable Agreements, Material Transfer Research Agreements, Specific Cooperative Agreements and Non-Funded Cooperative Agreements, Challenge Cost-Share Agreements, Collections Agreements, Cooperative Agreements, Inter-agency & Intra-agency Agreements, Joint Venture Agreements, Participating Agreements, Research Cost-Reimbursable Agreements, Research Joint Venture Agreements.

Table 5: Small businesses, startups, and young companies from Agricultural Research Service. CRADA = Cooperative Research and Development Agreement.

| | FY 2013 | FY 2014 | FY 2015 | FY 2016 | FY 2017 |
|---|----------------|----------------|----------------|----------------|----------------|
| Total number of small businesses supported (CRADAs and licenses) | 253 | 246 | 245 | 220 | 217 |
| Total number of startups and young companies supported (licenses) | 11 | 12 | 12 | 6 | 6 |

1.0. Agricultural Marketing Service (AMS)

<https://www.ams.usda.gov>

1.1. Mission Statement

The Agricultural Marketing Service (AMS) facilitates strategic marketing of agricultural products in domestic and international markets and ensures fair trading practices and promotion of a competitive and efficient marketplace across the entire supply chain. AMS operates a range of programs under the authorization of the Agricultural Marketing Act of 1946 and over 50 additional statutes. It provides services directly to producers, traders, and consumers of U.S. food and fiber products in private industry and Federal and State governments on a reimbursable basis and conducts a number of appropriated program activities through cooperative arrangements. More than half of the funds needed to finance AMS activities (excluding commodity purchase program funds) are derived from voluntary user fees.

1.2. Nature and Structure of Program

Because of its producer-consumer focus, AMS's technology developments and transfer are directed to customer service and the customer-consumer interface. Licensing and technology transfer is handled through the separate business units and divisions within AMS. Still, the agency oversees a number of programs where innovative technological tools and practices have been used to assist agency stakeholders in marketing their food and fiber commodities. Communication of the agency's technology perspective highlights awareness of new technologies and facilitates improvement of existing technologies used by AMS. For example, one context of technology transfer by AMS provides protocols

and procedures for unifying food and commodity data from different sources into harmonized platforms permitting easy access to data for stakeholders.

1.3. Current Technology Transfer Goals, Objectives, and Measures of Success (Metrics)

Market News

The Market News Service (Market News) provides current, unbiased information on supply, demand, prices, movement, location, quality, condition, and other market data on agricultural products in specific markets and marketing areas – both domestic and international. This information is made available to the public as soon as available and free of charge. Buyers and sellers, producers and handlers, transportation and logistics companies, insurance and lending institutions, and wholesalers continually use the information to conduct their businesses. The information reported by Market News provides a high level of market transparency that contributes to the orderly marketing of agricultural commodities and helps to promote fair trade for all market participants. The market information also supports Government policymakers and is widely used for value determinations, such as in courts and dispute mediation. AMS Market News issues hundreds of reports, some daily and others weekly, for some 3,700 products and commodities resulting in millions of e-views by the public on an annual basis. AMS responds to evolving markets and products by updating its services to meet the information needs of the public. The USDA Market News website offers users the opportunity to run customized reports, graphs, and dashboards. Example of improved reports and services include: reporting of local and regional markets (auctions, farmers markets, etc.), reports on traditional products with specific attributes, and bioenergy reports on a regional basis. AMS has been developing a modern data management solution that will allow Market News to collect and disseminate sensitive market information in real time to the

public in different formats that are consumable to a wide range of customers. The agency has continued its efforts to harmonize and merge 37 different data stores into one unified user-managed IT solution (the Market Analysis and Reporting Services, or MARS) with the successful release of the next generation of MARS 2.0. MARS has improved reporting security, speed, accuracy, and flexibility for the commodities in production. Improvements in data quality and management have been completed, and better cooperator relationship management tools are now implemented. In FY 2016, Market News reporters began using MARS to report at livestock auctions, and in 2017 collection for inventory, point of sale, forward contracts, and yearly varieties were added. In the near future, developers expect both public facing dissemination capabilities and inclusion of all voluntary Market News reporting data products.

Market Information Organization of the Americas (MIOA)

AMS serves in a leadership role for the MIOA, a network of market information organizations from 33 countries in North, Central, and South America and the Caribbean. The Inter-American Institute for Cooperation on Agriculture (IICA) serves as the Technical Secretariat for MIOA. With the support of IICA and the Foreign Agricultural Service (FAS), MIOA is working on several key projects that will assist all of the member countries. These projects include: An agricultural products dictionary for the Americas, known as Wiki; technology improvement for selected member nations, a cloud-based market information system that can be given to limited-resource nations; strengthened private-sector linkage to market information systems using a Short Message System, based upon the evaluation from well-established Short Message Systems within the MIOA countries, and a “knowledge library” or the compilation of training and reference materials created to date on or for the MIOA member nations. These efforts expand the availability of price information, which facilitates international trade.

Shell Egg Surveillance

The Shell Egg Surveillance (SES) Program monitors the disposition of "restricted eggs" (eggs that are cracked, dirty, incubator rejects, inedible, leaking, or otherwise unfit for human consumption) to ensure that only eggs fit for human consumption are available to consumers. Inedible eggs constitute a small proportion of all shell eggs and are most often used in animal feed; the remaining eggs are destroyed. AMS conducts this program, in cooperation with State departments of agriculture, to ensure that shell egg handling operations are inspected at least four times annually and hatcheries are inspected at least once each year to control the disposition of certain types of under grade and restricted eggs. This program diverts eggs that are not at least U.S. Consumer Grade B--and which cannot be sold in shell form to egg breaking plants, which reassures buyers and supports efficient markets. Section 56.3 of the Regulations Governing the Voluntary Grading of Shell Eggs provides for the authorization to conduct experimental work to assess new procedures and advanced technology. Technology associated with egg inspection, including both egg washing and candling, is consistently and systematically improved for inspection and customer applications.

Standards Development

AMS develops, reviews, and maintains agricultural commodity standards to encourage uniformity and consistency of product quality attributes such as taste, color, texture, yield, weight, and physical condition. There are currently more than 500 AMS quality grade standards in place for cotton, dairy products, eggs, fresh and processed fruits and vegetables, livestock, meat, olive oil, peanuts, poultry, rabbits, and tobacco. These standards provide a common marketing framework for buyers and sellers of

commodities and are widely used by the agricultural industry in domestic and international trading, futures market contracts, and as a benchmark for purchase specifications in most private contracts. AMS grade standards are the basis for AMS Market News reports, grading services for cotton, milk and dairy products, eggs, fresh and processed fruits and vegetables; livestock, meat, olive oil, peanuts, poultry, rabbits, and tobacco; and Federal commodity procurement. In FY 2017, AMS specialists reviewed commodity standards to ensure their accuracy in describing current products, including 21 for cotton products; 87 for fruit and vegetable products; 3 for meat products (beef, lamb, and pork); and 13 for tobacco. Of note were revisions for beef, canned baked beans, raisins, and various specialty crops. Commercial item descriptions (CIDs) provide an organized knowledge base for commodity requirements and identification. They are updated regularly for most agricultural commodities and products in commerce providing harmonized sales and marketing support for agricultural product evaluation. There were 11 updates and 2 new CIDs for FY 2017 including wild rice and butters and spreads.

International Standardization Activities

To support international markets, AMS provides technical expertise to international standards organizations to protect the interests of U.S. agricultural producers. AMS remains a leader in global marketing standards initiatives and represents the U.S. in meetings of the Codex Alimentarius, the International Dairy Federation, the United Nations Economic Commission for Europe (UNECE), the Organization for Economic Cooperation and Development, the International Organization for Standardization, the International Union for the Protection of New Varieties of Plants (UPOV), the International Seed Testing Association, the International Meat Secretariat, the American Society for Testing and Materials International, the U.S. Canadian Regulatory Cooperation Council, the Inter-

American Commission on Organic Agriculture, the International Cotton Advisory Committee, international cotton outreach, and several bilateral consultative committees on Agriculture. Much of the work in international standardization involves development of methods of analysis, establishing specialized characteristic descriptions, and capture and analysis of increasingly large datasets.

Pesticide Data Program

AMS' Pesticide Data Program (PDP) is a critical component in meeting the requirements of the 1996 Food Quality Protection Act (FQPA), which directs the Secretary of Agriculture to provide improved data collection of pesticide residues, standardized analytical and data reporting methods, and increased sampling of foods most likely to be consumed by infants and children. AMS has the largest database on pesticide residues in children's foods in the U.S. In a collaborative effort, AMS, the U.S. Environmental Protection Agency (EPA), and U.S. Food and Drug Administration (FDA) coordinate and prioritize residue-testing and program activities. In addition, AMS conducts annual planning meetings with all program participants, including the cooperating State agencies and agricultural industry stakeholders, to select commodities for inclusion in the program. During FY 2017, PDP achieved greater than 99 percent of its goal in collecting samples. PDP uses statistical tools and marketing data to enhance sample collection rates. Availability issues are quickly identified through the use of a real-time sample tracking database and the use of electronic sample information forms. PDP monitors product availability and makes necessary adjustments to sampling protocols to meet collection targets. For example, PDP was still able to meet its sampling targets by collecting and testing both fresh and frozen cranberries even though fresh cranberries are a seasonal commodity that is not consistently available in the marketplace. During FY 2017, PDP developed enhancements to its electronic sampling information collection system that allows both field samplers to capture additional/new information and sampling supervisors to more

efficiently view and manage sampling records and activities. PDP enhanced its testing methods to bring the total number of pesticides and metabolites tested to over 530. PDP laboratories continue to refine analytical screening methods and expand the use of automation to reduce costs for equipment maintenance, human resources, and the management of hazardous waste. Increased use of state-of-the-art instruments and consolidation of testing methods has augmented data quality by continuing to lower limits of detection (LODs). PDP continues to expand pesticide testing by adding new chemistries as they emerge in the agricultural industry. In FY 2017, PDP deployed a new online database search application. The app can be launched from any of the public PDP Web pages to search for pesticide residue findings on products tested across all published years (1994-2015). Each year, PDP collects over 10,000 samples from the U.S. food supply and analyzes the samples for a fixed list of pesticides. The test results are stored in the national PDP database. The new search app provides easier and more transparent public access to PDP data. The app was developed in-house by the Monitoring Programs Division (MPD) and AMS' Information Technology Service. The application is expected to be used by the MPD staff, other USDA offices, Federal and State agencies, chemical companies, grower groups, environmental groups, and students.

National Organic Program (NOP)

This nationwide program increases the efficiency and enhances the competitiveness of domestic agricultural marketing for organic products. The Agricultural Act of 2014 (2014 Farm Bill) amended the Organic Foods Production Act to provide funding to modernize NOP database and technology systems. AMS provides support to the National Organic Standards Board, reviews materials for the national list of allowed synthetic materials, and coordinates the enforcement and appeals process. The legislation also requires the program to examine and accredit State and private certifying agents, who in turn,

ensure that producers and handlers are in compliance with the national organic standards. At the beginning of FY 2016, AMS launched the first release of the Organic INTEGRITY Database for the public to promote market visibility for organic operations, increase supply chain transparency, support new market growth, and deter fraud. In November 2016, AMS launched the certifier reporting module of the system. All certifiers successfully submitted information about the certified operations they oversee by the end of January 2016. Today, the new system is providing better and more up-to-date information about organic farms and businesses and the products they produce. Any public user can now conduct market research, confirm an operation's certification status, and identify supply-chain connections between buyers and sellers. Farms and businesses seeking organic certification can now also find a certifier operating in their geographic area far more easily. These long-term technology investments were made possible by the 2014 Farm Bill.

Federal Seed Program

AMS administers Federal Seed Act (Act) regulations regarding the interstate shipment of agricultural and vegetable seeds. The Act requires that seed shipped in interstate commerce be labeled with information that allows seed buyers to make informed choices. The Act also requires that all seed labeling information and advertisements pertaining to the seed must be truthful. Each State maintains its own seed laws, which creates a complicated web of regulations for seed businesses. The Act contains minimum requirements that bridge many of these State requirements, which helps promote domestic trade, encourage uniformity among State laws, and drive fair competition within the seed trade. The Federal Seed Program has begun using customized seed evaluation equipment.

Country of Origin Labeling (COOL)

COOL requires country of origin labeling for muscle cuts of lamb and ground lamb; farm-raised fish and shellfish; wild fish and shellfish; perishable agricultural commodities; peanuts, goat, chicken, ginseng, and macadamia and pecan nuts. The law also requires method of production information (farm-raised or wild caught) for fish and shellfish to be noted at the final point of sale to consumers. The regulation outlines the labeling requirements for covered commodities and the recordkeeping requirements for retailers and suppliers. The program conducts retail surveillance reviews through cooperative agreements with State agencies. In addition to retail surveillance activities, products are audited through the supply chain for accuracy of and compliance with COOL.

Commodity Research and Promotion Programs

AMS provides administrative oversight to 22 industry-funded commodity research and promotion (checkoff) programs with over \$670.5 million in industry assessments for cotton, dairy, fluid milk, beef, lamb, pork, soybeans, sorghum, eggs, highbush blueberries, Hass avocado, honey, mango, mushrooms, peanuts, popcorn, potatoes, processed raspberries, softwood lumber, watermelon, Christmas trees, paper, and paper-based packaging.

National Bioengineered Food Disclosure Standard

AMS is developing a national mandatory system for disclosing the presence of bioengineered material to increase consumer confidence and understanding of the foods they buy and to avoid uncertainty for food companies and farmers.

Sheep Production and Marketing Grant Program

The Farm Bill made funding available for a grant to one or more national entities whose mission is consistent with strengthening and enhancing the production and marketing of sheep and sheep products in the United States.

Transportation and Marketing Development

AMS monitors the agricultural transportation system (inland waterways, rail, truck, ocean bulk, and ocean containerized) and conducts market analyses that support decisions regarding the transportation of agricultural products domestically and internationally. This program assesses how the Nation's transportation system serves the agricultural and rural areas of the United States with necessary rail, barge, truck, and shipping services. AMS provides technical assistance to shippers and carriers and participates in transportation regulatory actions before various Federal agencies. In addition, AMS provides economic analyses and recommends improvements to domestic and international agricultural transportation for policy decisions. AMS supports the development of agricultural markets through technical advice and assistance to States and municipalities that are interested in creating or upgrading wholesale market facilities, auction and collection markets, retail farmers markets, food hubs, and other direct or local markets. AMS also conducts feasibility studies in cooperation with the private sector, non-profit organizations, and other government agencies to evaluate and suggest efficient ways to handle and market agricultural commodities. AMS studies changes in the marketplace to assist States, localities, market managers/operators, and growers in making strategic decisions for future business development. AMS conducted research and updated the earlier study on rural transportation. This included an examination of the sufficiency of infrastructure along waterways in the United States; the

impact of the infrastructure on the movement of agricultural goods in terms of safety, efficiency, and speed; and the benefits derived through upgrades and repairs to locks and dams. In addition to issuing many regular transportation reports that are published weekly, quarterly, and annually, AMS developed, co-authored, sponsored, and published on its AMS Transportation Research and Analysis website several new, one-time transportation analyses, articles, and resources in FY 2016. Examples include: U.S. Ethanol: An Examination of Policy, Production, Use, Distribution, and Market Interactions (Co-authored chapters 2 and 5 of this Office of the Chief Economist report) and Impacts of Intramodal Competition on 2012 Railroad Rates for Wheat (Summary).

Farmers Markets and Local Food Promotion Programs

The purpose of the Farmers Market and Local Food Promotion Program is “...to increase domestic consumption of and access to locally and regionally produced agricultural products, and to develop new market opportunities for farm and ranch operations serving local markets....” Entities eligible to apply for grants include agricultural cooperatives, producer networks, producer associations, local governments, nonprofit corporations, public benefit corporations, economic development corporations, regional farmers’ market authorities, Tribal governments, and local and regional food business enterprises. In FY 2016, AMS partnered with over 20 universities and other organizations to research, develop, and support the growth of local and regional food systems. Some of the partnerships include: George Washington University where AMS partnered to host a “Local Food Impacts” conference in the spring of 2017 to: identify best practices for quantifying the impact of local food systems’ investments on farming and low-income communities; engage practitioners about successful data collection methods; and identify metrics that are most useful and effective to measure local food-related project impacts on targeted populations; Michigan State University where AMS partnered to develop a

“Farmers Market Price Reporting and Discovery System” via a mobile and web-based application that will enable market vendors to push current special prices to customers who have elected to receive such push notifications, thereby increasing sales and customer traffic to markets; Michigan State University, Maryland Farmers Market Association, and Washington State Farmers Market Association where AMS partnered with the three organizations to evaluate the impact of farmers market and nutrition incentive programs on the sales, performance, and viability of certain farmers markets with the results from the evaluation scheduled to be released by late 2017; Cornell University where AMS partnered to conduct a study entitled “The Promise of Urban Agriculture: National Case Study of Commercial Farming in Urban Areas” to assess the profit/loss of 2 major types of urban agriculture models, land-based and structure-based (hydro, aero, other), across 15 operations in the United States; University of Wisconsin-Madison where AMS partnered to assess the “Potential Demand for Local Fresh Produce by Mobile Markets” involving 59 interviews at 6 sites across the United States to assess the impact of mobile markets that had received funding from the Farmers Market Promotion Program (FMPP); and the University of Kentucky where AMS partnered with the University of Kentucky to facilitate the study “Community Supported Agriculture (CSAs): New Models for Changing Markets” scheduled to be released by spring 2017. This study assesses opportunities, challenges, and innovations of CSAs that affect their ability to compete successfully in a growing local food marketplace while maintaining a distinct and appealing identity to customers. Although AMS does not provide funding for the construction of facilities, the Agency develops architectural plans and offers design assistance to local food businesses to improve the efficiency of permanent food market facilities. FY 2016 examples include: McGehee Desha Alumni Community Center (MDACC), McGehee, AR, Wholesale Market and the Maryland Food Center Authority (MFCA), Jessup, MD, and the Sandhills AgInnovation Center, Bethel, North Carolina. AMS began developing an “Architectural Design for Farmers Markets and Food-Related Facilities.” The document will represent a compilation of AMS’ 15-year experience in the

design of farmers markets. It includes national-level observations of the evolution of markets and how their functions have expanded to include: community kitchens, value added, food hubs, mixed-use development, community gardens, and public-private development. The document will be published online and provide design professionals and market advocates with the skills and knowledge needed to successfully create farmers markets.

Plant Variety Protection Program (PVPP)

This program is authorized by the Plant Variety Protection Act, which encourages the development of novel varieties of sexually reproduced or tuber propagated plants by providing intellectual property rights protection to the developer. The program, funded by user fees, verifies the uniqueness of varieties and issues certificates that assure developers exclusive rights to sell, reproduce, import, or export such varieties, or to use them in the production of hybrids or different varieties, for a period of 20 years for most species and 25 years for woody plants. PVPP is involved with the International Union for the Protection of New Varieties of Plants (UPOV), headquartered in Geneva, Switzerland, in defining requirements for distinctness, uniformity, and stability of plant characteristics used for developing protection of varieties. These requirements require increasing levels of biomolecular characterization and technology. The Plant Variety Protection Office (PVPO) is continuing its work to further develop the electronic Plant Variety Protection (ePVP) system by adding additional crops that will bring the total to 55 crops available from the system. The project continues to use the Agile software development technique and has released two versions of the software, release 1 and release 2, internally for examination of 47 crops by the PVPO. The release 3 project will take place in 2017 with a projected release date of June 2017. The fully operational system available to the public and stakeholders is scheduled for an official launch in late calendar year FY 2017. The ePVP system will allow stakeholders

the ability to file new plant variety applications electronically and provide PVPO examination staff with tools to conduct full examinations including variety searches.

Specialty Crop Block Grant Program

AMS administers this program by awarding grants to State departments of agriculture to enhance the competitiveness of fruits and vegetables, tree nuts, nursery crops (including floriculture), and horticulture. AMS established standardized national outcome measures to demonstrate the program's performance toward fulfilling its statutory purpose.

Perishable Agricultural Commodities Act (PACA) and the Produce Agency Act

These Acts are designed to: (1) protect producers, shippers, distributors, and retailers from loss due to unfair and fraudulent practices in the marketing of perishable agricultural commodities; and (2) prevent the unwarranted destruction or dumping of farm products handled for others. Commission merchants, dealers, and brokers handling fresh and frozen fruits and vegetables in interstate and foreign commerce must obtain a PACA license and abide by the fair trading practices established by the PACA. Traders who have been found to have committed unfair trade practices face license suspension or revocation and may be required to post surety bonds before resuming operations.

Commodity Purchases and Diversions

AMS purchases non-price supported commodities such as meats, fish, fruits, vegetables, poultry and egg products, grains and bakery products, dairy products (including cheese), and oilseed products like peanut

butter and sunflower seed oil in order to stabilize market conditions, and in support of food assistance program needs within USDA. The Web-Based Supply Chain Management (WBSCM) system supports the procurement, delivery, and management of more than 200 commodities and 4.5 million tons of food through domestic and foreign feeding programs. From its inception in FY 2011, the WBSCM system has improved the procurement, delivery, and management of more than 200 commodities and 50.8 billion pounds of 100 percent domestically produced farm food commodities at an approximate value of \$16.3 billion. These commodities are distributed through domestic and foreign feeding programs administered by AMS, Farm Service Agency (FSA), FAS, Food and Nutrition Service (FNS), and the United States Agency for International Development (USAID). Currently, the system is supporting over 10,000 registered users, executing more than 7,000 transactions weekly. The WBSCM Project Management Office (PMO), with the assistance of the General Services Administration, awarded a new contract for the Operations and Maintenance of WBSCM to CACI (Consolidated Analysis Centers, Inc.) starting on January 5, 2016. The WBSCM PMO supervised a smooth transition from the former contractor, CSRA International, to CACI with CACI taking full control of WBSCM activities on May 23, 2016. During FY 2016, Commodity Procurement Services (CPS) managed and conducted testing for six system releases focusing on internal and external customer needs, three with the former contractor and three with the new contractor. CPS's WBSCM management team developed a Statement of Work, contracted for A-123 audit services, provided all documentation for the A-123 audit, and completed and compiled spreadsheets for the WBSCM Sample Prepared-by-Client (PBC) Request list. The Acquisition Approval Request was approved in December 2015 authorizing \$28.4 million in 2016 funds, the earliest approval ever received for the fiscal year. WBSCM was given a 4.0 perfect score by USDA's Office of the Chief Information Officer (OCIO) and is "green" on the Office of Management and Budget (OMB) IT Dashboard.

Marketing Agreements and Orders

The program was established to assist farmers, milk producers, and handlers by allowing them to collectively work to solve marketing challenges. These instruments are designed to stabilize market conditions and improve the returns for fluid milk and fruit and vegetable producers. AMS oversees these various activities to ensure that they operate in the public interest and within legal parameters.

Marketing agreements and orders: (1) establish minimum prices that handlers pay to dairy producers; (2) regulate the quality and quantity of fruits and vegetables sold in commercial channels; and (3) provide for market development and promotion (including paid advertising).

Auditing, Certification, Grading, Testing and Verification Services

AMS provides impartial services verifying that agricultural products meet specified requirements. These services are voluntary, with users paying for the cost of the requested service. These services include AMS' grading program, which confirms that product meets USDA grade standards. AMS has also developed voluntary testing and process verification programs in response to the industry's growing need to facilitate the marketing of agricultural products. AMS' laboratory testing service provides analytical testing services to AMS commodity programs, other Federal agencies, and the agricultural and food community, to ensure products meet testing requirements for food safety and quality. AMS' Process Verified Program provides producers and marketers of livestock, seed products, and poultry products with the opportunity to assure customers of their ability to provide consistent quality products by having their written production and manufacturing processes confirmed through independent third-party audits. The USDA Process Verified Program uses the ISO 9000 series standards for documented quality management systems as a format for evaluation documentation to ensure consistent auditing

practices and promote international recognition of audit results. AMS's Quality Monitoring Program (QMP) is a flexible, cost-effective, quality assurance service that provides third-party monitoring of product quality and quality systems for fresh, frozen, and processed fruits and vegetables as they are received, handled, and/or produced. The program supports brand and product quality, monitors quality systems, measures supplier performance, and meets any unique quality assurance needs of the customer. In FY 2016, Subway and Gourmet Factory became the newest QMP customers.

AMS Laboratory Approval and Testing Division (LATD)

The LATD provides lab testing and approval (audit) services to AMS commodity programs and to the agricultural community in order to facilitate domestic and international marketing of food and agricultural commodities. It provides scientific and market advice to Federal partners to assist in negotiating and establishing export requirements and policies and administers laboratory approval programs which verify that the analysis of products destined to be exported meets various countries' requirements. The National Science Laboratories (NSL) provide analytical testing services in the fields of chemistry, microbiology, and molecular biology on a fee-for-service basis. The NSL's primary mission is to serve AMS commodity programs, other Federal agencies, and industries, with analytical testing in support of grading, commodity purchases, exports, compliance, product specifications, and research. The laboratory performs tests on commodities such as food products, juice products, canned and fresh fruits and vegetables, eggs and egg products, honey, meats, milk and dairy products, military and emergency food rations, oils, peanuts and other nuts, organic foods and products, and tobacco. During FY 2016, LATD administered laboratory approvals in support of AMS commodity programs including the export program (23 labs in total), aflatoxin program (39 labs in total), and internal AMS programs (18 labs in total). In administering these programs, LATD conducted onsite lab audits and

desk audits, analyzed monthly check sample data sets for the programs, and monitored each lab's proficiency data. The AMS NSL analyzed over 42,700 samples (producing over 1 million discrete analytical results) of various agriculture commodities, many of which were tested for multiple analytes.

Grading, Certification, and Audit Verification

The grading process involves applying or verifying that agricultural commodities meet quality standards. AMS provides grading and certification services on agricultural commodities for which USDA standards have been developed. AMS certification services provide assurance to buyers that the products they receive are the quantity and quality specified in their contract with the seller.

Poultry and Egg Grading

During FY 2017, AMS provided grading services to 255 poultry plants, grading 7.5 billion pounds of poultry, and 275 shell egg plants, where 3.7 billion dozen shell eggs were graded. Poultry grading services covered about 28 percent of the turkeys slaughtered, 20 percent of the broilers slaughtered, and 45 percent of the shell eggs produced in the United States, excluding eggs used for breaking and hatching. AMS issued export certificates for over 134 million dozen shell eggs, assuring foreign buyers' requirements for product quality were met.

Meat Grading

During FY 2017, AMS provided grading services to 235 meat packing and processing plants. A total of 20.9 billion pounds of meat and meat products were graded using USDA quality standards (e.g., Prime,

Choice, Select) or evaluated against company or trade specifications. Roughly 95 percent of steer/heifer, 59 percent of lamb, and 36 percent of veal commercial slaughter in the United States are voluntarily graded.

Cotton Grading

AMS classified 13,032,235 bales of cotton under the grower-classing program in FY 2016, with all cotton classed by the High Volume Instrument (HVI) method. Classing information is provided electronically to owners of the cotton. In FY 2016, the Cotton Program disseminated data for over 49 million bales. This data represents multiple crop years or multiple requests for the same bale. The AMS Cotton and Tobacco Program provided classification/certifications services on 246,929 bales of cotton submitted for futures certification during 2016 and 7,735 bales on Foreign Growth bales.

Dairy Products Grading

Dairy products grading, laboratory analysis, and dairy plant inspections assure purity and quality of dairy products. The Dairy Grading Program implemented the electronic Document Creation System (eDOCS) to facilitate the issuing of export certificates for product going to the European Union. In FY 2016, the Dairy Grading program issued more than 47,000 export certificates, which was a slight increase over FY 2015, even though U.S. dairy export sales value declined 16 percent during the first 9 months of 2016, as compared to the same period in FY 2015.

Fresh Electronic Inspection and Reporting System (FEIRS)

In FY 2017, AMS deployed computers with the FEIRS application to Federal-State terminal market inspectors in an additional 3 States, bringing the total to 15. Use of this electronic inspection application for fresh fruit and vegetables across the inspection system harmonizes Federal and State cooperators' inspection processes, software, and capabilities, and provide more electronically captured data from market inspections nationwide.

ACE Implementation

In FY 2016, AMS implemented U.S. Customs and Border Protection's (CBP) Automated Commercial Environment (ACE) for Section 8e fruit and vegetable imports as part of the International Trade Data System (ITDS). The electronic filing option was added to bring import regulations for specialty crops into conformance with the current practice of electronically filing Form FV-6, Importer's Exempt Commodity, using the Marketing Order Online System, an Internet-based application implemented in 2008. Beginning July 23, 2016, CBP began requiring that all importers submit their entry filings through the ACE as part of a Government-wide deployment of the new ITDS. The ACE electronic interface is accelerating the processing of entry filings for all importers by automating clearance processes by all Government agencies, including AMS. With ACE, importers can determine the entry status under AMS' or any other agency's requirements that impact release by CBP for entry into the United States. Presenting products for AMS inspection segregated by Customs Entry Number allows AMS to notify CBP so that those products can be released into the trade channels quickly and efficiently.

Compliance Systems

AMS continued work on implementing the International Trade Data System (ITDS) and the Compliance and Enforcement Management System (CEMS) and remains on schedule to fully implement new procedures for industry members by the Executive Order's December 2016 mandate. The effort has been coordinated with Customs and Border Protection for connectivity with its Automated Commercial Environment.

2.0. Animal and Plant Health Inspection Service (APHIS)

2.0.1. Introduction

USDA broadly defines technology transfer as the *adoption of research outcomes (i.e., solutions) for public benefit*. Seemingly a simple statement, that process of adoption is complicated, requiring integration of many assets from disparate sources in the successful delivery of solutions. “Public benefit” is achieved through many mechanisms including public release of information, tools, and solutions (e.g., germplasm, plants, and other materials), adoption by partners through collaborative research, formal cooperative research and development agreements (CRADA) authorized by the Federal Technology Transfer Act (1986), direct Federal, State, or local technical assistance, or through licensing of biological materials or protected intellectual property directly to not-for-profit entities and for-profit private-sector firms. This report summarizes the Technology Transfer accomplishments of all APHIS Programs for fiscal year 2015.

2.0.2. Combined Metric Tables

TABLE 1. Collaborative Relationships for Research and Development (R&D)

| APHIS-Wildlife Services (WS) | FY 2013 | FY 2014 | FY 2015 | FY 2016 | FY 2017 |
|--|---------|---------|---------|---------|---------|
| • CRADAs, total active | 9 | 9 | 11 | 9 | 6 |
| - New, executed | 3 | 1 | 1 | 2 | 0 |
| ▪ Amendments ¹ , total active | 7 | 9 | 8 | 7 | 6 |
| - New, executed | 5 | 3 | 3 | 2 | 2 |
| ▪ Traditional CRADAs, total active | 9 | 9 | 11 | 9 | 6 |
| - New, executed | 3 | 1 | 1 | 2 | 0 |
| ▪ Small Business Cooperators, total active | 7 | 6 | 8 | 6 | 6 |
| - New, executed | 2 | 1 | 1 | 2 | 0 |
| ▪ Foreign Cooperators, total active | 7 | 5 | 3 | 2 | 1 |
| - New, executed | 1 | 0 | 0 | 0 | 0 |

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| | | | | | |
|--|----------------|----------------|----------------|----------------|----------------|
| • Other Collaborative R&D Relationships | | | | | |
| ▪ Confidentiality Agreements ³ | 48 | 59 | 69 | 74 | 33 |
| - New, executed | 9 | 9 | 10 | 7 | 5 |
| ▪ Material Transfer Agreements ³ | 41 | 71 | 93 | 106 | 75 |
| - New, executed | 11 | 18 | 34 | 17 | 7 |
| - Material Transfer Research Agreements | 0 | 0 | 0 | 7 | 11 |
| - New, executed | 0 | 0 | 0 | 7 | 6 |
| ▪ Other Agreements ² , total active | 81 | 203 | 269 | 320 | 147 |
| - New, executed | 72 | 107 | 147 | 127 | 77 |
| • Publications | 130 | 147 | 99 | | |
| -Peer-Reviewed (Indexed) Scientific Publications | 98 | 142 | 91 | 99 | 108 |
| -Non-Indexed Publications | 32 | 5 | 8 | 8 | 20 |
| APHIS-Veterinary Services (VS) | FY 2013 | FY 2014 | FY 2015 | FY 2016 | FY 2017 |
| • CRADAs, total active | 0 | 0 | 0 | 0 | 0 |
| • Other Collaborative R&D Relationships | | | | | |
| ▪ Confidentiality Agreements | 134 | 1 | 0 | 0 | 17 |
| - New, executed | 134 | 1 | 0 | 0 | 17 |
| ▪ Material Transfer Agreements | 21 | 9 | 63 | 64 | 62 |
| - New, executed | 21 | 9 | 22 | 16 | 17 |
| Material Transfer Research Agreements | | | 0 | 0 | 5 |
| - New, executed | | | 0 | 0 | 5 |
| ▪ Other Agreements ² , total active | 24 | 58 | 89 | 170 | 154 |
| - New, executed | 3 | 23 | 86 | 91 | 84 |
| • Publications | 26 | 35 | 29 | 46 | 33 |
| -Peer-Reviewed Scientific Publications | 24 | 35 | 29 | 40 | 32 |
| -Trade Journal Publications | 2 | 0 | 0 | 6 | 1 |
| APHIS-Plant Protection and Quarantine (PPQ) | FY 2013 | FY 2014 | FY 2015 | FY 2016 | FY 2017 |
| • CRADAs, total active | 0 | 0 | 0 | | 1 |
| • Other Collaborative R&D Relationships | | | | | |
| ▪ Confidentiality Agreements | 0 | 0 | 1 | | 2 |
| - New, executed | 0 | 0 | 1 | | |
| ▪ Material Transfer Agreements | 0 | 1 | 9 | | 24 |
| - New, executed | 0 | 1 | 8 | | 6 |
| Material Transfer Research Agreements | | | 4 | | 6 |
| - New, executed | | | 4 | | 2 |
| ARS Letter of Intent ³ | | | 2 | | 1 |
| ▪ Other Agreements ^{2,4} , total active | 198 | 380 | 389 | | |
| - New, executed | 99 | 147 | 132 | | 2 |
| • Publications | 31 | 68 | 54 | | |
| -Peer-Reviewed Scientific Publications | 22 | 39 | 30 | | 39 |
| -Trade Journal Publications | 9 | 29 | 20 | | |

Footnotes for Table 1

¹ Amendments extend existing Cooperative Research and Development Agreements (CRADAs) for additional years to a maximum of 5 years, and/or change Statements of Work, and/or change funding levels.

² Includes Trust Fund Agreements, Interagency Agreements, Cooperative Agreements, Cooperative Service (Reimbursable) Agreements, Non-Funded Cooperative Agreements and Memoranda of Understanding.

³ This type of agreement was developed this year to facilitate the rapid exchange of unpublished data from ARS to APHIS PPQ to support regulatory methods and protocols and decision making.

⁴ This includes 322 cooperative agreements (CAs); 109 of total funded with Farm Bill funds and 37 of total CAs funded with USDA Huanglongbing (HLB) Multi-agency Coordination Initiative Funds. This also includes 67 interagency agreements (IAs) and 35 of total IAs funded with Farm Bill funds.

TABLE 2. Invention Disclosures and Patenting

| APHIS-Wildlife Services (WS) | FY 2013 | FY 2014 | FY 2015 | FY 2016 | FY 2017 |
|---|---------|---------|---------|---------|---------|
| • New invention disclosures in fiscal year (FY) | 2 | 2 | 4 | 3 | 4 |
| • Patent applications filed in FY, total | | | | | 3 |
| ▪ Non-Provisional | 0 | 0 | 0 | 3 | 1 |
| ▪ Provisional | 0 | 0 | 3 | 2 | 2 |
| • Patents issued in FY | | | | | |
| ▪ Life Sciences | 0 | 1 | 1 | 2 | 1 |
| ▪ Chemical | 0 | 0 | 0 | 0 | 0 |
| ▪ Mechanical & Measurement | 1 | 0 | 0 | 0 | 0 |
| APHIS-Veterinary Services (VS) | FY 2013 | FY 2014 | FY 2015 | FY 2016 | FY 2017 |
| • New invention disclosures in FY | 0 | 1 | 1 | 1 | 0 |
| • Patent applications filed in FY, total | | | | | |
| ▪ Non-Provisional | 0 | 0 | 1 | 0 | 0 |
| ▪ Provisional | 0 | 0 | 0 | 1 | 0 |
| • Patents issued in FY | | | | | |
| ▪ Life Sciences | 0 | 1 | 1 | 0 | 0 |
| ▪ Chemical | 0 | 0 | 0 | 0 | 0 |
| ▪ Mechanical & Measurement | 0 | 0 | 0 | 0 | 0 |

TABLE 3. Licensing: Profile of Active¹ Licenses

| APHIS-Wildlife Services (WS) | FY 2013 | FY 2014 | FY 2015 | FY 2016 | FY 2017 |
|--|---------|---------|---------|---------|---------|
| • All licenses, total active in the FY | | | | | |
| ▪ Patent licenses, total active in FY | 1 | 1 | 1 | 3 | 3 |
| APHIS-Veterinary Services (VS) | FY 2013 | FY 2014 | FY 2015 | FY 2016 | FY 2017 |
| • All licenses, total active in the FY | | | | | |
| ▪ Patent licenses, total active in FY | 1 | 1 | 1 | 0 | 0 |

¹Active means legally in force at any time during the FY, whether or not the license is income bearing. USDA licenses are patent invention and material transfer (invention) licenses. There are no other invention licenses or other intellectual property licenses.

TABLE 4. Income Bearing Licenses¹

| APHIS-Wildlife Services (WS) | FY 2013 | FY 2014 | FY 2015 | FY 2016 | FY 2017 |
|---|---------|---------|---------|---------|---------|
| • All royalty bearing licenses ¹ | | | | | |
| ▪ Patent licenses | 1 | 1 | 0 | 2 | 3 |
| APHIS-Veterinary Services (VS) | FY 2013 | FY 2014 | FY 2015 | FY 2016 | FY 2017 |
| • All royalty bearing licenses ^{1,2} | | | | | |
| ▪ Patent licenses | 1 | 0 | 0 | 0 | 0 |

¹Totals include only those licenses that actually *received* royalty income.

TABLE 5. License Income

| APHIS-Wildlife Services (WS) | FY 2013 | FY 2014 | FY 2015 | FY 2016 | FY 2017 |
|--|--------------------|--------------------|--------------------|--------------------|--------------------|
| ▪ Patent licenses | 1 | 1 | 0 | 3 | 3 |
| • Total Earned Royalty Income (ERI)¹ | | | | | |
| ▪ Patent licenses, total ERI | \$0 | \$0 | \$0 | \$17,500 | \$5,000 |
| APHIS-Veterinary Services (VS) | FY 2013 | FY 2014 | FY 2015 | FY 2016 | FY 2017 |
| ▪ Patent licenses | 1 | 1 | 1 | 0 | 0 |
| • Total Earned Royalty Income (ERI)¹ | | | | | |
| ▪ Patent licenses, total ERI | \$0 | \$0 | \$0 | \$0 | 0 |

TABLE 6. Disposition of License Income

| APHIS-Wildlife Services (WS)¹ | FY 2013 | FY 2014 | FY 2015 | FY 2016 | FY 2017 |
|---|--------------------|--------------------|--------------------|--------------------|--------------------|
| • Income distributed, total | | | | \$17,500 | \$5,000 |
| - To Inventors | \$0 | \$0 | \$0 | \$6,625 | \$2,750 |
| ▪ Patent licenses, total | \$0 | \$0 | \$0 | \$17,500 | \$5,000 |
| - To inventors | \$0 | \$0 | \$0 | \$6,625 | \$2,750 |
| APHIS-Veterinary Services (VS) | FY 2013 | FY 2014 | FY 2015 | FY 2016 | FY 2017 |
| • Income distributed, total | | | | | \$0 |
| - To Inventors | \$0 | \$0 | \$0 | \$0 | \$0 |
| ▪ Patent licenses, total | \$0 | \$0 | \$0 | \$0 | \$0 |
| - To inventors | \$0 | \$0 | \$0 | \$0 | \$0 |

FY= fiscal year

2.1. WILDLIFE SERVICES

http://www.aphis.usda.gov/wildlife_damage/nwrc/

2.1.1. Mission Statement

The mission of USDA, APHIS Wildlife Services (WS) is to provide Federal leadership and expertise to resolve wildlife conflicts to allow people and wildlife to coexist. Wildlife is an important public resource greatly valued by the American people. However, wildlife is a dynamic and mobile resource that can damage agricultural and industrial resources, pose risks to human health and safety, and affect other natural resources. The WS program carries out the Federal responsibility for helping to solve problems that occur when human activity and wildlife are in conflict with one another. The WS program strives to develop and use wildlife damage management strategies that are biologically sound, environmentally safe, and socially acceptable.

2.1.2. Nature and Structure of Research Program

WS conducts program delivery through its Regional and State Offices and National Programs, providing high-quality wildlife damage management services for its customers that result in the protection of agriculture, wildlife, and other natural resources, property, and human health and safety. The National Wildlife Research Center (NWRC) is the research arm of Wildlife Services. WS NWRC is the only Federal Laboratory devoted to resolving problems caused by the interaction of wild animals and society.

WS NWRC is headquartered on the Foothills Research Campus of Colorado State University in Fort Collins, CO. The WS NWRC employs more than 150 scientists, technicians, and support personnel at its

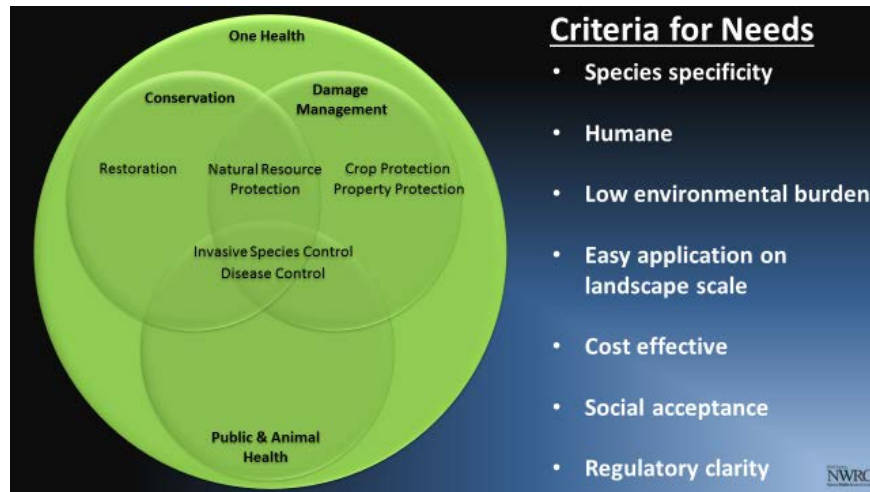
Fort Collins, CO, headquarters and at the 7 field stations located throughout the United States and Monell Chemical Senses Center in Philadelphia, PA. Approximately two-thirds of WS NWRC staff is located in Fort Collins. The remainder of the highly specialized staff is located in the other eight locations throughout the United States, facilitating a unique ability to address regional wildlife damage management issues. Further, WS NWRC routinely conducts international consultations in this specialized area.

Scientists at WS NWRC apply a diverse array of expertise to the development of practical, biologically, environmentally, and socially sound methods to resolve these problems and to maintain the quality of the environment shared with wildlife. Scientific staff specializes in several disciplines, including animal behavior/psychology, chemistry, biology, ecology, zoology, economics, genetics, immunology, pharmacology/toxicology, physiology, wildlife biology, and wildlife disease. In addition, WS NWRC works with other experts who have additional specialties through cooperative ties with universities, not-for-profit research facilities, and other public and private research entities.

WS NWRC works within three general focus areas, Damage Management, Conservation, Public and Animal Health, which complement the USDA One Health initiative. WS NWRC develops effective wildlife damage management methods through contributions in the following areas:

- Damage assessment
- Investigation of the biology and behavior of problem animals
- Evaluation of the impact of management practices on wildlife and the environment
- Development and improvement of existing management technologies
- Investigation of potential applications of new management technologies
- Support for registration of chemicals, drugs, and devices used to manage wildlife

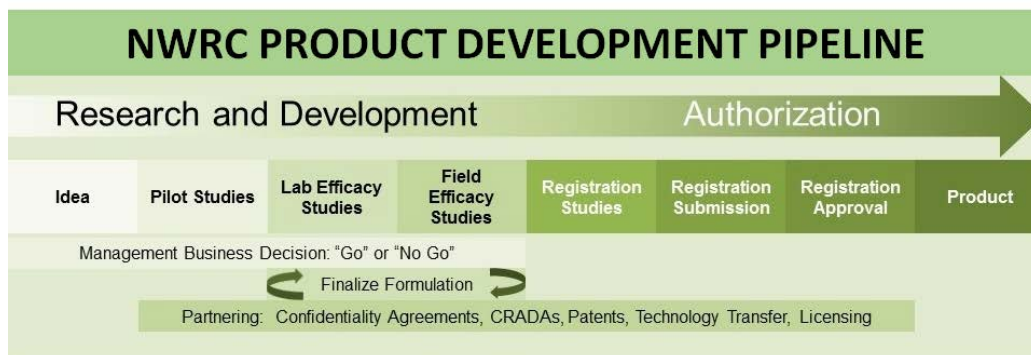
- Transfer of scientific and technical information
- Provision of scientific guidelines on wildlife damage for use by regulatory agencies
- Development of cooperative research and training with other organizations
- Responsiveness to needs of user groups and the public



Regardless of the method being developed by NWRC scientists, work is guided by a specific set of criteria to ensure that products and techniques will be accepted and adopted by industry and the public. That set of criteria includes striving towards tools and techniques that are as selective for the problem species as possible, are considered humane by today’s standards, present minimal environmental impact when employed, are cost effective, and receive appropriate regulatory oversight prior to release and during use.

In addition to this general set of criteria for each product development exercise, the NWRC also works under a “pipeline” workflow paradigm, originating with ideas from NWRC scientists, WS Operations field staff, or outside entities and culminating with a useful tool and/or technique. A key step in this pipeline is locating private or university partners to assist with product-development efforts, ultimately

taking the technology to a marketable product. Partnering can take a variety of forms including formal developmental technology transfer agreements through patenting and licensing.



CRADA= Cooperative Research and Development Agreement

2.1.3. WS Technology Transfer Goals, Objectives, and Measures of Success

Scientists at WS NWRC produce methods, technology, and materials for reducing animal damage. Through the publication of results and the exchange of technical information, WS NWRC provides valuable data and expertise to the public and the scientific community, as well as to APHIS' WS program.

WS follows the general USDA definition of technology transfer as the adoption of research outcomes (i.e., solutions) for public benefit. Through public and private partnerships, WS NWRC research creates new or improved technologies, processes, products, and services that benefit the Nation by increasing productivity, increasing efficiency (keeping costs low), and enhancing global competitiveness for the U.S. agricultural sector. Technology transfer is critical to accelerating use of public research and methods development, creating economic activity and jobs, and sustaining economic development. WS uses formal instruments of technology transfer, including Confidentiality Agreements (CA), Material

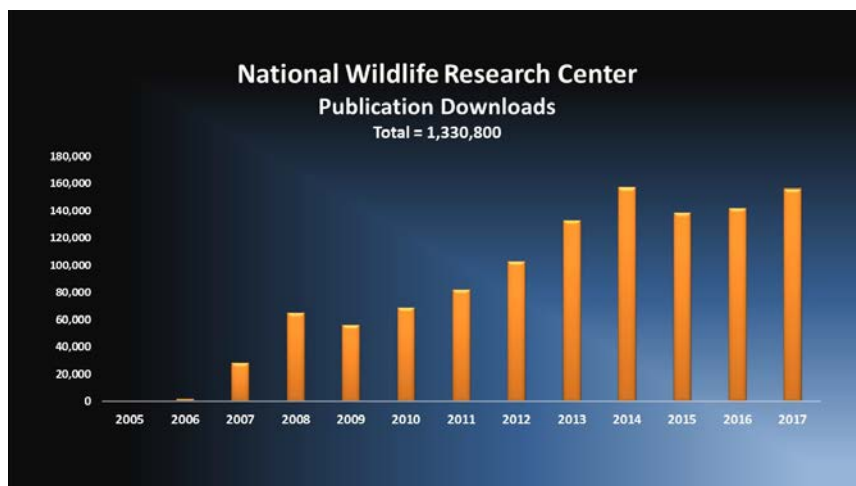
Transfer Agreements (MTA), Material Transfer Research Agreements (MTRA), and Cooperative Research and Development Agreements (CRADA). In addition, WS transfers technology through patents and invention licenses for commercialization by the private sector. WS has an ongoing formal agreement with USDA, Forest Service's Technology Transfer office (FS) to assist with the preparation of Intellectual Property Agreements and Patents. Licensing NWRC patented intellectual property is arranged through USDA, ARS Office of Technology Transfer (ARS OTT). NWRC's Technology Transfer Program Manager serves as the primary liaison for APHIS to the FS and ARS OTT. In addition, the Technology Program Manager prepares the APHIS contribution to the USDA Annual Report on Technology Transfer by providing ARS OTT with information on APHIS technology transfer activities and metrics, including tabular metrics of inventions, licenses, CAs, MTAs, MTRAs, CRADAs, as well as other notable "Downstream Outcomes."

In addition to patents and licenses, WS transfers knowledge and technology through many other formal and informal mechanisms. Primary among these methods for WS NWRC scientists is publication in peer-reviewed scientific journals. Other important mechanisms for transferring technology and knowledge include presentations at technical or professional conferences and publications in proceedings, technical assistance to the public or stakeholders, informal and formal exchange of information and products among colleagues, public outreach via factsheets, brochures, web pages and social media, and laboratory open houses.

WS Operations and the NWRC have dedicated staff devoted to registration/authorization of products with regulatory agencies, including the U.S. Environmental Protection Agency's Office of Pesticide Programs, the Food and Drug Administration's Center for Veterinary Medicine, and the USDA Center for Veterinary Biologics. When products are developed, they proceed through the research and

development pipeline (see schematic below) and are registered with the appropriate regulatory agencies. Products with limited private-market potential, but are highly desirable to WS Operations, are produced and distributed by the WS Pocatello Supply Depot. Products with significant private-market potential are licensed for sale to a private company. Efforts to increase the number of APHIS products licensed by private companies include patenting innovative technology; development of CRADAs and Material Transfer Research Agreements; participating in regional technology development functions; actively participating with the national Federal Laboratory Consortium and the Mid-Continent chapter; interacting directly with and national, State, and local governments, universities, and industries; and enhancing training for WS NWRC scientists in technology transfer.

NWRC currently measures success of its technology transfer using several metrics. The most basic metric of any research organization is its publication success. Over the past 5 years NWRC scientists have averaged 122 publications per year, 88 percent being released in peer-reviewed outlets. Even more impressive though is the rate at which publications have been downloaded by external audiences, especially because NWRC only employs 37 scientists in positions where publication is required. Since NWRC began tracking publication downloads in 2006, annual downloads have increased to approximately 175,000 per year. In 2017, NWRC surpassed the 1,000,000 download milestone.



Another measure of the NWRC’s technology transfer and research development efforts is the number of individual organizations our scientists and support staff collaborate with annually. In 2016, NWRC partnered or otherwise collaborated with 370 individual institutions, an impressive number given the size of the Center’s research staff. The majority of these efforts were with universities, but State and local governments and private partners were highly represented. NWRC scientists and staff collaborated with 11 foreign governments or institutions. It is expected that NWRC’s external collaborations remained at this level in FY17.

| Institution Type | Number of Unique Collaborations |
|--|---------------------------------|
| Wildlife Services State Operational Programs | 48 |
| Federal | 36 |
| State/Local | 49 |
| Non-Government Organizations | 27 |
| Private Institutions | 46 |
| Universities | 146 |
| Foreign Governments or Institutions | 18 |
| Total | 370 |

As stated above, NWRC also enters into technology transfer agreements (CAs, MTAs, MTRAs, and CRADAs), Cooperative Agreements, Cooperative Service Agreements, Grants, and Memoranda of Understanding with collaborators. WS NWRC tracks the number (the specifics of which are reported in the Combined Metrics Tables above) and monetary value of all types of agreements. In FY17, NWRC was actively involved in 126 intellectual property protection and/or development agreements, 18 of which were initiated in FY17. An additional 75 Cooperative Service Agreements, Cooperative Agreements, Grants, and Interagency Agreements were completed by the NWRC Agreements Office. Efforts to increase the amount of cooperator funding continue to be a priority. Cooperator funding at WS NWRC averages about 16 percent of the annual budget and has remained steady during the last 5 years,

generating \$2.7 million in 2013, and \$3.5 million in 2014, \$2.6 million in 2015, \$2.7 million in 2016, and \$2.7 million in 2017.

2.1.4. Downstream Outcomes



The development of an oral, field-stable vaccine against sylvatic plague: protecting endangered black-footed ferrets

Lewis and Clark first witnessed prairie dogs in 1804 in South Dakota as part of their famous expedition across North America. The small burrowing animals, with their “barking” calls and elaborate colonies, impressed the men so much that a live specimen was shipped back to President Jefferson. Only later would biologists learn how important prairie dogs are to the health and function of the prairie ecosystem.

One of the many factors that affect prairie dog populations is sylvatic plague, a non-native bacterial disease transmitted by fleas. It afflicts many mammal species, including black-footed ferrets and people. Plague is common throughout the Western United States and periodically causes the death of entire prairie dog colonies.

Black-footed ferrets are one of the most endangered mammals in the United States. They feed almost exclusively on prairie dogs. Black-footed ferret reintroduction efforts by the U.S. Fish and Wildlife Service (USFWS) can be severely impacted when plague sweeps through a prairie dog colony. Prairie dog colony collapse results in the death of reintroduced ferrets and the loss of millions of dollars in taxpayer money related to USFWS reintroduction efforts.

Scientists at the U.S. Geological Survey's (USGS) National Wildlife Health Laboratory have developed an oral vaccine to combat sylvatic plague in prairie dogs. Through a multi-year collaboration involving five Federal agencies, nine state wildlife management agencies, and two private organizations, the vaccine has undergone extensive field testing to demonstrate its effectiveness.

In 2016, Colorado Parks and Wildlife pioneered an affordable technique for mass-producing baits. The USFWS developed mechanized methods, including the use of drones and all-terrain vehicles (ATVs), for the cost-effective delivery of baits. Additionally, 300,000 baits were manufactured at the USDA National Wildlife Research Center with the help of multiple partners. The baits were then applied to over 5,000 acres of black-footed ferret recovery habitat in five Western States.

In 2017, these new methods and technologies again will aid in the production and distribution of baits. The USGS has licensed the production of the bait's vaccine component to Colorado Serum Company (Denver, CO) which has entered into a bait-manufacturing collaboration with the USDA's Wildlife Services Pocatello Supply Depot. Through this collaboration, more than 1 million baits will be produced and distributed to more than 20,000 acres of black-footed ferret recovery habitat.

The partnership between multiple State and Federal agencies and private entities has been critical to the success of this project. The conservation and economic benefits of the project will be realized for years to come as vaccine use continues to grow, black-footed ferrets repopulate areas of the Western United States and species recovery goals are achieved. This project was awarded the 2017 Outstanding Partnership Award by the Federal Laboratory Consortium, Mid-Continent Region.



Adaptive Strategy for Nonlethal Predation Management

Although the majority of sheep ranchers use nonlethal methods to protect their flocks from predators, disagreement still exists regarding the effectiveness and feasibility of many of these tools for large-scale grazing operations.

To gain a better understanding of how nonlethal methods may be used with large-scale grazing operations on public lands, the Idaho Wood River Wolf Project was formed. The collaborative effort was first conceived in 2008 by a USDA wolf specialist and the Defenders of Wildlife.

The 7-year project collected data on sheep depredations by wolves in a demonstration area where a variety of nonlethal methods were used and compared it to data from an adjacent area where sheep were

grazed without nonlethal protections. Both areas were occupied by wolves.

Between 10,000 and 22,000 sheep grazed across nearly 1,000 square miles of the protected demonstration area. Field specialists strategically applied nonlethal predator deterrents and animal husbandry practices by adjusting for things such as habitat conditions, locations of known wolf packs, and the frequency or type of nonlethal methods used. Nonlethal methods included increasing human presence and the number of livestock protection dogs; fladry and turbo-fladry; spotlighting; scare devices, such as air-horns, blank handguns, flashing lights, and radioactivated guard boxes; and monitoring the movements of radio-collared wolves.

Results showed sheep losses to wolves were 3.5 times higher in the unprotected area than in the protected area. While packs of wolves were killed in the unprotected and adjacent areas, no wolves were killed in the protected area over the course of the project. This project concluded the presence of one or more field specialists assisting in monitoring and deterring wolves played a critical role in minimizing wolf-sheep interactions because they were able to select appropriate deterrents based on site-specific conditions at the time. For instance, by monitoring the location of wolf packs and dens, field specialists were able to pen sheep bands and increase spotlighting at night when high-risk wolf encounters were likely.

Although encouraging, the adaptive approach to implementing nonlethal methods may not be easily repeatable, feasible, or cost-effective for some ranchers. Familiarizing livestock producers and shepherders with novel management techniques and gaining their participation in protecting sheep from wolves are critical for successfully reducing sheep depredations. While encouraging, additional studies evaluating the time and costs associated with using such methods are needed. This is the first peer-

reviewed study using multiple nonlethal deterrents to protect livestock across a large landscape. The findings provide valuable information to ranchers who may be interested in an adaptive predation damage management approach.



Predation Damage Management Workshops

WS partners with State agencies, universities, and producer associations to host training courses and workshops that showcase new and existing tools and techniques to help prevent livestock predation. Over the last few years, nonlethal predation damage management workshops have been held in 13 States: California, Colorado, Idaho, Minnesota, Montana, Nevada, North Dakota, South Dakota, Oklahoma, Oregon, Texas, Utah, and Wisconsin. As the research arm for WS, NWRC supports these workshops by providing experts and information on the latest predation damage management research. Scientists and others at NWRC have taken an active role in attending and presenting information at WS' predation damage management workshops.

Workshop attendees represented a broad range of interests and expertise, including livestock production, animal welfare and conservation, and State and Federal wildlife management. About 2,000 participants have attended the workshops to date, with the majority being livestock producers. Responses to the

workshops have been positive, including support from animal conservation and welfare groups, livestock producers, and resource managers alike.

The workshops present a unique opportunity to share and discuss NWRC research results directly with producers and conservationists, providing researchers and managers the opportunity to hear livestock producers' concerns and challenges, which helps us to design more practical and feasible damage management tools.



Expanding Rabies Work to Puerto Rico

The small Indian mongoose (*Herpestes auropunctatus*) is an invasive species in Puerto Rico. Mongooses were introduced to the island during the 19th century to control rats on sugar cane plantations. Since then, they not only have become agricultural pests on the island, but also reservoirs for rabies.

Mongooses account for more than 70 percent of the reported rabies cases in Puerto Rico. An average of 280 Puerto Ricans are bitten each year by mongooses. Two human fatalities have occurred from mongoose-variant rabies in Puerto Rico, the most recent in 2015. Currently, no rabies vaccination

program for mongooses exists on the island, and the vaccination of pets and domestic animals is limited.

In the continental United States, the WS' National Rabies Management Program (NRMP) coordinates efforts to prevent the spread of terrestrial rabies in raccoons, coyotes, and gray foxes. These efforts consist primarily of enhanced rabies surveillance and administering an oral rabies vaccination (ORV) program. In order to establish a similar rabies program on Puerto Rico for mongooses, basic information on mongoose population density, home range size, current rabies antibody levels, effective bait formulations, and delivery mechanisms are needed.

Starting in 2011, NWRC and NRMP experts began efforts to gather this information. In field studies at El Yunque National Forest and Cabo Rojo National Wildlife Refuge, mongoose population density estimates ranged from 44-75 mongooses/km² depending on the season. A sero-survey showed that 39 percent of sampled free-ranging mongooses had been exposed to rabies. In bait flavor trials, mongooses preferred cheese-flavored baits over coconut and fish, and the major non-target competitors for the baits were black rats.

With many of the basic questions answered, NWRC and NRMP began field trials on September 28, 2017 coinciding with World Rabies Day, at the Cabo Rojo National Wildlife Refuge and a nearby private property using placebo ORV bait developed by the German company IDT-Biologika. Baits containing iophenoxic acid as a biomarker were distributed by hand at a density of 200 baits/km². Initial results are very promising. More than 60 percent of the 88 mongooses captured after the ORV application contained biomarker residues in their blood, indicating that they had eaten the bait. A second placebo bait application is planned for April 2017 to evaluate seasonal changes in bait uptake by mongooses.

Working in partnership with the Puerto Rico government, these efforts will lead to increased public awareness of rabies in Puerto Rico. Due to the preliminary success of this project, talks are underway with a private vaccine manufacturing company for further development and eventual registration of a vaccine for managing mongoose rabies.

2.2. BIOTECHNOLOGY REGULATORY SERVICES (BRS)

<http://www.aphis.usda.gov/biotechnology/index.shtml>

2.2.1. Mission Statement

The mission of BRS is to protect and enhance U.S. agricultural and natural resources using a dynamic, science-based regulatory framework to ensure the safe importation, interstate movement, and environmental release of genetically engineered (GE) organisms.

2.2.2. Nature and Structure of Program

BRS does not perform research. BRS regulates the introduction (importation, interstate movement, and release into the environment) of GE organisms that may pose a risk to plant health. Researchers and product developers, Federal or private, should understand and work with the appropriate regulatory agencies that may have oversight of an organism at different stages in the development of a product. This can facilitate efficient development of the appropriate information necessary for regulatory review.

BRS provides compliance assistance to the regulated community through the Biotechnology Quality Management Support (BQMS) Program. This voluntary program is flexible, customizable, and cost-efficient. The BQMS Program is designed to help organizations of any size (universities, small businesses, and large organizations) develop sound quality management practices to enhance their ability to comply with the APHIS regulations governing certain genetically engineered (GE) organisms found at 7 Code of Federal Regulations (CFR) part 340. The-BQMS Program is a modular system, which allows each unique user the option of selecting from a list of web-based compliance assistance

tools referred to as modules. These modules are designed in a user-friendly question-and-answer format to help in creating a documented self-certifying quality management system to manage critical control points consistent with the requirements at 7 CFR part 340.

2.3. INTERNATIONAL SERVICES

http://www.aphis.usda.gov/international_safeguarding/index.shtml

2.3.1. Mission Statement

The mission of International Services (IS) is to protect U.S. agricultural and natural resources by working with foreign governments to prevent the spread of high-risk plant pests and animal diseases; facilitate the safe international movement of agricultural commodities through science-based regulations and internationally accepted standards; and enhance global health and U.S. biosecurity through the development of science-based regulatory systems and policies around the world.

2.3.2. Nature and Structure of the Program

IS' overseas presence enables APHIS to monitor and respond to pest and disease threats, develop international strategies and partnerships to prevent their spread to the United States, and support U.S. agricultural trade by resolving technical barriers. Through its services, IS contributes directly to global food security by promoting safe global trade and facilitating the development of science-based regulatory systems around the world. IS works closely with its sister units in APHIS, including Veterinary Services (VS), Plant Protection and Quarantine (PPQ), Biotechnology Regulatory Services (BRS), Wildlife Services (WS) and other headquarters staffs, to ensure that its day-to-day work overseas reflects the priorities of these domestic programs. This collaboration is key to IS' success and is achieved through joint planning, enhanced communications, clear direction to the field, and implementing coordinated strategies.

IS uses technology transfer to support APHIS' work overseas by creating linkages and supporting partnerships, collaborations, and cooperative programs. As part of its mission to safeguard U.S. agriculture and expand the safe exportation of unprocessed agricultural products, IS works with international partners through bilateral and multilateral treaties and agreements to improve animal and plant health systems around the world. IS partners with international organizations, including the International Atomic Energy Agency (IAEA), World Organization for Animal Health (OIE), the Food and Agricultural Organization of the United Nations (FAO), and the International Regional Organization for Agricultural Health (OIRSA) as well as with our international trading partners to help implement appropriate technologies to control or eliminate sanitary and phytosanitary (SPS) threats to the safe trade of agricultural products.

IS has organized and led several pest control programs in the Americas designed to reduce or eliminate the populations of pests like Screwworm, Mediterranean fruit fly (Medfly), and Mexican fruit fly (Mexfly). The control of these very costly pests requires a specific set of technologies involving several different control measures, including the design and methods of release of sterilized male flies, the application of environmentally friendly pesticides, and the design and application of fly traps for surveillance and population reduction. IS transferred sterile fly ground release technology and surveillance technology for sterile and fertile flies to VS and the Florida Department of Agriculture and Consumer Services during the 2016-2017 New World Screwworm outbreak in Florida. IS also works throughout Central America and the Caribbean to transfer technologies for effective and sensitive fruit fly surveillance and control in collaboration with its international partners and the USDA, Agricultural Research Service.

The U.S. Feral Swine Damage Management Plan includes several activities where WS, VS, and IS play critical roles. The feral swine program's goal in Mexico is to integrate Mexican federal agencies into the North American international (regional) group that develops joint activities for feral swine damage management. Coordination among WS and IS is essential for the success of this initiative, and IS is the primary organization in U.S.-Mexico binational negotiations to develop these activities. WS and IS collaborated during 2017 to conduct three feral swine workshops and one symposium in various locations throughout Texas and Mexico. General themes of this training included damage created by feral swine, diseases they carry, and control and trapping measures.

WS, with IS' collaboration, also conducts various activities with rabies and other wildlife diseases throughout Mexico, focusing on strategic planning and coordinating and implementing cooperative programs. During 2017, WS and IS provided technical support to the Mexican ministry on rabies control, provided technical information throughout Mexico on rabies transmitted by vampire bats, conducted vampire bat management training, and provided technical support to binational attendees of international rabies meetings to maintain links with Mexican authorities involved in rabies activities.

IS personnel in Mexico work closely with VS on various safeguarding activities along the U.S.-Mexico border. Examples from 2017 include: two regional workshops in coordination with Mexican federal agencies and Mexican state animal health committees on bovine Tuberculosis (TB) epidemiology, infected herd management, movement requirements, TB surveillance, and new diagnostic tools. Through these courses, the expertise and awareness of official and private veterinarians in Mexico was increased and updated to improve the TB program in those Mexican states.

IS and VS actively participated in three regional Cattle Fever Tick epidemiology and inspection procedures workshops in coordination with a Mexican federal agency. These theory-practical trainings helped official and private veterinarians and exporters better understand the actions needed to mitigate and eliminate the ticks in cattle intended for export to the United States and the reasons for rejecting shipments. IS Mexico also assisted the ministry (SENASICA) to send a Mexican veterinarian to VS's National Veterinary Services Laboratories (NVSL) for training in laboratory diagnostic techniques on brucellosis. Two Mexican veterinarians also attended a brucellosis epidemiology training in VS's Center for Epidemiology and Animal Health (CEAH).

IS Mexico and VS have coordinated with Mexican federal agencies and the State Government of Chihuahua and its industry on the Mexican Electronic tag (RFID) and Export Certification program for cattle from the state of Chihuahua. This new technology is being tested to eventually substitute for the current metallic export ear tags. The change will facilitate trade and improve the accuracy of the information, the inspection process, and the follow up of Mexican cattle throughout the United States.

Our long-standing support of foot-and-mouth disease (FMD) eradication from the Western Hemisphere is another example of technology transfer from the United States to foreign counterparts. USDA has been an active signatory partner in this effort for over 35 years. From the beginning of this international effort involving multiple treaties and agreements between the United States and our Western Hemisphere trading partners, the United States has been a critical leader in the transfer of effective FMD surveillance and control strategies. Each of these strategies in turn relies on several different technologies, for which the United States is usually the leader in developing. The United States has signed several treaties and international agreements through the U.S. Department of State and via the USDA to fully support the hemispheric effort through technology transfer.

NVSL developed a Polymerase Chain Reaction (PCR) test for the Seneca virus, a differential diagnosis for FMD, and has transferred this technology to the vesicular disease laboratory in Panama, PANAFTOSA (Pan American FMD Center), LANAGRO (Brazil), SENASA (Argentina), and SENASA (Uruguay). Technologies transferred in the past include high-volume vaccine production, infrared surveillance for febrile illnesses, animal computer chip ear-tag identification, computerized methods of managing surveillance, and sanitation technologies in slaughter facilities. FMD poses a constant threat to livestock production in the United States, with the potential to devastate our beef and pork industries if the virus were to appear in the United States. Between 1980 and 2010, the FMD virus was successfully reduced from its widespread presence in nearly all of South America to its current presence only in Venezuela with sporadic incursions into Colombia. The campaign to eradicate FMD from the Western Hemisphere is nearly complete and could not have been accomplished without the active participation of the United States in transferring technologies essential to the program.

In 2017, the national laboratories of USDA and Peru's SENASA began a collaborative effort to study and characterize the circulation of Classical Swine Fever (CSF) in Peru, improve Peru's CSF diagnostic capabilities, and develop new control strategies for Peru's CSF program. CSF is a highly contagious foreign animal disease that would be economically detrimental to the U.S. swine industry if introduced. To continue this collaboration, two U.S. subject matter experts visited Peru and selected samples for sequencing and analysis in the United States. The experts also presented SENASA with a study to validate current diagnostic techniques for use with pooled samples. USDA and SENASA look forward to continuing their collaborative effort by developing a diagnostic test for differentiation of the CSF vaccine from the field virus. This collaboration between USDA and SENASA will help Peru control

and eradicate CSF while assisting the USDA in developing efficient CSF diagnostics to protect the U.S. swine industry.

In 2017, the IS office in Costa Rica, the International Regional Agency for Agricultural Health (OIRSA), and the Inter-American Institute for Cooperation on Agriculture (IICA) conducted two workshops on Quarantine Fumigation in Costa Rica. The objective of the workshops was to train technicians from Central America, Dominican Republic, Mexico, Colombia, and Ecuador in the methodology for quarantine fumigation based on APHIS' Quarantine Treatment Manual. The workshops included theoretical and practical activities. The training facilitated a better understanding of quarantine fumigation operations and the common understanding among countries for quarantine decision making regarding plant health protection and trade facilitation.

2.3.3 Downstream Outcomes

International Technical and Regulatory Capacity Building (ITRCB)

The ITRCB, a unit of APHIS International Services, acts as a clearinghouse to review requests for APHIS technical assistance. When appropriate, it supports Agency efforts by facilitating technical cooperation activities with trading partners and developing countries. Although the training of foreign counterparts comprises a significant part of ITRCB's mission, technology transfer, when it occurs, is limited.

2.4 PLANT PROTECTION AND QUARANTINE

http://www.aphis.usda.gov/plant_health/index.shtml

2.4.1. Mission Statement

PPQ safeguards U.S. agriculture and natural resources against the entry, establishment, and spread of economically and environmentally significant pests, and we facilitate the safe trade of agricultural products.

2.4.2 Nature and Structure of PPQ's Methods and Technology Development Program

PPQ's technology development is facilitated and implemented through cooperation between its three divisions; namely Policy Management (PM), Field Operations (FO), and Science and Technology (S&T). The Center for Plant Health Science and Technology (CPHST) is the primary component of PPQ's Science and Technology core functional area, which also includes the National Clean Plant Network (NCPN). APHIS is one of three agencies of the USDA (along with ARS and NIFA) that, through a memorandum of understanding, support research, quarantine, and outreach activities for the NCPN. The NCPN is a voluntary association of specialty crop networks that promote the use of pathogen-tested, healthy plant material for food crops in the United States.

[\(http://nationalcleanplantnetwork.org/about/\)](http://nationalcleanplantnetwork.org/about/).

CPHST provides scientific and technical support for the regulatory decisions, policies, and operations of APHIS' Plant Protection and Quarantine (PPQ) program in order to safeguard U.S. agriculture and natural resources. CPHST is responsible for ensuring PPQ has the information, tools, and technology to

make the most scientifically valid policy and regulatory decisions possible and is headquartered on the campus of North Carolina State University in Raleigh, North Carolina. The broader CPHST system however consists of approximately 216 scientists, analysts, and support staff at 7 principal laboratories, 2 stations and satellite locations throughout the United States and in Guatemala. It also includes four programs and multiple work units. CPHST supports regulatory plant protection activities by developing methods and conducting analyses in the following program areas: Agricultural Quarantine and Inspection, Trade Issues and Risk Analysis, Identification and Diagnostics, Pest Detection, and Pest Management.

In FY 2017, CPHST continued planning the expansion of operations for construction of a new laboratory in California. The location selected for this laboratory is in Sacramento, California, adjacent to the California Department of Food and Agriculture's Meadowview facility. The new lab will foster cooperation with one of the premier State regulatory labs, regional universities such as University of California Davis, ARS labs, and industry will fill a major need for additional science and technology support for West Coast pest programs and agricultural trade. This effort will continue as a major S&T initiative for FY 2018.

CPHST activities primarily focused on providing scientific support for PPQ needs and decision making, but also supported stakeholders such as State plant regulatory programs and the agricultural and nursery industries. CPHST conducts its work with internal stakeholders but also engages other Federal agencies (e.g. ARS, NIFA, Forest Service, DOE National Labs, DHS and EPA), Tribal Nations, academia, international institutions, and industry to acquire knowledge, best management practices, products and

protocols, and to develop methods and protocols needed for plant protection and management of invasive pests.

2.4.3. Current Technology Transfer Goals, Objectives, and Measures of Success

PPQ is committed to use of the best science, tools, and technologies to strengthen the efficiency and effectiveness of PPQ's work. PPQ transfers new methods and technology through several mechanisms, including technical documents, protocols, risk assessments, and pest survey guidelines that are distributed directly to stakeholders or are made available through PPQ websites. Another important mechanism to transfer information is through the publication of results in peer-reviewed scientific journals. Other important mechanisms for transferring technology and knowledge include hands-on training at our labs, presentations at technical or professional conferences, publications in proceedings, trade publications, and direct technical assistance to the public, stakeholders, and industry through various outreach activities and events.

PPQ's Identification Technology Program (ITP) provides technology-based pest identification products (e.g., molecular diagnostics, websites, mobile apps, etc.). These products are used by APHIS scientists as well as scientists in Customs and Border Protection, in State departments of agriculture, in domestic and international academic institutions, and by national and regional plant protection organizations to screen and identify plant pests off-shore, at our ports, and domestically. Many of the program's products are available via an open-access searchable portal (<http://idtools.org>).

CPHST provides technical training to stakeholders in certain areas (i.e., diagnostic testing, pest risk assessment, treatments) and also provides information and training on quality management and accreditation. For example, the CPHST Beltsville Lab provides hands-on training on molecular diagnostics for regulated plant diseases to diagnosticians from National Plant Diagnostic network (NPDN), State and Federal laboratories, and in FY 2017, conducted 7 training workshops for 74 diagnosticians. The CPHST Quality Management Program provided auditor training in several sessions with diagnosticians from the NIFA National Plant Diagnostic Network (NPDN) and organized onsite audits of several NPDN labs in an effort to support the NPDN quality management system STAR-D. The National Plant Protection Laboratory Accreditation Program (NPPLAP) accredits NPDN, State, Federal and commercial laboratories to perform regulatory diagnostics. NPPLAP currently manages proficiency testing and certification for Plum Pox Virus, *Phytophthora ramorum* and citrus greening. In FY 2017, NPPLAP had 26 active accredited labs with 107 certified diagnosticians.

Formal agreements, including cooperative and interagency agreements and memoranda of understanding, are used to formalize collaborations with other government scientists, universities, private companies, and other stakeholders. In FY 2017, CPHST provided oversight of 239 cooperative and interagency agreements for a total of over \$28 million. The total includes funded with Farm Bill Section 10007 funds and USDA Huanglongbing Multi-Agency Coordination Initiative funds.

In FY 2017, PPQ entered into an interagency agreement with the USDA, Forest Service to provide agreement, patent and licensing support. This agreement also supports VS and Wildlife Services WS).

The Forest Service Technology Transfer Coordinator (TTC) works with the PPQ National Scientific

Technologies Coordinator to provide technology transfer agreements training to the PPQ Phytosanitary Issues Management (PIM) program. PIM facilitates and negotiates, through the use of scientifically based processes, the safe export and import of agricultural commodities. The training with PIM focused on IP safeguarding while sharing scientific products with our trading partners. PPQ worked closely with the Forest Service TTC to identify technology transfer opportunities and will continue to in FY 2018 as CPHST reviews projects for additional technology transfer needs.

2.4.3 Downstream Outcomes



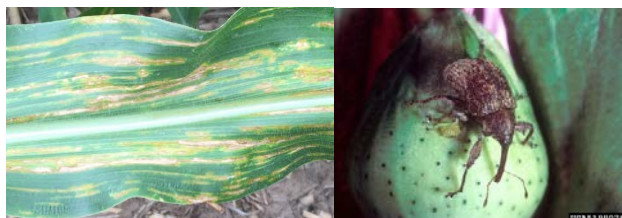
Biological control of Asian Citrus Psyllid, the vector of citrus greening disease

The Asian citrus psyllid (ACP) has invaded citrus-growing areas in the United States over the past decade and is a vector of a bacterium that causes citrus greening disease or Huanglongbing (HLB). A key component to a management program is aggressive control of ACP vector. *Tamarixia radiata* is a species-specific ectoparasitoid of the ACP that was imported from Pakistan after satisfying APHIS PPQ permitting requirements for field release in Texas.

In FY 2017, the PPQ Mission Laboratory developed the technology to mass produce and release 677,550 *T. radiata*, and an additional 144,000 were produced using a field insectary cage approach for

the biological control of ACP in south Texas. An additional 105,000 insects were provided for releases in Louisiana. A collaborative project with APHIS International Services and SENASICA of Mexico has resulted in an additional 347,600 parasitoids released in Tamaulipas and 505,200 for releases in Baja California. Our cumulative total produced during FY 2017 at the Mission Laboratory was 1,779,350 beneficial insects.

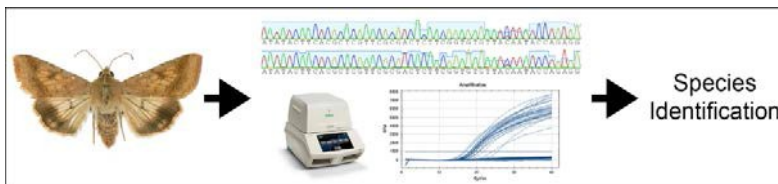
Since the project began in 2011, over 6.86 million beneficial insects have been produced by the Center for Plant Health Science and Technology (CPHST) Mission Lab for field release. Asian citrus psyllid nymph levels in 2010 were reported at 43 nymphs per flush in the urban environment of south Texas. After releases were initiated, data based on thousands of flush samples indicated a reduction over the last 7 years in ACP nymph populations down to 2.4 nymphs per flush. This is a reduction of 94.2 percent of the vector population. We continue to try and improve on our methods developed to enhance our tech transfer support to the Texas Citrus Pest & Disease Management Corporation, Texas A&M AgriLife Extension Service, Texas A&M Citrus Center, PPQ Field Ops for Texas and Louisiana, SENASICA, and APHIS International Services of Mexico.



Identification of boll weevils to support cotton production

Since the early 1920s, the boll weevil has been a major economic pest of cultivated cotton in the United States. To support cotton production, eradication programs have been directed at boll weevil populations in the southern United States and northern Mexico. These programs have been successful for many areas, but reintroduction of new weevil populations is always possible. Early detection and identification of weevils is an important part of boll weevil control. Accurate identification of trapped weevils can sometimes require specialized morphological and DNA analysis. In FY 2017, the PPQ Mission Laboratory provided DNA analysis of weevils to distinguish between commercial and wild cotton boll weevil variants. These methods have been published and were presented to entities working to eradicate the weevil in the United States and Mexico. The results of molecular tests conducted by PPQ in 2017 on trapped weevils from northern Mexico and New Mexico has provided cotton programs with information that has helped maintain areas in the Southwestern United States free from boll weevil.

In addition, methods for the source estimation of boll weevil captures have been developed in 2017 through collaboration with the Texas Boll Weevil Eradication Foundation, Inc., and researchers at Texas A&M and AgriLife using Next Generation Sequencing. These newer methods and technology are being evaluated and may help trace future captures to source population, thus aiding development of more effective eradication strategies in the United States and Mexico. (Photo by Florida DPI, FDACS, Bugwood.org)



Advanced molecular diagnostics for the Old World bollworm

The Old World bollworm (OWB) is a moth that can attack and damage more than 180 plant species including cotton, corn, peanut, sorghum, and tomato. This moth was not thought to be present in the New World (i.e., the Americas) until 2012, when specimens were identified from an outbreak that started in Brazil. Since that outbreak, new records have been reported in North and South America and the Caribbean. This species is difficult to diagnose because it is nearly identical in appearance to a common native moth, the corn earworm. These two pests also attack similar crops, further complicating detection of the Old World bollworm.

Scientists from the PPQ Fort Collins and Mission laboratories and USDA-ARS Southern Insect Management Unit have been developing new methods to identify these moths based on slight differences in DNA. These published technologies have been developed into protocols for diagnosing a single moth and were presented to State and Federal scientists at a strategic planning meeting for Old World bollworm held in Florida in 2016. In FY 2017, PPQ used these published molecular techniques to identify moths intercepted at U.S. borders to confirm safe trade practices. In 2017, PPQ published an additional molecular technique that makes it possible to diagnose hundreds of moths in a single reaction. These methods development and diagnostic activities are helping to exclude invasive exotic species from the United States in order to protect crops and natural resources. This protocol provides an efficient, rapid, reproducible, and scalable method for processing future OWB survey trap samples and demonstrates the potential for applying this new technology to screening for other invasive pests. The transfer of technologies to outside laboratories is an important final step in the development of any molecular assay. Before a new assay can be trusted to provide accurate identifications, it must be validated for several standard performance criteria including sensitivity, specificity, repeatability,

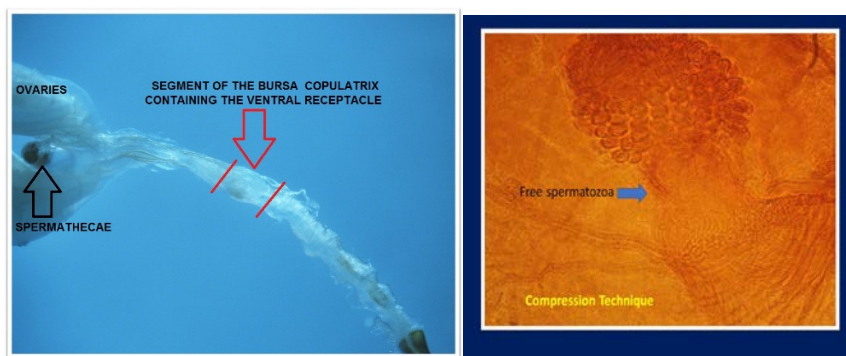
reproducibility, etc. S&T and cooperators have developed several other molecular protocols to identify individual OWB specimens. In 2017, ITP worked with other USDA and university laboratories to validate these assays and to develop a proficiency testing protocol that will be transferred to partner laboratories.



Developing and sharing new resources to accurately diagnose exotic fruit flies

Fruit flies in the family *Tephritidae* pose a significant threat to U.S. production and trade of fruits and vegetables. The larvae of fruit flies feed and grow within host plants causing direct damage. Some exotic fruit flies such as the oriental fruit fly can develop in hundreds of plant species. To minimize the risk of an accidental introduction and establishment of exotic flies, PPQ coordinates Fruit Fly Exclusion and Detection programs. The PPQ Mission Laboratory develops and tests molecular methods to identify fruit flies. Correct identification of a detected fly is necessary to develop an effective response based on trapping strategies and pest management decisions. In FY 2017, the Mission Laboratory verified and enhanced identification resources for several important pests. New DNA sequence resources to identify five New World *Anastrepha* species and the African species *Ceratitis cosyra*, were published for use by State, Federal and international stakeholders. An ongoing collaboration among PPQ, the University of Hawaii, and ARS resulted in new genomes and identification methods for the melon fly (*Bactrocera cucurbitae*), guava fruit fly (*B. correcta*), the peach fruit fly (*B. zonata*), and the Mexican fruit fly (*Anastrepha ludens*). Throughout 2017, PPQ continued a project to document and compare genotypes for the oriental fruit fly (*Bactrocera dorsalis*) and the medfly (*Ceratitis capitata*). These profiles were

used to compare flies trapped in Florida and California to populations intercepted at borders or collected offshore. The genotyping projects are collaborative efforts between APHIS and States to recognize and shut down high-risk pathways. In 2017, the new resources were used to confirm that independent outbreaks of fruit flies in California were the result of new introductions, not failure of eradication efforts in a previous year. To strengthen fruit fly exclusion programs, PPQ and ARS developed and published a new DNA test for identifying lab-reared medflies. The test can discriminate between wild individuals and sterile flies from the Sterile Insect Technique lab strain. This technique has been implemented by PPQ in 2017 as a routine test for medflies trapped in California that lack the marking dye applied to all lab-reared flies.



Fruit Fly Program Support: The Ventral Receptacle Compression (VRC) Technique

An important component of fruit fly programs is the identification of the mated status of wild females captured in fruit fly monitoring and trapping programs. The traditional means of diagnosing a female as mated is by checking for the presence of sperm in the spermathecae (structures used to receive sperm during copulation) using the spermathecal squash technique. This technique, however, is prone to error. Some mated females can be scored as unmated because the spermathecae is depleted through the course

of egg laying. A better measure of mating status is the ventral receptacle (VR). The VR is the primary seminal storage organ in females. It is located on the ventral side of the bursa copulatrix where the male ejaculates sperm and is the first and the last organ to contain spermatozoa. Thus it is the organ most likely to have spermatozoa if the fly has mated.

PPQ and ARS collaborated in developing a new technique of squashing the bursa copulatrix under a microscope slip releasing visible sperm. This technique called Ventricle Receptacle Compression (VRC) Technique can be performed with or without staining. In 2017, the technique was validated with *Bactrocera*, *Ceratitis* and *Anastrepha* species. The method provides an increased level of confidence when classifying the female mated status in addition to the current spermathecal squash method. APHIS approved the programmatic use of VRC procedure for determination of mated status of wild female fruit fly detections in August of 2017.

Using a new pest prioritization model to target the highest impact pests in exotic pest detection surveys

The PPQ Cooperative Agricultural Pest Survey (CAPS) program conducts surveys in the United States targeted at exotic plant pests, diseases, and weeds identified as threats to U.S. agriculture and/or the environment. The PPQ CPHST Ft. Collins, CO, laboratory evaluates new pests to determine which are of the greatest threat to the United States. In 2016, the Ft. Collins laboratory used a new pest prioritization model, the Objective Prioritization for Exotic Pests (OPEP) model, created by the CPHST Plant Epidemiology and Risk Analysis Laboratory (PERAL). The predictive model is based on a series of questions which require objective, documented evidence from the scientific literature to answer. Each question is scored based on its power to predict impact, and the final result is given as high, moderate, or

low impact. The model has been in development for several years, and 2016 was the first year that the model was used to evaluate new pest threats and current pests on the CAPS Priority Pest List: Pests of Economic and Environmental Importance.

This list is one of two Priority Pest Lists that form the foundation of survey activity for the CAPS program. In 2017, two new separate models, one for arthropods and one for plant pathogens, were used to evaluate 15 pests that are suggested as new. CPHST then performs another step of analysis for each of the high-ranking pests, by evaluating: (1) the ease of detection of the pest; (2) the ease of identification; and (3) the available expertise and diagnostic/identification capacity for the pest. Pests must have both survey and diagnostic/identification methods available to be added to the final pest list. Annually, the Priority Pest Lists are shared with the team for Farm Bill Section 10007 Goal Area 3 “Pest Identification and Technology Enhancement.” The specific needs (e.g., a lure for a specific moth target) are documented in the Farm Bill guidance document that is posted on the Farm Bill website during the suggestion open period. Farm Bill suggestions that specifically address these areas of need are rated higher.

The following pests had a significant likelihood of having a high impact in the United States and also had survey and diagnostic/identification methods and capacity available were added to the FY 2017 CAPS Priority Pest List: Pests of Economic and Environmental Importance: *Anguina tritici* (Wheat gall nematode), ‘*Candidatus* Phytoplasma phoenicium’ 16SrIX-B (Almond witches’ broom), *Eurygaster integriceps* (Sunn pest), *Laodelphax striatellus* (Small brown planthopper), *Thaumetopoea pityocampa* (Pine processionary moth), *Cucumber green mottle mosaic virus* (CGMMV), and *Groundnut bud necrosis virus* (GBNV). Finally, to educate the CAPS community of Federal and State

stakeholders regarding how results of the new model impacted the final pest list, the Ft. Collins Lab developed support documents and conducted outreach to the National CAPS Committee and to the National Plant Board at their annual Central and Eastern Plant Board meetings. CPHST is now developing support products for these new pests, including pest datasheets, approved survey and diagnostic methods, and pest host maps. These are made available - CAPS resources - to our stakeholders on the APHIS PPQ website.



Isothermal DNA amplification (LAMP) technique for rapid screening of Citrus Black Spot (CBS) in packing houses

Citrus Black Spot (CBS) is a fungal disease of quarantine significance that was initially identified in 2010 in a few orange groves in South Florida. CBS causes a disfiguring disease on fruit and can also infect citrus leaves and stems. The affected area in Florida has remained limited and under quarantine restrictions since that time. More importantly, symptomatic fruit cannot be shipped to lucrative markets like that of the EU. If even a single suspect infected fruit is encountered by inspectors working at packing houses, an entire shipment can be held pending confirmatory diagnostics. The confirmatory diagnostic procedure requires that suspect samples are shipped to a well-equipped Federal or State

diagnostics laboratory where PCR-based testing is conducted. This process can take 2-3 days, and meanwhile the shipment cannot be processed at the packing house.

At the request of the Florida Citrus Board, CPHST-Beltsville scientists have examined and validated a rapid, field-deployable, screening method that can be used by diagnosticians with minimal equipment and setup. This new Isothermal DNA amplification (LAMP) technique allows for rapid screening of Citrus Black Spot (CBS) suspect samples. During early spring of 2017, CPHST-Beltsville scientists traveled to Ft. Pierce, FL, to provide hands-on training on using this method to APHIS and ARS scientists.

During this training, we familiarized our trainees with the portable Genie III isothermal amplification machine operating details and reagents, and the steps needed to prepare the critical diagnostic reagents. We demonstrated a rapid, simple, and straightforward method for DNA isolation that can be accomplished in under 20 minutes. The isothermal amplification detection method can then be used to distinguish suspect positive CBS samples within 15-20 minutes. The entire process from setup to result can be accomplished in under 1 hour, in a battery-operated, portable, and easily programmable machine. Each trainee had the opportunity to independently set up, run, and evaluate results from two to three runs. The CPHST-Beltsville scientists received valuable feedback from the trainees on improving future training and on improving Work Instructions for conducting the DNA isolation and LAMP procedures. Deploying this tool will permit PPQ and State regulators to more rapidly assess and to potentially release shipments of samples that are free of CBS infection.

Improving Sensitivity of Huanglongbing Diagnostics

Huanglongbing (HLB), commonly known as citrus greening, is considered the most serious disease affecting citrus production worldwide. It is associated with three species of phloem-limited, unevenly distributed, non-culturable bacteria: “*Candidatus*” *Liberibacter asiaticus* (CLas), *CL. africanus* (CLaf) and *CL. americanus* (CLam). Only CLas, of Asian origin but globally distributed, is currently found in the United States and is recognized as a major threat to California’s multi-billion-dollar citrus industry. Statewide surveys rely on sensitive and specific methods to find and quickly remove initial residential CLas introductions to help prevent the spread of the pathogen into commercial groves. A recent publication describes a new real-time polymerase chain reaction (PCR) assay claiming to be more specific and sensitive at detecting CLas than current methods. The assay targets part of a gene (ribonucleotide reductase, or RNR) found five times in CLas genomes. This is unusual because most genes are found at only one copy per genome. The current APHIS-approved real-time PCR method targets the taxonomic 16S rRNA gene present in three copies per CLas genome, suggesting the RNR assay targeting a five-copy genomic region would be a more sensitive assay. CPHST verified that the RNR-based real-time PCR assay functions well on both our soon-to-be-discontinued Cepheid real-time PCR instruments as well as on popular commercial platforms with high throughput capabilities. Multiple NPPLAP certified diagnosticians validated the assay through the testing of HLB CLas positive or negative DNA samples from over 230 plants or psyllids. The RNR assay showed improved specificity and a lower limit of detection over the 16S HLB real-time PCR method, and acceptable performance characteristics of precision, repeatability, and linearity. Continued assessment of the assay for use in field and survey testing is ongoing, via organized collaborative trials in State labs. This RNR method is expected to enhance the efficiency of our mission to track and prevent the dispersal of CLas, thereby limiting the spread of HLB disease.

Molecular diagnostics workshops for NPDN diagnosticians

Since 2004, the APHIS PPQ Center for Plant Health Science and Technology (CPHST) Beltsville Laboratory has conducted hands-on, advanced molecular diagnostic workshops to members of the National Plant Diagnostic Network (NPDN), State Departments of Agriculture, and Federal and commercial laboratories to provide trainings on PPQ-approved and validated testing protocols for pathogens of regulatory significance that are known to affect a number of ornamental crops, specialty crops, and forest ecosystems in the United States. During March –April of 2017, the Beltsville laboratory held a total of 7 workshops with the participation of 20 instructors to train 74 NPDN diagnosticians from 40 institutions including 22 universities, 12 State departments, 2 Federal laboratories and 3 companies. A new workshop focusing on “Quality Management System” (QMS) was presented for the first time by USDA APHIS CPHST Raleigh in collaboration with CPHST Beltsville Laboratory, Cornell University, and New Mexico State University. The focus of the other five workshops was on the molecular diagnostics of Citrus Greening, *Phytophthora ramorum*/*P. kernoviae*, Plum Pox Virus, Potato Cyst Nematode, and Phytoplasmas. The workshops were presented using lectures, computer sessions, hands-on experiments, and discussions. Each participant was trained to use the current molecular diagnostic protocols for detection of the pathogens, which consisted of completing DNA extractions, running real-time PCR or conventional PCR diagnostic assays, and practicing interpretation of the results to make final determinations. The “Bioinformatics of Plant Pathogens” 2017 workshop was presented in 2 different weeks to include 21 participants with 7 instructors. Aspects of bioinformatics of Fungi- Oomycetes, Bacteria, Phytoplasmas, Viruses, and Nematodes; data resources; molecular tools; and techniques that are useful for identification and diagnostics of plant pathogens, with emphasis to species of concern, were presented. Additional topics for the “Bioinformatics of Plant Pathogens” 2017 workshop were presentations on aspects of Innovative Genomic Sequencing

Technologies (IGST) with Next Generation Sequencing (NGS) and Third Generation Sequencing (TGS). Participants of the workshops have expressed great appreciation for the excellent work and high level of professionalism of instructors, organizers, and collaborators for the workshops at the CPHST-Beltsville laboratory. These workshops have not only enhanced the molecular plant diagnostic capability in the United States, but also prepared the United States diagnosticians to provide surge capacity in the event of an unexpected plant pathogen outbreak or a national agricultural emergency.

Rapid Field Identification of Imported Fire Ants by Immunoassay

The red imported fire ant is an aggressive, highly invasive pest ant species from South America that was introduced into United States in the 1930s. Damage caused by the red imported fire ant is wide ranging, resulting in physical damage to agricultural commodities, livestock, equipment, and infrastructure (e.g., roads and electrical equipment). These ants inflict a painful, venomous sting that represents the most common form of venom allergy in much of the Southeastern United States. Costs to control and repair damage caused by red imported fire ants are estimated at 6 billion dollars annually in the United States. In an effort to reduce damage and limit the human-assisted spread of imported fire ants, the USDA imposed quarantine measures (7 CFR 301.81). APHIS is responsible for enforcing the Federal quarantine and works with State governments to regulate the movement of nursery stock, grass sod, hay, soil, and soil-moving equipment possibly contaminated with red imported fire ants. Cargo moved from a quarantined to a non-quarantined area requires certification or inspection to certify that it is free of imported fire ants. When ants are found on the cargo, it is not permitted to enter the non-quarantined region until the ants are identified and determined to not be imported fire ants. Unfortunately, visual identification of fire ants to species is difficult, requiring considerable expertise in ant taxonomy and is prone to error. Indeed, specimens generally have to be shipped to an expert for identification, which can

result in prolonged delays of shipment transportation. To support the quarantine and minimize human-assisted spread of the ant, there was a need for a rapid identification tool that anyone in the field could use.

To this end, in 2010 APHIS and ARS collaborated on development of an imported fire ant identification tool. In 2016, work on a lateral flow immunoassay-based field test that could specifically identify red imported fire ant in less than 30 minutes was completed. The scientists then approached their respective ARS and APHIS Technology Transfer specialists who worked together to transfer this new tool from the laboratory to commercial development with a private company. In August 2017, the first commercially produced InvictDetect™ kits were delivered to APHIS, which then began distribution to its stakeholders for field use to identify ant samples.

2.5. VETERINARY SERVICES (VS)

http://www.aphis.usda.gov/animal_health/index.shtml

2.5.1. Mission Statement

As the recognized animal health leader and trusted partner, Veterinary Services safeguards the health of animals, people, and the environment.

VS's authorities derive from the Animal Health Protection Act and the Virus Serum Toxin Act. VS integrates One Health principles with USDA business objectives by contributing leadership, expertise, infrastructure, networks, and systems to collaborate effectively with local, State, Tribal, national, and international partners. Its comprehensive and integrated onfarm surveillance activities provide VS the capability to achieve national goals for animal disease prevention, detection, and early response.

2.5.2. Nature and Structure of the Program

VS is organized into four strategically focused organizational units. The four units are: Science, Technology and Analysis Services (STAS), Surveillance, Preparedness and Response Services (SPRS), National Import Export Services (NIES), and Program Support Services (PSS). Organizing by major services allows VS to better align with the changing dynamics of animal health and the needs of our customers. SPRS carries out functions ranging from early awareness and surveillance to the development and field implementation of animal health programs and emergency response, including One Health issues. NIES brings together VS' import and export activities, from policy setting to inspection at ports of entry. PSS provides key support services for both VS personnel and stakeholders.

Although scientists and scientific activities are distributed across VS, STAS brings together VS science centers to provide the solid scientific, technical, and analytical foundation needed to support VS in meeting its mission responsibilities. The three science centers are described below:

The National Veterinary Services Laboratories (NVSL)

The mission of NVSL is to safeguard U.S. animal health and contribute to public health by ensuring that timely and accurate diagnostic laboratory support is provided directly or by its coordination of the nationwide animal-health diagnostic system. NVSL accomplishes its mission through:

- Performing diagnostic laboratory testing for Veterinary Services' program diseases and for suspected outbreaks of foreign/transboundary animal diseases;
- Serving as the U.S. national and international reference laboratory for animal disease diagnosis by providing unique veterinary diagnostic capabilities, providing other diagnostic laboratories with animal disease information, technical guidance, reagents and reference materials;
- Providing national leadership in coordination of the National Animal Health Laboratory Network (NAHLN) and emergency laboratory response by training State, Federal, university, and foreign laboratory personnel, providing proficiency testing, and developing improved diagnostic technologies;
- Preparing for and responding to animal health emergencies and emerging threats to animal agriculture including threats to the poultry and aquaculture industries by being able to conduct and/or support diagnostic testing in an outbreak environment.

Among other potential technology transfer activities, NVSL develops and validates assays, and manufactures and distributes over 500 biological reagents to support veterinary diagnostics, many of which are not available from any other source.

Before a test is utilized by Veterinary Services for disease control or surveillance, it must be validated for that purpose. Samples for test validation for program diseases such as brucellosis and tuberculosis are in serum and tissue banks generated and maintained at the NVSL. These samples are made available to commercial kit manufacturers for their initial validation, and additional test validation is conducted at the NVSL. This is in addition to any testing for licensure required by the Center for Veterinary Biologics.

The NVSL is also involved in the development and validation of assays used to detect diseases that are foreign to the United States. Some of these assays are utilized in the reference laboratory as confirmatory tests, while others are deployed to the NAHLN laboratories and utilized in surveillance programs and for outbreak preparedness. The NVSL is also responsible for managing the North American Foot-and-Mouth Disease Vaccine Bank and is considered a World Organisation for Animal Health (OIE)/Food and Agriculture Organization of the United Nations (FAO) Reference Holding Facility for rinderpest virus.

Identification, feasibility testing, development, optimization, and validation of new assays and/or technologies are all accomplished within the NVSL, often with the support of NAHLN laboratories in areas of study design and testing. The NVSL staff collaborates with and provides scientific advice to other Federal and State government agencies and university and research laboratories that are also developing new assays and technologies, and NVSL scientists partner with other reference laboratories

around the world to obtain diagnostic specimens from naturally infected animals. These collaborative efforts result in enhanced expertise at the NVSL and in reference collections that are available for assay development and validation.

Centers for Epidemiology and Animal Health (CEAH)

The mission of CEAH, with a view to the future, is to explore and analyze animal health and related agricultural issues to facilitate informed decision-making in government and industry. CEAH also partners with the World Organization for Animal Health (OIE) and its member countries to improve international disease surveillance capabilities and analytic methods supporting trade decisions. CEAH has a multidisciplinary staff that includes agricultural economists, spatial analysts, geographers, informaticists, veterinary epidemiologists, statisticians, and biological scientists.

CEAH collaborates with university partners on analysis methods and tools. In some cases, the products produced are commercialized by academic partners.

Center for Veterinary Biologics (CVB)

The mission of the CVB is to implement the provisions of the Virus-Serum-Toxin Act (VSTA) to assure that pure, safe, potent and effective veterinary biologics are available for the diagnosis, prevention, and treatment of animal diseases. This mission mandates the use of sound scientific technology to:

- Ensure that biologics are free of disease-producing agents, especially foreign animal diseases
- Develop appropriate standards and procedures for product release
- Issue licenses and permits

- Monitor and inspect products and facilities
- Control field tests and release of veterinary biologics

CVB-developed methods and biological standards are applied equally to all products but, by the same token, can be adopted whole by the regulated commercial manufacturers, becoming part of their manufacturing and release process.

2.5.3. Current Technology Transfer Goals, Objectives, and Measures of Success.

APHIS-VS transfers technology to State and international animal health agencies, animal owners, animal industry, and domestic and international universities via a variety of methods, including collaborations. Recent examples include:

- APHIS-VS collaborated with the USDA, Agricultural Research Service (ARS) to better understand genetic resistance to scrapie in goats and to share information from this research with State and Federal regulatory personnel and the goat industry. VS is developing the ability to genotype goats for scrapie susceptibility and developing a panel to use to approve private laboratories to conduct official genotyping of goats.
- APHIS-VS and the University of Minnesota collaborated on the development of the One Health Systems Mapping and Analysis Resource Toolkit (OH-SMART™), and the University has now copyrighted the toolkit and created a “zero-cost license” to protect the tool from commercial use and other unapproved adaptations. The tool was developed to help people from different disciplines and sectors better understand and strengthen their “operational” approaches to

working across organizational and disciplinary lines. Using real-life challenges like zoonotic disease surveillance and response, facilitators led workshop participants through a series of specific steps adapted from business process improvement and participatory leadership methods to create a visual representation, or map, of the system of communication and coordination across their organizations, allowing them to analyze the One Health system. OH-SMART™ has supported One Health systems strengthening in over 30 U.S. States and 12 countries, and VS has partnered with several country-level governments to tailor the tool for their use.

- Fifty-five classroom courses were provided to participants including 125 State employees and 8 international individuals as well as VS and other APHIS personnel. The courses included foreign animal disease diagnostician and incident management training, and courses on specific diseases (scrapie, classical swine fever) and situations (e.g., radiological incident). In addition, numerous lectures were provided to other agencies and universities on specialized topics (e.g., population management and humane euthanasia of wild horses and burros).
- VS undertook modernization efforts for mobile tools and coordinated requirements for the development and training for Mobile Information Management systems (MIMS) for recording animal health information in the field. MIMS allows for direct incorporation of data into both VS support databases and industry databases utilized by industry, and State/Federal animal health.
- VS funded a cooperative agreement with Iowa State University to support Minor Use Animal Drug Program work. Studies included: ivermectin for control of cattle fever ticks (information from the field trial on the Texas-Mexico border); chlortetracycline (CTC) for sheep respiratory

disease (a pilot study was conducted to determine if a natural exposure model or a pharmacokinetic approach [plasma CTC levels] can be used to demonstrate efficacy); CIDR-g® (controlled internal drug-releasing devices containing progesterone) efficacy in goats (data was transferred to UC-Davis to assemble the efficacy study report); and polyanhydride *Haemonchus contortus* vaccine (lambs have been vaccinated and serology is being performed to determine antibody response to the vaccine).

- Biological samples collected through National Animal Health Monitoring System surveys are used to estimate historical seroprevalence of a specific disease in the United States, provide data used by industry, State/Federal animal health, livestock extension, and academia on antimicrobial resistance and production-related issues in pre-harvest settings.
- VS, in conjunction with the Institute for International Cooperation in Animal Biologics held the 2017 OIE Veterinary Biologics Training Program in Ames, Iowa. This program gave participants an overview of the scientific principles of vaccines, vaccination, and the USDA regulatory process for assuring the purity, safety, potency, and efficacy of veterinary biologics. The program was made available to both domestic and international attendees, with 168 registrants including 38 international attendees from 20 countries, and was publicized through Iowa State University, the USDA, and the World Organisation for Animal Health.
- An experimental vaccine against cattle fever tick gut antigens was administered to dairy cattle in Puerto Rico and in beef cattle in Texas, in cooperation with State/territorial authorities. The vaccine was the result of collaboration between USDA-ARS and a commercial veterinary biologics manufacturer.

- VS is modernizing the Cattle Fever Tick Eradication Program (CFTEP) by moving quarantine paper records into the VS Surveillance and Collaboration Services (SCS) software to more efficiently manage more than 2,500 quarantines. Additionally, VS began collaboration with the CFTEP Radio Tower Project that is being designed to support the safety of the Mounted Patrol Inspectors along the Rio Grande River in South Texas.
- VS coordinated tick training events with Mexican animal health authorities. In FY17, there were 3 trainings, with a total of 240 attendees. The attendees were primarily Mexican veterinarians and animal health technicians. The objective was to train and update the veterinarians and technicians on how to manage the tick programs for cattle for export to the United States.
- Diverse surveillance and mitigation measures were deployed in a State-Federal program. Robotic ground vehicles for tick collection and molasses tubs treated with acaricide in infested pastures were used as part of the CFTEP. APHIS-VS worked with ARS to create a sprayer to apply entomopathogenic nematodes to control cattle fever ticks on nilgai.
- VS transferred animal movement records for use in estimating parameters on swine movement patterns. The records are used by industry, State/Federal animal health, and academia to assess epidemiologic and economic impacts of countermeasures and vaccination strategies in disease outbreaks.
- VS funded a cooperative agreement with Texas A&M, “Screening the White-tailed Deer Genome to Search for Chronic Wasting Disease-Resistant Animals.” This cooperative

agreement supports an indepth genome-wide screening of the white-tailed deer genome for the presence of genes that increase susceptibility or resistance to chronic wasting disease.

- VS partnered with Texas State employees in providing Incident Management Team training in the use of SCS for data entry, part of the modernization effort for the CFTEP. More than 30 staff were trained over a 6-week period during the incident management team rotations in south Texas.
- VS provided a training session in Bryan, TX, to the Texas Animal Health Commission and the Texas Poultry Improvement Association regarding the New Gateway Portal permitting process in Emergency Management Response System (EMRS) 2 for movement of animals and products during disease emergencies. Sixty participants attended the meeting.
- VS developed an off-line support software product called EMRS 2 To Go. This product streamlines data entry ensuring better data integrity, allowing users to focus on activities performed in the field.

3.0. Agricultural Research Service (ARS)

<http://www.ars.usda.gov>

3.1. Mission Statement

ARS conducts research to develop and transfer solutions to agricultural problems of high national priority and provides information access and dissemination to:

- Ensure high-quality, safe food, and other agricultural products;
- Assess the nutritional needs of Americans;
- Sustain a competitive agricultural economy;
- Enhance U.S. natural resources and the environment;
- Provide economic opportunities for rural citizens, communities, and society as a whole; and
- Provide the infrastructure necessary to create and maintain a diversified workplace.

3.2. Nature and Structure of Research Program

ARS is the U.S. Department of Agriculture's (USDA's) principal intramural scientific research agency. Agency goals are to find solutions to agricultural problems that affect Americans every day, from field to table, such as (a) protecting crops and livestock from pests and diseases, (b) improving the quality and safety of agricultural products, (c) determining the best nutrition for people from infancy to old age, (d) sustaining our soil and other natural resources, (e) ensuring profitability for farmers and processors, (f) keeping costs down for consumers, and (g) supporting the growth and development of rural America.

In fiscal year (FY) 2017, ARS employed approximately 2,000 scientists and postdoctoral researchers,

and approximately 6,000 other employees to conduct 690 research projects at more than 90 locations. The research projects were organized within 1 of 17 national programs (see table below). The Office of National Programs in Beltsville, MD, plans the scope and objectives of agency’s research projects, whereas five area directors implement research projects at the locations in their geographic areas.

Research program management of ARS, showing 17 National Programs.

| Animal Production and Protection | Natural Resources and Sustainable Agricultural Systems | Crop Production and Protection | Nutrition, Food Safety, and Quality |
|---|---|---|--|
| Food Animal Production | Water Availability and Watershed Management | Plant Genetic Resources, Genomics and Genetic Improvement | Human Nutrition |
| Animal Health | Climate Change, Soils, and Emissions | Crop Production | Food Safety (animal and plant products) |
| Veterinary, Medical, and Urban Entomology | Pasture, Forage and Rangeland Systems | Plant Diseases | Quality and Utilization of Agricultural Products |
| Aquaculture | Biorefining | Crop Protection and Quarantine | |
| | Agricultural and Industrial Byproducts | | |
| | Agricultural System Competitiveness and Sustainability | | |

ARS conducts a series of reviews designed to ensure the relevance and quality of its research work and maintain the highest possible standards for its scientists. Customer input helps keep the research focused on the needs of the American food and agricultural system. Plans for each of the active research projects undergo a thorough, independent external prospective peer review managed by the Office of Scientific Quality Review (OSQR). All ARS employees, including the scientific workforce, are subject to annual performance reviews, and all research scientists and engineers have technology transfer as a performance element in their annual performance appraisal. Research scientists undergo a rigorous peer review Research Position Evaluation System (RPES) on a 3- to 5-year cycle. These processes ensure the continuing high-quality output of the ARS research addressing the needs of U.S. agriculture.

3.3. ARS Approach and Plans for Conducting Technology Transfer

Because of the delegations of authority by the Secretary of Agriculture, the ARS Office of Technology Transfer (OTT) is assigned the responsibility for obtaining patent protection for intellectual property (IP), developing strategic partnerships with outside organizations, licensing USDA technologies to the private sector and academia, and performing other activities that effectively transfer ARS research outcomes and technologies to the marketplace. USDA, Office of the General Counsel provides legal guidance to OTT in regard to intellectual property as needed.

The ARS technology transfer program has centralized policy and approval procedures that are managed by OTT. Research agreement negotiation and implementation is decentralized and managed by the ARS area offices. Area office technology transfer staff members serve as liaisons with scientists, ARS managers, OTT, university partners, and the private sector.

To facilitate technology transfer, OTT is organized into three sections. The *Partnership and Administrative Section* conducts day-to-day operations, coordinates technology transfer policy development, interacts with the Office of National Programs on agreement policy and review, and coordinates the activities between the partnership, patenting, and licensing sections. This section maintains strong stakeholder relationships at the local, regional, and national levels, ensuring the adoption of research results. This section is also responsible for coordinating, managing, and reviewing agreements, and overseeing and managing the Agricultural Research Partnerships (ARP) Network. The *Patenting Section* provides strategic guidance to scientists regarding patent protection for their research results. The section is also responsible for receiving invention reports; convening three National Patent Committees (Mechanical and Measurement, Life Sciences, and Chemistry), and a Plant Protection

Committee; preparing and prosecuting patent applications; and reviewing patent legal work performed by cooperator and ARS contract law firm. The *Licensing Section* manages invention licensing from all the intramural scientists in every USDA agency, including the review of license applications, negotiation of licenses, and monitoring of license agreements to ensure compliance. This section also collects and disburses license revenues, manages international patent filings, and provides expert advice on all matters related to USDA invention licensing.

At ARS, technology transfer is accomplished through many mechanisms, such as these:

- Developing written information for customers and stakeholders, including scientific publications, publications in trade journals, and reports to stakeholders;
- Releasing plant germplasm to the public;
- Transferring research materials to scientists outside of ARS;
- Entering into formal partnership agreements, such as Cooperative Research and Development Agreements (CRADAs), and other cooperative agreements;
- Licensing IP (patents, Plant Variety Protections Certificates, and biological materials); and
- Participating in meetings with industry organizations and universities and workshops and field days; and
- Distributing information to the public via the ARS Office of Communications, the National Agricultural Library, and other sources.

Because the ARS mission is to transfer technologies for broad public use by the most effective mechanism, ARS pursues patents and licensing principally to incentivize commercialization and to facilitate technology transfer to the marketplace. This is usually the case when complementary investment by the private sector is necessary to commercialize a product, and patent protection is

required to protect this investment. By ARS policy, patents are not filed on inventions that are considered to be only research tools. The purpose of this policy is to encourage scientific research. Judicious use of intellectual property rights (IPR) is an important cornerstone of the patent committees. IPR is used as an incentive for commercialization and full realization of the research impact of USDA technologies. In licensing practices, ARS continues to reserve the right to allow use of any IP-protected technology for research purposes (non-commercial).

Meaningful performance metrics in technology transfer are often difficult for research agencies to formulate. ARS has defined better metrics for technology transfer within USDA. For example, successful outcomes for ARS may include improved agricultural practices, gathering and compilation of scientific information that enhances U.S. competitiveness, increased awareness about pathogens to help prevent human and animal diseases, or findings that help corporations and universities make informed decisions in allocating their research resources. Many of these outcomes do not require patenting or subsequent licensing for implementation. Additionally, ARS uses its ARP Network to match technical expertise of ARS researchers with firms that can capitalize on the ARS research capacities, facilities, and research outcomes.

Licensing policies also promote small business success with reasonable licensing fees in the early years, but with annual maintenance fees and royalties that escalate in subsequent years, sometimes after the first commercial sale of the product. Licensing further enhances commercialization by encouraging the broadest utilization of a Federal invention. ARS also incentivizes scientists on the reporting of inventions, patenting, and licensing by providing 25 percent of the license revenues to inventors (this is a higher percentage than the 15 percent required by statute). Thus, there are policies in place that incentivize commercialization, minimize transaction costs, and yet provide fair and equitable

compensation for those who create Federal innovations.

OTT founded the ARP Network to expand the impact of ARS research by enhancing the likelihood that these outcomes will be adopted. Although replete with scientific expertise, the ARS research program does not have the resources or the authority to provide ARS commercial partners with business mentoring, marketing, manufacturing, and fiscal resources needed for the success of their businesses. Consequently, the ARP Network was established to provide these complementary assets. By combining ARS research expertise with complementary capabilities and talents of partnering organizations, the ARP Network stimulates economic growth through technological advancements.

3.4. Technology Transfer Highlights

- There are 249 active CRADAs, with 57 having been newly executed this year. The 57 new CRADAs contribute \$2,804,160 directly into ARS research projects. Approximately 30 percent of the new CRADAs are with small businesses. There are 432 active Material Transfer Research Agreements (MTRAs), with 101 newly executed this year. The 101 new MTRAs contribute \$743,603 directly into ARS research projects. (Refer to Table 1 in Section 3.5 and Figures 1 and 2 in Section 3.9.)
- This year, 1,048 Trust Fund Cooperative Agreements, Reimbursable Agreements, Interagency Agreements, and Non-Funded Cooperative Agreements were executed. Coupled with the newly executed CRADAs and MTRAs, this amounts to a little over one collaborative research agreement per scientist. (Refer to Table 1 in Section 3.5 and Figure 2 in Section 3.9.)
- The ARP Network coordinated a Webinar with U.S. Small Business Administration (SBA) and the USDA, National Institute of Food and Agriculture (NIFA) on the new Small Business

Innovation Research (SBIR) Technology Transfer Program. This program encourages SBIR applicants to collaborate with ARS researchers and/or license ARS technologies. The relevant language in the SBIR Request for Applications states: “Additional factors that will be considered in the review process include whether an application involves a CRADA with a USDA laboratory, or a license to a USDA technology.” Of the 56 newly executed CRADAs, 5 were with small businesses that applied for SBIR Phase I grants to further commercialize the CRADA research. Three of these businesses were successful in obtaining SBIR funding, leading to a 60-percent success rate. The average success rate for USDA-SBIR Phase I funding for FY 2017 was 16.6 percent. In addition, three ARS CRADA partners applied for and received SBIR Phase II funding. There are several reasons for this higher funding rate of USDA-SBIR proposals. For example, a company with a CRADA already had its project reviewed and approved by ARS before the SBIR review process. In addition, many of the CRADAs focused on ARS technologies that are known to have a commercial application. (Refer to Figure 3 in Section 3.9.)

- One hundred fifty-two new invention disclosures were received; 101 patent applications were filed; and 50 utility patents, six plant patents, and six Plant Variety Protection Certificates were obtained. Although the year in which a patent is issued is not typically the year in which the patent application is filed, over time the ratio of patent applications filed over the number of patents issued represents a trend in the percentage of patents that are issued. The trend suggests that about 60 percent of the patent applications result in an issued patent. This reflects the quality of the patent applications and subsequent prosecution. (Refer to Table 2 in Section 3.5 and Figures 4, 5, and 6 in Section 3.9.)
- Thirty-eight new licenses were executed, of which 50 percent were with small businesses and 24 percent with universities. The total number of income-bearing licenses has steadily increased

over the last 5 years from 378 to 425. Sixty-nine percent of the income-bearing licenses were granted exclusively. The total earned royalty income (ERI) of \$3,503,866 was slightly lower than that of the previous year. Most of FY 2017's ERI came from a few licenses; the median ERI was \$3,698. (Refer to Tables 3, 4, and 5 in Section 3.5 and Figures 5, 6, and 7 in Section 3.9.)

- OTT professional staff authored a paper describing the new ARS paradigm for technology transfer (Bahar, M. and R. J. Griesbach. A New Strategic Approach to Technology Transfer. *les Nouvelles*, June 2017). In this new paradigm, technology transfer is an essential and integrated part of the research process beginning when the research objectives are first conceived. By aligning technology transfer with research objectives, the impact of research outcomes will be strengthened.
- OTT employees served as members/moderators/speakers/trainers in broad technology transfer activities and forums such as FLC National and Regional Meetings, and the I2C (Innovation to Commercialization) Conference; as member of U.S. and India Science and Technology Endowment Board; various career-related panels; as USDA representative at the Tri-Societies meeting; and at the Organization for Economic Co-operation and Development (OECD) and U.S. Department of Commerce workshops for capacity building in Pakistan, Sri Lanka, and Armenia.
- Worked with area offices, Office of National Programs (ONP), and Administrative and Financial Management to update the Professional Activities Policy and Procedure Manual to support scientific gatherings and conferences to support the ARS science mission. In FY 2017, 13 conferences across different national programs were supported.

- Devised and enhanced a two-way communication mechanism between technology transfer professionals (both at OTT and area offices), ONP, and scientists in the field through the use of technology transfer strategy calls. In FY 2017, OTT conducted more than 300 strategy calls resulting in devising a customized technology transfer strategy to ensure the adoption of research outcomes of each project.
- Worked with the ONP, research leaders, and plant breeders to develop a new mechanism for evaluating plant selections/inventions (cultivars, germplasm enhancements, etc.) through a quarterly Plant Protection Committee to ensure the most appropriate mechanism for distributing new plant releases. In FY 2017, 24 plant selections/inventions were reviewed and decisions were rendered on whether to publicly release the cultivar/germplasm or seek protection as an incentive to commercialization.
- Held a 3-day workshop for technology transfer professionals across the agency to discuss new policies and procedures on agreement processing; to exchange ideas on roles and expectations of all technology transfer professionals; to inform everyone of new initiatives; and to exchange ideas with ONP staff thereby strengthening the agency's mission of "transferring solutions" for the benefit of the public.
- Conducted comprehensive technology transfer training at 18 ARS locations, followed by project-specific consultations with scientists at each location to ensure the appropriate technology transfer strategy is in place to maximize the probability of adoption of ARS's research outcomes.
- Conducted an agency-wide webinar on "Onboarding Foreign Visitors" for scientists in the field to ascertain that the Federal intellectual property and materials are protected and preserved.

- Established a robust export control review process for ARS agreements through the training of three staff members at headquarters and in the field to ensure ARS compliance with export-control laws. Developed an on-demand training module entitled “Commerce Regulations: What Every Scientist Needs to Know” through collaboration with ONP and area directors. In FY 2017, more than 150 scientists have taken advantage of this training and more than 50 export-control matters have been reviewed
- In FY 2016, OTT established an Innovation Fund to enhance the commercial potential of an agricultural solution currently under development at ARS and to enable the adoption of ARS’s research outcomes by industry, academia, and other stakeholders. In FY 2017, 76 Innovation Fund applications were received and 29 were funded.
- Created a quarterly electronic newsletter called “ARP Notes” to update ARP Network members on ARS and members’ activities and events, as well as inform members of ARS partnerships and/or licensing opportunities. In FY 2017, the quarterly ARP Notes distribution list consisted of 150 individuals that included ARP Network members, technology scouts, business development specialists, university faculty and staff, and other people involved in helping businesses and small companies commercialize technologies. In addition, ARS tweets an announcement of each new issue of ARP Notes.
- Participated in the following ARP Network member events: (1) Von Allmen Center for Entrepreneurship’s “Kentucky Science and Technology Corporation Road Show”; (2) Center for Innovative Food Technology’s “Ohio Food Industry Summit”; and (3) Florida High Tech Council’s “Innovation Workshop.”

- Participated in the Kauffman Foundation summit on ecosystem building. At the summit, entrepreneurial ecosystem builders from 48 States and 10 countries collaborated to craft actionable plans for activating and transforming the startup communities.

3.5. Metric Tables

TABLE 1. Collaborative relationships for research and development.

| | FY 2013 | FY 2014 | FY 2015 | FY 2016 | FY 2017 |
|--|---------|---------|---------|---------|---------|
| Total number active CRADAs | 188 | 217 | 223 | 219 | 249 |
| Active traditional CRADAs | 140 | 163 | 163 | 190 | 215 |
| Active non-traditional CRADAs ¹ | 48 | 54 | 60 | 29 | 34 |
| Active CRADAs with small businesses | 116 | 96 | 98 | 70 | 62 |
| Number newly executed CRADAs, total | 59 | 38 | 41 | 39 | 57 |
| Newly executed amendments ² | 86 | 72 | 76 | 64 | 62 |
| Newly executed traditional CRADAs | 38 | 58 | 61 | 52 | 47 |
| Newly executed non-traditional CRADAs | 21 | 14 | 15 | 12 | 10 |
| Newly executed CRADAs with small businesses | 21 | 10 | 31 | 12 | 17 |
| Total number active MTRAs³ | 64 | 137 | 199 | 288 | 432 |
| Newly executed MTRAs | 62 | 73 | 62 | 89 | 101 |
| Total number of active other agreements⁴ | 1,926 | 2,438 | 2,899 | 3,230 | 4,108 |
| Newly executed other agreements | 609 | 687 | 756 | 876 | 1,048 |
| Number newly executed MTAs | 991 | 906 | 743 | 823 | 664 |
| Newly executed outgoing MTAs | 647 | 506 | 513 | 539 | 445 |
| Total number of publications⁵ | 6,257 | 5,983 | 6,196 | 5,123 | 4,892 |
| Peer-reviewed scientific journal | 4,409 | 4,367 | 4,395 | 3,851 | 3,992 |
| Trade journal | 73 | 68 | 55 | 59 | 61 |
| Meeting abstracts | 1,775 | 1,548 | 1,746 | 1,213 | 839 |

¹ Material Transfer CRADAs.

² Amendments extend existing Cooperative Research and Development Agreements (CRADAs) for additional years to a maximum of 5 years, change Statements of Work, and/or change funding levels.

³ Material Transfer Research Agreements. Involves collaborative research on a specific material.

⁴ Includes Trust Fund Cooperative Agreements, Reimbursable Agreements, Interagency Agreements, and Non-Funded Cooperative Agreements.

⁵ Number of published manuscripts.

TABLE 2. Invention disclosures and patenting

ND- no data available.

| | FY 2013 ⁴ | FY 2014 | FY 2015 | FY 2016 | FY 2017 |
|---|----------------------|---------|------------------|---------|---------|
| Total number new invention disclosures¹ | 165 | 101 | 175 ⁵ | 174 | 169 |
| University co-owned | 46 | 37 | 40 | 58 | 27 |
| Non-university co-owned | ND | ND | 27 | 29 | 21 |
| Based on scientific discipline | | | | | |
| Biological materials | ND | ND | 32 | 19 | 8 |
| Life science | 74 | 39 | 64 | 73 | 72 |
| Chemical | 49 | 32 | 48 | 48 | 43 |
| Mechanical & measurement | 19 | 9 | 18 | 21 | 28 |
| Plant patents ³ | 12 | 4 | 3 | 5 | 5 |
| Plant variety protection ³ | 11 | 17 | 10 | 8 | 13 |
| Total number patent applications filed² | 144 | 110 | 110 | 92 | 101 |
| University co-owned | 36 | 34 | 25 | 10 | 21 |
| Non-university co-owned | ND | ND | 26 | 9 | 23 |
| Based on scientific discipline | | | | | |
| Life science | 62 | 47 | 47 | 50 | 45 |
| Chemical | 44 | 25 | 38 | 24 | 38 |
| Mechanical & measurement | 13 | 17 | 15 | 10 | 7 |
| Plant patents | 14 | 6 | 4 | 6 | 11 |
| Plant variety protection | 11 | 6 | 6 | 2 | 8 |
| Total number patents issued² | 60 | 78 | 84 | 53 | 62 |
| University co-owned | 17 | 23 | 12 | 15 | 22 |
| Non-university co-owned | ND | ND | 20 | 12 | 19 |
| Based on scientific discipline | | | | | |
| Life science | 17 | 36 | 33 | 23 | 37 |
| Chemical | 25 | 21 | 20 | 13 | 13 |
| Mechanical & measurement | 11 | 11 | 10 | 9 | 6 |
| Plant patents | 7 | 10 | 15 | 5 | 6 |
| Plant variety protection | ND | ND | 6 | 3 | 6 |

1. Inventions arising at the Federal lab. For FY 2013 and 2014 also includes the plants protected through Plant Variety Protection.
2. Includes U.S. patent applications, foreign patent applications filed on cases for which no U.S. application was filed, divisional applications, continuation-in-part applications, provisional applications, and Plant Variety Protection.
3. Plants may be protected in one of two ways based upon their mode of reproduction: patent (vegetatively reproduced) through the U.S. Patent and Trademark Office (USPTO) or variety protection (seed reproduced) through USDA Agricultural Marketing Service.
4. FY 2013 numbers were revised (higher) in FY 2014.
5. FY 2015 includes the addition of Biological Material Invention Disclosures for the first time.

TABLE 3. Profile of active licenses

ND- no data available.

| | FY 2013 | FY 2014 | FY 2015 | FY 2016 | FY 2017 |
|--|---------|---------|---------|---------|---------|
| Total number active licenses | 380 | 392 | 404 | 419 | 426 |
| Executed to small businesses ¹ | 137 | 150 | 147 | 150 | 155 |
| Executed to start-up businesses ² | 11 | 12 | 12 | 6 | 6 |
| Executed to universities | 169 | 168 | 175 | 187 | 186 |
| Amended in FY | ND | 10 | 5 | 4 | 4 |
| Invention licenses³ | 331 | 341 | 339 | 348 | 351 |
| Executed to small businesses | 113 | 125 | 112 | 112 | 114 |
| Executed to start-up businesses | 11 | 12 | 12 | 6 | 6 |
| Executed to universities | 162 | 160 | 166 | 178 | 176 |
| Other IP Licenses⁴ | 49 | 51 | 65 | 71 | 75 |
| Executed to small business | 24 | 25 | 35 | 38 | 41 |
| Executed to start-up businesses | 0 | 0 | 0 | 0 | 0 |
| Executed to universities | 7 | 8 | 9 | 9 | 10 |
| Total number newly executed licenses | 23 | 28 | 35 | 29 | 38 |
| Executed to small businesses | 9 | 15 | 16 | 9 | 19 |
| Executed to start-up businesses | 0 | 1 | 0 | 0 | 0 |
| Executed to universities | 10 | 10 | 9 | 14 | 9 |
| Invention licenses | 17 | 26 | 20 | 23 | 29 |
| Executed to small businesses | 5 | 14 | 5 | 6 | 13 |
| Executed to start-up businesses | 0 | 1 | 0 | 0 | 0 |
| Executed to universities | 10 | 10 | 8 | 14 | 8 |
| Other IP Licenses | 6 | 2 | 15 | 6 | 9 |
| Executed to small businesses | 4 | 1 | 11 | 3 | 6 |
| Executed to start-up businesses | 0 | 0 | 0 | 0 | 0 |
| Executed to universities | 0 | 0 | 1 | 0 | 1 |

1. A small business, together with its affiliates, must not have more than 500 employees.
2. For the purpose of this report, a startup company is a privately-held, U.S. for-profit company operating for less than 5 years and actively seeking financing to commercialize a Federal scientific work product.
3. Invention licenses refer to patents and plant variety protection certifications.
4. Other intellectual property (IP) licenses refer to biological materials licenses.

TABLE 4. Characteristics of income bearing licenses

| | FY 2013 ⁴ | FY 2014 | FY 2015 | FY 2016 | FY 2017 |
|--|----------------------|---------|---------|---------|---------|
| Total number of income-bearing licenses | 378 | 390 | 402 | 418 | 425 |
| Exclusive | 273 | 278 | 274 | 289 | 293 |
| Partially exclusive | 13 | 15 | 11 | 9 | 6 |
| Non-exclusive | 92 | 97 | 117 | 120 | 126 |
| Invention licenses¹ | 329 | 339 | 337 | 347 | 350 |
| Exclusive | 265 | 269 | 266 | 280 | 283 |
| Partially exclusive | 13 | 15 | 11 | 9 | 6 |
| Non-exclusive | 51 | 55 | 60 | 58 | 61 |
| Other IP licenses² | 49 | 51 | 65 | 71 | 75 |
| Exclusive | 8 | 9 | 8 | 9 | 10 |
| Partially exclusive | 0 | 0 | 0 | 0 | 0 |
| Non-exclusive | 41 | 42 | 57 | 62 | 65 |
| Total number royalty-bearing licenses | 134 | 131 | 139 | 145 | 129 |
| Invention licenses | 115 | 117 | 121 | 123 | 107 |
| Other IP licenses | 19 | 14 | 18 | 22 | 22 |

1. Invention licenses refer to patents and plant variety protection certifications.
2. Other intellectual property (IP) licenses refer to biological materials licenses.

TABLE 5. Income from licensing

ND- no data available; NP- not presented; IP- intellectual property.

| | FY 2013 | FY 2014 | FY 2015 | FY 2016 | FY2017 |
|--|--------------------|--------------------|--------------------|--------------------|--------------------|
| Total income all active licenses | \$4,385,952 | \$4,927,938 | \$5,066,988 | \$4,784,466 | \$5,713,803 |
| Invention licenses ¹ | \$4,053,931 | \$4,733,200 | \$4,842,256 | \$4,456,054 | \$5,377,909 |
| Other IP licenses ² | \$332,021 | \$194,738 | \$224,732 | \$328,412 | \$325,566 |
| Total earned royalty income (ERI) | \$3,353,876 | \$3,610,774 | \$3,509,904 | \$3,633,239 | \$3,503,866 |
| Median ERI | \$3,609 | \$3,232 | \$3,525 | \$3,966 | \$3,698 |
| Minimum ERI | \$5 | \$32 | \$13 | \$5 | \$15 |
| Maximum ERI | \$856,987 | \$575,753 | \$728,017 | \$818,537 | \$769,167 |
| ERI from top 1% of licenses | NP ³ | NP ³ | NP ³ | NP ³ | NP |
| ERI from top 5% of licenses | \$1,969,155 | \$2,048,317 | \$1,756,460 | \$1,811,637 | \$1,639,557 |
| ERI from top 20% of licenses | \$2,892,796 | \$3,103,143 | \$2,856,924 | \$3,043,395 | \$2,933,342 |
| ERI distributed⁴ | | | | | |
| Inventors | \$1,192,808 | \$1,305,695 | \$1,632,130 | \$1,188,389 | \$2,443,702 |
| Funds used for salaries | ND | \$2,812,269 | \$2,819,906 | \$2,051,317 | \$1,449,005 |
| Innovation Fund | ND | ND | ND | ND | \$483,814 |
| Patent filing preparation, fees, & annuity payments paid | ND | \$809,974 | \$621,701 | \$393,533 | \$576,120 |

1. Invention licenses refer to patents and plant variety protection certifications.

2. Other IP licenses refer to biological materials licenses.

3. Not presented, represents one license.

4. Not all of funds disbursed are from the fiscal year they were collected.

TABLE 6. Licensing management: elapsed execution time and termination

| Agricultural Research Service (ARS) | FY 2013 ¹ | FY 2014 ² | FY 2015 ³ | FY 2016 ⁴ | FY 2017 ⁵ |
|--------------------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| All licenses | | | | | |
| Average (months) | 3.5 | 5.9 | 2.8 | 4.9 | 6.1 |
| Median (months) | 2.3 | 5.8 | 2.5 | 3.7 | 5.1 |
| Minimum (months) | 0.4 | 0.9 | 0.5 | 0.9 | 1.3 |
| Maximum (months) | 12.5 | 21.5 | 10.0 | 16.0 | 13.7 |
| Licenses terminated for cause | 0 | 0 | 0 | 0 | 0 |

- ¹ During FY 2013, USDA received 28 new invention license applications, for which 8 new licenses were granted, 15 license agreements are currently in negotiation, 3 applications were withdrawn by the applicants, and 2 applications are on hold by request of the applicant. The FY 2012 data is based upon 18 licenses granted to commercial licensees and does not include licenses executed with universities for co-owned inventions. In accordance with 35 USC 202(e), such licenses are granted for the purpose of consolidating rights in the invention, and therefore license applications are not required.
- ² During FY 2014, USDA received 15 new invention license applications, for which 8 new licenses were granted, 5 license agreements are currently in negotiation, 2 applications were withdrawn by the applicants, and 0 applications are on hold by request of the applicant. The FY 2014 data is based upon 17 licenses granted to commercial licensees and does not include licenses executed with universities for co-owned inventions. In accordance with 35 USC 202(e), such licenses are granted for the purpose of consolidating rights in the invention, and therefore license applications are not required.
- ³ During FY 2015, USDA received 42 new invention license applications, for which 21 new licenses were granted, 18 license agreements are currently in negotiation, 2 applications were withdrawn by the applicants, and 1 application is on hold by request of the applicant. The FY 2015 data is based upon 26 licenses granted to commercial licensees and does not include licenses executed with universities for co-owned inventions. In accordance with 35 USC 202(e), such licenses are granted for the purpose of consolidating rights in the invention, and therefore license applications are not required.
- ⁴ During FY 2016, USDA received 26 new invention license applications, for which 6 new licenses were granted, 15 license agreements are currently in negotiation, 5 applications were withdrawn by the applicants, and 0 applications are on hold by request of the applicant. The FY 2016 data is based upon 14 licenses granted to commercial licensees and does not include licenses executed with universities for co-owned inventions. In accordance with 35 USC 202(e), such licenses are granted for the purpose of consolidating rights in the invention, and therefore license applications are not required.
- ⁵ During FY 2017, USDA received 29 new invention license applications, for which 7 new licenses were granted, 20 license agreements are currently in negotiation, 1 application was withdrawn by the applicant, and 1 application is on hold by request of the applicant. The FY 2017 data is based upon 23 licenses granted to commercial licensees and does not include licenses executed with universities for co-owned inventions. In accordance with 35 USC 202(e), such licenses are granted for the purpose of consolidating rights in the invention, and therefore license applications are not required.

3.6. Downstream Outcomes



NUTRITION, FOOD SAFETY, QUALITY

National Programs:

- **Human Nutrition, NP 107**
- **Food Safety, NP 108**
- **Quality and Utilization of Agricultural Products, NP 306**

Whole grain replacement of refined grains improves calorie balance.

Dietary recommendations, including Dietary Guidelines for Americans, suggest replacing refined grains with whole grains, but the evidence for this is not consistent. ARS-supported scientists in Boston, Massachusetts, studied 81 older volunteers who were given meals for 6 weeks that were designed to maintain body weight containing either 0 or 7 ounces of whole grain foods daily. Whole grain intake led to a 92-calorie/day higher net energy loss compared with refined grain intake. There were modest beneficial changes in some of the large-intestinal bacteria and two types of immune cells in the bloodstream as a result of this diet. These data strengthen the recommendation from the U.S. Departments of Agriculture and Health and Human Services that at least half of a person's grain servings should come from whole grain foods. [NP 107, Project 8050-51000-090-00D]

Improved nutrient intake recommendations for infants, young children, and lactating women.

It is important to know the concentration of nutrients in human milk because it is recommended as the sole source of nutrition for infants during the first 6 months of life. Additionally, it is the basis for setting nutrient intake recommendations for infants, nursing women, and young children. Unfortunately, the reported nutritional values for human breast milk are few and inconsistent across studies due to differences in methods and timing of milk collection and maternal nutritional status. ARS researchers in Davis, California, have developed and validated more efficient methods for measuring nutrients in human milk that has spawned a new study to obtain reference values for nutrients and other milk components in four countries. The studies have shown that poor maternal nutritional status and/or dietary quality results in low concentrations of many nutrients in milk, and that various ways of improving a mother's micronutrient status can increase the micronutrient concentrations in milk. This research will be useful for improving nutrient intake recommendations for infants, lactating women, and young children, and for informing global public health policy about the need for maternal or infant supplementation during lactation. [NP 107, Project 2032-51000-004-00D]

The glycemic index is highly variable and not a reliable dietary guide.

The glycemic index (GI) was developed to identify how specific carbohydrate-rich foods influence blood sugar levels in the hours after consumption. Glycemic load (GL) incorporates both the GI and quantity of food to adjust for serving size. These measurements did not consider how blood sugar levels are affected when carbohydrate-containing foods are eaten in combination with other nutrients such as fat or protein. ARS-funded researchers in Boston, Massachusetts, found that adding protein to a person's diet resulted in a presumably healthier, significant decrease in measured GI and GL, whereas adding carbohydrate, fat, or fiber had little effect on these values. These data indicate significant variability in meal GI and GL determinations results from the consumption of different food

combinations and caution against using these values for dietary guidance. [NP 107, Project 8050-51000-097-00D]

High doses of vitamin D in seniors may pose a risk.

Many seniors take supplements of vitamin D because deficiency has been associated with an increased risk of falling. Vitamin D supplements are usually taken daily, but less frequent dosing would be more convenient for many older individuals. A human clinical trial conducted by ARS-funded researchers in Boston, Massachusetts, in collaboration with colleagues at the University of Zurich, assessed the effectiveness of taking different doses of vitamin D monthly on the risk of falling in older community-dwelling men and women. A higher monthly dose was equivalent to 2,000 international unit (IU) per day, and a lower dose was equivalent to the standard dose of 800 IU per day. Over the 1-year follow-up period, there were significantly more falls among individuals in the high-dose group compared with those in the standard dose group. This study showed that high monthly doses of vitamin D are not warranted in seniors because of a potentially harmful effect of increased falls. [NP 107, Project 8050-51000-092-00D]

High folate intake is linked with nerve damage risk in older adults with a common gene variant.

One in six Americans carries two copies of a genetic variant in the gene for a vitamin B12 transport protein. In a study of more than 170 older adults, ARS-supported scientists in Boston, Massachusetts, collaborated with colleagues from Boston University and Pfizer, Inc., and found that individuals with the gene variant were three times more likely to have a type of nerve damage called peripheral neuropathy. Subjects with the variant who consumed more than twice the recommended amount of folate were seven times more likely to develop peripheral neuropathy. These results strongly suggest

that older people should exercise caution in taking folic acid supplements and limit their folate intake to no more than the recommended amount. [NP 107, Project 8050-51000-093-00D]

Antimicrobial resistance in meats from animals produced with and without antibiotics.

Meats produced from animals raised without antibiotics (RWA) are perceived to harbor lower levels of antimicrobial resistance than meats from animals produced with no restrictions on antimicrobial use (conventional). ARS researchers in Clay Center, Nebraska, measured the prevalence and concentrations of antimicrobial-resistant bacteria and the levels of 10 antimicrobial resistance genes in ground beef and pork chops from animals raised without antibiotics or by conventional methods. The researchers found that generally the levels of antimicrobial resistance were similar between the meats from animals raised either way. These results demonstrate that conventional beef and pork products do not pose a greater risk of exposure to antimicrobial resistance than RWA products. [NP 108, Project 3040-42000-017-00D]

Rapid residue screening test developed.

Zilpaterol is an FDA-approved beta-agonist feed additive that increases feed efficiency, improves growth rate, and produces lean meat in livestock. Several major U.S. trading partners do not allow the import of meat from animals fed zilpaterol, and in the United States, zilpaterol is illegal to use in some food animal species. ARS researchers in Fargo, North Dakota, developed a sensitive, selective, inexpensive, and rapid test to determine whether animals have been exposed to zilpaterol. The assay, which is similar to an over-the-counter pregnancy test, can be used on-site with minimal training, and results are ready in about 10 minutes. The accuracy and sensitivity of the assay was verified in tissues and urine from animals exposed to zilpaterol. This simple and inexpensive assay could be used to determine accidental, illegal, or purposeful zilpaterol exposure. [NP 108, Project 3060-32420-001-00D]

FDA and industry use ARS research to develop food safety practices.

Fresh produce processors traditionally have used a specific free-chlorine level (1 part per million) as the control limit and a re-wash as the corrective action solutions in hazard analysis and critical control points (HACCP) programs. ARS researchers in Beltsville, Maryland, determined that the industry standard control-limit chlorine concentration does not prevent pathogen cross-contamination, and that re-washing of contaminated product is an ineffective corrective action. The research clearly documented significant risk factors associated with generally considered safe operating practices. Follow-up studies further demonstrated that a minimum of 10 ppm free-chlorine was required to effectively prevent pathogen cross-contamination during washing. Recommendations have been adopted by leading processors and incorporated in the interagency and industry taskforce whitepaper titled “Guidelines to Validate Control of Cross-Contamination during Washing of Fresh-Cut Leafy Vegetables.” [NP 108, Project 8042-32420-006-00D]

Development of a host plant volatile blend that attracts navel orangeworm in almonds.

Damage of fruit nuts by navel orangeworm has been associated with increases in *Aspergillus* infection, a risk factor for aflatoxin contamination. ARS researchers in Albany, California, developed and patented (U.S. Patent No. 9,655,366) a new blend of host plant volatiles that attract the navel orangeworm to almonds. The efficacy of this blend in attracting both male and female navel orangeworms was demonstrated in orchards and used in the monitoring of worm infestation and as an aid in pest management. The navel orangeworm blend is being developed as a product for commercialization. This new technology will help farmers monitor and reduce navel orangeworm infestation in orchards and, thus, eliminate aflatoxin contamination. [NP 108, Project 2030-42000-039-00D]

The U.S. Environmental Protection Agency registers biopesticides for aflatoxin management.

Biopesticides based on atoxigenic strains of *Aspergillus flavus* have become the most widely used intervention for preventing aflatoxin contamination. However, these biopesticides must be approved by and registered with regulatory authorities, and each target crop and each atoxigenic genotype require additional regulatory action. Thousands of atoxigenic genotypes of *A. flavus* exist with broad adaptation, but regulatory approval for use in commercial products has been granted for only a few genotypes. ARS researchers in Tucson, Arizona, addressed this through direct interactions with regulatory authorities, field and laboratory experimentation, and collaborations with the Arizona Cotton Research and Protection Council, the University of California, the International Institute of Tropical Agriculture, commodity groups, and several national governments. The result is new and expanded registrations of biopesticides for preventing aflatoxin contamination, including approval for new target crops (figs and almonds), additional *A. flavus* genotypes, and less restrictive handling requirements. Full registrations for the United States, Senegal, and Burkina Faso were added to existing registrations in the United States (partial), Kenya, and Nigeria. [NP 108, Project 2020-42000-022-00D]

Vaccination with live-attenuated vaccine significantly reduces Salmonella levels in turkeys.

ARS researchers in Ames, Iowa, created a *Salmonella* vaccine with genetic mutations in the bacterial genome that limits *Salmonella* serotype-specific immunity (more than 2,500 *Salmonella* serotypes exist) and induces an immune response that would be cross-protective against diverse *Salmonella* serotypes. The researchers have previously shown the effective reduction of *Salmonella* disease, colonization, and fecal shedding in vaccinated swine. To highlight utility of the vaccine, researchers also tested the vaccine in turkeys that showed a reduction in systemic and intestinal colonization of vaccinated turkeys following challenge with multi-drug resistant *Salmonella* Heidelberg. Pre-harvest control of *Salmonella* in food-producing animals can protect animal health, limit antibiotic usage, decrease environmental

contamination, reduce *Salmonella* carriage into the human food chain, and diminish the cost of meat product recalls to producers. The results highlight the utility of the ARS-designed vaccine for enhancing pre-harvest control of *Salmonella*. [NP 108, Project 5030-32000-113-00D]

Guayule-rubber tires: establishing a U.S. rubber-production industry.

Parthenium argentatum, commonly known as guayule (gwai'u'li), is a flowering shrub native to the southwestern United States. The plant has been studied for nearly 150 years as a possible source of natural rubber, organic resins, and as a biofuel feedstock. In the 1920's guayule became a likely important source of rubber after leaf blight destroyed the Brazilian rubber industry. However, no additional effort to make rubber from guayule was attempted until World War II, when America's total source of rubber was under a blockade after Japan cut off the U.S. sources in Malaysia. Currently, the U.S. tire industry still relies on 100 percent imported natural rubber, which comprises 80 percent of a tire. Developing guayule rubber for use in modern tires is a critical step in supplementing the ever-growing need for rubber worldwide, and in particular, for developing a U.S. natural rubber-production industry. With funding from NIFA and ARS, a 5-year collaborative research effort was led to domesticate and develop a commercial guayule farming system in Maricopa, Arizona, for rubber production, and to refine rubber biotechnology and chemistry for converting the plant into rubber at commercial scale in Albany, California. In collaboration with university partners and rubber and tire industry leaders, ARS produced breakthroughs in guayule rubber processing, stabilization, and performance that allowed passenger tires to be produced with 100 percent guayule rubber. The tires, developed by an industry partner, passed both the specified testing by the U.S. Department of Transportation and the more stringent internal industry testing. Seventy-five percent guayule-rubber tires with exceptional wear and performance are available commercially at a price comparable to that of high-performance tires. [NP 306, Project 2030-21410-021-00D]

Milk: an edible-packaging film.

Packaging is a critical part of modern food technology because of the increased consumer interest in consumption of processed, prepackaged foods. The challenge for the food industry, however, is to develop packaging that has the correct utility while being consumer and environmental friendly. Most foods are wrapped in petroleum-based plastic packaging, which is not only poor at preventing spoilage, but is also nonbiodegradable and creates a lot of waste when removed. Recently, ARS researchers in Wyndmoor, Pennsylvania, developed a milk-based edible film from casein (a milk protein) that can be used to wrap fresh foods to preserve quality; create pouches that dissolve in hot water to release instant soup or coffee; or coat breakfast cereals to keep them crispy in milk, thus replacing the sugarcoating that serves the same purpose. The technique of electrospinning was used to produce very fine porous mats of casein fibers called nanofibers with small diameters, but large surface areas. Due to their large surface areas, these fibers can be formed into edible films that have the potential to introduce intense colors, flavors, or textures within or on foods, and can be used to deliver controlled amounts of nutrients such as vitamins and minerals, or therapeutics from foods. This edible milk-protein film is being tested by Lipton Soup Company for potential use in production of its various food products. [NP 306, Project 8072-41000-096-00D]

Crispy, healthy fruit and vegetable-snack drying system is commercialized.

Currently the hot-air drying of fruit and vegetables is an important U.S. industry worth \$50 billion annually, but is also the third largest industrial energy user in California. As a solution to substantially reduce energy usage and improve dried produce appearance and flavor, ARS scientists in Albany, California, developed a two-stage, infrared-blanching and hot-air drying system. Crispy, healthy fruit and vegetable snacks were produced at a commercial scale through the support of the California Energy Commission. The project demonstrated the novel drying system technology in producing healthy crispy

snacks from carrots, kale, bell peppers, squashes, pears, and apples. This demonstration showed the benefits of the new technology, both in a 75-percent energy savings and a reduction in environmental pollution, while providing new healthy snacks with desirable texture and flavor at an affordable cost. This technology was recently licensed by a private company to produce healthy snacks, while saving energy and water. [NP 306, Project 2030-41000-064-00D]

Environmentally friendly BBQ starter charcoal.

Millions of consumers use lighter fluid to light charcoal for cooking, thereby contributing to the level of volatile organic compounds in the air around residential neighborhoods. ARS scientists in Albany, California, developed a porous charcoal material from plant waste using plant starch to bind biochar powder from walnut and almond hulls into quick igniting charcoal briquettes that can be easily lit without lighter fluid. The “starter” briquettes can be used to ignite traditional briquettes without the use of lighter fluid. This patented technology will help consumers comply with recommendations by regional air districts to reduce air polluting activities when air alerts are issued. [NP 306, Project 2030-41000-058-00D]



ANIMAL PRODUCTION AND PROTECTION

National Programs:

- **Food Animal Production, NP 101**
- **Animal Health, NP 103**
- **Veterinary, Medical, and Urban Entomology, NP 104**
- **Aquaculture, NP 106**

An improved reference genome assembly for cattle and swine.

Reference genomes that accurately represent all the genes and regulatory sequences in their correct order and orientation can be used by breeders to develop improved livestock breeds with desirable traits. The reference genome for cattle was published in 2009 and had many inaccuracies and deficiencies, as does the reference genome for pigs, which was published in 2012. To improve the cattle genome sequence, ARS researchers in Clay Center, Nebraska, collaborated with researchers at the University of California; the University of Missouri; the University of Maryland; the National Human Genome Research Institute; and ARS researchers in Beltsville, Maryland, to generate an improved cattle reference assembly 100 times more continuous (a key measure of accuracy and quality) than the existing cattle reference. This new reference assembly more accurately represents the genes related to immune functions, which are notoriously difficult to assemble. For swine, ARS researchers in Clay Center worked in a collaboration led by the Roslin Institute in Scotland and collaborators at two U.S.

universities and three genome industry partners to develop an improved reference assembly for swine that is 200 times more continuous than the existing reference, and a second assembly of a crossbred pig that is 100 times more continuous than the original reference. The new assemblies of the original cow and pig are now the accepted reference genomes for cattle and swine, and the alternate crossbred pig assembly is being used to investigate genome structure and function in commercial pig populations. These improved genomes will facilitate progress on genomic selection in beef cattle and swine. [NP 101, Project 3040-31320-012-00D]

Identifying genetic variations that may affect important livestock traits.

One of the key aims of livestock genetics and genomics research is to discover and use the genetic variants underlying economically important traits such as reproductive performance, feed efficiency, disease resistance/susceptibility, and product quality. However most critical variants are not known. ARS scientists in Clay Center, Nebraska, sequenced the genomes of 72 influential sires and dams of the research location's swine herd, identified approximately 22 million variants, and submitted them to public databases. By aligning these sequences to the pig genome, researchers found that ~139,000 of these variants were expected to alter or disrupt proteins coded by genes in the genome, or were likely to regulate protein production. Because these variants are likely to alter proteins, they are most likely to have a significant effect on various traits of interest to livestock producers. Five hundred sixty-five variants were classified as high-impact, loss-of-function (LOF) mutations, meaning they render the protein inoperable. These LOF variants, along with functional variants likely to influence various reproductive traits, were included in a commercially available genotyping microarray, and this information is expected to improve breeding efforts to enhance production traits. [NP 101, Project 3040-31000-094-00D]

The value of more prolific sheep breeds in a rangeland setting.

The number of lambs produced by U.S. ewes every year does not currently meet market demand for weaned lambs. Researchers in Dubois, Idaho, in collaboration with ARS scientists in Clay Center, Nebraska, and researchers at Virginia Tech University; and Montana State University assessed the use of more prolific sheep breeds to increase the number (and therefore the weight) of lambs weaned in range production systems. Researchers demonstrated that using more prolific breeds, such as Polypay and Romanov-cross, in a rangeland setting yielded more lambs and higher lamb-weight yields than using traditional wool-type breeds. The more prolific breeds produced lower-quality wools and lighter fleeces than wool-type breeds, but the higher total lamb weight compensated for reduced returns from wool sales. Results are being used by the U.S. sheep industry to guide producers in selecting breeds and genetics that will increase lambing rates in rangeland production systems. [NP 101, Project 2056-31000-011-00D]

Maps of bovine DNA methylation in cattle.

DNA methylation is a biological process that affects gene expression and plays important roles in development and various diseases. Methylation varies across tissues within an animal and is one way the same genetic code within all cells can cause differences across different organs within an organism. However, data are needed to more fully describe methylation in various cattle tissues. ARS scientists in Beltsville, Maryland, evaluated methylation distributed throughout the bovine genome in 10 different bovine tissues and detected hundreds of differentially methylated regions in which methylation is thought to control gene expression. Additional analyses revealed that the degree of methylation was correlated with the expression of nearby genes in those tissues. This study provided a baseline dataset and essential information for DNA methylation and gene expression profiles of cattle that will help understand DNA sequence regions that affect gene expression. [NP 101, Project 8042-31000-104-00D]

Use of the animal germplasm collection to restore lost genetic resources.

ARS has a large and important collection of animal genetic resources, and the stored collection has been used to regenerate or analyze important lost animal genetic resources. For example, Purdue University acquired pig germplasm samples from the stored collection to reconstitute a research line of pigs that was no longer available. The reestablished line had traits known to affect meat quality and were used in a project that garnered substantial funding, generated more than 10 scientific articles, and prompted Virginia Tech University to establish a second research population of this pig line. In another example, the Angus Association obtained a stored semen sample from a prominent bull and determined that the bull was free of a lethal mutation, which meant more than 29,000 other cattle did not have to be genotyped, saving the association approximately \$2 million. In a final example, collaborative research between ARS scientists in Fort Collins, Colorado, and researchers at Pennsylvania State University, determined there were only two different Y chromosomes (which determines whether an animal is male) in the current U.S. Holstein population (our major milk producing breed), and that there were two additional Y chromosomes in semen stored in the collection that were not identified in the present Holstein population. ARS and Pennsylvania State University scientists worked with industry to produce bull calves with these two lost Y chromosomes from the collection as a first step to re-introducing them to increase genetic diversity. These examples demonstrate the value of the germplasm collection to the U.S. livestock sector as a tool for industry and researchers to use in their efforts to solve a range of livestock industry problems. [NP 101, Project 3012-31000-005-00D]

Protecting livestock producers from the threat of foot-and-mouth disease.

Foot-and-mouth disease (FMD), a highly contagious disease that affects cattle, pigs, and small ruminants, is considered to be a major global threat to animal agriculture. Although FMD was eradicated from the United States in 1929, its reintroduction could result in billions of dollars in annual

lost revenue to U.S. livestock producers. Although FMD diagnostics and vaccines have been used to control the disease, significant gaps remain in the availability of effective veterinary medical countermeasures suited for use in the United States. ARS scientists working at the Plum Island Animal Disease Center in Orient Point, New York, have made significant breakthroughs in developing better veterinary countermeasures to detect, prevent, and control FMD should an incursion ever happen in the United States. The first breakthrough is a vaccine platform called the “leaderless” FMDLL3B3D vaccine. The attenuated vaccine has a portion of the viral sequence known as the leader deleted (hence, leaderless). When injected, this vaccine stimulates the same immune response that is stimulated after vaccination with inactivated FMD vaccines made with virulent wild-type virus strains. Unlike current FMD vaccine platforms, the FMDLL3B3D vaccine strains are fully attenuated, and they can be produced safely in the United States without the risk of causing a devastating FMD outbreak if they escape from a manufacturing facility. [NP 103, Project 8064-32000-061-00D]

Transmission of foot-and-mouth disease virus from persistently infected cattle.

Foot-and-mouth disease (FMD) is a major global threat to animal agriculture. More than half of FMD virus-infected cattle, whether or not they have been vaccinated, become persistently infected carrier animals. This phenomenon is established when the FMD virus is maintained in an animal’s tissues for 28 days or more after infection. Although carrier animals eventually clear the infection, the length of time to do so varies greatly. Although a large proportion of infected cattle become carriers, it is unclear whether carrier cattle can spread the infection to uninfected cattle. As a result, FMD-free countries experiencing an FMD outbreak destroy carrier animals largely because of the perceived risk of transmission from carrier animals. However, destroying carrier animals is not economically feasible where FMD is endemic. ARS scientists at the Plum Island Animal Disease Center, in Orient Point, New York, are deciphering the biological mechanisms that make the FMD virus a persistent infection in

cattle. They are also investigating the potential for transmission of the FMD virus from persistently infected cattle to uninfected cattle under typical husbandry conditions. Results from a research collaboration with scientists in Vietnam showed that no transmission occurred during 6 months of contact between FMD carrier and uninfected cattle, and that the carrier state in the study lasted an average of 27.7 months. These results suggest the duration of persistent infection in cattle may be longer than previously recognized, though transmission risks appear low. ARS scientists also evaluated one carrier animal for 12 months and fully sequenced the genome of seven viruses recovered from that animal during the study period. Genome sequence analysis of these seven viruses showed that a number of mutations occurred during the carrier stage. This is the first report of complete sequences of the FMD virus isolated from one persistently infected animal under natural conditions. The characterization of these viruses provides insights into within-host FMD virus evolution during persistent infection and has implications for FMD control in areas where the disease is endemic. [NP 103, Project 8064-32000-061-00D]

Development of foot-and-mouth disease diagnostic tests.

In the event of an outbreak of foot-and-mouth disease, it is important to be able to determine which animals have been infected and which have been vaccinated. In developing the leaderless FMDLL3B3D vaccine virus platform, ARS scientists genetically engineered the platform with two markers so that vaccinated animals can be differentiated from infected animals. This ability would be critical during FMD outbreaks for differentiating infected animals from vaccinated animals (DIVA). This FMD vaccine is now in the advanced development phase with a commercial partner, and distribution is expected to begin within 2 years. With the availability of these DIVA markers, a consortium of academic, industry, and Federal agencies, including ARS, has developed a novel companion diagnostic test for the FMDLL3B3D vaccine. This is the first licensed FMD diagnostic kit

approved for manufacturing on the U.S. mainland. The FMDLL3B3D vaccine together with its companion diagnostic test kit will provide animal health first-responders with important new methods for mitigating the potentially catastrophic economic effect of an FMD outbreak. [NP 103, Project 8064-32000-061-00D]

Early warning strategies for outbreaks of vector-borne animal diseases.

Vesicular stomatitis virus (VSV) is an animal pathogen spread by insects and is one of the most common vesicular diseases affecting horses, cattle, and pigs throughout the Americas. There is currently limited understanding of the cause of VSV outbreaks, although VSV has occurred in the United States every decade since 1916. The disease is complex, with ecological, environmental, climatic, and time factors that may contribute to disease outbreaks. Having a better understanding of the cause and progression of VSV could provide a research model for predicting animal disease outbreaks spread by insects and other arthropods. ARS scientists from Colorado, Kansas, New Mexico, New York, and Wyoming collaborated to develop early warning strategies for VSV. Coupling big-data model integration with human and machine learning, ARS scientists evaluated the relative importance of a large and diverse suite of variables to patterns in VSV disease outbreaks. Their findings showed a sequence of early indicators accompanied by the presence of important disease-transmitting insects. Before this analysis, little information was available about the different roles insects and environmental factors played in disease outbreaks. These findings about the role of latitude, elevation, and long-term precipitation in disease outbreaks will allow livestock producers or horse owners to monitor local conditions for determining the likelihood that VSV could occur in any month of the year. [NP 103, Project 8064-32000-059-00D]

Swine-to-human transmission of methicillin-resistant *Staphylococcus aureus*.

Staphylococcus aureus is a common bacteria generally found in the nose and throat of humans and animals. It can also be a devastating human pathogen that has the ability to acquire resistance to antibiotics, resulting in, for example, methicillin-resistant *S. aureus* (MRSA). Swine can carry strains of MRSA that do not cause disease in swine, but it is unclear whether livestock-associated (LA)-MRSA is a risk for humans. ARS scientists in Ames, Iowa, investigated the genetic mechanisms of antimicrobial resistance among swine LA-MRSA and human clinical MRSA isolates and found that swine LA-MRSA isolates exhibited resistance to fewer antibiotics than MRSA isolates from humans who have had no swine contact. Furthermore, differences in the antimicrobial resistance genes between swine LA-MRSA and human clinical MRSA isolates suggest there are distinct populations of MRSA in swine and humans, antibiotic resistance is more prevalent in human strains, swine-to-human transmission is infrequent, and LA-MRSA may not be a common zoonotic threat. [NP 103, Project 5030-32000-119-00D]

A new research tool for tick-transmitted diseases that eliminates the need for using animals in testing.

Ticks are serious pests because they transmit a range of diseases to humans and animals. Laboratory methods to enhance large-scale preparations of purified pathogens from ticks that transmit disease are paramount to advance research of tick-transmitted diseases such as bovine anaplasmosis, bovine babesiosis, Lyme disease, and Heartwater. But these methods require the use of live host animals to “feed” the ticks and propagate these pathogens. ARS scientists in Pullman, Washington, designed and developed a novel continuous-flow laboratory tick-feeding system that facilitates isolating pure infectious tick-borne pathogens and eliminates the traditional method of using animals to isolate pathogen cultures. Ticks feed on a silicone membrane that covers blood that is being circulated at a constant temperature, which mimics a live animal. The laboratory tick-feeding system will be a useful

method in processes to develop live vaccines for tick-borne diseases and for conducting studies to understand pathogen-tick vector interactions and the tick-mammalian host interface. This new laboratory method not only improves pathogen isolation, but will provide a framework for following the Three Rs for ethical use of animals in research (replacement, reduction, and refinement) in studying tick-transmitted diseases. [NP 103, Project 2090-32000-039-00D]

Direct-fed microbials as an antibiotic alternative.

Because of rising concerns over the development of antibiotic resistance, there is a need to develop protocols for the appropriate use of antibiotics in food animals and viable alternatives for antibiotic use that maintain optimal animal health and performance. Direct-fed microbials (DFMs), often referred to as probiotics, are a potential nonantibiotic replacement that has been studied extensively and used in commercial applications. DFMs are beneficial bacteria often used as feed supplements to promote gut health. To better understand how probiotics enhance gut health in poultry and the mechanisms used by the nonpathogenic probiotic bacteria *Bacillus subtilis*, ARS scientists in Beltsville, Maryland, carried out extensive animal studies to show that certain *Bacillus* strains stimulate innate host immune responses, decrease harmful inflammatory responses, and promote gut integrity when used as a feed additive in young chickens. These results provide scientific evidence for the beneficial effects of probiotic bacteria and the potential use of *B. subtilis* as a feed additive to promote gut health in commercial poultry production and reduce the use of medically important antibiotics. [NP 103, Project 8042-32000-107-00D]

A computational tool to characterize the diversity of swine influenza viruses.

Infection with swine influenza A viruses (IAV) is the second most common diagnosis of respiratory disease of swine in the United States. Swine and humans share common receptors for IAV, and this

results in cross-species infections. More importantly, the global diversity of swine IAV creates substantial risks for both human and swine populations and could be a major contributor to future outbreaks and potential human pandemics. Although there have been efforts to improve the control of IAV in swine through vaccination, it has been difficult to acquire the computational expertise to analyze and characterize the variation of swine IAV genetic information to properly match vaccines to field strains. ARS scientists in Ames, Iowa, in collaboration with OFFLU (the global network of animal influenza virus experts), have developed a computational tool that automatically classifies global swine genetic variation, particularly variation in the HA gene. The corresponding HA protein in vaccines is a critical component for inducing a protective immune response. This open-access tool is now widely available and will aid swine producers, veterinarians, vaccine manufacturers, and IAV vaccine researchers in selecting vaccine strains to match strains currently circulating on swine farms. [NP 103, Project 5030-32000-120-00D]

Improving the accuracy of diagnostic tests for bovine babesiosis.

Bovine babesiosis (also known as cattle tick fever) is caused by the protozoan parasites *Babesia bovis* and *B. bigemina*. *Babesia* parasites can be transmitted by ticks to cattle of any age, and can result in 90 percent mortality in newly infected adults. Babesiosis was a significant problem in the southern United States until eradication of the tick vector in the 1940s. The United States imports 1 million head of cattle annually from Mexico, where babesiosis and cattle fever ticks are present. Control measures for preventing babesiosis from coming to the United States include treating all arriving cattle with acaricides to eliminate cattle fever ticks. The recent discovery of acaricide-resistant tick populations capable of transmitting *Babesia* species and the re-emergence and spread of cattle fever ticks by wildlife on the Texas–Mexico border is increasing the risk that bovine babesiosis will be reintroduced to the United States. ARS scientists in Pullman, Washington, have improved diagnostic testing methods to

determine the infection prevalence of bovine babesiosis on the U.S.–Mexico border. This improved test was fully developed in collaboration with a commercial partner and is now available for use. [NP 103, Project 2090-32000-039-00D]

Publication of the cattle fever tick genome sequence.

The cattle fever tick *Rhipicephalus microplus* transmits the disease cattle fever (babesiosis) to cattle. The genome of the cattle fever tick, which contains more than twice the amount of DNA as the human genome, is difficult to sequence. ARS scientists in Kerrville, Texas, worked with researchers at Murdoch University Centre for Comparative Genomics in Murdoch, Australia, and published the genome sequence for this cattle fever tick. They identified genes associated with cattle fever pathogen maintenance, the cattle host immune response, pesticide resistance, tick feeding, and others. This new comprehensive sequence information is facilitating tick vaccine research and pesticide resistance monitoring, which will help protect cattle health. [NP 104, Project 3094-32000-036-00D]

Finding a virus that is a natural enemy of fire ants.

Fire ants inflict serious and sometimes fatal bites to animals and humans, and they cause billions of dollars of crop damage and other structural damage every year. *Solenopsis invicta* virus 4 (SINV-4) belongs to a new virus family, Polycipiviridae, and viruses within this family appear to infect only ant species. ARS scientists in Gainesville, Florida, discovered SINV-4 in South American fire ant populations and determined that this virus is also present in U.S. fire ant populations. Because it is known to infect only ant species, SINV-4 may be a good biocontrol agent for controlling invasive ants, including fire ants. This research is useful to the pest control industry and other industries that are harmed by this pest. [NP 104, Project 6036-32000-048-00D]

Fire ant control improved with water-resistant bait.

More than \$2 billion a year is spent on fire ant control, which primarily consists of baits that contain pesticides. The bait carrier in one effective product is a form of corn grit, but the grit carrier disintegrates under wet or moist conditions. ARS researchers in Gainesville, Florida, conducted a field evaluation of a water-resistant fire ant bait under conditions where there was heavy dew on the ground and found the water-resistant bait outperformed the equivalent standard bait. The water-resistant bait overcomes current bait use restrictions in damp environments and will be useful for controlling fire ants in wet environments, such as in Hawaii. [NP 104, Project 6036-32000-048-00D]

Developing transgenic male-only screwworm strain.

Screwworms burrow into the skin of live animals and inflict serious wounds while they feed on the tissue. ARS researchers in Kerrville, Texas, worked with researchers at North Carolina State University and the Panama U.S. Commission for the Eradication and Prevention of Cattle Screwworm (COPEG) to complete a critical step in bioengineering a transgenic male-only strain of screwworms to mate with females in the wild. The genetically engineered male-only strains were transferred to the Methods and Development section of COPEG for further evaluation in field trials scheduled for the coming year. The ability to produce a colony consisting only of males is expected to decrease production costs and biological waste by approximately 50 percent. In related research, ARS researchers in Lincoln, Nebraska, and Kerrville identified four volatile attractants that influence female egg laying. These results are expected to support the development of products that will increase the average number of eggs produced for creating sterile screwworm males. It will be particularly important for producing the male-only strain because fewer fertile females will be produced, which will reduce production costs. [NP 104, Project 3094-32000-038-00D]

Reducing Zika risk by improving mosquito control.

Zika, yellow fever, and dengue virus are transmitted by the yellow fever mosquito (*Aedes aegypti*), and Zika virus is one of the newest viruses to be introduced into the United States. Developing a regional strategy to reduce the yellow fever mosquito population is needed to help reduce the spread of these diseases. ARS researchers in Gainesville, Florida, worked with university and local government public health agency collaborators to develop a comprehensive regional program to reduce the population of vectors (insects and other arthropods that carry and transmit disease) including the yellow fever mosquito. ARS researchers led the development of a program that combined traditional vector control, community engagement, and vector surveillance solutions in a unique, innovative way to reduce the risk of Zika virus transmission by reducing or eliminating mosquito populations. This system has not yet been adopted, but has contributed significantly to development of new vector control strategies in the United States and partner agencies at local, national, and international levels. [NP 104, Project 6036-32000-050-00D]

RNAi used to manipulate gene function in the biting midge.

Culicoides biting midges transmit viruses that cause disease in livestock and deer. Understanding the interactions between these insects and the viruses they transmit is the first step in developing methods for blocking virus transmission. ARS scientists in Manhattan, Kansas, and their collaborators at Kansas State University showed for the first time that the molecular tool RNA-interference (RNAi) can be used both to suppress, then restore genetic activity in midges. This technology will allow scientists to conduct studies that will help explain genetic components associated with the midge's ability to transmit viruses. [NP 104, Project 3020-32000-007-00D]

Fast-growing rainbow trout.

Rapid growth rate is one of the most important economic traits in rainbow trout that can be improved through selective breeding. ARS researchers in Leetown, West Virginia, selectively bred a pedigreed, commercial-scale rainbow trout population to market weight for five generations. Compared with the control line, body weight in the growth-selected line increased by approximately 12 percent per generation through 13 months of age, resulting in a line that grows approximately 60 percent faster to and beyond standard market weight. The improvement in growth over contemporary commercial lines was consistent when fish were reared in different environments. This genetically improved and highly characterized population has been released for commercial propagation. [NP 106, Project 8082-31000-012-00D]

Development and commercialization of a *Lactococcus* vaccine for rainbow trout.

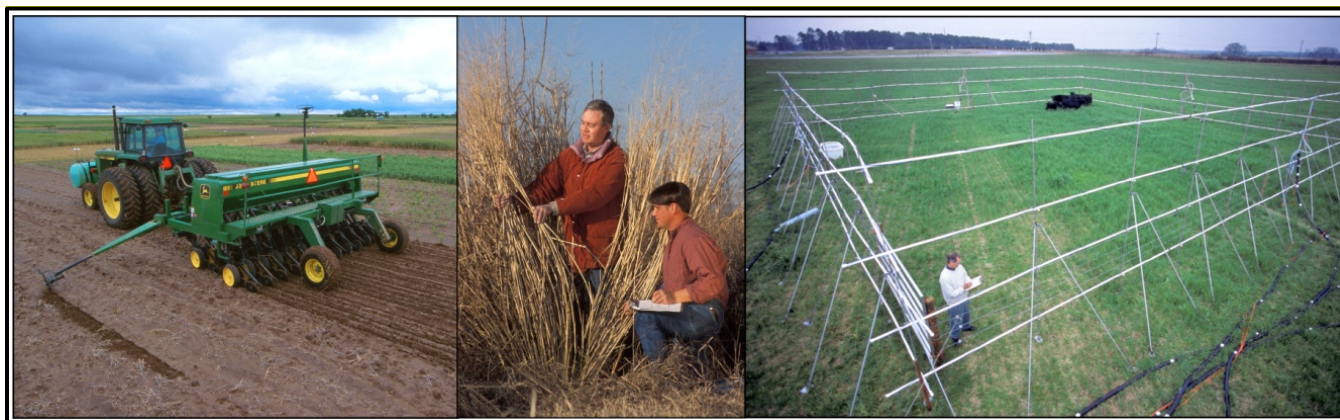
Lactococcus garvieae infection is a major cause of on-farm losses of rainbow trout in Washington State. ARS researchers in Leetown, West Virginia, successfully developed a vaccine against *L. garvieae* and validated the safety and efficacy of a commercially manufactured version of the vaccine. Field evaluation results demonstrated that vaccination induced a strong antibody response and robust protection against experimental pathogen exposure. Mortality due to *L. garvieae* was dramatically reduced the first year after vaccination, and the disease has not been detected in vaccinated fish since the program began. The commercial vaccine is in large-scale use at affected farm sites, and 6 million fish have been vaccinated since 2015. The rapid development and implementation of a *Lactococcus* vaccine prevented substantial rainbow trout losses due to this emerging disease. [NP 106, Project 8082-32000-006-00D]

A novel vaccine against enteric septicemia of catfish.

Enteric septicemia of catfish (ESC) is one of the most problematic bacterial diseases affecting channel catfish fingerling production in aquaculture. ARS collaborators from Mississippi State University developed an effective vaccine and delivery method against ESC, and to date, approximately 180 million stocked catfish have been orally vaccinated in field trials on commercial farms. Improved survival of vaccinated catfish increased the average value of farm production by \$1,800 to \$2,500 per acre. [NP 106, Project 6066-31320-004-00D]

Breeding for disease resistance in Nile tilapia.

Worldwide tilapia aquaculture is valued at about \$8 billion, and the U.S. aquaculture industry produces nearly 30 million pounds of tilapia per year. However, production is hindered by two bacteria, *Streptococcus iniae* and *S. agalactiae*, which are responsible for around \$1 billion in annual worldwide losses. ARS scientists in Auburn, Alabama, collaborated with industry partners and verified that tilapia resistance to *S. iniae* infection is heritable and that selective breeding of superior individuals produced increased disease resistance in subsequent generations. They also demonstrated that resistance to *S. agalactiae* was also heritable. Tilapia industry breeding programs now select for resistance to the two *Streptococcus* species, and for increased harvest weights and reduced disease risks in rapidly growing fish. The improved tilapia are being sold throughout the Americas and abroad. Based on current production statistics and available models, representative gains from growing the improved tilapia means \$635,000 in additional revenue for the average-size farm. This research helps U.S. fish farmers and paves the way globally for reducing antibiotic use on farms, leading to safer products entering the United States. [NP 106, Project 6010-32000-026-00D]



NATURAL RESOURCES AND SUSTAINABLE AGRICULTURAL SYSTEMS

National Programs:

- **Agricultural System Competitiveness and Sustainability, NP 216**
- **Water Availability and Watershed Management, NP 211**
- **Climate Change, Soils, and Emissions, NP 212**
- **Pasture, Forage and Rangeland Systems, NP 215**
- **Biorefining, NP 213**
- **Agricultural and Industrial Byproducts, NP 214**

Remote sensing toolkit improves water resource management with first-ever daily delivery of crop water use data.

Accurately measuring crop water use (evapotranspiration or ET) at appropriate temporal and spatial scales is important for effectively managing agricultural water use. To address this need, ARS scientists in Beltsville, Maryland, developed and distributed a novel ET mapping toolkit that combines remote sensing data from a range of satellite platforms into daily crop water use estimates at an unprecedented 30-meter spatial resolution. Because of its significant resolution advantages, the toolkit has already been used to address many water resource issues in agriculture: studying groundwater depletion via irrigation in central Wisconsin; assessing the impact of expanding agricultural drainage on regional hydrology in the Corn Belt; improving water use in managed forest plantations; calibrating hydrologic/water quality models for the Chesapeake Bay watershed; making irrigation management decision in vineyards;

assessing consumption for the U.S. Water Census and California's new Sustainable Groundwater Management Act; and delivering drought and water information for the Near-East North African region. The toolkit will also be used to generate ET and water stress products for NASA's ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) mission. Using this ET mapping tool in these projects has greatly expanded monitoring and has optimized water use and availability across a broad range of agricultural systems. [NP 211, Project 8042-13610-028-00D]

Improving nitrate removal using saturated buffers with tile drainage.

Streamside vegetation buffers are a proven practice for removing nitrate from both overland flow and shallow groundwater before it can enter surface waters. But in landscapes with tile pipe drainage, most of the subsurface flow travels from farm fields through tile pipes, leaving little opportunity for this nitrate removal process. ARS scientists in Ames, Iowa, and university cooperators showed that re-routing a fraction of field tile drainage through riparian buffers can remove hundreds of pounds of nitrate before it enters nearby surface waters each year. This buffer system has been adopted by the USDA, Natural Resources Conservation Service as Conservation Management Practice Standard #604 and is now eligible for Environmental Quality Incentives Program (EQIP) funding across the Midwest. Research shows the practice could be installed along thousands of miles of rivers in Iowa alone and potentially remove millions of pounds of nitrate from U.S. surface waters. [NP 211, Project 5030-13000-010-00D]

Lowering the cost of removing phosphate from agricultural drainage waters.

Filter treatment systems containing synthetic goethite (iron oxyhydroxide) could be a viable means of capturing phosphate and reducing nutrients in agricultural drainage, but goethite can be costly unless it can be regenerated for continual use. ARS scientists in Columbus, Ohio, conducted laboratory and field drainage phosphate removal tests on synthetic goethite, and afterwards regenerated the same material

using a sodium hydroxide flush. Laboratory treatment tests showed that both the original and regenerated goethite removed greater than 98 percent of the phosphate in agricultural drainage waters. Field agricultural drainage water treatment tests showed that the original goethite removed 75 percent of the phosphate, while the regenerated synthetic goethite removed 34 percent. These results suggest that in field settings, regenerating synthetic goethite will probably require a two-step procedure that uses a diluted acid wash to remove calcium phosphate precipitates followed by a sodium hydroxide flush to release any remaining adsorbed phosphate. Using refined regeneration process filter treatment systems containing synthetic goethite could be a cost-effective, phosphate-removal treatment for drainage water. [NP 211, Project 5080-13000-010-00D]

Better soil spatial variability mapping tools improves local and regional resource management.

Soil spatial variability influences water flow and the transport of nutrients, salinity, trace elements, and pesticides that affect the environment and crop yield. State and Federal action agencies involved with agricultural, natural resources, and environmental management urgently need methods to more easily map important soil properties that affect management decisions. ARS scientists in Riverside, California, have extended and updated protocols for mapping soil spatial variability to include expanding the scale of salinity mapping from local- to landscape-scale mapping of soil properties, including water content, texture, bulk density, and organic matter. Their state-of-the-art methods for mapping soil spatial variability have direct applications in site-specific irrigation and crop management and provide information needed for modeling the transport of root zone solutes and assessing soil salinity and soil health. Government agencies, agricultural consultants, university associates, and other resource managers will be able to use the protocols to improve water and land management. [NP 211, Project 2036-61000-016-00D]

Modeling to assess consequences of flooding disasters.

Water quality computer models are needed to more comprehensively study water quality problems covering large areas, such as rivers, lakes, and coastal environments. ARS researchers in Oxford, Mississippi, developed a two-dimensional numerical model and tested it using data obtained from Lake Pontchartrain, Louisiana, after floodwaters from the Mississippi River were released into the lake. The model simulates water flow, sediment transport, and algal biomass distributions, with its results generally in good agreement with field observations provided by the U.S. Geological Survey and NASA satellite imagery. The model provides a tool for U.S. Environmental Protection Agency and State departments of environmental quality to assess flood-related environmental disasters. [NP 211, Project 6060-13000-025-00D]

Improving access to and the usefulness of GRACEnet data for improved soil management.

GRACEnet (the Greenhouse gas Reduction through Agricultural Carbon Enhancement Network) is a network of scientists and locations focused on improving agricultural management and improving the environmental footprint of agriculture. Specifically, GRACEnet activities support efforts to mitigate greenhouse gas (GHG) emissions associated with agricultural production through large-scale studies that address how management strategies affect both soil carbon and GHG emissions. The GRACEnet community has expanded the network's role in these efforts by establishing new field/laboratory measurement protocols; refining a standardized Excel data entry template; developing and implementing software to perform data entry quality control; and introducing a web-accessible GRACEnet database. The public portal of the data management system was further improved during 2017 and integrated with the Natural Resource and Genomics Data Systems server. The GRACEnet web portal now contains extensive data from 17 ARS locations with more than 450,000 total records, including 116,000 soil GHG emission measurements and 83,000 soil measurements. Furthermore, the data developed by the

GRACEnet network and housed by the GRACEnet project have been used to increase the accuracy of GHG emission estimates reported in the U.S. national GHG inventories, including the latest U.S. Environmental Protection Agency (EPA) inventory published in FY 2017. Additionally, project data have been used to develop scaling factors to quantify the GHG reductions for improved management practices. GRACEnet data are now being used to validate the underlying models used by the USDA, Natural Resources Conservation Service (NRCS) Carbon Online Management Evaluation Tool (COMET-Farm) decision support tool. [NP 212, Project 3012-11120-001-00D]

Recovery of ammonia and production of high-grade phosphates from animal and municipal effluents.

New processes and technologies to recover and reuse nitrogen and phosphorus from wastes will help conserve valuable crop nutrient resources and mitigate their release into the environment. ARS researchers in Florence, South Carolina, developed a new technology that separates and recovers ammonia and phosphorus from liquid effluents and filed a U.S. patent application for this process in 2016 (USDA Docket 83.15). The new technology can recover 98 percent of the nitrogen, and when enhanced, it was able to reduce costs by 70 percent. ARS scientists combined the nitrogen recovery process with a novel phosphorus recovery process, and the combined process produced phosphorus bio-minerals that were similar to the very-high phosphate grade commercial fertilizers favored by the fertilizer industry. This process enabled 100 percent phosphorus recovery efficiencies. This technology has a number of wide-ranging applications, including treating anaerobic digester effluents arising from swine operations, dairy operations, and even municipal waste water systems. The potential value of implementing this nutrient recovery system in dairy farms alone is about \$1.3 billion. This technology will dramatically support livestock producers, municipalities, industrialists, extension practitioners and other scientists interested in manure nutrient recovery technologies. [NP 212, Project 6082-12630-001-00D]

Wheat yields and soil water improve under no-tillage practices.

Results from plot trials in the inland Pacific Northwest suggested that no-tillage production, which helps conserve soil resources, provides sufficient soil water for autumn planting of winter wheat. ARS researchers in Pendleton, Oregon, expanded upon these findings to conduct field scale experiments to compare soil water content and winter wheat yields between traditional inversion tillage and current no-tillage technology in two arid upland drainages. They found winter wheat yields were similar between no-tillage and conventional tillage, and that no-tillage fields had significantly more plant-available water in topsoil before planting. These results confirmed that improvements in herbicides, equipment, and wheat varieties in the last 30 years have resolved earlier plant-water problems in no-tillage practices and demonstrate that no-tillage production is capable of meeting or exceeding crop productivity using traditional inversion tillage. By reducing the tillage operations, this finding will save money for inland Northwest wheat producers. [NP 212, Project 2074-11120-004-00D]

Quantification of Escherichia coli O157 in environmental samples.

An ARS scientist in Riverside, California, evaluated an improved approach for quantifying low concentrations of the pathogen *Escherichia coli* O157 in environmental samples and determined specificity and detection limits of *E. coli* O157 in inoculated samples of fresh produce, soil, and water. The assay was applied to swine, dairy, beef, poultry manure, and wastewater effluent collected from a dairy wetland over a 12-month period. The accuracy of this assay improves the quantification of low levels of *E. coli* O157 in environmental samples and gives growers and researchers a valuable tool for protecting humans from environmental sources of *E. coli* O157 pathogens. [NP 212, Project 2036-32000-005-00D]

Creating enzyme ladders to efficiently convert crop waste into green chemicals.

Crop residues such as cornstalks, straw, and sugarcane bagasse are abundant feedstocks that can supplement the world's fuel and chemical needs through biorefining. Biorefining requires a host of different enzymes to convert plant materials into commercially viable byproducts. ARS scientists in Albany, California, developed a way for enzymes to work more efficiently by mounting up to 18 different enzymes in a ladder structure called a Rosettazyme. To release sugars from the feedstock, enzymes were linked to each other, then a different combination of enzymes was linked on a different enzyme-ladder to convert the sugars into acid compounds. Those compounds are the building blocks in the green manufacture of nylon plastics. Four different types of enzymes were combined on these enzyme-ladders, resulting in a 71-percent greater efficiency than when using the same nonlinked enzymes in biorefining systems. [NP 213, Project 2030-41000-054-00D]

'Liberty' switchgrass produces high yields of bioethanol.

An established field of 'Liberty' switchgrass, an ARS cultivar, was grown on marginal, non-food cropping land in central Wisconsin in 2014 and 2015 and processed into bioethanol, yielding 3,510 to 4,960 liters per hectare. By comparison, corn grown on nearby high-quality food cropping land (yielding an above-average 200 bu/acre) produced 5,300 liters per hectare of bioethanol. 'Liberty', the newest ARS cultivar bred for biomass production of bioethanol, has far exceeded the yield of other popular switchgrass cultivars ('Summer' and 'Kanlow'). This is the first study of field-to-fermentation integration and the first study using 'Liberty' switchgrass. These findings help establish 'Liberty' switchgrass as a viable industrial crop, a critical need in lowering the risk for U.S. farmers and ethanol processors considering the production of advanced biofuels in the northern United States. [NP 213, Project 5010-41000-161-00D]

Newly discovered yeast increases biomass conversion yield.

Yarrowia yeast strains are critical for the bioconversion of lignocellulosic biomass into diverse lipids for potential conversion to biodiesel; for food and healthcare applications; for organic acids; and recently, as protein-rich feed supplements for the animal and aquaculture industries. ARS scientists in Peoria, Illinois, screened 45 types of *Yarrowia* from the ARS culture collection. Those different strains of *Yarrowia* were evaluated in a harsh, dilute-acid, switchgrass media for growth robustness, and breadth of sugars and lipids produced. The top-producing strain accumulated more than three times the quantity of lipids than the strain that is commonly used in commercial bioconversion systems. This more robust strain offers a new and better option for conversion of biomass into lipid biofuels and other bioproducts. This reduces the risk faced by bioconversion companies. [NP 213, Project 5010-41000-162-00D]

Postfire grazing does not harm plant recovery or plant communities.

After wildfires on western U.S. rangelands, natural resource agencies often prohibit grazing from 1 to 3 years, and ranchers who need to rent other pasture for their grazing livestock can incur annual costs exceeding \$54 million. ARS scientists in Miles City, Montana, in cooperation with the USDA, Forest Service, found that post-fire plant production increased 56 percent the year a fire occurred. Where grazing occurred the second and third years after fire, the post-fire pastures yielded slightly more or had similar production as unburned sites. A companion study demonstrated that plant response to fire was similar whether sites were mowed or not mowed after fire. These combined results suggest it isn't necessary to prohibit or delay grazing in northern mixed-grass prairies after spring wildfires to be able to maintain plant productivity and species composition. These results were similar to recent research from the same laboratory indicating northern mixed prairie is resistant to grazing after summer fire. Natural resource agencies can use these findings to support grazing management decisions after a fire and reduce pasture costs for ranchers affected by wildfire. [NP 215, Project 3030-21630-003-00D]

Developing forage kochia for enhanced winter grazing.

Winter feeding can account for up to 70 percent of annual livestock production costs in the western United States. These costs can be reduced by extended grazing into the fall and winter, but grasses that become dormant in the fall lack the protein needed by ruminants such as cattle. Forage kochia is a semi-shrub that has been seeded on rangelands for fall and winter forage. Previous research showed that the kochia cultivar 'Immigrant' provided needed protein and reduced winter feed costs by 25 percent, but it has been limited by poor establishment and short stature. 'Snowstorm' is a new forage kochia cultivar developed and released in 2012 by ARS scientists in Logan, Utah, that in field comparisons was 64 percent taller than Immigrant, produced 68 percent more forage, and had increased protein and digestibility. Snowstorm has quickly become a popular selection for private and public rangeland seedings; for instance, the Bureau of Land Management annual bid for reclamation plant materials included a significant portion of Snowstorm in the 2016 seed buy, purchasing 4,000 pounds valued at \$101,500. [NP 215, Project 2080-21000-014-00D]

Weather tools for rangeland restoration planning.

Rangeland restoration efforts in the western United States Intermountain region have historically had relatively low success rates, primarily due to the general aridity of this region, and the extremely high variability in weather. These dry landscapes often require multiple iterations of applied restoration practices to re-establish resilient perennial vegetation that can support wildlife communities and livestock grazing. ARS researchers and collaborators in Boise, Idaho; Burns, Oregon; Moscow, Idaho; Logan, Utah; Provo, Utah; and Woodward, Oklahoma, collaborated in developing a general strategy for adapting rangeland restoration planning and management to accommodate weather variability and help establish diverse plant communities on Great Basin rangelands that have been severely disturbed by wildfire and are dominated by introduced annual weeds. Efforts are underway to work with Federal land management

agencies to implement this weather-based landscape restoration strategy via development of programmatic management plans on southern Idaho public rangelands. Implementing these plans could improve rangeland restoration success rates on millions of acres of disturbed rangeland throughout the western United States Intermountain region. [NP 215, Project 2052-13610-011-00D]

Alfalfa is a source of sustainable protein for aquaculture. The growing demand for fish and seafood products is accelerating development of aquaculture nationally, and alternative feed ingredients that are sustainably produced and widely available are needed to meet these demands. Some alternative proteins extracted from crop plants lack essential nutrients or have anti-nutritional components. ARS scientists in St. Paul, Minnesota, and University of Minnesota collaborators tested a protein concentrate made from alfalfa foliage as a replacement for fishmeal in yellow perch diets. They found fish that consumed this concentrate had the same growth rates as fish that consumed fishmeal, which indicates that alfalfa protein concentrate can substitute for this feed ingredient. A simple heat treatment after juicing produced the highest yield of protein concentrate from alfalfa leaves. Alfalfa stems, the “cake” resulting from leaf juicing, and the de-proteinized juice have potential as additional value-added products in alfalfa biorefining, whereas high-value alfalfa products will increase the value of crop and farm gate revenue. [NP 215, Project 5062-12210-002-00D]

Higher strawberry yields with a longer growing season may revitalize the Mid-Atlantic strawberry industry.

Mid-Atlantic strawberry production is limited to a short 5-week harvest. The fresh berry market would benefit by adopting repeat-fruiting cultivars, but new production systems are needed for the cultivars. ARS scientists in Beltsville, Maryland, tested and evaluated low-tunnel raised-bed production systems for repeat-fruiting cultivars and results indicated repeat-fruiting cultivars could be successfully grown over

several months, which would lengthen the harvest season. Yields and berry quality were higher under covered beds than under non-covered beds. Warmer air, crown, and soil temperatures extended the growing season, and the light quality within the tunnels was also better for the berries. The researchers used the study data to develop mathematical models to further improve the design and management of these systems, which gives breeders and growers an environment suitable for generating economically viable strawberry yields over an extended period for harvest. [NP 216, Project 8042-61660-009-00D]

Crop productivity expected to decline as temperatures warm and precipitation becomes more variable.

Projected climate changes across the Midwest have the potential to affect regional corn and soybean production, but little detailed analysis on expected changes has been conducted at the county or cropping district level. ARS researchers in Ames, Iowa, linked climate projections at the county level with statistical models of yield gaps (the difference between the genetically driven maximum potential yield and the yield attained by producers) for corn and soybean from 2025 through 2075. Yield gaps were projected to increase during this period in the southern portion of the Corn Belt because of the rising July maximum and August minimum air temperatures; yield gaps increased to 75 percent for corn and 30 percent for soybean. There was a strong north/south gradient of the magnitude of the yield gaps for corn and to a smaller degree for soybean, because soybean has a higher temperature limit during grain-fill. Adaptation strategies for Midwest corn and soybean production systems could include improving soil water availability to reduce crop stress and offset the effect of maximum temperature extremes. However, exposure to higher minimum temperatures can also be offset by altering the planting date or using a shorter growing season to avoid late summer heat stress. This analysis provides producers with options to consider when seeking to change their production systems to cope with climate change. [NP 216, Project 5030-11610-003-00D]

Pelletized poultry litter applied in sub-surface bands extends soil nitrogen for two growing seasons of cotton.

ARS researchers at Mississippi State, Mississippi, studied how long nitrogen persists in minimal tillage systems after amending soils with broiler litter using sub-surface banding. When pelletized poultry litter (PPL) was applied in sub-surface bands for 3 years, the PPL provided at least 56 kilograms of nitrogen per hectare for each of the 2 years following 2013 PPL applications. Beneficial fertilizer effects were observed in cotton lint yield, plant leaf density, and nitrogen uptake; the residual effect of PPL containing 84 kilograms of nitrogen per hectare increased lint yield by approximately 10 percent during 2014 and 5 percent during 2015, which were higher than yields resulting from standard nitrogen fertilization rates of 140 kilograms per hectare. This result indicates that the option for reduced fertilizer application rates exist during years following PPL application, which would reduce fertilizer application costs in minimal tillage systems and reduce probabilities for excess nitrogen loss to the environment. [NP 216, Project 6064-21610-010-00D]

A soil and land management app debuts.

Smartphones are increasingly being used for quick and convenient access to information for improving farm management decisions and helping agricultural managers maximize the productivity, profitability, and sustainability of their production systems. ARS scientists in Las Cruces, New Mexico, with support from USAID, developed the Land-Potential Knowledge System (LandPKS) app for iOS and Android phones and tablets, which allows managers to rapidly collect and store soil and topographic information and monitor vegetation status for a given area. A new LandPKS algorithm can be used to identify soils based on user observations and provides a more precise and accurate tool for determining soil color using smartphone cameras. These tools, combined under a simple-to-use interface, help land managers develop information databases for identifying options that might improve risk management, productivity,

economic returns, and environmental enhancement. The app is available for download at <https://www.landpotential.org/>. [NP 216, Project 3050-11210-007-00D]

Alabama cotton fiber quality and profitability affected by row spacing, variety, and tillage.

Agricultural producers are faced with a range of conditions that influence their profitability, from weather variability to pressure from weeds, insects, and disease. ARS researchers in Auburn, Alabama, conducted experiments to test how narrow row spacing, transgenic variety selection, and conservation tillage affected cotton profitability and fiber quality. Results showed net returns were influenced by row spacing and crop variety, while fiber qualities were most commonly affected by variety selection and tillage. These results provide cotton producers information when assessing production options for maximizing seed cotton yield and fiber quality. [NP 216, Project 6010-12610-005-00D]

Managing cover crops can reduce corn root disease transmission.

Cereal rye cover crops in corn-soybean rotations have been shown to significantly reduce erosion, decrease nitrogen and phosphorus losses, and increase soil organic matter. However, corn yields following a cover crop of cereal rye can be reduced during some years and some fields, possibly because cereal rye may be acting as a host for pathogens that can be transferred to corn seedlings after rye termination. ARS scientists in Ames, Iowa, and university collaborators used field and controlled environment studies to show this relationship does exist between fungal *Pythium* and *Fusarium* corn pathogens and corn seedlings. Additionally, they showed infection was reduced when the interval between terminating rye cover crops with herbicides and planting corn was increased to more than 10 days. Understanding how cover crops affect disease incidence in subsequent corn crops will help develop management strategies to address this risk and will help farmers, extension personnel, crop advisors, and USDA, Natural Resources Conservation Service conservationists use and manage cover crops more

effectively, thus leading to more cover crop adoption, less risk to corn yield, and greater environmental benefits. [NP 216, Project 5030-21610-002-00D]



CROP PRODUCTION AND PROTECTION

National Programs:

- **Plant Genetic Resources, Genomics and Genetic Improvement, NP 301**
- **Plant Diseases, NP 303**
- **Crop Protection and Quarantine, NP 304**
- **Crop Production, NP 305**

Resistance identified for new types of wheat stem rust.

Wheat, a staple of life for billions of people, had a farm gate value of about \$10 billion in the United States in 2015. For centuries, wheat production has been threatened by a highly virulent microbe, wheat stem rust, which is able to rapidly change into new dangerous types. New and highly virulent races of the wheat stem rust pathogen, known as Ug99, have arisen in Africa and are a severe threat to U.S. and world wheat production. To protect the U.S. wheat crop from Ug99, new research tools are needed to help wheat breeders identify new sources of genetic protection. ARS researchers in Aberdeen, Idaho, and St. Paul, Minnesota, discovered genetic markers that speed the selection for the resistance gene Sr28, which is effective against Ug99, from wheat breeding stocks. Also, a potentially new type of genetic resistance that acts at the adult wheat plant stage was identified and its location has been mapped

on the wheat genome. These advancements are substantially aiding U.S. wheat breeders by providing them with new wheat varieties that are resistant to stem rusts. [NP 301, Project 2050-21000-029-00D]

Durable sunflower downy mildew and rust resistance.

Downy mildew and rust are plant diseases that can seriously reduce sunflower yields. Commercial confection (i.e., edible) sunflower breeders rely on ARS to provide inbred strains of sunflower with disease resistance, but very few suitable confection sunflower inbred lines are available with resistance to both downy mildew and rust. ARS scientists in Fargo, North Dakota, have developed and released three germplasm lines of sunflower that are resistant to both diseases. Each germplasm carries a gene for downy mildew resistance combined with one for rust resistance, thus providing resistance to all known races of North American rust and downy mildew. This represents the first confection germplasm that exhibits combined resistance to both downy mildew and rust. Molecular markers linked to both disease-resistance genes were developed and released to the sunflower industry, enabling breeders to develop additional hybrids with resistance to multiple pathogens, and thus assuring sustainable sunflower production in the presence of these two devastating diseases. [NP 301, Project 3060-21000-039-00D]

Strawberries perform better under low tunnels.

Strawberries are economically valuable to farmers and are popular with consumers who expect availability all year long; however, in much of the United States, traditional strawberries produce fruit only 3 to 4 weeks each year. To produce strawberry fruit for several months, farmers need to use a repeat-fruiting strawberry variety that fruits nearly all year long, and protect it from mid-summer outdoor conditions. ARS scientists in Beltsville, Maryland, compared the performance of repeat-fruiting strawberries under two different production systems (raised beds with and without low tunnels) to

determine the effect of day length, brightness, soil moisture, humidity, and temperature on strawberry yield. They found that higher temperatures under low tunnels, especially in early spring and late fall, resulted in a much longer harvest season. Strawberry yield increased as light increased, and with temperatures up to about 28°C, above which yields dropped. Further evaluations showed that yields were more strongly associated with soil temperatures than air temperatures. This new discovery will be useful to strawberry growers by helping them increase the length of the strawberry season to match consumer demand. The new discoveries by ARS researchers have been published in scientific journals and presented at grower and professional meetings. Strawberry growers are rapidly adopting the low-tunnel production system. [NP 301, Project 8042-21220-254-00D]

Sugarcane aphid-resistant sorghum.

Sugarcane aphid has become a major pest in sorghum in the last few years. ARS scientists in Lubbock, Texas, developed two new lines of pollinator sorghum (restorer, or R), designated LBK1 and LBK2 (tested as R.11259 and R.11143), that showed significant tolerance to sugarcane aphid. These two new R lines have been transferred to four seed companies and have been adopted in their breeding programs. [NP 301, Project 3096-21000-020-00D]

Big Data toolbox.

Whereas computer-aided simulation may be useful in designing optimal breeding strategies, the complexity of simulation is a barrier for breeders to taking the first step in using the software. ARS researchers in Ithaca, New York, developed a simple and flexible computational software suite called the breeding scheme language (BSL), which allows users to more easily simulate breeding options and estimates of benefit from selection under specific genetic criteria and options. This software will be useful for breeders to evaluate breeding schemes and to choose an optimal breeding strategy among a

number of possible ones, and also serves as a training platform for plant breeders. [NP 301, Project 8062-21000-038-00D]

Two USDA potato varieties chosen by McDonald's for French fry production.

The retail market for potatoes used for French fries in the United States is approximately \$1.5 billion before the added value of retail sales. The quick-service restaurant industry prefers lighter colored French fries with a wider range of storage temperatures that can resist the conversion of starch to sugars, which promotes an unacceptably dark French fry. But breeding and identification of new potato varieties with these enhanced attributes involves careful testing and data collection across several locations and years. ARS scientists in Aberdeen, Idaho, collaborated with the University of Idaho, Washington State University, and Oregon State University to develop suitable potato varieties for the French fry industry. The research team released 'Blazer Russet' in 2005 and 'Clearwater Russet' in 2008, and partnered with growers, processing companies, and the restaurant industry to conduct extensive testing for more than 10 years. McDonald's recently accepted these two varieties for use as their French fries. Both varieties exhibit better culinary characteristics, greater fry recovery, less processing waste, higher marketable yields, more efficient nitrogen use, and greater tolerance to temperature and water stress. They also have fewer tuber defects than industry standard varieties. McDonald's now uses seven potato varieties, four of which originated from the ARS breeding program in Aberdeen. [NP 301, Project 2050-21000-032-00D]

Release of soybean germplasm line with superior tolerance to high temperature stress.

High heat (>90°F) damages soybean seed by reducing seed germination and seedling vigor. It also causes seed coat impermeability and green seed discoloration. Unacceptable seed quality and economic loss are major challenges for soybean producers where temperatures are consistently high, such as the

Mississippi Delta region. There has been little attention in commercial breeding programs to address the issue, but ARS researchers in Stoneville, Mississippi; Columbia, Missouri; Jackson, Tennessee; and Raleigh, North Carolina, discovered a heat-tolerance gene, and developed and released a maturity group IV soybean germplasm line to seed companies and public breeders. This germplasm line maintains excellent seed germination and high seed quality under elevated temperatures. ‘DS25-1’ is the first U.S. soybean germplasm release to address heat tolerance in soybean, and it will enable breeding to develop better seed quality in high-temperature stress environments. Commercial and public soybean breeders are now using DS25-1 in their breeding programs to develop heat-tolerant soybean cultivars for producers. [NP 301, Project 6066-21220-012-00D]

Genetic mapping of the location imparting resistance to root knot nematode in cotton.

The root-knot nematode is found throughout the Cotton Belt, and crop rotation with non-host crops can provide short-term nematode suppression. But growers prefer to raise plants that have nematode resistance rather than rotate their crops, which is usually a challenge to implement. Chromosome 14 holds one of the two known genetic locations that imparts resistance to root knot nematode in cotton. But this genetic location has been only sparsely mapped, and genetic markers were not linked closely enough to the gene location to effectively select them. ARS researchers in Tifton, Georgia, collaborated with University of Georgia scientists to create new molecular markers that are more closely linked to the gene location, and demonstrated that the resistance gene(s) are confined to a much smaller segment of DNA than had been previously identified. Additionally, the researchers used the cotton genome of *Gossypium raimondii*, a precursor of modern cotton, to identify 20 genes in the newly delineated region that could be involved in nematode resistance. The improved markers allow better pinpointing of their precise location, and breeding programs are now developing resistant germplasm with the markers.

Identification of these potentially resistance genes advances researchers closer to the goal of identifying the specific resistance genes and their function. [NP 303, Project 6048-21220-015-00D]

Cloning of a durum wheat stem rust resistance gene.

Wheat provides a substantial proportion of the calories and proteins consumed by humans, and additional increases in wheat production are necessary to feed a growing population. Reducing yield losses caused by pathogens can contribute to production increases. ARS scientists in St. Paul, Minnesota, report the identification and development of perfect markers for Sr13, a gene from durum wheat that confers resistance to the new virulent races of the stem rust pathogen that appeared in Africa at the beginning of this century, including Ug99. Two phenotypic alleles, Sr13a and Sr13b, were identified as having effectiveness in controlling stem rust pathogen races. The perfect markers developed for Sr13 and knowledge of allelic differences will allow U.S. durum wheat breeders to more effectively develop Ug99-resistant cultivars. In addition, Sr13 can be a useful component of transgenic cassettes that include multiple resistance genes. [NP 303, Project 5062-21220-023-00D]

Bee mite identification using the internet.

Bees play a crucial role in U.S. agriculture as pollinators of many important crops. Some mites that live on bees are parasitic to their hosts, spreading viruses that contribute to colony collapse, whereas other mites have little detrimental effect on their bee hosts. ARS scientists in Beltsville, Maryland, along with researchers at the University of Michigan and USDA, Animal and Plant Health Inspection Service, designed an interactive, web-based tool for identifying mites found on bees. The searchable image gallery contains more than 850 mite images with an emphasis on mites associated with honey bees, mason bees, bumble bees, and other important pollinators in temperate regions, and stingless bees and large carpenter bees in the tropics. This interactive internet site (<http://idtools.org/id/mites/beemites/>) is

useful to beekeepers, scientists, extension agents, and quarantine officers throughout the world who need to distinguish harmless mites from those that might harm bees or bee colonies. [NP 303, Project 8042-22000-278-00D]

Optimizing anaerobic soil disinfestation as a replacement for methyl bromide.

Because methyl bromide is no longer available to producers for use as a crop fumigant and there is increasing regulatory pressure against the use of chemical fumigants, producers need new, inexpensive, and reliable chemical-independent soil fumigation methods. Anaerobic soil disinfestation (ASD), or the elimination of plant pathogens from soil by anaerobic soil microbes and their toxic byproducts, shows great promise for use as a potential fumigant. A key determinant for ASD success, however, is the carbon source used in the ASD process, which should be easily applied by growers, readily available, inexpensive, and able to suppress a broad range of pathogens and pests. ARS researchers in Davis, California, evaluated 18 different carbon sources derived from agricultural waste and identified the 5 most effective sources for controlling the bacterial pathogen that causes crown gall disease and other target pathogens. ASD using agricultural waste is proving to be a reliable and cost-effective alternative to conventional soil fumigation. [NP 303, Project 2032-22000-015-00D]

Grain contaminant vomitoxin made in subcellular toxisomes.

Harmful byproducts of fungi, called mycotoxins, are important risks to human and livestock health. Little is known about how fungal mycotoxins are produced and how the toxin is delivered to contaminated cereal grain. ARS researchers in St. Paul, Minnesota, have discovered that the toxic fungal product vomitoxin, which can contaminate wheat and barley grain, is produced in specialized portions of fungal cells called toxisomes. Changes within the fungal cell causes the toxosome to convert the cell into a so-called toxin factory that is capable of delivering vomitoxin to wheat and barley grains.

This information is important for developing novel strategies of preventing contamination of grain with vomitoxin. [NP 303, Project 5062-22000-024-00D]

Discovery of new environmentally friendly mosquito repellent.

Mosquitoes are responsible for spreading such diseases as yellow fever, Zika, and chikungunya to humans, thus, the development of new, environmentally friendly repellents is a high priority, particularly for the protection of U.S. troops deployed overseas in areas where these diseases are readily spreading. However, significant health and environmental risks are encountered in the use of effective mosquito control strategies that are pesticide-based. Therefore, ARS researchers in College Station, Texas, along with collaborators at Texas A&M University and the University of Paris-Saclay, identified a class of ‘neuropeptide’ hormone in the legs and mouth parts of mosquitoes involved in the taste perception. A novel version of the neuropeptide hormone was developed that deters and/or repels mosquitoes from feeding, resulting in an immediate ‘fly-away’, ‘walk-away’ and/or ‘jump-away’ behavior. The work, funded by a joint USDA/Department of Defense program, and published in the *Proceedings of the National Academy of Sciences of the United States*, represents a major breakthrough that might find practical use as a completely new and effective mosquito repellent. [NP 304, Project 3091-22000-33-00D]

Impact of various pesticide classes on honey bee survival.

Information regarding the impact of direct sprays and residues from different pesticide classes on honey bee populations is needed to understand which classes may pose the greatest risks. ARS scientists in Stoneville, Mississippi, tested the toxicity of imidacloprid, a commonly used agricultural pesticide, mixed with seven different pesticide classes on honey bees through direct sprays and residues. The scientists determined that that residue levels of seven pesticides in pollens/hive may not adversely affect

honey bees, but long-term exclusive ingestion of the maximal residue levels of some of the insecticides may induce substantial bee mortality. Rotating pesticide chemistries and proper selection of pesticide mixtures can alleviate toxicity risks to honey bees. [NP 304, Project 6066-22000-084-00D]

Optimum production systems for two new alternative oilseed crops.

ARS research was critical in domestication and establishment of camelina and pennycress (*Thlaspi* spp.) as new oilseed crops, though sound agricultural management practices are critical to the success of farmers growing them. Although ARS has published information on effective crop production systems that include these crops, optimum seeding methods for best stand establishments have not been determined. Therefore, ARS researchers in Morris, Minnesota, developed better methods for timing and planting both crops that can lead to improved plant establishment, and potentially higher seed and oil yields. Much of the research information developed on camelina, including using winter varieties in dual cropping systems, was summarized in an ARS-produced growers guide, and published in two different review articles in collaboration with universities. In addition to providing new alternative crops for growers, this work offers producers a way to teach themselves how to grow camelina and pennycress for maximum economic benefit. [NP 305, Project 5060-21220-005-00D]

Improved re-seeding methods for rangeland restoration.

Throughout the western United States, rangelands are being invaded by annual grasses such as cheatgrass and medusahead that provide fuel for wildfires and destroy the health and usefulness of these ecosystems. The only effective way to manage invaded and degraded rangeland is to reseed the ground with desired perennial vegetation, but most reseeding attempts have failed. Therefore, ARS scientists in Burns, Oregon, determined the best season to reseed, seeding rate, and weather conditions for reseeding rangeland invaded by these undesirable annual grasses. They compared the effects of spring versus

autumn seeding of desired perennial grasses and various seeding rates, and determined effects on perennial and annual grass establishment under conditions typical of Western rangelands. They found that perennial grass establishment was unacceptably low when the number of annual grass seeds in the soil exceeded 150 per square yard, regardless of weather conditions, and recommend that, prior to reseeding desired perennial grasses, land managers should sample the field to determine the number of annual grass seeds in the soil to decide whether annual grasses must be controlled before proceeding. This work produced solid guidelines that land managers can use when considering rangeland re-seeding projects. Professionals who make recommendations for rangeland management can use this information to develop guidelines for stand establishment under various conditions. [NP 304, Project 2070-22000-005-00D]

Honey bee spermatozoa cryopreserved.

The lack of reliable sperm cryopreservation is a key roadblock to the development of a comprehensive and integrated honey bee breeding program. To address this problem, ARS researchers in Fargo, North Dakota, in collaboration with ARS scientists in Baton Rouge, Louisiana, and the ARS National Bee Gene Bank Program in Fort Collins, Colorado, have developed a better method to cryopreserve honey bee spermatozoa, including development of the Fargo Honey Bee Extender Medium. This medium not only improves sperm quality after cryopreservation, but also allows for semen shipment at room temperature before and after storage, potentially improving the accessibility of cryopreserved samples for bee breeding programs worldwide. [NP305, Project 3060-21000-041-00D]

Validation of intelligent sprayer for managing pests in nurseries.

Conducting on-farm evaluations of pest control and determining its economic feasibility is a necessary procedure to assure successful adoption of new spray technologies by commercial horticulture

enterprises. ARS researchers in Wooster, Ohio, developed and tested in three commercial nurseries in Ohio and Oregon a new intelligent sprayer that targets insect pests. Efficacy of the sprayer for pest control treatments was compared with two types of conventional air-assisted sprayers. Variable rates from the intelligent sprayer were achieved automatically based on the plant presence, canopy structure, and foliage density. Compared with conventional sprayers with comparable and effective insect control, the intelligent sprayer used 30 to 78 percent less spray volume (and thus fewer chemicals) to control pest insects, thereby offering an economically and environmentally responsible spray system for controlling pests. [NP 305, Project 5082-21620-009-00D]

Water-saving strategies developed for highbush blueberries.

Many blueberry growers are facing serious water limitations due to warmer and drier weather conditions, greater scrutiny of water used for agricultural purposes, and greater demand by other sectors. To stay profitable under these conditions, blueberry growers need to use less water to grow blueberries. ARS scientists in Corvallis, Oregon, evaluated the potential of using water-saving management strategies, including deficit irrigation, early and late-season irrigation cut-offs, and crop thinning, to maintain yield and fruit quality with less water in northern highbush blueberry. Fruit production was unaffected by deficit irrigation and, by the second year, was actually greater with crop thinning than with no thinning in the early cutoff treatment. Late cutoffs, on the other hand, reduced yield, but increased several fruit quality characteristics, including firmness, storability, and sugar content of the berries. Compared with using full irrigation, deficit irrigation saved nearly 270,000 gallons per acre of water per year, whereas early and late-season irrigation cutoffs saved approximately 140,000 and 250,000 gallons per acre of water per year, respectively. [NP 305, Project 2072-21000-048-00D]

Release of new plant germplasm and cultivars.

In FY 2017, there were 68 new plant releases of enhanced germplasm and cultivars of sorghum, sugar beet, table grape, wheat, pennycress, orange, blackberry, blueberry, sunflower, chickpea, soybean, triticale, watermelon, orchard grass, cotton, pepper, sugarcane, and witch hazel. Of the released cultivars, 18 are being protected through a Plant Patent or Plant Variety Protection.

The National Genetic Resources Program (NGRP).

The NGRP is responsible for acquiring, characterizing, preserving, documenting and distributing to scientists germplasm of all life forms important for food and agricultural production. In FY 2017, 265,460 samples were distributed. The table below lists the number of distributions from the NGRP repositories in the Germplasm Resources Information Network (GRIN) to different organizational categories. Samples are typically distributed to: foreign genebank/resources units; international agricultural research centers; U.S. and foreign commercial companies; and U.S. and foreign agencies and universities.

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| Site | Samples | Accessions | Requests | Countries |
|---|----------------|----------------|--------------|------------|
| C.M. Rick Tomato Genetics Resource Center (TGRC) | 105 | 105 | 1 | 1 |
| National Arboretum (NA) | 422 | 349 | 104 | 7 |
| National Arid Land Plant Genetic Resources Unit (PARL) | 308 | 133 | 29 | 4 |
| National Center for Genetic Resources Preservation (NSSL) | 3,954 | 3,930 | 45 | 2 |
| National Small Grains Collection (NSGC) | 48,943 | 30,514 | 767 | 45 |
| Natl. Germplasm Repository - Corvallis (COR) | 5,810 | 2,830 | 798 | 17 |
| Natl. Germplasm Repository - Davis (DAV) | 2,881 | 1,421 | 257 | 11 |
| Natl. Germplasm Repository - Geneva (GEN) | 6,837 | 2,117 | 413 | 11 |
| Natl. Germplasm Repository - Hilo (HILO) | 56 | 34 | 3 | 2 |
| Natl. Germplasm Repository - Mayaguez (MAY) | 124 | 84 | 57 | 3 |
| Natl. Germplasm Repository - Miami (MIA) | 771 | 534 | 111 | 9 |
| Natl. Germplasm Repository - Riverside (RIV) | 19 | 18 | 5 | 2 |
| North Central Regional PI Station (NC7) | 54,958 | 22,508 | 1,392 | 61 |
| Northeast Regional PI Station (NE9) | 6,609 | 3,982 | 189 | 25 |
| Ornamental Plant Germplasm Center (OPGC) | 402 | 308 | 60 | 1 |
| Plant Genetic Resources Conservation Unit, Griffin, GA (S9) | 50,097 | 32,655 | 966 | 44 |
| Plant Variety Protection Voucher Collection (PVPO) | 6 | 6 | 1 | 1 |
| Potato Germplasm Introduction Station (NR6) | 8,474 | 2,867 | 246 | 9 |
| Rice Genetic Stock Center (GSOR) | 8,479 | 3,363 | 172 | 17 |
| Soybean Collection (SOY) | 23,340 | 12,468 | 566 | 27 |
| US Nicotiana Germplasm Collection (TOB) | 381 | 208 | 80 | 12 |
| Western Regional PI Station (W6) | 42,484 | 27,244 | 1,445 | 47 |
| Total | 265,460 | 147,678 | 7,707 | 358 |



NATIONAL AGRICULTURAL LIBRARY

The National Agricultural Library (NAL) is one of the largest and most accessible agricultural research libraries in the world. NAL provides services directly to the staff of USDA and to the public, primarily via the NAL Website, www.nal.usda.gov. The Library's vision is "advancing access to global information for agriculture."

Development of the Ag Data Commons.

In FY 2017, the staff of the NAL expanded the Ag Data Commons catalog for agricultural research datasets (<https://data.nal.usda.gov>). Improvements focused on multiple platform upgrades for the enhancement of the Ag Data Commons DKAN distribution. The Ag Data Commons was successfully added to the USDA Enterprise Inventory with the support of ARS data steward and data architect from the USDA, Office of the Chief Information Officer. Considerable effort was given to creating sustainable business models and strategic partnerships with senior program leadership within ARS and NIFA. The NIFA FY 2018 requests for grant applications will include requirements for data management plans and ensuring public access to the resulting data and publications.

Implementation of the i5K Workspace.

The NAL has implemented new tools, added new data, and performed updates to the i5K Workspace@NAL, a web resource for arthropod genome access and curation. New software suites include a GFF3 Toolkit package for the generation of official gene sets (OGS). The software was used

to generate three OGSs, and a manuscript describing the new tool was submitted to the journal *Methods in Molecular Biology*. Three new species and 30 new datasets were added to the Workspace. An analysis of the sequenced arthropod genomes found that 20 percent of all sequenced genomes are in the i5K Workspace@NAL—a good market penetration for a small unit.

The LTAR data portal is functional.

Meteorological observations as part of the Long-Term Agro-ecosystem Research (LTAR) project exceeded 1.2 million individual readings. New sites were added and some sites expanded their data offerings by increasing the number of PhenoCam cameras being used to document weather and vegetation conditions at LTAR sites (now up to 45 PhenoCams at 13 LTAR sites). The geographic information systems (GIS) catalog now has more than 100 reusable metadata snippets for frequently used entries and 27 distinct keyword list thesauri, in addition to the National Agricultural Library Thesaurus (NALT). Each keyword is linked to its source thesauri. At present, the GIS server is hosting 113 data layers. A new tool was added to the GeoServer in response to customer feedback that allows the comparison of any two raster layers using a slider feature.

Update on the Life Cycle Assessment Commons.

In FY 2017, the NAL team and its partners were recognized by an industry association for their contributions to the field of Life Cycle Assessment (LCA). The memorandum of understanding (MOU) supporting this accomplishment, which formalizes the Federal LCA Commons, is moving through the approval process. The U.S. Environmental Protection Agency and the Department of Energy have both signed the MOU. In support of its leadership in the field, the NAL team was called upon to conduct an expert review of the Australian life cycle inventory database on behalf of the United Nations Environmental Program (UNEP)/SETAC, and the UNEP Global Network of Interoperable Databases.

This year, the team added the Federal Highway Administration as a new partner. The LCA team is making significant progress toward meeting the standards of a trusted repository, and providing reliable and long-term data stewardship for the LCA and Federal LCA Commons.

Implementing PubAg and expanding digital collections.

During 2017, NAL expanded its efforts to improve the technical development of PubAg and to build up the content of the service. In 2017, PubAg reached 1,707,868 citations to peer-reviewed, agriculture-related scientific articles. Each article citation in PubAg includes NAL Thesaurus subject terms and a link to the article if available from internal NAL repository, PubMed Central, and the publisher. PubAg was migrated and modernized to a Blacklight platform with features added to improve the user experience, including an advanced search function and type-ahead suggestions using Elasticsearch technology. Building on upgrades developed for PubAg, NAL has modified database, search, and user-interface technology to support an upgrade to its digital collections scheduled for deployment in FY 2018. The National Agricultural Library's Digital Collections had nearly 14 million online page views of more than 30,000 historical documents and reports across 10 major collections in 2017. PubAg can be found at <http://pubag.nal.usda.gov>.

NAL digital collections.

During fiscal year 2017, NAL staff digitized and created citation information for 19,741 items (690,304 pages), bringing the total number of digitized items to 135,397 (approximately 6 million pages). These items include historic USDA-issued publications, nursery and seed trade catalogs, and topic-specific content to support NAL online exhibits and information. NAL has also upgraded the metadata records for items in the Organic Roots, Historical Dietary Guidance, and the Animal Welfare Act collections. In addition, NAL continues contributing rare and historical titles to the Biodiversity Heritage Library.

Until all mass-digitized publications are migrated to NAL web services, public access is available at <https://archive.org/details/usdanationalagriculturallibrary>.

Exhibits.

In fiscal year 2017, NAL completed and readied for launch the “Small Agriculture” online exhibit, which describes three of USDA’s historical initiatives in niche agriculture. NAL-GC, the Library’s quarterly review article on its website home page, featured a new article on cranberries. Also, in collaboration with Maryland State Highway Administration, NAL staff developed a display exhibit about archeological discoveries and stream restoration on ARS property in Beltsville, Maryland. The exhibit features Native American artifacts that were unearthed during recent construction of a local highway.

DigiTop.

In FY 2017, NAL and USDA partners licensed on behalf of USDA users a \$5.5 million portfolio of content consisting of full-text and databases to support research and scientific discovery. During FY 2017, DigiTop continued shifting subscription periods away from December to third quarter of the fiscal year to make the service more resilient to the budgetary challenges and to ensure better continuity of access for researchers.

Automated indexing.

In FY 2017, NAL continued improving full-scale production—automated indexing/text analytics software to generate the AGRICOLA Index of agricultural literature. This application combines semantic analysis, machine learning, and human-constructed rules to automatically assign NAL Thesaurus subject terms to journal article citations. This metadata facilitates effective literature

classification, management, search, and retrieval. In FY 2017, NAL used the system to index 481,827 articles, an increase of 51,701 articles over FY 2016 production. In FY 2017, NAL migrated production from Luxid 6 to Luxid 7 application. Additionally, NAL begin migration to the next version of the Expert System software, called Cogito.

NAL Thesaurus (NALT).

NAL collaborated with the USDA, Forest Service (FS) on a project to replace the “uncontrolled/semi-controlled vocabulary” in the FS library database with a “controlled vocabulary” called the NAL Thesaurus (NATL; <http://agclass.nal.usda.gov>). To accomplish this goal, NAL mapped the FS index terms (many from CAB Thesaurus) to NALT. Of the 14,307 unique index terms, 9,185 were automatically mapped to NALT terms. The remaining 5,120 did not have a match and needed to be “human reviewed,” resulting in many new additions to NALT.

Global ariculture concept scheme.

In FY 2017, NAL continued working in collaboration with CAB International and the Food and Agriculture Organization of the United Nations on integration of three agricultural thesauri to produce GACS, a core agricultural vocabulary of 15,000 concepts in 26 languages. The vocabulary supports Linked Data and is seen as the first step toward the realization of a hub that links to and from other concept schemes beyond the initial three, and in multiple language areas, to achieve interoperability among information systems. During FY 2017, GACS was incorporated under the GODAN Secretariat to facilitate better and more structured collaboration. GACS can be found at <http://browser.agrisemantics.org/gacs/en/>.

3.7. Outreach Activities: Workshops, Field Days, Trainings/Demonstrations, and Stakeholder Presentations/Meetings



3.7.1. Field Days

| Laboratory | Location | Description |
|-----------------------------------|------------|---|
| Agroecosystem Management Research | Ames, IA | Gave presentation at the Soil and Water Week Declaration and Saturated Buffer field day. Fifty people in attendance; including the Governor and Secretary of Agriculture of Iowa. |
| Agroecosystem Management Research | Ames, IA | Gave presentation on siting and design of Saturated Buffers at the 2017 Iowa Watershed Academy, Boone, Iowa. Sixty people in attendance. |
| Soil Dynamics Research | Auburn, AL | Invited to present at the Cover Crop Workshop and Field Demo. Agricultural Economist Dr. Leah Duzy presented on the economics of conservation systems. Research Agronomist Dr. Kip Balkcom and Agricultural Science Research Technicians Trent Morton and Jeffrey Walker attended the workshop and provided technical expertise during the field day. |

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| Bee Research Laboratory | Beltsville, MD | All laboratory members hosted and gave presentations to 45 beekeeping stakeholders who signed up for an optional field trip from the North American Pollinator Partnership Conference in Washington, D.C., to visit the laboratory and learn about bee research. Visit was followed by numerous emails and correspondence about laboratory activities. |
| Genetic Improvement for Fruits and Vegetables Laboratory | Beltsville, MD | Field day for American Cranberry Growers Association. August 17, 2017. Presented research on mycorrhizae colonization of cranberry. |
| Food Animal Environmental Systems Research | Bowling Green, KY | Participated in field day with Kentucky State University. Guest speaker for cover crop demonstration at Bunton Farms; provided research results and information related to improving soil health. Anticipated number of participants ranged from 60 to 80 underserved population. |
| Integrated Cropping Systems Research | Brookings, SD | Held annual field day. |
| Sugarcane Production Research | Canal Point, FL | Dr. Gordon participated in a farm field day hosted by Deas Bros Farms where she taught about 800 students in elementary and middle school about sugarcane and plant breeding. |
| Forage Seed and Cereal Research | Corvallis, OR | On May 24, 2017, participated in an Oregon State University (OSU) organized field day at the OSU Hyslop field laboratory. Presentations were given by four research unit staff on biochar research, stem rust, grass viruses, grass endophytes, and slug control research. |
| Horticultural Crops Research | Corvallis, OR | Field day presenting current information on soil-borne disease and nematode management in raspberry. |
| Horticultural Crops Research | Corvallis, OR | Presented talk on plant-parasitic nematode management in raspberry at annual stakeholder conference (California Caneberry field day). |
| Horticultural Crops Research | Corvallis, OR | Presented data on leaf and petiole nutrient status for managing nitrogen, phosphorus and potassium levels for optimum growth, yield, and berry nutrients in Pinot noir at the Oregon State University Grape Day. |

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| Horticultural Crops Research | Corvallis, OR | Gave lecture on managing grapevine nutrition and mycorrhizal fungi, provided handout for leaf/petiole nutrient guidelines at the Oregon LIVE (Low Input Viticulture & Enology). |
| Horticultural Crops Research | Corvallis, OR | Discussed machine harvestability of red raspberry selections and cultivars at Washington State University Machine Harvest Field Day. |
| National Clonal Germplasm Repository | Corvallis, OR | Home Orchard Society volunteers came to collect fruit samples for the October "All About Fruit Show." |
| National Clonal Germplasm Repository | Corvallis, OR | Field day featured blueberries; the public was invited to learn about blueberry research and taste the diversity of the blueberry collection at the genebank. |
| Peanut Research | Dawson, GA | Dr. Chris Butts, Research Agricultural Engineer, served as an organizer member of the Georgia Peanut Tour Committee and participated in the 2017 Georgia Peanut Tour. Approximately 150 participants met in Albany, GA, and listened to a Hot Topics seminar, visited peanut fields, research facilities including the ARS National Peanut Research Laboratory, a peanut shelling plant, and seed facility. The tour visited President Jimmy Carter's boyhood farm where Mr. Carter described life in south Georgia. |
| Foreign Disease-Weed Science Research | Ft. Detrick, MD | Presented research to approximately 42 participants, consisting of nursery owners, managers, grower groups, and State government officials. Presentation was on biological control of soil-borne plant pathogens and how that can be incorporated into ornamental nursery practices. A demonstration was given on recently licensed biological control agent to manage ramorum blight (nursery equivalent of sudden oak death) and how it can be used. |
| Sugarcane Research | Houma, LA | Lafourche/Terrebonne Parish Sugarcane Field Day at the USDA Ardoyne Farm in Schriever and Raceland Ag Center. Discussion of billet cane chemical seed treatment results and aspects of soil fertility and precision agriculture research. |
| Sugarcane Research | Houma, LA | Assumption Parish Sugarcane Field Day at Napoleonville, Louisiana "Using Sun Hemp as a Cover Crop." |
| Sugarcane Research | Houma, LA | Iberia/St. Mary/Vermilion Sugarcane Field Day at Erath, Louisiana, on "Filter press mud and broiler litter additions improve soil health." |

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| Emerging Pests and Pathogens Research | Ithaca, NY | Employees participated in the New York State Farm Show in Syracuse, New York, one of the largest agriculture shows in the Northeast, attracting more than 25,000 visitors and 400 vendors. ARS scientists were on hand to explain their research projects. The display consisted of posters from each research unit and the Robert W. Holley Center. A video monitor continuously looped slides representing the research performed at the center. We also had a table with microscopes and insects for children to see and enjoy. |
| Cool and Cold Water Aquaculture Research | Leetown, WV | Jill Birkett and Lisa Radler participated in the U.S. Geological Service (USGS) Earth Day Open House demonstrations. The event took place at the USGS Leetown Science Center. |
| Agroecosystem Management Research | Lincoln, NE | Field presentation made for ARS bioenergy and cropping systems research to seven undergraduate research interns, one graduate student coordinator, and one faculty coordinator for the University of Nebraska's Applied Plant Systems Internship program. |
| Wheat, Sorghum and Forage Research | Lincoln, NE | Attended stakeholder event, the annual Hard Winter Wheat Breeders' Field Day, Bushland, Texas. Discussed the ARS Hard Winter Wheat Regional Nursery Program, and presented information on ARS-developed winter wheat breeding lines with virus resistance. |
| Wheat, Sorghum and Forage Research | Lincoln, NE | Attended Wheat Field Days sponsored by the University of Nebraska. Presented and discussed research on breeding virus-resistant wheats to small and large farmers and university researchers |
| Pollinating Insect-Biology, Management, Systematics Research | Logan, UT | Invited to participate in Bugfest at the Utah Natural History Museum in Salt Lake City, Utah. Had three tables that included live bees, pinned specimens, and videos. Staff also set out posters and interacted with approximately 2,000+ visitors, ranging in all ages and with very diverse backgrounds. |

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| Office of the Area Director | Maricopa, AZ | Hosted Farm Science Day, a signature event with AZSciTech Festival. Despite rain and wind, nearly 500 from the local community and Phoenix metro area came to learn about the science behind agriculture. Event included an interactive insect zoo, cotton 101, biotechnology, remote/proximal sensing, auto-steer tractors, new crop development, photosynthesis, and cotton breeding. |
| Tropical Crops and Germplasm Research | Mayaguez, PR | Eighteen staff members of the Mars Cacao Plant Science Division visited cacao research plots and the cacao germplasm collection at the ARS Tropical Agriculture Research Station in Mayaguez, Puerto Rico, on February 15–16, 2017. The group, headed by Director Ray Schnell, wanted to learn more about ARS research on cacao including long-term variety trials, crop management practices, and techniques on conservation and characterization of cacao genetic resources. |
| Soil Management Research | Morris, MN | Drs. Heather Dose and Frank Forcella co-presented "Clean water and sweet nectar: The benefits of cover crops" at the Soil Health Workshop on June 28 in Morris, Minnesota. The event was sponsored by the West Central Research and Outreach Center, University of Minnesota Extension and North Dakota State University. |
| Northwest Sustainable Agroecosystems Research | Pullman, WA | Presentation at the Washington State University Wilke Farm Field day. About 100 people in attendance. |
| Wheat Health, Genetics, and Quality Research | Pullman, WA | Field Day presentation in Ralston, Washington. Presented on "Blackleg of Canola." |
| Wheat Health, Genetics, and Quality Research | Pullman, WA | Field Day Presentation in Almira, Washington. Talk was on "Blackleg of Canola and other canola diseases." |
| Great Basin Rangelands Research | Reno, NV | Hosted students in the Reno High School AP Science Class on seed and seedling propagation of big sagebrush for restoration activities. AP Science instructor Scott Huber and 18 students visited the ARS wildland seed laboratory and greenhouse facilities and learned on-hand step-by-step procedures to germinate and grow big sagebrush for future class restoration efforts. |

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| Great Basin Rangelands Research | Reno, NV | The unit conducted a field tour in cooperation with the Eureka County Conservation District and the Dean Ranch, owned by Barrick Gold, in a hands-on implementation of using the Lawson Aerator as a tool for rangeland rehabilitation practices. ARS staff presented on the application of the mechanical tool and data from past Lawson aerator application efforts to 40+ stakeholders and individuals. The Lawson aerator is owned by the ARS unit. |
| Office of the Laboratory Director | Riverside, CA | Hosted a tree and vine field day on Crop Management and Salinity: Grapes, Avocado and Passion Fruit, a Potential New Crop. The field day at the Laboratory was held in cooperation with a University of California Farm Advisor, Sonia Rios, and UC Cooperative Extension. Approximately 30 local farmers participated in the event that include presentations on management of these high-value crops under saline conditions and a field tour including grape and passion fruit experimental sites. |
| Grassland, Soil and Water Research Laboratory | Temple, TX | The field day was attended by approximately 93 local farmers, crop consultants, and researchers from university, State, and Federal agencies throughout Central Texas. Tours of grassland and cropping systems research encompassing 17 presentations were followed by a hosted luncheon. |
| Southwest Watershed Research | Tucson, AZ | A field visit to conduct an initial evaluation of gullying induced by water spreader structures on the Tohono O'odham Nation was conducted with NRCS and local land owners/managers. Field discussion included insights into erosion and gullying processes as well as opportunities for mitigation. |
| Pasture Systems & Watershed Management Research | University Park, PA | Four exhibits were developed and presented at the Pennsylvania Ag Progress Days. Ag Progress Days is a 3-day educational outreach event held in Centre County, Pennsylvania, that is attended by approximately 45,000 producers and the general public. This year the exhibits featured riparian management options, inter-seeding cover crops for early establishment, and the locations participation in the Long-Term Agro-ecosystem Research network and the Northeast Climate Hub. |

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| Global Change and Photosynthesis Research | Urbana, IL | The University of Illinois Agronomy Days is held in conjunction with the University of Illinois Department of Crop Sciences to give a tour and make a presentation about the SoyFACE Global Change Research Facility. |
| Floral and Nursery Plants Research | Washington, DC | In cooperation with scientists from Tennessee State University, Louisiana State University, Texas A&M, Mississippi State University, and the University of Georgia, the unit organized and hosted a nursery and landscape symposium and field day at the ARS site in McMinnville, Tennessee. Local growers, scientists, students, and nursery professionals learned about new varieties and production practices at this half-day event. |
| Gardens Unit | Washington, DC | In collaboration with Davey Trees, Casey Trees, Penn State University, and the Friends of the National Arboretum, the U.S. National Arboretum hosted a Kid's Tree Climb event. During the course of the day, 250 children had the opportunity to climb into a tree using rigging provided by professional tree climbers. |
| Gardens Unit | Washington, DC | Staff of the U.S. National Arboretum hosted the Bonsai Festival, which included giving tours and demonstrations to ~1,000 visitors from the general public. |
| Physiology and Pathology of Tree Fruits Research | Wenatchee, WA | Grower field day held at the Monterey Bay Academy Field site in Watsonville, California. The field day reviewed six different field trials that were undertaken to examine the use of host resistance and/or biologically active soil amendments for the control of soil-borne diseases of strawberry, with an emphasis on management of Fusarium wilt caused by <i>Fusarium oxysporum</i> f. sp. <i>fragariae</i> . Approximately 120 growers, stakeholders, and industry personnel were in attendance. |
| Rangeland and Pasture Research | Woodward, OK | The Southern Plains Range Research Station and the Oklahoma Cooperative Extension Service hosted the Southern Plains Livestock, Forage, and Soil Conference on August 15. The 108 producers in attendance heard presentations on current and planned research. |

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| <p>Application Technology Research</p> | <p>Wooster, OH</p> | <p>The 2017 Maumee Valley Growers Association winter conference was attended by growers, extension educators, and allied industry members. It included a tour of the ARS research greenhouse at the Toledo Botanical Garden and a presentation of four demonstration trials highlighting recent research focused on improving greenhouse production of ornamentals. This included the benefits of supplemental lighting, carbon dioxide concentration, and silicon on plant growth, as well as reducing energy costs.</p> |
| <p>Biobased and Other Animal Co-Products Research and Residue Chemistry and Predictive Microbiology Research</p> | <p>Wyndmoor, PA</p> | <p>Participated in the Pennsylvania Farm Show 2017, representing the mission of the Eastern Regional Research Center (ERRC). A poster presenting ERRC work and flyers describing research and accomplishments of each research unit were displayed. Answered questions from farm show visitors concerning ERRC research.</p> |

3.7.2. Workshops

| Laboratory | Location | Description |
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| Agroecosystem Management Research | Ames, IA | Invited presentation to National Press Foundation-sponsored Training Workshop for Journalist Fellows "Farm to Table: Where your food comes from," Des Moines, Iowa. Presentation title "Impacts of Organic Farming on Soil and Water Quality." |
| Agroecosystem Management Research | Ames, IA | Presentation of cover crops to Women in Agriculture cohort at Field Extension Education Laboratory near Ames, Iowa, sponsored by Iowa State University Extension. |
| Research Porgram Support | Ames, IA | Dr. Keith visited Oahu to present a paper "Rapid Ohia Death: Pathology Research Summary" at the Rod Summit. |
| Soil Dynamics Research | Auburn, AL | Invited to participate in the Flue Gas Desulfurization (FGD) Gypsum in Ag Workshop of the 2017 Electric Power Research Institute Advisory Committee meeting in Newport Beach, California. Dr. Dexter Watts made the presentation entitled, "Influence of FGD Gypsum on Reducing P Losses from Pastures and Row Cropping Systems," and Dr. Allen Torbert made the presentation entitled, "Update on USDA-NRCS National Conservation Standard for Gypsum and Gypsum as a Bedding Material in Poultry Broiler House." |
| Soil Dynamics Research | Auburn, AL | Dr. Allen Torbert was invited to participate in the 2017 World of Coal Ash Workshop, Lexington, Kentucky, and made a presentation entitled, "FGD Gypsum uses in Agriculture: Status of Federal Regulations and Support." The presentation updated the attendees on the status of the joint USDA and EPA risk evaluation of FGD gypsum. Also included was an update on the adoption of the NRCS National Conservation Standard for the use of gypsum in agriculture. |
| Genetic Improvement for Fruits and Vegetables Laboratory | Beltsville, MD | Lead a workshop/breakout group discussion at the <i>Vaccinium</i> Planning Meeting in Kannapolis, North Carolina, focused on abiotic stress research in <i>vaccinium</i> . |

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| Genetic Improvement for Fruits and Vegetables Laboratory | Beltsville, MD | A blueberry pruning demonstration and workshop was conducted at Whitesbog Blueberry Farm, demonstrating the principles of blueberry pruning. Attendees had a hands-on opportunity to prune dormant bushes. About 20 attended. |
| Hydrology and Remote Sensing Laboratory | Beltsville, MD | The GRAPEX workshop will be to review field experiment data collected by GRAPEX researchers for the 2013-2016 growing seasons, coordinate research, share and conduct analyses of data and model results to generate a collection of scientific papers from the GRAPEX project for submission to a peer-reviewed journal. In addition, there will be discussions among the participants of proposed field experiment activities for the upcoming 2017 growing season. |
| Nutrition, Food Safety, and Quality | Beltsville, MD | Organized and moderated a 2-day workshop cosponsored by ARS and National Institutes of Health on best practices for design and reporting of diet in microbiome studies. |
| Dale Bumpers Small Farms Research Center | Booneville, AR | Dr. Craig Willson held a workshop with local science teachers and two University of Arkansas students on the corn ear worm. Farm Bureau sponsored and provided pizza for lunch. |
| Office of the Director | Clay Center, NE | Hosted a meeting of approximately 15 ARS scientists, university collaborators, and industry contacts to discuss sheep research. During the workshop, attendees discussed current and future research interests related to sheep, as well as toured the U.S. Meat Animal Research Center sheep facilities. |
| Office of the Director | Clay Center, NE | An Antimicrobial Resistance Workshop was held at the U.S. Meat Animal Research Center for approximately 35 ARS and APHIS scientists, university collaborators, focus group members, and industry contacts. The 1.5-day workshop consisted of presentations about current research in antimicrobial resistance, as well as discussion about future research and collaborations. |

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| U.S. Meat Animal Research Center | Clay Center, NE | The Weight Trait Project meeting, "DNA Technology in Beef Cattle: Where we've been, where we are, and where we're going," was held at the U.S. Meat Animal Research Center, in collaboration with the University of Nebraska. The 1.5-day workshop provided presentations focused on current research in genetics, breeding, and animal health related to beef cattle. Approximately 50 collaborators, local cattle producers, and cattle industry contacts attended. |
| U.S. Meat Animal Research Center | Clay Center, NE | The "Farmers and Ranchers Cow/Calf College" was held at the U.S. Meat Animal Research Center, in collaboration with the University of Nebraska. The 1-day workshop provided presentations focused on current research and information related to beef cattle production. Approximately 80 collaborators, local cattle producers, and cattle industry contacts attended. |
| Soil Drainage Research | Columbus, OH | Gave presentation entitled "Reducing nutrient movement: data from edge of field studies" to approximately 100 producers, extension educators, crop advisors, students, and scientists at the annual Manure Science Review in Paulding, Ohio. |
| Horticultural Crops Research | Corvallis, OR | Organized blind wine tasting with collaborators at Oregon State University with industry partners (Erath Wine Estates) to examine wines from ARS vineyard versus winery nitrogen management trial. The results will be used to guide sensory panel research on these wines. |
| Horticultural Crops Research | Corvallis, OR | Presented: "Assessing transportability of decision support systems: ascospore release prediction;" "The grape powdery mildew conundrum: Fungicide selection and timing;" and "Biophysical modeling of pathogen dispersion;" during the 2017 Workshop on Grape Powdery and Downy Mildew. |
| Crops Pathology and Genetics Research | Davis, CA | Gave a presentation to policymakers (15–20) from the California Department of Food and Agriculture, Resources Agency, and Air Resources Board to inform their efforts at quantifying carbon storage and greenhouse gas emissions from agriculture as part of the SB1350 Healthy Soils Program Act (2016). The presentation was entitled "Conservation Tillage Practices for California Agriculture." |

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| Range Sheep Production Efficiency Research | Dubois, ID | Conducted a half-day workshop in the field for Clark County School District high school students and University of Idaho Vet Externship participants. ARS scientists and technicians, Bureau of Land Management technicians, and Idaho Fish and Game biologists involved students in sage grouse conservation efforts. Students were taught how to place trackers on sage grouse and determine health and age of sage grouse, and how to assess sage grouse habitat. |
| Sugarbeet and Bean Research | East Lansing, MI | Participation in development and presentation of hands-on activities and informational displays for Fascination of Plants Day, organized by Michigan State University. This activity was aimed at the general public to increase awareness of plants and their roles as well as plant research in East Lansing, Michigan. More than 100 people were reached at this activity. Unit Program Support Assistant, Melissa Stiefel, assisted with this activity. |
| Office of the Director | ElReno, OK | BlueSTEM AgriLearning Center at the Grazinglands Research Laboratory hosted a Soil Science Teacher Professional Development Workshop for local teachers. |
| Insect Genetics and Biochemistry Research | Fargo, ND | A workshop comprised of working with graduate students to lead a game of insect-themed Family Feud to teach students more about insects in a fun, engaging way. There were three sessions (of approximately 10 students each) of the game. |
| Poultry Production and Product Safety Research | Fayetteville, AR | The week-long Armed to Farm Boot Camp providing hands on training and on-farm demonstrations to military veteran small farmers. Conducted in partnership with the University of Arkansas and NCAT (nonprofit), the unit staff provided hands-on training on topics ranging from development of business plans, livestock care and handling, pasture management and water systems, soil assessment, and pasture poultry production. |
| Foreign Disease-Weed Science Research | Ft. Detrick, MD | Presented a plant pathology research seminar to a group of Hood College undergraduate and graduate students (+50). |

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| Foreign Disease-Weed Science Research | Ft. Detrick, MD | Dr. Shishkoff was part of a Specialty Crop Research Initiative (SCRI) Planning Grant to present a workshop, in Philadelphia, Pennsylvania, November 15-16, 2016, to stakeholders (growers and industry and extension personnel) of proposed research on downy mildew pathogens. She helped plan the meeting and presented two oral presentations. |
| Tropical Plant Genetic Resources and Disease Research | Hilo, HI | Assisted with planning for 2017 International Macadamia Nut Symposium, including design of the abstract submission form, receiving abstract submissions, and developing symposium program. |
| Innovative Fruit Production, Improvement and Protection | Kearneysville, WV | Drs. Ann Callahan and Chris Dardick, in conjunction with the University of Maryland, hosted a Bioinformatics Training Workshop for local high school biology teachers and students in West Virginia. Five students and nine teachers participated in this workshop, which was funded by the National Science Foundation, to train them in the latest tools and techniques in genomics data analysis, including gene editing. The teachers and students worked together to create learning modules that can be integrated into their current curriculum. |
| Cotton Ginning Research | Las Cruces, NM | Conducted workshop classes at the 2017 Southwestern Ginners School held in Lubbock, Texas, on behalf of the National Cotton Ginning Association to 145 ginners to maintain ginners certifications. |
| Cotton Ginning Research | Las Cruces, NM | Conducted workshop courses to maintain ginner's certification at the 2017 Western Ginners School, on behalf of the National Cotton Council, at the SW Cotton Ginning Research Laboratory, Mesilla Park, New Mexico. Workshops taught include: (1) Efficient operation, adjustment, and maintenance of gin equipment; (2) Unloading through cylinder cleaners; (3) Drying systems; (4) Hydraulic systems: Applications in the gin; (5) Bale presses and hydraulic systems; (6) Plastic Detection and Removal; (7) Air Measure Procedures; (8) Air Measurements Theory and Practice; and (9) Fan Tables-Fan Laws-High Efficiency Fans. |
| Range Management Research | Las Cruces, NM | White Sands National Monument Climate Change Scenario Planning Workshop. |
| Range Management Research | Las Cruces, NM | Workshop on Climate /Water in Socorro, New Mexico. |

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| Range Management Research | Las Cruces, NM | Ecological Site Descriptions (ESD) Workshop for classifying ecological areas for land management purposes, as well as for understanding the effects of climate change. |
| Range Management Research | Las Cruces, NM | Jornada Field Botany Workshops. The workshops bring members of the public together to learn about range ecosystems in and around the Chihuahuan Desert. |
| Range Management Research | Las Cruces, NM | Jornada Experimental Range Botany Workshop, Pitchfork Ranch. |
| Forage and Range Research | Logan, UT | Met with scientists and graduate students at Kings Park Botanic Garden, Perth, Australia (gave two seminars). |
| Forage and Range Research | Logan, UT | Gave the opening plenary and two volunteered talks (February 6-9, 2017) at the Restore, Regenerate, Revegetate meeting at Armidale, Australia. |
| Pollinating Insect-Biology, Management, Systematics Research | Logan, UT | Invited to present at Pollinators in Managed Forests Workshop in Corvallis Oregon- "Practical considerations for augmenting bloom for native bees in northwestern forests" and "Wildflower restoration for bee habitat in managed western forests." |
| Pollinating Insect-Biology, Management, Systematics Research | Logan, UT | Attended the U.S. Fish and Wildlife Service <i>Bombus affinis</i> conservation planning meeting |
| Pollinating Insect-Biology, Management, Systematics Research | Logan, UT | Held a week-long workshop entitled, "Partnership for Native Bee Surveys Between Native American Tribes and the Pollinating Insect Research Unit," to convey information needed to conduct native bee surveys and partner with ARS for basic identification, information and methods for survey. |
| Pollinating Insect-Biology, Management, Systematics Research | Logan, UT | Workshop facilitator at the EPA/Pollinator Partnership-sponsored meeting, "Exposure Assessment Paradigm for non- <i>Apis</i> bees." |

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| Pollinating Insect-Biology, Management, Systematics Research | Logan, UT | Invited to teach at the first Alabama Bee Workshop at Auburn University; sharing expertise on bees, including bee taxonomy, pollination, bee biodiversity, and conservation to diverse group of researchers, professors, students, and general public |
| Dairy Forage Research | Madison, WI | Participated in the Global Research Alliance (GRA)/Croplands Research Group meeting, in Phoenix, Arizona. Participants focused on aligning their work with the new GRA Strategic Plan for 2016–2020 and with GRA flagship projects. The GRA, with 46 member countries, is focused on research, development, and extension of technologies and practices that will help deliver ways to grow more food (and more climate-resilient food systems) without growing greenhouse gas emissions. |
| Environmentally Integrated Dairy Management Research | Madison, WI | Hosted a 3-day meeting of the Dairy Agroecosystem Work Group, a research collaboration among five ARS units. Also conducted a tour of research activities at the U.S. Dairy Forage Research Center's research farm. |
| Environmentally Integrated Dairy Management Research | Madison, WI | Invited to the Centers for Disease Control and Prevention in Atlanta, Georgia, to participate in a structured expert judgement to estimate the number of illnesses in the United States that are from foodborne and waterborne transmission. |
| Natural Resource Management Research | Mandan, ND | Hosted groups from the North Dakota Crop Improvement Association, Morton County Soil Conservation District, Area 4 Research Farm Supervisors, Annie's Project (NDSU), North Dakota State Fair Superintendents, and others in their meeting facilities. |
| Natural Resource Management Research | Mandan, ND | On February 28, ARS scientists provided leadership and collaborated with North Dakota State University, Bismarck State College, NRCS, and the Area 4 SCD Cooperative Research Farm to present "Farming and Ranching for the Bottom Line," a free 1-day conference for family farmers and ranchers in which nearly 200 attended. |

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| Plant Physiology and Genetics Research | Maricopa, AZ | In collaboration with the University of Arizona and with financial support from the U.K. Science and Innovation Network, ARS scientists conducted a 2-day workshop to examine key issues in field-based high throughput phenotyping. Approximately 35 researchers from the United States and the United Kingdom and private company personnel participated. |
| Soil Management Research | Morris, MN | Presented invited session entitled "Nutrient Cycling and the Haney Soil Test," at the Soil Health Workshop. The Workshop was sponsored by the Ridgewater College Ag Department, Willmar campus. In addition to the students, approximately 30 farmers, ag professionals, and consultants attended. |
| Soil Management Research | Morris, MN | Dr. Russ Gesch presented "Cashing in on oilseed cover crops" at the Soil Health Workshop on June 28 in Morris, Minnesota. The event was sponsored by the West Central Research and Outreach Center, University of Minnesota Extension, and North Dakota State University. |
| Soil Management Research | Morris, MN | Drs. Frank Forcella and Heather Dose co-presented "Clean water and sweet nectar: The benefits of cover crops" at the Soil Health Workshop on June 28 in Morris, MN. The event was sponsored by the West Central Research and Outreach Center, University of Minnesota Extension and North Dakota State University. |
| National Cold Water Marine Aquaculture Center | Orono, ME | The Maine Hatchery Roundtable is an annual professional development workshop organized by Dr. Mike Pietrak at the Center. This year, 35 hatchery workers attended the tour of a commercial and State hatchery to learn about operations at different facilities. Discussion covered a range of topics including feeding systems, vaccination, grading, water treatment, and tank design. |

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| Watershed Physical Processes Research | Oxford, MS | In collaboration with and hosted by Mississippi State University, the unit conducted a 1-day workshop to introduce students and staff of Mississippi State University and staff of various Mississippi and U.S. Government agencies to basic principles and assessment of channel adjustment processes for stream restoration. Approximately 25 students, researchers, and government personnel participated. |
| Grain Legume Genetics Physiology Research | Pullman, WA | ARS Prosser, hosted the Western Regional Potato Variety Development Team 1007 Curly Top Virus Biology, Transmission, Ecology, and Management regional project workshop that was attended by 16 current researchers and two retired researchers from the local community. Talks were presented 1 day with a short field tour of dryland and irrigated agriculture in the region on the following morning. |
| Wheat Health, Genetics, and Quality Research | Pullman, WA | Washington State University Oilseed Cropping Systems Workshops at Hartline, Ritzville, and Clarkston, Washington. The talks were on the diseases of Brassicas and canola diseases. |
| Wheat Health, Genetics, and Quality Research | Pullman, WA | Washington Grain Commission Review in Pullman, Washington. Talk was on "Research on Nematodes and Fusarium Crown Rot." |
| Wheat Health, Genetics, and Quality Research | Pullman, WA | Spokane Farm Forum, Ag Expo in Spokane, Washington. Talk was on "What's New in Research on Soilborne Plant Pathogens." |
| Wheat Health, Genetics, and Quality Research | Pullman, WA | Washington Department of Ecology in Spokane, Washington. Talk was on "Management of Fresh Wheat Residue for Irrigated Winter Canola." |
| Wheat Health, Genetics, and Quality Research | Pullman, WA | Washington State Report in Riverside, California. Talk was on "Multistate Group Managing Plant-Microbe Interactions in Soil to Promote Sustainable Agriculture." |

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| Contaminant Fate and Transport Research | Riverside, CA | Dr. Todd Skaggs met with a delegation from Can Tho University (Vietnam) on a U.S. State Department-sponsored trip, and participated in a planning workshop with faculty from Can Tho University and the University of California-Riverside. The purpose of the workshop was to identify research needs related to salinity in the Mekong Delta, and to plan for future technical and cultural exchanges. An overview of ARS research was presented and a tour of ARS facilities was provided. |
| Pest Management Research | Sidney, MT | Dr. Stefan Jaronski recently conducted a short course about developing insect pathogenic fungi as biopesticides at the University of Vermont. The audience was a group of two university faculty and four graduate students studying these fungi. Methods for mass production and formulation, as well as experimental methods used in Jaronski's research, were covered in the 5-day course. |
| Grassland, Soil and Water Research Laboratory | Temple, TX | Dr. Haney discussed a new approach to testing soil that determines the nutrients and minerals that will be available to crops for the next growing season at the 2017 Organic Matter Matters Workshop and Tradeshow in Minot, North Dakota, via videoconference. |
| Southwest Watershed Research | Tucson, AZ | Led an abstract writing and guide to PowerPoint presentation preparation workshop for the University of Arizona/NASA Space Grant Undergraduate Internship program. The abstract was attended by 24 students (10 female, 8 Hispanic, 1 African American, 1 Native American, and 3 Asian). |
| Pasture Systems & Watershed Management Research | University Park, PA | Held a forage workshop for high school 4-H students to teach about forage terminology, how to read a forage quality report, and how forage quality effects animal performance. The workshop was organized by Penn State Extension and the Pennsylvania 4-H council. |
| Soybean and Maize Germplasm, Pathology, and Genetics Research | Urbana, IL | Dr. Hartman gave a disease diagnostic workshop on soybean for researchers in Ghana. |

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| Floral and Nursery Plants Research | Washington, DC | The U.S. National Arboretum (USNA) hosted the International Society of Arboriculture's International Tree Climbing Championship and Arbor Fair, which attracted thousands of visitors, as well as arborists from 19 countries. This was one of the largest public events at the USNA in recent history and was hugely successful for the USNA, partners, stakeholders, and the public. |
| Floral and Nursery Plants Research | Washington, DC | Participated on a panel at the American Elm Restoration Workshop in Worthington, Ohio, by providing expertise on inoculation methods to screen for resistance to Dutch elm disease. Attendees included scientists, arborists, nursery professionals, and foresters. |
| Floral and Nursery Plants Research | Washington, DC | Taught a workshop on plant propagation at the U.S. National Arboretum to members of the Federated Garden Clubs of America. |
| Floral and Nursery Plants Research | Washington, DC | Participated in a workshop sponsored by the ARS Northeast Area to foster research collaborations and scientific training opportunities between historically black colleges and universities (HBCUs) and ARS. Representatives from ARS and NIFA met with scientists from several regional HBCUs to discuss funding opportunities and areas of potential research, and to learn from past successes. |
| Floral and Nursery Plants Research | Washington, DC | Staff from the ARS worksite in McMinnville, Tennessee, worked with Tennessee Tech University to present a pollinator workshop to 30 high school students. |
| Gardens Unit | Washington, DC | The U.S. National Arboretum jointly hosted a workshop with the D.C. Department of Energy and Environment targeting the auto repair industry. The workshop focused on educating auto repair personnel on steps to take to prevent pollution of waterways. |

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| Dairy and Functional Foods Research | Wyndmoor, PA | ARS scientist participated in the American Chemical Society sponsored program, Philadelphia Area Girls Enjoying Science, PAGES, held twice a year at Chestnut Hill College in Philadelphia, Pennsylvania. Program encourages 6th grade girls from the Philadelphia and suburb schools to increase their interest in science. The Saturday program has a guest keynote speaker and three workshops for the girls to attend. The ARS scientist conducted three hands-on workshops on "The chemistry behind dairy foods." |
| Food Safety and Intervention Technologies Research | Wyndmoor, PA | Presented keynote address at Delaware State University sponsored workshop entitled "Seafood Safety Workshop," for university staff and students. |

3.7.3. Trainings & Demonstrations

| Laboratory | Location | Description |
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| Healthy Processed Foods Research | Albany, CA | ARS scientists and students from the University of California, Davis, demonstrated the infrared drying of walnuts to the walnut growers and processors in Maxwell, California. |
| Agroecosystem Management Research | Ames, IA | ARS staff delivered a training workshop on the Agricultural Conservation Planning Framework, a software toolbox for watershed analysis and conservation planning that is operated in a GIS programming environment, on the campus of Purdue University in West Lafayette, Indiana. Trainees included university faculty, staff, and graduate students, and consulting engineers, State agency staff, and environmental organizations. |
| Animal Biosciences & Biotechnology Laboratory | Beltsville, MD | The ARS Administrator awarded a \$100,000 Faculty Fellowship Capacity Building Grant at 1890 Land Grant Universities to support Dr. M. Singh, faculty at Fort Valley State University in his sabbatical at ARS where he will establish genome editing of goats at Fort Valley State University. |
| Bee Research Laboratory | Beltsville, MD | Six ARS scientists gave presentations to the West Virginia panhandle “Bee University” hosted by Ed Forney of Geezer Ridge farms. Talks were given to military veterans, hobby beekeepers, and community college agriculture students on bee research, sustainable beekeeping, and disease control at James Rumsey Technical Institute, Hedgesville, West Virginia. Each of the talks was given to an audience of 150 beekeepers. |
| Genetic Improvement for Fruits and Vegetables Laboratory | Beltsville, MD | Participated as a teaching volunteer at the Mobile Science Lab presentations to the Beltsville Academy Elementary School in November 2016. Volunteers assist professional teachers who bring various aspects of biology, including agricultural science, to elementary school children. |
| Genetic Improvement for Fruits and Vegetables Laboratory | Beltsville, MD | Had research discussions with representative of TRUE FOOD TV/Manic media that led to production of a How Does it Grow? video on blueberries, www.youtube.com/watch?v=aB9U1wTsx2c TRUE FOOD TV is the web's most watched series dedicated to food and agriculture education |

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| Natural Germplasm Resources Laboratory | Beltsville, MD | The laboratory presented an exhibit on crop diversity at the Take Your Daughters and Sons to Work event in the National Agricultural Library on April 27, 2017. |
| Dale Bumpers Small Farms Research Center | Booneville, AR | Two scientists from CONABIO, a governmental agency in Mexico City, Mexico, participated in training in digital soil mapping. |
| Biological Control of Insects Research | Columbia, MO | Location staff demonstrated the detection of honey bee parasites and pathogens at the State beekeepers association 2017 annual workshop. |
| Soil Drainage Research | Columbus, OH | Provided field tour and overview of edge-of-field research to 25 county commissioners and staff at Ohio Farm Bureau Demonstration Farms event in Dunkirk, Ohio. |
| Horticultural Crops Research | Corvallis, OR | Provided consultation and training on root staining for mycorrhizal fungi to Oregon State University, Rangeland Department. |
| Horticultural Crops Research | Corvallis, OR | Transferred plans for building spore traps and protocols for detecting <i>Erysiphe necator</i> spores; trained James Woodland on building and spore traps at the University of Idaho. |
| Horticultural Crops Research | Corvallis, OR | Provided training on berry cultivars to food industry personnel in the use of berries in recipe and institutional product development at the Oregon State University's Food Innovation Center in Portland, Oregon. |
| Horticultural Crops Research | Corvallis, OR | Identifying database needs for National Clean Plant Network and evaluation systems in use at various centers at Purdue University in Indiana. |
| Horticultural Crops Research | Corvallis, OR | Provided consultation for identification of tree pathogen to USDA, Forest Service forest pathologist. |
| Horticultural Crops Research | Corvallis, OR | Provided consultation on identifying field locations to conduct fungicide research on <i>Phytophthora</i> root rot of raspberry to IR-4 Project member at Rutgers University. |
| Horticultural Crops Research | Corvallis, OR | Provided consultation on identifying soilborne root disease of raspberry in Mexico to Dole Berry Company grower. |
| Horticultural Crops Research | Corvallis, OR | Provided consultation on developing a screening assay to screen raspberry for resistance to <i>Phytophthora</i> root rot to a fruit research scientist from Plant and Food Research, New Zealand. |
| Horticultural Crops Research | Corvallis, OR | Provided consultation and diagnostic services for approximately 20 acres of rhododendron with <i>Phytophthora</i> root rot at ornamental nursery field site, wholesaler. |

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| National Clonal Germplasm Repository | Corvallis, OR | Provided training in tissue culture, genetic analysis, and germplasm management of a clonal genebank. |
| National Clonal Germplasm Repository | Corvallis, OR | Three students from local high schools are trained in horticultural practices on a weekly basis from September through December. |
| Peanut Research | Dawson, GA | Participated in a 1-day Workshop on "Use of Soil Sensors for Irrigation Scheduling" organized by Dr. Brenda Ortiz, Auburn University. Presented demonstration to 50 growers/potential users of the irrigation scheduling tool, IrrigatorPro, developed by ARS for cotton, corn, and peanuts. |
| Peanut Research | Dawson, GA | Crop consultants, Mr. and Mrs. Larry Worsely, visited Dr. Chris Butts for a tutorial on how to use the online version of Irrigator Pro. Irrigator Pro is the decision support software developed for scheduling irrigation in peanut, cotton, and corn. |
| Range Sheep Production Efficiency Research | Dubois, ID | A half-day training session in the field was conducted for the Idaho Master Naturalists (IDMN). Scientists presented procedures used each spring to survey sage grouse populations based on appearance of sage grouse at historic lekking sites. IDMN members and scientists discussed ARS research that is focused on sheep grazing in sage grouse habitat. |
| Sugarbeet and Bean Research | East Lansing, MI | Taught and led an invited participatory activity on disease diagnosis in sugar beet to 4-H students at the Michigan Sugar Beet Day. Approximately 80 children from 3rd grade through high school participated, along with 8 parents/chaperones. Also provided a tour of the ARS sugar beet research at the Saginaw Valley Research and Extension Center for the students and answered questions about career opportunities in ag research. Tom Goodwill assisted in the activities. |
| Subtropical Insects and Horticulture Research | Fort Pierce, FL | Met with 60 girl scouts during a campout, talked to them about being entomologists, and showed them ways to collect insects. Three sessions, 20 girls at a time. |
| Mosquito and Fly Research | Gainesville, FL | Conducted classes on insect surveillance |

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| Tropical Crop and Commodity Protection Research | Hilo, HI | AgVenture hands-on demo for up to 100 4th grade students, in conjunction with 10 other presenters/booths and organized by the county 4-H Extension Agent. ARS presented food technology/postharvest quality assessment instruments which measured papaya fruit firmness and color of unripe and ripe fruit and the sugar content of papaya juice compared to lemon juice. Students collected data on the formatted sheets provided. |
| Cotton Ginning Research | Las Cruces, NM | Set up ginning demonstrations for visitors at the New Mexico State Fair held in Albuquerque, New Mexico. |
| Range Management Research | Las Cruces, NM | Asombro Institute for Science Education staff presented science methods to New Mexico State University preservice teachers. |
| Range Management Research | Las Cruces, NM | Assessment, Inventory, and Monitoring (AIM) Workshop /training for land managers. |
| Range Management Research | Las Cruces, NM | Workshop for training land managers in Reno, Nevada, and Casper, Wyoming. |
| Range Management Research | Las Cruces, NM | Provided Assessment Inventory Monitoring (AIM) training in partnership with BLM to develop and implement AIM to include leading selection of the core indicators and methods for measuring them; developing guidance and tools for statistically valid monitoring programs; conducting AIM field crews; developing tools for the electronic capture and analysis of monitoring data; and supporting individual AIM projects. |
| Range Management Research | Las Cruces, NM | Trained U.S. Geological Survey personnel on “Wind Erosion Methods” at Moab, Utah. |
| Range Management Research | Las Cruces, NM | Asombro Institute for Science and education trained teachers/adults (Las Cruces Public School Professional Development Day) on science content (Data Jam, New Mexico Climate, Data Collection). |
| Range Management Research | Las Cruces, NM | Training science applications on resilience-based rangeland management: Applications to Mongolia. Mongolian participants with New Mexico State University. |

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| Range Management Research | Las Cruces, NM | ARS Jornada hosted NRCS Soil Geomorphology Institute to expand field skills and conceptual knowledge needed to generate and deliver scientifically accurate soil inventory products. The course provided a comprehensive treatment of key soil geomorphic principles and processes including: (1) soil geomorphology; (2) stratigraphy; (3) hydrology, and (4) pedology and use of current tools to apply these principles and processes. |
| Range Management Research | Las Cruces, NM | Collaborating and training Mongolian students on phenology and statistical measures. |
| Cool and Cold Water Aquaculture Research | Leetown, WV | Dr. Cleveland provided samples and technical support to student interns at Hagerstown Community College who are completing requirements to receive an associate's degree in biotechnology. |
| Forage-Animal Production Research | Lexington, KY | Presentation/workshop given to high school students as part of the Ag Discovery Program at Kentucky State University. Provided introduction to microscopy for high school students interested in veterinary and animal sciences. |
| Pest Management and Biocontrol Research | Maricopa, AZ | As part of an ongoing collaboration, an ARS scientist presented methodologies and training for amplifying and functionally characterizing lobster receptors using an insect cell expression system. The training lasted 2 weeks and included two faculty members from Bowdoin College and the University of Hawaii at Manoa. |
| Pest Management and Biocontrol Research | Maricopa, AZ | Natalie Boyle and Amber Tripodi, ARS Postdoctoral researchers from the Bee Laboratory in Logan, Utah, received training on the protein immunomarking (ELISA) procedure. They plan to use this procedure to track pollinators (e.g., blue orchid bees and bumble bees) in their natural habitat. Both researchers presented a 30-minute seminar to location scientists. |
| Water Management and Conservation Research | Maricopa, AZ | Unit scientists participated in a drone flight demonstration that collected multispectral images over sorghum and cotton fields at the University of Arizona-Maricopa Agricultural Center. The sorghum trials are part of the TERRAref project. These trials are to test accuracy, repeatability, and information content in the multispectral cameras for phenomics and precision agriculture. |

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| Water Management and Conservation Research | Maricopa, AZ | Dr. Eduardo Bautista traveled to Uruguay at the invitation of Dr. Claudio Garcia, Instituto Nacional de Investigacion Agropecuaria (INIA) to meet with Dr. Garcia and two of his graduate students, faculty from the Universidad de la Republica, and Dr. Roberto S. Martinez and two of his graduate students (Instituto Nacional de Tecnologia Agropecuaria, Argentina). These researchers are collaborating with Dr. Garcia on surface irrigation projects. |
| Tropical Crops and Germplasm Research | Mayaguez, PR | In collaboration with Penn State University personnel, the Mayaguez location hosted eight Cochran Fellows from Ecuador and Colombia during the week of January 22-27, 2017. During the visit, the Cochran Fellows learned numerous aspects of cacao (<i>Theobroma cacao</i>) cultivation and processing as well as an overview of GRIN-Global. |
| Tropical Crops and Germplasm Research | Mayaguez, PR | Scientists participated in activities targeting minority, historically under-served operators/stakeholders by providing information on alternative high-cash crops and best management practices to Hispanic producers in rural areas through farm visits, hosting growers at experimental sites and on-farm research at Martex Farms, La Balear Farm, Rainforest Fruits Farm in Santa Isabel, Adjuntas, and Jayuya, Puerto Rico, respectively. Also, new lines of papaya were provided to fruit growers in Florida. |
| Tropical Crops and Germplasm Research | Mayaguez, PR | Provided propagation material of superior varieties of rambutan, lychee, cacao, banana, plantain, mango, mangosteen, and papaya from ARS research; hands-on training on grafting and other propagation procedures; and technical expertise on crop nutrition to socially disadvantaged growers of tropical fruits in Puerto Rico, Florida, and Hawaii. |
| Soil Management Research | Morris, MN | Invited and presented hands-on demonstration of soil erosion at the Governor's Water Summit that consisted of dropping soil aggregates that have had different tillage treatments into a column of water and observing how they break up. Answered questions. |

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| Soil Management Research | Morris, MN | Gary Amundson demonstrated the soil cohesion model at the Aqua Chautauqua - Otter Tail Watershed Festival in Fergus Falls, Minnesota. The University of Minnesota Extension sponsored the event. More info is available at http://blog-water-resources.extension.umn.edu/2017/04/aqua-chautauqua.html . |
| Soil Management Research | Morris, MN | Gary Amundson built a soil aggregate stability demonstration model at the request of Barrett Farm Supply as a tool to educate farmers. |
| Soil Management Research | Morris, MN | Gary Amundson gave an aggregate stability demonstration as part of the cover crop tour in Grant County, Minnesota. The event was sponsored by the Grant County Soil and Water District. |
| Wheat Health, Genetics, and Quality Research | Pullman, WA | A training course on solvent retention capacity testing and procedures for flour was held for eight employees of Ardent Mills. |
| Great Basin Rangelands Research | Reno, NV | Mark Wertz and Jason Nesbit of ARS in Reno and Ken Spaeth, NRCS in Fort Worth, Texas, were invited to Almaty, Kazakhstan, to provide a 5-day workshop on assessing risks to rangeland health/sustainability. Training was provided in use and application of the Rangeland Hydrology and Erosion Model and the KINEROS2 watershed assessment to 40 faculty members of Kazakh National Agrarian University to assess soil erosion and its potential to degrade rangelands. Funding used for travel. |
| Dale Bumpers National Rice Research Center | Stuttgart, AR | Performed demonstration and training for two African-American undergraduate summer intern students from the University of Arkansas at Pine Bluff (an 1890 Land Grant Institution). Sessions were on weed research in rice that included measurement of rice root architecture using a computerized scanning system, and measurement of chlorophyll content and leaf photosynthesis of rice or weed species under natural conditions. |
| Southwest Watershed Research | Tucson, AZ | Training and information sessions, including a keynote presentation, were given for 12 attendees at the meeting of the International Soil Conservation Society in Lleida, Spain, in June 2017. Scientists from around the world were presented a half-day personalized training of the model concepts and use of the web-based interface. |

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| Southwest Watershed Research | Tucson, AZ | Presented an Automated Geospatial Watershed Assessment Tool training class during a 2-day training workshop in Tucson, Arizona, October 13-14, 2016, to a wide range of local, State, and Federal agencies, consultants, and university students. |
| Gardens Unit | Washington, DC | A series of workshop/demonstrations for the public called "Under the Arbor" was held in the National Herb Garden at the U.S. National Arboretum. The events focused on chili peppers, cilantro, and herbal bouquets. |
| National Soil Erosion Research | West Lafayette, IN | Ten-week internship for two students from Northeastern Illinois University. The students were accepted by Dr. Laura Sanders, a professor at Northeastern, who received a USDA grant in support of the internship. The laboratory has hosted students interested in environmental sciences, soil erosion, etc., for a number of years. Students get real-life laboratory experience where none is available at the university. Students design an experiment, implement and document results. |
| National Soil Erosion Research | West Lafayette, IN | Hosted students from the Northeastern Illinois University, a Hispanic serving institution. This year, Dr. Laura Sanders, Department of Earth Science, provided top students who spent their spring break in March 2017 at the laboratory. These students are presented opportunities to see laboratory functions that are not available at their university. |
| Dairy and Functional Foods Research | Wyndmoor, PA | Pieter Van den Abeele, Contract Research and Technology Director, Prodigest visited the location to look at the Simulator of Human Intestinal Microbial Ecosystem (SHIME) system and discuss collaboration on SHIME stabilization. |
| Molecular Characterization of Foodborne Pathogens Research | Wyndmoor, PA | A 2-hour presentation entitled "On-farm production and utilization of AM fungus inoculum" was given to farmer trainees and other visitors and staff at Glynwood Farm, Cold Spring New York. The presentation included an introduction to AM fungi, producing inoculum, using it in the greenhouse, demonstrations of its effectiveness with vegetable crops, and an example of how to conduct a field experiment. |
| Sustainable Biofuels and Co-Products Research | Wyndmoor, PA | Demonstrating to Dr. Efren Delgado of New Mexico State University the procedure for production of protein and fuel ethanol from grain sorghum. |

3.7.4. Stakeholder Presentations

| Laboratory | Location | Description |
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| Crop Improvement and Genetics Research | Albany, CA | Dr. James Thomson presented his biotechnology research approach to a group of citrus farmers at the Citrus Showcase, March 2, 2017, in Visalia, California. |
| Exotic and Invasive Weeds Research | Albany, CA | Presentation and transfer of technical information to managers of the Baskett Sough National Wildlife Refuge, Willamette Valley on options for controlling a new invasion of <i>Ludwigia hexapetala</i> in seasonal wetlands and canals, Federal refuge lands, and adjacent agricultural lands with Federal conservation easements. |
| Exotic and Invasive Weeds Research | Albany, CA | Dr. Pratt organized a stakeholder workshop in March 2017 where the various State weed coordinators and other participants from 10 States developed a western U.S. weed priority list and characterized the impacts (qualitatively) of each weed. An online survey was developed to facilitate broader consultation on the weed lists and impacts among the participants. |
| Healthy Processed Foods Research | Albany, CA | Dr. Tara McHugh and Dr. Roberto Avena-Bustillos were invited to present their nano science research at the J.M. Smucker Co., Terminal Island, California. |
| Agroecosystem Management Research | Ames, IA | Invited presentation at the 16th Annual Iowa Organic Farming Conference, Iowa City, Iowa entitled, "Organic no-till: Opportunities and Challenges." |
| Agroecosystem Management Research | Ames, IA | Invited presentation to an international audience, including researchers and industry representatives, addressing root factors that influence the amount of potassium fertilizer required by a crop in Rome, Italy. Outreach Activities also covered by this presentation included presentations to other scientists. |

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| Agroecosystem Management Research | Ames, IA | Presentation of "What's New in Cover Crop Research" to field agronomists in-service training at Field Extension Education Laboratory, Boone, Iowa; 30 people. |
| Agroecosystem Management Research | Ames, IA | Presented "What Cover Crops Can Do for Your Soil" to Iowa State University Southeast Research and Demonstration Farm Annual Meeting, Iowa State Extension in Iowa City, Iowa; 40 people. |
| Agroecosystem Management Research | Ames, IA | Presentation of Iowa Cover Crops Working Group research updates and recommendations for Iowa State Extension Crop Advantage meetings in Iowa City, Iowa, for approximately 60 attendees. |
| Agroecosystem Management Research | Ames, IA | Presentation on "Soil Biology: Effects on Soil Health" at two NRCS-sponsored Soil Health Workshops in Allison and Hampton, Iowa. Total attendance for both workshops: approximately 30 local farmers. |
| Soil, Water, and Air Resources Research | Ames, IA | Presentation in Conrad, Iowa, field evaluations of the "Yield Igniter" humic product at the annual meeting of Ag Logic Distributors, manufacturer of Yield Igniter. About 20 company staff and distributors of Ag Logic Distributors were present. |
| Soil, Water, and Air Resources Research | Ames, IA | Presented in Nashua, Iowa, on the current knowledge of mechanisms for humic product effects on crop growth at a meeting of farmer clients of Cedar Basin Crop Consulting. About 12 farmers and crop consultants were present. |
| Soil, Water, and Air Resources Research | Ames, IA | Presented in Houston, Texas, on field evaluations of the "GrowMate Soil" humic product at the annual meeting of GrowMate International, manufacturer of GrowMate Soil. Discussed plans for future research. About 15 company staff and distributors of GrowMate International were present. |
| Soil, Water, and Air Resources Research | Ames, IA | Presented the current knowledge of mechanisms for humic product effects on crop growth at the annual meeting of the Iowa Independent Crop Consultants Association in Ames, Iowa,. About 20 crop consultants were present. |
| Soil, Water, and Air Resources Research | Ames, IA | Presented field evaluations of humic products in Belle Plaine, Iowa, to clients of Stamp Ag, a distributor of Ag Logic Distributors. Nine clients and company staff were present. |

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| Poultry Microbiological Safety and Processing Research | Athens, GA | Dr. Buhr provided two lectures and three lab demonstrations for the University of Georgia Poultry Processing class/lab at the university and in the location's pilot plant. Dr. Buhr provided a lecture and processing lab demonstration at the university for the Poultry School in Spanish. |
| Soil Dynamics Research | Auburn, AL | Four location scientists were invited to present at the Southern Agricultural Soil Health, Cover Crops, and Water Management Conference in Jonesboro, Arkansas. Dr. Kip Balkcom presented on establishing and managing cover crops. Dr. Leah Duzy presented on the economic benefits of conservation practices. Dr. Ted Kornecki presented on the use of roller/crimpers in conservation systems. Dr. Andrew Price presented on weed management benefits associated with cover crops. |
| Soil Dynamics Research | Auburn, AL | Three location employees were invited to present at the Conservation Production Systems Conference in Douglas, Georgia. Dr. Kip Balkcom presented on managing cover crops, equipment, and planting. Dr. Leah Duzy presented on the economics of conservation tillage systems. Dr. Andrew Price presented on managing weeds in conservation tillage systems. |
| Soil Dynamics Research | Auburn, AL | Dr. Kip Balkcom was one of 25 people invited from across the United States to attend a tour of forage and cover crop seed production in the Willamette Valley of Oregon, sponsored by the Oregon Forage Seed Commission. The tour focused on grower fields that produce 90 percent of U.S. cool season forage and turf seeds. Dr. Balkcom was also one of two participants chosen to make a presentation entitled, "Cover Crop Opportunities and the Southeast," during the tour. |
| Soil Dynamics Research | Auburn, AL | ARS employees hosted employees from AGCO Corporation (Duluth, Georgia). Dr. Kip Balkcom presented on managing cover crops, equipment, and planting. Dr. Leah Duzy presented the economics of conservation tillage systems. Dr. Andrew Price presented on managing weeds in conservation tillage systems. Dr. Ted Kornecki presented on using rolling/crimping technology in conservation systems. |

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| Soil Dynamics Research | Auburn, AL | Dr. Kip Balkcom was invited to present at the Southern Agricultural Soil Health, Cover Crops and Water Management Conference in Jonesboro, Arkansas, on "Considerations for Establishing and Managing Cover Crops." Participants included growers, industry representatives, and professionals from universities and other government agencies. |
| Soil Dynamics Research | Auburn, AL | Dr. Kip Balkcom was invited to present at the 17th Annual Conservation Production Systems Conference in Douglas, Georgia, on "Getting Started with Conservation Systems." Participants included growers, industry representatives, and professionals from universities and other government agencies. |
| Soil Dynamics Research | Auburn, AL | Participated in the 2017 Waste to Worth Conference in Cary, North Carolina, which is targeted to agriculture advisors and extension agents working with animal waste management. Dr. Allen Torbert made a presentation entitled, "USDA-NRCS Conservation Practice Standard: Amending Soil Properties with Gypsum Products," and Dr. Dexter Watts made a presentation entitled, "Gypsum as a Best Management Practice for Reducing P Loss from Agricultural Fields?" |
| Crop Production and Protection | Beltsville, MD | Dr. Jose Costa gave a presentation overview of corn research conducted by ARS at the national level at the National Corn Growers Association research meeting in Alexandria, Virginia. The 2018–2022 action plan for National Program on Plant Genetic Resources, Genomics and Genetic Improvement was also discussed. |
| Food Components and Health Laboratory | Beltsville, MD | 2017 John Milner Nutrition and Cancer Prevention Research Practicum |
| Genetic Improvement for Fruits and Vegetables Laboratory | Beltsville, MD | Presentation at the New Jersey Agricultural Convention that discussed resources available to growers for disease diagnostics. About 75 growers in attendance. |
| Genetic Improvement for Fruits and Vegetables Laboratory | Beltsville, MD | Blueberry open house presentation. Discussed stem blight and phomopsis infection in blueberry. About 120 growers in attendance. |

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| Genetic Improvement for Fruits and Vegetables Laboratory | Beltsville, MD | Presentation and cover crop demonstration to blueberry growers in Hammonton, New Jersey. |
| Genetic Improvement for Fruits and Vegetables Laboratory | Beltsville, MD | Presentation to owners of small farms at the Bob Rouse Agriculturalist, LLC, grower client meeting in Felton, Delaware, November 30, 2016. Novel frost protection approaches for strawberry were discussed. |
| Genetic Improvement for Fruits and Vegetables Laboratory | Beltsville, MD | Presentation at Blueberry Session of Annual New Jersey Agricultural Convention and Trade Show entitled "Pruning: Concepts, Principles, and Practices," Atlantic City, New Jersey; February 8, 2017. Presentation was made to a group of approximately 120 grower/attendees. |
| Hydrology and Remote Sensing Laboratory | Beltsville, MD | Two presentations to the 43rd Annual Hermiston Farm Fair Seminars and Tradeshow on the use of small unmanned aircraft for farming. |
| Office of Associate Administrator | Beltsville, MD | Spoke on partnering and collaboration with ARS to the National Council of University Research Administrators. |
| Integrated Cropping Systems Research | Brookings, SD | Presentation for Farm Managers and Rural Appraiser of America (South Dakota Chapter). |
| Integrated Cropping Systems Research | Brookings, SD | Tour of the rearing section of the lab for Oxitec lab, United Kingdom. |
| Range and Meadow Forage Management Research | Burns, OR | Presentation to the Sage-Grouse Initiative at the IL Ranch in Nevada. |
| U.S. Meat Animal Research Center | Clay Center, NE | Hosted a group of seven extension researcher/educators and research station directors from Argentina. In addition to presentations regarding the germplasm evaluation project and grazing, attendees were provided with an overview of the research conducted at the U.S. Meat Animal Research Center (USMARC) and a driving tour of the property/facilities. |

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| U.S. Meat Animal Research Center | Clay Center, NE | Hosted 49 cattle producers from eastern Tennessee. During their visit, individuals were provided with an overview of the research conducted at USMARC and activities at the Great Plains Veterinary Educational Center, as well as presentations about cattle reproduction, animal health, and genetics research at USMARC. Following the presentations, participants were given a driving tour of the property/facilities. |
| U.S. Meat Animal Research Center | Clay Center, NE | Hosted seven Chi-Angus cattle producers from Missouri who are interested in the Germplasm Evaluation Project at the USMARC. During the visit, attendees visited with scientists involved in genetics, breeding, and animal health research and were taken on a driving tour of the property/facilities. |
| U.S. Meat Animal Research Center | Clay Center, NE | Hosted 16 individuals associated with the Lower Loup Cattlemen organization from Hall, Howard, and Buffalo counties in Nebraska. During the visit, visitors were provided with an overview of the research conducted; presentations about genetics, nutrition, and meat safety research; and a driving tour of the property/facilities. |
| Soil Drainage Research | Columbus, OH | Gave a presentation in Columbus, Ohio, at the spring meeting of the Ohio Chapter of the American Institute of Professional Geologists. The title of the presentation was: "USDA/ARS Soil Drainage Research and Recent Developments in Agricultural Geophysics." Approximately 25 people attended the meeting. |
| Soil Drainage Research | Columbus, OH | Gave a presentation at the Agricultural Drainage Management Systems Task Force Meeting in Champaign, Illinois, "Planned Research for Subsurface Drainage Mapping Using Airplanes, Drones, and Satellite Imagery." The conference had around 60 to 70 people in attendance. |
| Soil Drainage Research | Columbus, OH | Gave presentation entitled "Edge of Field Research to Assess Agricultural Management Practices," at the NOAA National Weather Service in Fort Wayne, Indiana. Presentation to eight National Weather Service forecasters about ARS, and specifically edge of field research in the context of Lake Erie. |

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| Soil Drainage Research | Columbus, OH | Presented seminar on “Benefits of Drainage Water Management” to the Conservation Tillage and Technology Conference, Ada, Ohio. Audience was about 80 farmers, extension agents, and certified crop advisors. |
| Soil Drainage Research | Columbus, OH | Provided a presentation, "Using Edge of Field Research to Assess Agricultural Management Practices," to approximately 50 industry producers and non-governmental organizations (NGOs) at the Ohio Grain Farmers Symposium (Columbus, Ohio). |
| Soil Drainage Research | Columbus, OH | Made in-field presentation, "What are we learning from edge-of-field studies," and provided field tour of edge-of-field research site near Cygnet, Ohio to 90 producers, municipality employees, mayors, extension personnel, researchers, and congressional representatives. |
| Soil Drainage Research | Columbus, OH | Made an invited presentation, "Agricultural best management practices," at the Agriculture: Economy and Ecology Conference in Perrysburg, Ohio (80 local government representatives, producers, policy makers, extension agents, and industry representatives). |
| Soil Drainage Research | Columbus, OH | Provided a presentation update on edge-of-field research and effects of agricultural management practices at the Conservation Tillage and Technology Conference to approximately 100 producers and extension specialists in Ada, Ohio. |
| Soil Drainage Research | Columbus, OH | Provided presentation on using edge-of-field research to assess agricultural management practices for Reducing P Losses from Cropland: State of the Science conference to 90 producers, stakeholders, and extension agents in Tiffin, Ohio. |
| Soil Drainage Research | Columbus, OH | Provided presentation update on edge-of-field phosphate research to address Lake Erie algal blooms to 100+ farmers and producers at Field to Lake conference in Archbold, Ohio. |
| Soil Drainage Research | Columbus, OH | Provided presentation, "Using edge-of-field research to assess conservation management," at edge-of-field stakeholder focus group to 20 commodity, agribusiness, and NGO leads in London, Ohio. |
| Soil Drainage Research | Columbus, OH | Provided presentation "Using edge-of-field research to assess agricultural management practices" at Lake Erie Annex 4 meeting to 30 U.S. and Canadian Lake Erie stakeholders (webinar). |

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| Soil Drainage Research | Columbus, OH | Provided presentation update on edge-of-field research in Ohio to 80 fertilizer retailers at the 4R nutrient stewardship information field day in London, Ohio. |
| Forage Seed and Cereal Research | Corvallis, OR | Ryan Hayes gave a presentation in February 2017 at the Union County Grass Seed Growers annual meeting. Attendance was approximately 50 people from seed companies, seed producers, and Oregon State University. The presentation focused on rust and viral diseases of grasses and a general overview of unit research. |
| Forage Seed and Cereal Research | Corvallis, OR | Presentation given, "Best management practices for priority diseases and pests," at the Vermont Annual Hop Growers Conference, February 2017, Burlington, Vermont. (Invited) |
| Forage Seed and Cereal Research | Corvallis, OR | Presented "Winter and spring die out of hops: possible causes and considerations" at the D and M Chem Grower Meeting February 3, 2017, in Yakima, Washington. (Invited) |
| Forage Seed and Cereal Research | Corvallis, OR | Gave presentation, "Mildew update and outlook for 2017," at Wilbur Ellis grower meeting. February 2, 2017, in Woodburn, Oregon. (Invited) |
| Forage Seed and Cereal Research | Corvallis, OR | Gave presentation on "Overwintering biology of the hop powdery mildew fungus: from focal infections to landscape-level spread" at the Winter Meeting of the Hop Research Council, January 18, 2017, in Bend, Oregon. |
| Forage Seed and Cereal Research | Corvallis, OR | Gave presentation on "The multifaceted impact of nitrogen fertilization" at the winter meeting of the Hop Research Council, January 18, 2017, in Bend, Oregon. |
| Forage Seed and Cereal Research | Corvallis, OR | Gave presentation, "Cascade and powdery mildew: why, where, and what's next," at the winter meeting of the Hop Research Council, January 18, 2017, in Bend, Oregon. |
| Forage Seed and Cereal Research | Corvallis, OR | Gave presentation, "The 2016 powdery mildew experience," at the GS Long Grower Meeting, January 11, 2017, in Yakima, Washington. (Invited) |
| Forage Seed and Cereal Research | Corvallis, OR | Gave presentation, "Nitrogen fertility: influences on pests, mildew, and cone quality factors of concern to brewers," at the GS Long Grower Meeting on January 11, 2017, in Yakima, Washington. (Invited) |

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| Forage Seed and Cereal Research | Corvallis, OR | Gave presentation "From Flag Shoots to Landscape-Level Development of Powdery Mildew," for the Washington Hop Industry annual meeting, January 6, 2017, in Yakima, Washington. (Invited) |
| Forage Seed and Cereal Research | Corvallis, OR | Gave presentation "What We Know (and Don't) About Powdery Mildew on Cascade" for the Washington Hop Industry Annual Meeting, January 6, 2017, in Yakima, Washington. (Invited) |
| Forage Seed and Cereal Research | Corvallis, OR | Gave presentation "Nitrogen Fertility: Influences on Pests, Mildew, and Cone Quality Factors of Concern to Brewers" at the Washington Hop Industry Annual Meeting, January 6, 2017, in Yakima, Washington. (Invited) |
| Horticultural Crops Research | Corvallis, OR | Provided consultation on diagnosis and treatment of Verticillium wilt in 30 acres of blueberry to Agricare farm management company. |
| Horticultural Crops Research | Corvallis, OR | Provided consultation on diagnosis and lack of treatment options for new canker disease of incense-cedar to Paradise Cryptobiota Biodiversity Survey LLC (forest management company). |
| Horticultural Crops Research | Corvallis, OR | Presented survey results on which pathogens are causing disease in red raspberry fields at the Soilborne Diseases in Red Raspberry Field Day - for Washington, Oregon, and Canada raspberry growers |
| Horticultural Crops Research | Corvallis, OR | Provided consultation on screening raspberry for resistance to soilborne pathogens to the Pacific Berry Breeding Company and Driscoll Nursery. |
| Horticultural Crops Research | Corvallis, OR | Presentation on monitoring for fungicide resistance to the Washington Wine Grape Society, the Southern Oregon Grape Growers Association, and at a Napa Valley Grape Growers meeting. |
| Horticultural Crops Research | Corvallis, OR | Presentation on use of sulfur for managing grape powdery mildew, dispersion modeling of plant pathogens, and development of genetic tools to monitor for fungicide resistance at the Sustainable Ag Expo, at the annual Northwest Center of Small Fruit Research meeting, and to the American Vineyard Foundation. |
| Horticultural Crops Research | Corvallis, OR | Presentation on managing grape powdery mildew at the annual Vineyard Team meeting. |
| Horticultural Crops Research | Corvallis, OR | Monthly open discussion with grape growers about research and production issues at the Willamette Valley Tech group. |

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| Horticultural Crops Research | Corvallis, OR | Presentation on phenological timing of fungicide applications at the Oregon State University Grape Day meeting. |
| Horticultural Crops Research | Corvallis, OR | Presented lace bug control to pest control advisors, industry representatives |
| Horticultural Crops Research | Corvallis, OR | Grapevine red blotch research meetings organized by California Department of Food and Agriculture, San Diego, California. |
| Horticultural Crops Research | Corvallis, OR | Sponsored speaker invitation to present ARS research results at annual BC Wine Grape Council Conference and Tradeshow. |
| Horticultural Crops Research | Corvallis, OR | Presented introduction of RNAi technology and application to crop protection. |
| Horticultural Crops Research | Corvallis, OR | Consultation with Farm Management Company about mycorrhizal fungi in blueberry systems. |
| Horticultural Crops Research | Corvallis, OR | Met to discuss challenges to tea production in the United States with growers from Oregon and North Carolina with the Minto Island Tea Company. |
| Horticultural Crops Research | Corvallis, OR | Camelia Forest Nursery and Tea Farm visited ARS lab to discuss tea research. |
| Horticultural Crops Research | Corvallis, OR | AOHATA Corp. of Hiroshima, Japan, visited ARS lab to discuss ericoid mycorrhizal fungi. |
| Horticultural Crops Research | Corvallis, OR | Seminar on plant-parasitic nematodes on wine grapes to Oregon Wine Research Institute. |
| National Clonal Germplasm Repository | Corvallis, OR | Met with Ferrero Italian Hazelnut Company representatives, Oregon Hazelnut growers, and Oregon State University researchers regarding hazelnut germplasm research. |
| National Clonal Germplasm Repository | Corvallis, OR | Gave tour of the genebank, tissue culture lab, molecular lab, and collections to Lassen Canyon Nursery staff; Markus Kobelt of the berry industry; Wrigley and Mint commission representatives; and Philipp Schulze, breeder at Royal Berries in Spain. |
| National Clonal Germplasm Repository | Corvallis, OR | Scientific visit from industry representative Mark Hessel from Gardens Alive! and toured blueberry and hardy kiwifruit collections at the Repository. |

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| National Clonal Germplasm Repository | Corvallis, OR | Yutaka Kikoku from AOHATA (Fruit Jam Maker) visited the Repository to discuss strawberry distribution for research and the symbiotic microorganisms of blueberry root. |
| National Clonal Germplasm Repository | Corvallis, OR | Small fruit industry representative from Peru toured the Repository collection of raspberries, strawberries, and blueberries. |
| National Clonal Germplasm Repository | Corvallis, OR | Presentation and demonstration of grafting and scionwood exchange with Oregon Home Orchard Society. |
| National Clonal Germplasm Repository | Corvallis, OR | Keynote speaker at Western Washington Fruit Tree Society, Mount Vernon, Washington. |
| National Clonal Germplasm Repository | Corvallis, OR | Presentation and demonstration of grafting and scionwood exchange with Oregon Home Orchard Society. |
| National Clonal Germplasm Repository | Corvallis, OR | Presentation on <i>Rubus</i> research results to the Oregon Raspberry and Blackberry Commission. |
| Crops Pathology and Genetics Research | Davis, CA | Presentation to California Walnut Research Conference on the development of disease-resistant walnut rootstocks and integration of conventional and genomic approaches. Conference attendees include research scientists, California farm advisors, walnut industry representatives, and producers. |
| Crops Pathology and Genetics Research | Davis, CA | A presentation on "Reuse of Winery Wastewater" and associated impacts on soil was given to stakeholders, extension agents, and researchers (200+) at the 19th Annual Enology and Viticulture Conference sponsored by the British Columbia Wine and Grape Council. |
| Crops Pathology and Genetics Research | Davis, CA | An outreach presentation called, "Winery Wastewater Reuse in California," was given to stakeholders/industry representatives at a meeting called "On the Road," sponsored by the Department of Viticulture and Enology at the University of California at Davis. Attendees included industry stakeholders and cooperative extension agents (60+). |

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| Crops Pathology and Genetics Research | Davis, CA | An outreach presentation called, "Impact of Winery Wastewater Irrigation on soil, grape nutrition, grape and wine quality," was given to industry representatives and stakeholders at the "On the Road" outreach meeting sponsored by the Department of Viticulture and Enology at the University of California at Davis. Attendees included industry stakeholders and cooperative extension agents (40). |
| Crops Pathology and Genetics Research | Davis, CA | A public dataset on vineyard soil microbiomes was provided to BiomeMakers, a private company developing tools to determine how microorganisms affect wine-grape production. This was the first dataset of its kind that could be used as a validation set for their internal work. This dataset was submitted to EBI under accession number ERP020648 on December 20, 2016. |
| Peanut Research | Dawson, GA | Dr. Marshall Lamb presented the latest information on the sustainability for peanut production during the Hot Topics seminar at the opening session of the 2017 Georgia Peanut Tour. He spoke to approximately 125 persons representing all segments of the peanut industry and several nations including the United States, Malawi, and Canada. |
| Peanut Research | Dawson, GA | Meet with John Powell with American Peanut Shellers Association and Mark Milliron with Golden Peanut to discuss current peanut grading equipment and the research being done on the new grading equipment. |
| Range Sheep Production Efficiency Research | Dubois, ID | A presentation on the "Role of small ruminant enterprises in feeding the world in the future" was delivered to the members of the National Institute for Animal Agriculture. Approximately 40 scientists, veterinarians, producers, and sheep industry representatives from Montana, Wyoming, and Idaho attended the talk. The overall goal of the presentation was to demonstrate the predicted demand of small ruminant products domestically and internationally. |
| Range Sheep Production Efficiency Research | Dubois, ID | A presentation on "Best vaccination strategies and solutions" was delivered to the members of the West Central States Wool Growers Association. Approximately 200 producers and sheep industry representatives from Wyoming, Colorado, Idaho, Utah, Montana, Texas, and New Mexico attended the talk. The goal of the presentation was to deliver vaccination solutions that increase the survivability of lambs from birth through weaning. |

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| Foreign Disease-Weed Science Research | Fort Detrick, MD | Drs. Douglas Luster and Timothy Widmer attended the Annual Stakeholder Meeting at the National Ornamentals Research Site at the Dominican University of California (NORS-DUC) in San Rafael, California. Stakeholder and research community representatives were in attendance. Discussions included priorities and timeframes for the FY 2017 Farm Bill Program and ideas to expand the scope of research at NORS-DUC. |
| Mosquito and Fly Research | Gainesville, FL | Invited by Dan Suiter, Center for Urban Agriculture Webinar Team, University of Georgia, College of Agricultural and Environmental Sciences, Griffin, Georgia, to present the webinar, "Biology and Management of House Flies." |
| Mosquito and Fly Research | Gainesville, FL | Invited by CMDR Fred Stell to present "Update on the Air Curtain System for Mechanical Disinfection of Aircraft" at the Armed Forces Pest Management Board Meeting. |
| Tropical Plant Genetic Resources and Disease Research | Hilo, HI | Jon Suzuki gave the presentation "The Road to Anthurium Cultivar Improvement through Basic Molecular-Genetic Research," to the Hawaii Floriculture and Nursery Association Special Occasion 16 Import Replacement Educational Grower's Seminar; and gave a tour of the PBARC anthurium collection. Tracie Matsumoto gave a presentation, "Acquisition of Anthurium Germplasm for Preservation and Development of New Cultivars." |
| Tropical Plant Genetic Resources and Disease Research | Hilo, HI | Roxana Myers gave a presentation to local growers on "Nematology Research Update from USDA DKI-PBARC" at the 8th Annual CPS Nursery Seminar Program at the Hilo Hawaiian Hotel. |
| Tropical Plant Genetic Resources and Disease Research | Hilo, HI | Dr. Tracie Matsumoto gave the presentation "Coffee Tree Management to Control CBB" and Lisa Keith discussed Botanigard in the CBB program at the Ka'u coffee growers seminar. |
| Tropical Plant Genetic Resources and Disease Research | Hilo, HI | ARS staff visited coffee and papaya collaborators on Oahu to discuss coffee and papaya production issues. |

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| Sugarcane Research | Houma, LA | The data collected from boron, molybdenum, and cobalt fertilizer research in plant-cane, first- and second-ratoon fields of HoCP 96-540, L01-299 and HoCP 04-838 was presented at the U.S. Ag Associates meeting in Houston, Texas. Information presented will benefit sugar producers, extension agents, private consultants, and domestic and international scientists. |
| Sugarcane Research | Houma, LA | At the St. Martinville Parish grower meeting, presented aspects of soil fertility research. |
| Sugarcane Research | Houma, LA | At the New Iberia/St. Mary Parish grower meeting, presented aspects of soil fertility research. |
| Sugarcane Research | Houma, LA | At the Assumption Parish grower meeting, presented aspects of soil fertility research. |
| Sugarcane Research | Houma, LA | At the Pointe Coupee Parish grower meeting, presented aspects of soil fertility research. |
| Sugarcane Research | Houma, LA | At the Avoyelles Parish grower meeting, presented aspects of soil fertility research. |
| Sugarcane Research | Houma, LA | At the Bayouland's Young Farmer meeting, presented aspects of soil fertility research. |
| Sugarcane Research | Houma, LA | At the Lower Mississippi Delta Resource Unit meeting in the USDA Service Center in Addis, Louisiana, presented cover crop research at the Sugarcane Research Unit. |
| Delta Water Management Research | Jonesboro, AR | Presented the group's work on the AR CGWR on-farm irrigation reservoir inventory to NRCS engineers in Lonoke, Arkansas. |
| Innovative Fruit Production, Improvement and Protection | Kearneysville, WV | Talk entitled "Fire Blight of Apple and Its Management" presented to growers in Hardin, and Mt. Vernon, Illinois, in conjunction with University of Illinois cooperative extension meetings. |
| Innovative Fruit Production, Improvement and Protection | Kearneysville, WV | Presentation at Washington Tree Fruit Research Commission Apple Pest Control Review entitled, "Fire Blight Resistance and Fruit Quality in New Washington Cultivars" held in Yakima, Washington. |
| Innovative Fruit Production, Improvement and Protection | Kearneysville, WV | Tracy Leskey presented an overview of research programs at the Appalachian Fruit Research Station to about 250 stakeholders at the Mid-Atlantic Fruit and Vegetable Conference. |

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| Innovative Fruit Production, Improvement and Protection | Kearneysville, WV | Dr. Tracy Leskey made several presentations to tree fruit and small fruit growers at an Integrated Pest Management School organized by Michigan State University and held in Traverse City, Michigan. The presentations included monitoring and management tools for brown marmorated stink bug and spotted wing drosophila. There were about 100 stakeholders in attendance. |
| Innovative Fruit Production, Improvement and Protection | Kearneysville, WV | West Virginia University Workshop on small fruit production at WVU Fruit Experiment Station in Kearneysville, West Virginia. Approximately 20 local citizens and university personnel were present. In attendance were berry growers and Master Gardeners from the Eastern Panhandle. Information on blueberry production, diseases and pests of berry crops, blueberry harvest mechanization, and blackberry production on the rotating cross-arm trellis were presented. |
| Innovative Fruit Production, Improvement and Protection | Kearneysville, WV | Presented talk about spring frost damage and the relationship between temperature and bud injury and the use of rotating cross-arm trellis and cane training system to mitigate heat stress at the Southeast Bramble Conference in Savannah, Georgia, that was sponsored by the North American Raspberry and Blackberry Association and the Georgia Blackberry Growers Association. In the audience were university extension personnel, berry growers, and industry vendors with 150 people in the blackberry session. |
| Innovative Fruit Production, Improvement and Protection | Kearneysville, WV | Presented a talk on technologies to improve mechanical harvesting system to obtain higher quality fruit at the blueberry conference organized by the Oregon Blueberry Commission and held in Salem, Oregon. There were about 300 people in attendance made up of growers, vendors, university extension personnel, and industry representatives. |
| Innovative Fruit Production, Improvement and Protection | Kearneysville, WV | Brent Short presented current information on pesticide use in tree fruit for management of the brown marmorated stink bug at a Syngenta University researcher meeting in Philadelphia, Pennsylvania. He participated in group discussions on product development, resistance, and evaluation of materials. |
| Range Management Research | Las Cruces, NM | Malpai Borderland Group presentation/meeting to address the research objectives of ecological site diversity and productivity. |

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| Forage-Animal Production Research | Lexington, KY | Gave a talk entitled, "Why is Intake Reduced When Cattle are Fed Tall Fescue?" at the 36th Annual Kentucky Alfalfa and Stored Forage Conference. |
| Agroecosystem Management Research | Lincoln, NE | Presented residue management effects on soil properties and crop production to livestock producers, extension educators, and agribusiness representatives attending the Beef Production Systems Workshop in Lincoln, Nebraska. |
| Agroecosystem Management Research | Lincoln, NE | Presented soil quality effects on crop production to producers, extension personnel, and agribusiness representatives at the Soil Health Conference in Ames, Iowa. |
| Wheat, Sorghum and Forage Research | Lincoln, NE | Presentation to Nebraska Wheat Board describing ARS Lincoln research in wheat genetics, germplasm development, virus resistance, genetic engineering, and forage utilization. |
| Wheat, Sorghum and Forage Research | Lincoln, NE | Dr. Deanna Funnell-Harris was invited to present research she conducted on sorghum to the Nebraska Grain Sorghum board. The audience included producers, industry and university researchers, and Nebraska State officials. The presentation included recent results as well as future research plans. |
| Wheat, Sorghum and Forage Research | Lincoln, NE | By invitation from the Nebraska Crop Improvement Association, an ARS scientist gave a presentation to a seed commodity group on the portfolio of perennial grass cultivars released by the ARS Unit through the University of Nebraska, Lincoln. The presentation covered yield characteristics and adaptation zones for released cultivars within five grass species (switchgrass, big bluestem, indiangrass, bromegrass, and wheatgrass). The cultivars were released for use as forage, bioenergy, or restoration. |
| Poisonous Plant Research | Logan, UT | Presented research on revegetation on broom snakeweed-infested rangelands at the 70th Annual Society of Range Management meeting in St. George, Utah. Approximately 1,200 people in attendance. |
| Poisonous Plant Research | Logan, UT | Presented and discussed how to reduce selenium poisoning of wildlife and livestock on reclaimed phosphate mines. |

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| Poisonous Plant Research | Logan, UT | Presented research on tall larkspur grazing studies. |
| Poisonous Plant Research | Logan, UT | Presented Poisonous Plant Research Lab's research on toxic range plants. |
| Poisonous Plant Research | Logan, UT | Presented current research in regard to swainsonine-containing plants at the 70th Annual Society of Range Management meeting in St. George, Utah. Approximately 10 people were in attendance. |
| Poisonous Plant Research | Logan, UT | Presented current research in regard to the effects of climate change on toxic plants at the 70th Annual Society of Range Management meeting in St. George, Utah. Approximately 20 people were in attendance. |
| Pollinating Insect-Biology, Management, Systematics Research | Logan, UT | Presented a seminar on "Landscaping for native bees: easy to do, beautiful to behold," at the Utah Green Conference, Sandy Utah. |
| Pollinating Insect-Biology, Management, Systematics Research | Logan, UT | Presented "Bumble bees and climate-induced habitat fragmentation in alpine systems," at the Pacific Branch Entomological Society Meeting in Portland, Oregon. |
| Pollinating Insect-Biology, Management, Systematics Research | Logan, UT | Presented ARS research on pollination in alfalfa and health of bees to the Wyoming and Montana Alfalfa Seed Growers Association meetings. |
| Pollinating Insect-Biology, Management, Systematics Research | Logan, UT | Presented poster on "Sustainable management and propagation of the blue orchard bee in commercial cherry orchards" and talk at the Orchard Bee Association Meeting. |
| Pollinating Insect-Biology, Management, Systematics Research | Logan, UT | Presented "Sustainable management and propagation of the blue orchard bee in commercial cherry orchards" at the Washington State Horticulture meeting. |

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| Cell Wall Biology and Utilization Research | Madison, WI | Presented "What manure evaluation can tell us about cows and rations," to 65 dairy producers and industry representatives at the Dairy Forage Seminar Stage of World Dairy Expo, a dairy industry trade show. |
| Cell Wall Biology and Utilization Research | Madison, WI | Presented "Sugars in rations for dairy cows" to 200 dairy industry and university professionals and graduate students at the Tri-State Dairy Nutrition Conference in Fort Wayne, Indiana. |
| Cell Wall Biology and Utilization Research | Madison, WI | Presented "Carbohydrates: Measuring them and managing them in dairy rations" to 200 dairy industry representatives, university professionals, and graduate students at the California Animal Nutrition Conference in Fresno, California. |
| Cell Wall Biology and Utilization Research | Madison, WI | Michael Sullivan presented "Making Caffeic Acid Derivatives in Alfalfa: Challenges to Molecular Approaches for Improving Forage Crops" at the Gordon Research Conference for Plant Metabolic Engineering in Waterville Valley, New Hampshire. |
| Cell Wall Biology and Utilization Research | Madison, WI | Paul Weimer received notice his article, "Transient changes in milk production efficiency and bacterial community composition resulting from near-total exchange of ruminal contents between high- and low-efficiency Holstein cows," was selected as an Editor's Choice by the <i>Journal of Dairy Science</i> for the September 2017 issue. As such, the article was featured prominently on the journal's homepage, and was made freely accessible to all. |
| Cell Wall Biology and Utilization Research | Madison, WI | Gave two presentations at the Penn State Nutrition Workshop in Grantville, Pennsylvania. "Balancing rations to optimize milk components" was presented at the general session to more than 400 consulting nutritionists and affiliated industry professionals; and "Amino acid nutrition beyond methionine and lysine for milk protein" was given at a workshop for 70 attendees. |
| Cell Wall Biology and Utilization Research | Madison, WI | Gave a presentation, "Opportunities and challenges of applying recent advances in dairy cattle nutrition to beef cattle nutrition," to about 40 industry professionals, educators, students, and researchers at the American Society of Animal Science Southern Section meeting in Franklin, Tennessee. |

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| Cell Wall Biology and Utilization Research | Madison, WI | Wayne Zeller presented the U.S. Dairy Forage Research Center's condensed tannin NMR database to 50 students and researchers at the 253rd national meeting of the American Chemical Society in San Francisco, California. |
| Cell Wall Biology and Utilization Research | Madison, WI | Wayne Zeller was co-author on an article that describes a method of purifying condensed tannins, "Facile Purification of Milligram to Gram Quantities of Condensed Tannins According to Mean Degree of Polymerization and Flavan-3-ol Subunit Composition" appeared in the Journal of Agricultural and Food Chemistry as an open access article. |
| Dairy Forage Research | Madison, WI | Presented "Establishing Alfalfa in Silage Corn" to about 125 producers, farm consultants, and industry reps at the Wisconsin Classic in Madison, Wisconsin. |
| Dairy Forage Research | Madison, WI | Presented a talk on interseeding alfalfa with corn to overcome the low first-year yield of alfalfa to about 50 producers at the annual meeting and conference of the Eastern Iowa Hay Producers Association in Vinton, Iowa. |
| Dairy Forage Research | Madison, WI | Presented "Update on alfalfa interseeding in silage corn," to 30 forage agronomists and graduate students at the NCCC31 Ecophysiological Aspects of Forage Management meeting in Lincoln, Nebraska. |
| Dairy Forage Research | Madison, WI | Geoffrey Brink presented "Nitrogen source and application effects on pasture productivity, legume persistence, and forage nutritive value" to 64 producers at the American Forage and Grassland Council annual conference in Roanoke, Virginia. |
| Dairy Forage Research | Madison, WI | Presented "Nitrogen cycling on Wisconsin dairy farms" to about 125 producers, farm consultants, and industry reps at the Wisconsin Agribusiness Classic in Madison, Wisconsin. |
| Environmentally Integrated Dairy Management Research | Madison, WI | Presented "Groundwater-borne Infectious Disease in Wisconsin," to about 200 students, faculty, and policy makers at the Water@UW-Madison Symposium on Freshwater Research in Madison, Wisconsin. |

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| Environmentally Integrated Dairy Management Research | Madison, WI | Presented "Dairy manure and human wastewater contamination in the dolomite aquifer in Northeastern Wisconsin" to about 100 dairy producers and industry professionals at the Midwest Manure Summit in Green Bay, Wisconsin. |
| Environmentally Integrated Dairy Management Research | Madison, WI | Presented "Sources of Fecal Contamination in the Dolomite Aquifer in Northeastern Wisconsin" to approximately 200 students, researchers, Iowa State legislators, and non-governmental organizations (NGOs) involved with water quality at the Karst, Water Quality, and Livestock: Finding Balance for a Sensitive Geography Conference at Luther College in Decorah, Iowa. |
| Environmentally Integrated Dairy Management Research | Madison, WI | Presented "Assessing Groundwater Quality in Kewaunee County" to 12 dairy producers at a board meeting of the Professional Dairy Producers of Wisconsin. |
| Environmentally Integrated Dairy Management Research | Madison, WI | Mark Borchardt advised Diamond V Feed Company employees and Peninsula Pride dairy producers on a study design to evaluate the effects of their feed products on pathogen levels in dairy cattle manure. |
| Environmentally Integrated Dairy Management Research | Madison, WI | Upon the release of "Assessing Groundwater Quality in Kewaunee County," a report on a recent groundwater study, Mark Borchardt was interviewed by writers from the Center for Investigative Journalism, WisPolitics, and Milwaukee Public Radio. He also gave several television interviews. |
| Environmentally Integrated Dairy Management Research | Madison, WI | Presented "Hay preservatives and cutting management for maximum quality" to about 60 producers and industry reps at the Southwest Hay and Forage Conference in Ruidoso, New Mexico. |
| Environmentally Integrated Dairy Management Research | Madison, WI | Gave two presentations at Symposium 2017 hosted by the Midwest Forage Association, the Wisconsin Custom Operators, and the Professional Nutrient Applicators Association of Wisconsin in Wisconsin Dells, Wisconsin: "Making the most of your baleage," to 70 producers and custom operators; and a brief update on a research project, "Interaction of bale size and preservative rate for large round bales of alfalfa hay". |

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| Environmentally Integrated Dairy Management Research | Madison, WI | Gave two presentations at the Alabama Farmers Federation Commodity Organizational Meeting: "Forage Management" to 15 producers at the dairy producers commodity group, and "Post-harvest Hay Management" to 40 producers at the hay and forage growers commodity group. |
| Environmentally Integrated Dairy Management Research | Madison, WI | Presented "Heifer Stocking Density and Performance" at a University of Wisconsin Extension on Raising Quality Dairy Heifers Conference in Kimberly, Wisconsin, to 50 dairy producers. |
| Environmentally Integrated Dairy Management Research | Madison, WI | Wayne Coblenz gave a presentation "Baleage made tight, made right" to 220 dairy and forage producers at the Michigan State University Agricultural Innovation Day: Focus on Forages and the Future in Lake City, Michigan. |
| Environmentally Integrated Dairy Management Research | Madison, WI | Presented "Assessment of human health risk due to airborne pathogens during spray irrigation of dairy manure" to about 100 dairy producers and industry professionals at the Midwest Manure Summit in Green Bay, Wisconsin. |
| Office of the Director | Madison, WI | Alison Duff delivered a presentation, "FarmLab: Integrated agroecosystem research to inform policy and practice," to eight policy makers at the State agency head's meeting, which is attended by leadership from two Wisconsin Departments (Agriculture, Trade, and Consumer Protection, and Natural Resources); two University of Wisconsin-Madison entities (UW-Extension and UW College of Agricultural and Life Sciences); and three USDA agencies. |
| Natural Resource Management Research | Mandan, ND | During June 12-16, 2017, Dr. David Toledo, supported the NRCS National Training Center by teaching a class on "Interpreting Indicators of Rangeland Health" for 35 NRCS employees and collaborators in Manhattan, Kansas. |
| Natural Resource Management Research | Mandan, ND | David Toledo was invited to give a talk at the 5th annual reclamation conference in Dickinson, North Dakota on February 21, 2017, on "Use of Cover Crops for Reclamation After Energy Development in Northern Mixed Grass Prairie." |

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| Natural Resource Management Research | Mandan, ND | On February 1, 2017, David Toledo, presented "Assessing and managing rangeland and enterprise resilience using an integrated grazing land assessment method" at the Society for Range Management Annual Meeting in St. George, Utah. |
| Natural Resource Management Research | Mandan, ND | John Hendrickson and David Archer attended the Soil Health Conference in Ames, Iowa, February 16-17, 2017, and gave presentations, "Integrated Crop and Livestock Management Effects on Soil Health" and "Economics of Soil Health," respectively. |
| Natural Resource Management Research | Mandan, ND | David Archer presented "Determining the \$ Behind Soil Health" and made a joint presentation with Mark Liebig on "Soil Health and Economics" at the 2016 Conservation Tillage Conference December 13-14, 2016, sponsored by the University of Minnesota and North Dakota State University in Fargo, North Dakota. |
| Natural Resource Management Research | Mandan, ND | Mark Liebig supported the North Dakota Chapter of the Soil and Water Conservation Society with a presentation at the Society's annual workshop in Bismarck, North Dakota. |
| Natural Resource Management Research | Mandan, ND | The laboratory hosted an exhibit on current research at the Area 4 Soil Conservation Districts Research Farm at Mandan, North Dakota, for the North Dakota Soil Conservation District's Annual Meeting in Bismarck November 20-22, 2016. |
| Natural Resource Management Research | Mandan, ND | Cal Thorson and Dave Archer hosted an exhibit on ARS research at Mandan, North Dakota, at the annual Prairie Ag Innovator's Network Annual Meeting in Minot, North Dakota. |
| Natural Resource Management Research | Mandan, ND | Cal Thorson supported North Dakota State University County Agent training in Agronomy at ARS locations. |
| Natural Resource Management Research | Mandan, ND | David Archer presented a poster "Oilseeds for Jet Fuel: Economics and Sustainability" at the Commercial Aviation Alternative Fuels Initiative Biennial General meeting in Washington, D.C., October 25-27, 2016. |

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| Natural Resource Management Research | Mandan, ND | David Archer presented "Determining the \$ Behind Soil Health" and made a joint presentation with Mark Liebig on "Soil Health and Economics" at the 2016 Conservation Tillage Conference sponsored by the University of Minnesota and North Dakota State University in Fargo, North Dakota, December 13-14, 2016. |
| Office of the Director | Maricopa, AZ | Hosted a 2-day visit by three private crop consultants from New South Wales, Australia who were interested in learning about the success of our integrated pest management program for whitefly in cotton and adapting the system to Australian cotton production systems. |
| Plant Physiology and Genetics Research | Maricopa, AZ | Presented/chaired a scientific session on Synthetic Biology at the Gordon Research Conference - Plant Lipids: Structure, Metabolism & Function in Galveston, Texas. There was discussion/ interactions to determine how this technology will impact society, improve crop performance/yield, and create new opportunities for increasing the number/types of oils that can be produced in plants. In attendance were representatives from industry and government labs, as well as students, postdoctoral researchers, and other scientists. |
| Plant Physiology and Genetics Research | Maricopa, AZ | Invited presentation to the Washington State University Crop and Soil Science Seminar Series on adopting high-throughput phenotyping technology into a breeding program. After the presentation there were one-on-one meetings to discuss the available resources and needs for the Washington group and how this technology will impact their breeding program and long-term goals. Other scientists from academia, industry, and government labs, students, post-doctoral fellows, and the general public attended. |
| Tropical Crops and Germplasm Research | Mayaguez, PR | A team of North Carolina Soybean Producers visited Mayaguez to learn about variety development and the importance of the winter nursery nurseries at the ARS Research Farm. The nursery is used to advance breeding generations during the winter in Puerto Rico. The North Carolina State winter nursery was initiated more than 40 years ago, and all varieties released in the State have an important stop in the ARS nursery. |

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| Soil Management Research | Morris, MN | Frank Forcella and Russ Gesch, along with research collaborators, presented "Converting field pennycress into the next cash cover crop: A weed no more" at the Sustainable Farming Association meeting. |
| Soil Management Research | Morris, MN | Frank Forcella gave an invited presentation entitled "Cash cover crops: Concept, research, and potential application in sugar beet" to the Board of Directors of the Southern Minnesota Beet Sugar Cooperative in Renville, Minnesota. |
| Soil Management Research | Morris, MN | Weyers presented an invited talk entitled "Soil health and potential impact on water quality" and discussed the effect of soil health and soil organic matter on flow and nitrate concentration in drain effluent at the a meeting of the Drainage Management Team, an interagency/university team comprised of staff members from State and Federal agencies and the University of Minnesota to coordinate and network regarding agricultural drainage topics. |
| Soil Management Research | Morris, MN | Presented research seminar entitled "Winter oilseeds as 'cash' cover crops for sustainable crop production" at the 2017 Third Crop Producer Meeting on March 20, 2017, in Fairmont, Minnesota. The meeting was sponsored by Rural Advantage, which promotes the interconnection of agriculture, the environment, and rural communities. |
| Soil Management Research | Morris, MN | Russ Gesch accepted an invitation to participate in an Agriculture CEOs Agriculture/Food Initiative meeting at the University of Minnesota in St. Paul, and to discuss research progress on developing winter camelina and pennycress as cash cover crops for double and relay cropping with soybean and other commodity crops, as well as discuss strategies for their commercialization. |
| Northwest Sustainable Agroecosystems Research | Pullman, WA | Accompanied National Program Leader to visit a producer and learn about concerns for the future of dryland farming in the Pacific Northwest |
| Northwest Sustainable Agroecosystems Research | Pullman, WA | Informed industry representative in Spokane, Washington, about benefits and hazards of applying nitrogen fertilizer in autumn in eastern Washington State. |

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| Northwest Sustainable Agroecosystems Research | Pullman, WA | Provided information to industry representative about performance of models that simulate wind erosion. |
| Northwest Sustainable Agroecosystems Research | Pullman, WA | Provided articles and shared information with a producer concerning the depth to which soils freeze in the Pacific Northwest. |
| Crop Improvement and Protection Research | Salinas, CA | Presented at a plant disease seminar hosted by the University of California Cooperative Extension on research developing diagnostics for soil-borne strawberry pathogens. Attendees included several growers and people from the agriculture-associated industries in Salinas. In total, around 150 attended this seminar. |
| Crop Improvement and Protection Research | Salinas, CA | ARS scientists presented at the biennial meeting of the American Society of Sugar Beet Technologists (ASSBT) on the characterization of sources of rhizomania resistance under Rz1 resistance-breaking strains of the causal virus. This information will impact selection of future sources of rhizomania resistance in commercial varieties. Approximately 200 scientists, ASSBT members, and industry personnel participated. |
| Crop Improvement and Protection Research | Salinas, CA | ARS scientists presented at the annual research meeting of the California Beet Growers Association (CBGA) on the results of commercial varieties reaction to sugar beet cyst nematode (SBCN) infestation and high temperatures in the field. This information will impact the choice of cultivars that growers plant in SBCN-infested fields. Approximately 30 scientists, CBGA members, local sugar beet growers, and industry personnel participated. |
| Hydraulic Engineering Research | Stillwater, OK | Tour with a presentation given to NRCS New Employees Orientation Course participants. Approximately 30 participants in the course. |
| Wheat, Peanut, and Other Field Crops Research | Stillwater, OK | Provided research update to growers and seed industry representatives at the Peanut Expo and Oklahoma/Texas Seed Meeting. |
| Crop Genetics and Breeding Research | Tipton, GA | Presentation of forage work to other scientists and hay and livestock producers at the American Forage and Grassland Council annual meeting in Roanoke, Virginia. |

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| Crop Genetics and Breeding Research | Tipton, GA | Presentation to beef producers at the Georgia Beef Cattle Short Course prior to the bull sale in Irwinville, Georgia, on February 28, 2017. The talk provided an update on research and current state of affairs concerning the Bermudagrass stem maggot. There were approximately 100-150 participants. |
| Crop Genetics and Breeding Research | Tipton, GA | Met with forage producers, livestock producers, scientists, and students at the University of Costa Rica and presented at least two presentations "Screening of Bermudagrass Forage Germplasm for Multiple Traits" and "Breeding of Perennial Warm Season Grasses" to students, faculty and producers at different times during the week. |
| Pasture Systems & Watershed Management Research | University Park, PA | Helped organize and presented at the Northeast Pasture Consortium meeting (NEPC) in conjunction with the Maryland Cattlemen's Association Maryland Hay and Pasture Conference on "Evaluation of Fodder Production Systems for Grazing Dairy Farms." The NEPC is attended by farmers, livestock producers, stakeholders, scientists, educators, and agribusiness suppliers. |
| Pasture Systems & Watershed Management Research | University Park, PA | Gave presentation at the Northeast Pasture Consortium meeting (NEPC) in conjunction with the Maryland Cattlemen's Association Maryland Hay and Pasture Conference on "Management Characteristics of Grass-finished Beef Operations in the Northeastern U.S." The NEPC is attended by farmers, livestock producers, stakeholders, scientists, educators, and agribusiness suppliers. |
| Pasture Systems & Watershed Management Research | University Park, PA | Gave invited presentation on "Phosphorus Trade-offs in No Till: and a Possible Solution" at the University of Wisconsin Extension Meeting World Dairy Expo, which is attended by approximately 70,000 dairy enthusiasts from nearly 100 countries. |
| Global Change and Photosynthesis Research | Urbana, IL | Williams gave a talk entitled "Goss's wilt incidence in sweet corn is independent of transgenic traits" at its annual convention. |
| Global Change and Photosynthesis Research | Urbana, IL | Williams gave a presentation entitled "Sweet corn research in Illinois and beyond" at the Stateline Fruit and Vegetable Conference. |

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| Floral and Nursery Plants Research | Washington, DC | Kevin Conrad presented a workshop to Montgomery County (Maryland) Master Gardeners on the introduction to woody landscape plant identification. |
| Floral and Nursery Plants Research | Washington, DC | Kevin Conrad conducted a workshop for Howard County (Maryland) Master Gardeners on plant identification. |
| Floral and Nursery Plants Research | Washington, DC | Presented a booth at the Mid-Atlantic Nursery Trade Show in Baltimore, Maryland, where approximately 11,300 attendees from the nursery and allied industries gathered to view products from 952 vendors in 45 States. The booth's theme was "Our science, your success" and was targeted towards green industry professionals. The major outcome was meeting new and reconnecting with existing stakeholders, and hearing about problems, challenges, and pressing needs of the industry. |
| Physiology and Pathology of Tree Fruits Research | Wenatchee, WA | Presented a seminar entitled "Understanding soil microbiology to build system resilience and enhance plant productivity" to about 175 growers/producers. |
| Physiology and Pathology of Tree Fruits Research | Wenatchee, WA | Presentations by seven location personnel (four scientists, two graduate students, one postdoctoral researcher) at the Washington Tree Fruit Association annual meeting, with ~50 in the audience of industry, extension, and researcher personnel as well as students. |
| Physiology and Pathology of Tree Fruits Research | Wenatchee, WA | Presentations describing recent pear fruit quality research to NW Pear Research Review, February 16, 2017, in Hood River, Oregon. Audience was ~100 pear fruit industry personnel, university extension specialists, and other researchers. |
| Physiology and Pathology of Tree Fruits Research | Wenatchee, WA | Four location scientists gave presentations to the Washington Tree Fruit Research Commission Apple Horticulture and Crop Protection research review. Presentations described progress in research to extend apple fruit market life and to manage apple tree root diseases. |
| Physiology and Pathology of Tree Fruits Research | Wenatchee, WA | Two location scientists gave invited presentations at the International Fruit Tree Association Annual Meeting, Wenatchee, Washington. Audience was about 400. |

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| Physiology and Pathology of Tree Fruits Research | Wenatchee, WA | Invited presentation at InterPera, a meeting attended primarily by pear industry (growers, packers) personnel. |
| Physiology and Pathology of Tree Fruits Research | Wenatchee, WA | Presentation regarding new technologies for apple fruit storage to Apple and Pear Australia, Ltd. tour group. |
| Application Technology Research | Wooster, OH | Gave a poster presentation on "Intelligent sprayer technology of nursery production" at the Midwest Green Industry Xperience (MGIX) Show in Columbus, Ohio. The show was hosted by the Ohio Nursey and Landscape Association. Attendees were growers, researchers, students, farm managers, extension educators, farm equipment manufacturers, and chemical company representatives. |
| Application Technology Research | Wooster, OH | Invited by Florida Growers Association to present "Development of Advanced Intelligent Spray Technologies for Tree Fruit" at the 2017 Florida Citrus Show Program in Fort Pierce, Florida. There were 779 people who attended the show and at least 200 people at the presentation, including growers, researchers, students, farm managers, extension educators, farm equipment manufacturers, and chemical company representatives. |
| Corn, Soybean and Wheat Quality Research | Wooster, OH | Presentation title: "Expression of Sucrose Synthase Differs in Soft Wheat Varieties and May Impact Yield and Baking Quality" to the Soybean and Wheat Quality Lab research review at Purdue University in Lafayette Indiana. |
| Corn, Soybean and Wheat Quality Research | Wooster, OH | Presentation title: "Crop Quality of 2016 soft red winter wheat and Pacific Northwest soft white wheat; solvent retention capacity test for quality evaluation of soft wheat" at the 2016 Caribbean and Central America Crop Quality Seminars attended by 25 millers and bakers from five Latin American and Caribbean countries. |
| Corn, Soybean and Wheat Quality Research | Wooster, OH | Presentation title: "Bran characteristics influencing quality attributes of whole wheat pancakes and biscuits" at the Soft Wheat Quality Laboratory Annual Research Review Conference attended by 86 wheat milling, baking, seed, breeding companies, universities, quality testing instrument companies, and ARS researchers. |

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| Corn, Soybean and Wheat Quality Research | Wooster, OH | Presentation title: "Soft Wheat Quality Laboratory activity updates" at the Soft Wheat Quality Laboratory Annual Research Review Conference attended by 86 wheat milling, baking, seed, breeding companies, universities, quality testing instrument companies, and ARS researchers. |
| Corn, Soybean and Wheat Quality Research | Wooster, OH | Presentation Title: "Soft Wheat Quality Laboratory's quality testing of breeding lines, research activities and research outcomes" at the Ohio Small Grains Field Day, attended by 50 wheat growers, researchers, and students. |
| Corn, Soybean and Wheat Quality Research | Wooster, OH | Presentation title: "Solvent Retention Capacity Tests for Estimation of Soft Wheat Flour Baking Quality; Improving Milling and Baking Quality of Eastern U.S. Soft Winter Wheat" at the Solvent Retention Capacity Test workshops attended by nine Latin American and Caribbean buyers of U.S. wheat. |
| Dairy and Functional Foods Research | Wyndmoor, PA | Presented talk about cheese chemistry and conducted cheese tasting at the Central New Jersey Section of Institute of Food Technologists. |
| Dairy and Functional Foods Research | Wyndmoor, PA | Marjorie Kiechel and Julie Hirsch of Systems Design and Measurement, Ingredion, requested assistance to analyze the carbohydrate composition of seven fiber samples from berry fruits and possibly sugar beet pulp for the monosaccharide composition. They would like to develop a CRADA for a multiple-year project with a \$20,000 a year budget and hire a technician to work at the laboratory part-time. |
| Dairy and Functional Foods Research | Wyndmoor, PA | James Cropper, Executive Director, Northeast Pasture Consortium discussed papers and other details for NEPC 2017 meeting which was held in March. |
| Dairy and Functional Foods Research | Wyndmoor, PA | Consulted with Lyndsay Leal, Senior Chemist, Dow Chemical Company about hands-on dairy chemistry workshops suitable for school children. |
| Dairy and Functional Foods Research | Wyndmoor, PA | Provided guidance to Gary Steuart, CEO, Steuart Labs on extracting phospholipid from dairy fats using green methodologies. |

3.7.4. Stakeholder Meetings

| Laboratory | Location | Description |
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| Small Grains and Potato Germplasm Research | Aberdeen, ID | Attended the American Malting Barley Association Barley Improvement Conference and presented the results of using gene expression screening to identify new malting quality traits. |
| Exotic and Invasive Weeds Research | Albany, CA | The ARS Delta Region Area-wide Aquatic Weed Project (DRAAWP) held a meeting entitled "All About Water Hyacinth" in Stockton, California, to discuss problems created by water hyacinth and other invasive aquatic weeds in the Sacramento-San Joaquin Delta, and new integrated adaptive management solutions being implemented under the DRAAWP. About 30 people attended and two local TV stations aired stories, including interviews of the lead ARS scientist on the project, Patrick Moran. |
| Quality and Safety Assessment Research | Athens, GA | Bowker gave an overview of the research on poultry meat quality and safety conducted in the research unit and received feedback from industry stakeholders on current technical issues and potential areas where further research is needed. |
| Food Quality Laboratory | Beltsville, MD | Yu, Jurick, Verneta, Gaskins, and the team visited the Penn State University orchard, met Kari Peter and discussed current apple diseases and control strategies. Also visited Rice Fruit Company and held a discussion section with their technical and management leaders to discuss ARS research progress on controlling apple decay. |
| Genetic Improvement for Fruits and Vegetables Laboratory | Beltsville, MD | Made a presentation at a meeting of the American Cranberry Growers Association and discussed advances in breeding for fruit rot resistance in cranberry. |
| Genetic Improvement for Fruits and Vegetables Laboratory | Beltsville, MD | Presented a research summary of the ARS blueberry breeding program to a group of approximately 40 members of the New Jersey Farm Service Agency. |

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| Nutrition, Food Safety, and Quality | Beltsville, MD | Served as Government liaison to the International Food Information Council and was invited to speak to the foundation trustees about nutrition and health at their annual meeting. |
| Nutrition, Food Safety, and Quality | Beltsville, MD | Participated in a small group discussion with leadership of the Egg Nutrition Center on research priorities for the egg industry. |
| Nutrition, Food Safety, and Quality | Beltsville, MD | Invited to attend a United States Pharmacopodia roundtable on prebiotics. Prebiotics are fermentable carbohydrates like dietary fiber that feed the intestinal microbiome and promote health. |
| Nutrition, Food Safety, and Quality | Beltsville, MD | Invited to give a talk on red meat and cancer to the Meat Industry Summit in San Diego, California. This group is comprised of about 300 executives from the meat industry. |
| Nutrition, Food Safety, and Quality | Beltsville, MD | Planned and conducted the Food Safety Program stakeholder and customer research workshop (February 22-24, 2017) which brought together administrators, program leaders, and scientists from Federal agencies, Departmental officials, and academia involved in food safety research and regulatory and public health oversight. The workshop strengthened inter-departmental collaborations and helped to address future USDA and U.S. Department of Health and Human Services needs and budget initiatives. |
| Integrated Cropping Systems Research | Brookings, SD | Attended Customer Focus Group Meetings. |
| Integrated Cropping Systems Research | Brookings, SD | Farm Board Meeting. |
| Genetics, Breeding, and Animal Health Research | Clay Center, NE | Hosted 15 individuals of the beef focus group for a 1.5-day meeting, during which group members were given presentations about beef research being conducted in the various research units at the location. |

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| Forage Seed and Cereal Research | Corvallis, OR | Location scientists presented posters at the Annual Ryegrass Growers Annual meeting January 18, 2016, describing research on breeding cover crops, grass endophytes, biochar, slug control, and grass viruses. |
| Forage Seed and Cereal Research | Corvallis, OR | The location held an open house with approximately 20 grass seed cropping systems stakeholders, including seed companies, seed producers, and Oregon State University. Scientists discussed biological herbicides, biochar, cover crop breeding, improving grasses for abiotic stress tolerance, use of green leaf volatiles to increase growth, effect of grass seed crop rotations on stand establishment and longevity, slug control, and grass virus research. |
| Forage Seed and Cereal Research | Corvallis, OR | Location staff meet with the Oregon Wheat Commission was on February 23, 2017, to provide an update on research at the unit and to discuss stakeholder priorities. |
| Forage Seed and Cereal Research | Corvallis, OR | Location staff ran an informational booth at the annual meeting of the Oregon Seed Growers League December 12-13, 2016. General information on unit research was provided, in addition to more specific information on breeding annual ryegrass for cover cropping, slug control, and biochar. |
| Forage Seed and Cereal Research | Corvallis, OR | Location staff meet with the Ryegrass Growers Seed Commission several times during FY 2017 to provide updates on research at the unit and to discuss stakeholder priorities. |
| Forage Seed and Cereal Research | Corvallis, OR | Location staff meet with the Fine Fescue Commission in April and May 2017 to provide updates on research at the unit and to discuss plans for commission-supported research on residue management of creeping fine fescue seed production. |
| Forage Seed and Cereal Research | Corvallis, OR | Location staff meet with the Tall Fescue Commission several times during FY 2017 to provide updates on research at the unit and to discuss stakeholder priorities. |

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| Forage Seed and Cereal Research | Corvallis, OR | Location staff meet with the Oregon Seed Council several times during FY 2017 to provide updates on research at the unit and to discuss stakeholder priorities. |
| Horticultural Crops Research | Corvallis, OR | Attended stakeholder meeting to learn about the industry's disease concerns. |
| Horticultural Crops Research | Corvallis, OR | Presented information on management of Pseudomonas canker on blueberry and two new blueberry diseases: bacterial wilt and silver leaf. |
| Horticultural Crops Research | Corvallis, OR | Attended grower meeting to learn about challenges and disease concerns of strawberry growers. |
| Horticultural Crops Research | Corvallis, OR | Presented data to the Berry Disease Resistance Technical Working Group on fungicide resistance in Botrytis isolated from Oregon small fruit crops, and participated in discussion on disease management strategies in light of emerging resistance. |
| Horticultural Crops Research | Corvallis, OR | Discussed disease management strategies and sampling diseases of blueberry with representatives of Halls Ferry Blueberry farm. |
| Horticultural Crops Research | Corvallis, OR | Gave overview of USDA berry breeding program and described promising selections for propagation at Agromillora annual research meeting in Orlando, Florida. |
| Horticultural Crops Research | Corvallis, OR | Held monthly open discussion with the Willamette Valley Tech Group, a regular meeting of local grape growers, about research and production issues. |
| Horticultural Crops Research | Corvallis, OR | Visited farm to observe and discuss problems with ARS cultivar 'Columbia' Star blackberry with Kutsev Farm in Woodburn, Oregon. |
| Horticultural Crops Research | Corvallis, OR | Discussed research in red raspberry and blackberry breeding, and potential collaboration with Pacific Berry Breeding in Watsonville, California. |
| Horticultural Crops Research | Corvallis, OR | Discussed ongoing strawberry breeding research and collaboration with Washington State University in Puyallup, Washington. |

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| Horticultural Crops Research | Corvallis, OR | Discussed research in ornamental berry development with Georgia-based Star Roses at ARS plots in Aurora, Oregon. |
| Horticultural Crops Research | Corvallis, OR | Presentation to Willamette Valley Tech Group stakeholders. |
| Horticultural Crops Research | Corvallis, OR | Met with cooperators in southern Oregon and Willamette Valley to set up field trials for red blotch and discuss the virus movement in fields. |
| Horticultural Crops Research | Corvallis, OR | Met to discuss harmonizing grapevine quarantine and certification in Washington, Oregon, and Idaho with stakeholders in Dalles and Hood River, Oregon. |
| Horticultural Crops Research | Corvallis, OR | Met to discuss strategy and progress on eradication of blueberry fruit drop virus at Enfield Farms. |
| Horticultural Crops Research | Corvallis, OR | Presented a research report on RNAi development to control spotted wing drosophila. |
| Horticultural Crops Research | Corvallis, OR | Presented to stakeholders molecular tools that apply to the development of slug control. |
| Horticultural Crops Research | Corvallis, OR | Presented a research proposal for RNAi-based pest management to cherry stakeholders. |
| Horticultural Crops Research | Corvallis, OR | Monthly potato cyst nematode research call involving APHIS, potato commissions, and universities. |
| Horticultural Crops Research | Corvallis, OR | Presented talk on plant-parasitic nematode management in raspberry at the Small Fruit Conference, an annual stakeholder conference. |
| Horticultural Crops Research | Corvallis, OR | Met with stakeholders and presented information on nematodes in small fruits during the NW Center for Small Fruit Research meeting. |
| Horticultural Crops Research | Corvallis, OR | Met with stakeholders to discuss replant issues in wine grapes during the Washington wine grape industry forum. |
| Horticultural Crops Research | Corvallis, OR | Presented information on biology, symptoms, risks, research, and disease management of <i>Phytophthora</i> root rot and <i>Verticillium</i> wilt of blueberry. |

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| Horticultural Crops Research | Corvallis, OR | Presentation on use of inoculum monitoring as a decision aide at a University of California Cooperative Extension UCCE Mendocino integrated pest management (IPM) seminar. |
| National Clonal Germplasm Repository | Corvallis, OR | Meeting with the Small Fruit Crop Germplasm Committee and the National Crop Coordinating Committee 212 (NCCC-212) Small Fruit Research Committee in Virginia Beach, Virginia. |
| National Clonal Germplasm Repository | Corvallis, OR | Joseph Postman and Nahla Bassil attended the Nut Growers Society Annual Meeting at Oregon State University. |
| Peanut Research | Dawson, GA | Scientists met with peanut shellers to discuss peanut storage and grading equipment. |
| Peanut Research | Dawson, GA | Addressed Oklahoma peanut producers at the Oklahoma Peanut Expo in Altus, Oklahoma. |
| Peanut Research | Dawson, GA | Met with crop consultants concerning irrigation scheduling and the use of IrrigatorPro. |
| Range Sheep Production Efficiency Research | Dubois, ID | Delivered a presentation on "Profitability of semiprolific ewe breeds in rangeland systems" to members of the Montana Wool Growers Association. Approximately 175 producers and industry representatives from Montana, Wyoming, and Idaho attended. The goal of the presentation was to demonstrate that semiprolific breeds, such as Polypay or Romanov-cross, can increase pounds of lamb weaned from traditional wool-type flocks. |
| Coastal Plan, Soil, Water and Plant Conservation Research | Florence, SC | The location held its annual Customer/Partner Dialogue Workshop in March 2017. Approximately 60 stakeholders from academia, Federal agencies, and industry (including farmers) attended. Stakeholders spent time with individual scientists discussing research findings, and formal presentations were made pertaining to water quantity and water quality issues. |
| Invasive Plant Research Laboratory | Fort Lauderdale, FL | A representative of the Army Corps of Engineers met with all location scientists to discuss research updates, techniques, and progress in preparations for a future meeting with higher level Army Corps at Loxahatchee. |

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| Tropical Plant Genetic Resources and Disease Research | Hilo, HI | Participated in a meeting in Kohala with the Hawaii Department of Agriculture, local fish farmers, and fish feed experts. Discussed the Zero Waste project and opportunities to use algae grown with papaya as a fish feed ingredient. |
| Tropical Plant Genetic Resources and Disease Research | Hilo, HI | Visited the Kainaliu, Kona, station to meet farm manager and learn about opportunities to exchange germplasm and collaborate on research. Collected seed for persimmon rootstock with the goal of obtaining additional persimmon accessions for University of California, Davis, repository in collaboration with John Preece. |
| Tropical Plant Genetic Resources and Disease Research | Hilo, HI | Established contact with Jim West, who maintains a collection of more than 600 fruit tree species in Ecuador, including species of <i>Vasconcellea</i> , <i>Passiflora</i> , and <i>Psidium</i> not currently in the USDA collection. Discussed the importance of the USDA germplasm collection. |
| Tropical Plant Genetic Resources and Disease Research | Hilo, HI | Assisted with planning for Hawaii Ulu Producer's Cooperative (HUPC) workshop on breadfruit identification in collaboration with HUPC coordinator Dana Shapiro, University of Hawaii at Manoa professor Noah Lincoln, and Breadfruit Institute director Diane Ragone. |
| Innovative Fruit Production, Improvement and Protection | Kearneysville, WV | Held a meeting for fruit industry representatives to learn about research programs and advances at the location. |
| Northwest Irrigation and Soils Research | Kimberly, ID | Participated in a stakeholder meeting with the Amalgamated Sugar Co. |
| Forage-Animal Production Research | Lexington, KY | Invited by the county cooperative extension agent to report research results and applications to the Cattleman's Association in Anderson County, Kentucky. The chapter includes women, small farmers, and veterans. |
| Forage-Animal Production Research | Lexington, KY | Provided a presentation on the location's research accomplishments at the Forage Session for the annual meeting of Kentucky Farm Bureau in Louisville. The session was attended by approximately 90 stakeholders and State policymakers. |

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| Forage-Animal Production Research | Lexington, KY | Provided a presentation on management options for mitigating fescue toxicosis at the annual Kentucky Grazing Conference sponsored by the Kentucky Forage and Grassland Council. The meeting was attended by approximately 75 stakeholders. |
| Forage-Animal Production Research | Lexington, KY | Provided a presentation on management options for mitigating fescue toxicosis at the winter meeting of the Madison County Cattlemen's Association in Richmond, Kentucky. The meeting was attended by approximately 25 stakeholders. |
| Forage-Animal Production Research | Lexington, KY | Provided a presentation on the hidden benefits of clovers at the annual meetings of the Boyle and Mercer County Cattlemen's Associations. The meeting was attended by approximately 40 stakeholders. |
| Forage-Animal Production Research | Lexington, KY | Provided a presentation on the science of seedhead suppression of toxic endophyte-infected tall fescue at the Dow Pasture Symposium held during the National Cattlemen's Beef Association in Nashville, Tennessee. The symposium was attended by freelance writers and representatives from approximately 10 popular press outlets. |
| Forage-Animal Production Research | Lexington, KY | Provided a presentation on the grazing management of non-toxic novel endophyte tall fescue at a workshop sponsored by the Pasture Alliance in Lexington, Kentucky. The session was attended by approximately 65 stakeholders. |
| Forage-Animal Production Research | Lexington, KY | Provided a presentation on the location's research on fescue toxicosis at a workshop in Rock Springs, Georgia, sponsored by the Georgia Extension Service. The workshop was attended by approximately 40 stakeholders. |
| Poisonous Plant Research | Logan, UT | Drs. Kevin Welch and Clint Stonecipher reported on the location's current poisonous plant and range restoration research at the Wyoming Farm Bureau convention. |
| Pollinating Insect-Biology, Management, Systematics Research | Logan, UT | Presented "Exploring strategies to control bomber flies that attack alkali bees" at the annual Alfalfa Seed Growers Conference. |

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| Pollinating Insect-Biology, Management, Systematics Research | Logan, UT | Invited to Natural Areas meeting in Davis, California, where presented two talks, "Pollinator-friendly forbs to seed for sagebrush-steppe," and "Unexpected ways that bees experience and accommodate variable climate: Let's undertake tasks to benefit native bees now." |
| Pollinating Insect-Biology, Management, Systematics Research | Logan, UT | Attended the annual Integrated Crop Pollination investigator meeting. |
| Pollinating Insect-Biology, Management, Systematics Research | Logan, UT | Presented data at the annual Western Alfalfa Seed Growers Association Winter Seed Conference in Las Vegas Nevada. |
| Pollinating Insect-Biology, Management, Systematics Research | Logan, UT | Presentation at the 2016 annual Almond Conference on research into the interaction of pesticides and diseases on honey bee health. |
| Pollinating Insect-Biology, Management, Systematics Research | Logan, UT | Invited presentation entitled "Pollinating with multiple bee species (honey bees and others): What we have learned about the common stresses and pathogens impacting these bees" at the North American Beekeeping Conference and Trade show. |
| Pollinating Insect-Biology, Management, Systematics Research | Logan, UT | Presented "Sustainable management and propagation of the blue orchard bee in commercial cherry orchards" at the annual Orchard Bee Association meeting. |
| Office of the Director | Madison, WI | Hosted a Research and Industry Stakeholder Conference for about 30 producers, representatives of the dairy and forage industries, and ARS researchers. The purpose was to share research results and to gather stakeholder input on industry priorities related to forage improvement and utilization. |

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| Natural Resource Management Research | Mandan, ND | Location scientists hosted the Laboratory's Customer Focus Group for their Winter Meeting on February 9, 2017. The meeting was devoted to a review of ARS research and issues, and discussions with members concerning research needs and current and proposed research. |
| Office of the Director | Maricopa, AZ | Location scientists held the 2nd Focus Group meeting of the year to discuss current, ongoing, and future research, including proximal and remote sensing to support crop production via crop monitoring and crop improvement via high throughput phenomics. The meeting provided a venue for stakeholders to offer ideas and suggestions on research direction to help maintain a strong relationship among scientists and stakeholders at the local, regional, and national level. |
| Office of the Director | Maricopa, AZ | The Center Director and scientists met with representatives of BioHumaNetics, a private company that markets nutritional supplements for crops that enhance organic matter and water use efficiency. Scientists summarized their research programs and discussed collaborative research projects in crop fertility and remote and proximal sensing for assessing crop water use. |
| Tropical Crops and Germplasm Research | Mayaguez, PR | In a Participating Agency Service Agreement (PASA), an ARS scientist visited Haiti in November 2016 for an assessment of Haiti sorghum production and the effects of sugarcane aphids. After a 2-week visit/inspection to different sorghum production systems of Haiti, the scientist prepared an assessment report with suggestions to improve the sorghum industry. |
| Range and Livestock Research | MILES CITY, MT | Held the annual Laboratory Customer Focus Group meeting. |
| Office of the Director | Oxford, MS | Water Resources meeting with the Delta Council. |
| Office of the Director | Oxford, MS | Met to discuss a new scientific initiative by the U.S. Geological Survey to assess water availability issues within the Mississippi Alluvial Plain that includes portions of Mississippi, Arkansas, Louisiana, Tennessee, and Missouri. |

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| Northwest Sustainable Agroecosystems Research | Pullman, WA | Held a Liaison Committee meeting and location tour to inform the committee members on current research findings and to discuss future research. A presentation was given by a Washington State University faculty member on regional modeling for the sustained use of lands under a changing climate in the Pacific Northwest. |
| Great Basin Rangelands Research | Reno, NV | Presented a paper entitled "Cheatgrass Soil Engineering/Perennial Grass Suppression of Cheatgrass: The Yin and Yang of Plant Competition in Northern Nevada," to the Nevada Chapter of the Society for Rangeland Management. There were approximately 50 attendees at the meeting. |
| Great Basin Rangelands Research | Reno, NV | ARS scientists gave presentations entitled "Towards a Remote Sensing Base Indicator of Rangeland Ecosystem Resistance and Resilience;" "Grass Seedling Growth and Survival Under Different Post-Fire Grazing Management Scenarios;" "Effects of Mulch on Plant and Soil Recovery after Wildfire in the Eastern Great Basin;" and "Natural Recruitment of Wyoming Big Sagebrush Relative to Burned Areas During an El Nino Year" at the annual meeting of the Society for Range Management that included land managers and public stakeholders. |
| Crop Improvement and Protection Research | Salinas, CA | California Leafy Greens Research Board presentation and stakeholder meeting. |
| Crop Improvement and Protection Research | Salinas, CA | Presentation and stakeholders meeting - Enza Zaden. |
| Crop Improvement and Protection Research | Salinas, CA | Presentation and stakeholders meeting - Nipomo Native Seeds. |
| Crop Improvement and Protection Research | Salinas, CA | Presentation and stakeholders meeting - Pinnacle Seeds. |
| Crop Improvement and Protection Research | Salinas, CA | Presentation and stakeholders meeting - Salinas Valley Seeds. |

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| Crop Improvement and Protection Research | Salinas, CA | Presentation and stakeholders meeting - Bayer. |
| Hydraulic Engineering Research | Stillwater, OK | Hosted exhibit booth at the Oklahoma Association of Conservation Districts Annual State meeting that allowed ARS scientists to interact with stakeholders and provide information on current research at the location. |
| Wheat, Peanut, and Other Field Crops Research | Stillwater, OK | Location hosted a quarterly meeting of stakeholders from the Oklahoma Peanut Commission and the National Peanut Board and ARS personnel conducted a tour of the facilities afterwards for 20 participants. |
| Warmwater Aquaculture Research Unit | Stoneville, MS | Fish hybrid producers' meeting including 13 fish farmers. |
| Pasture Systems & Watershed Management Research | University Park, PA | Helped organize and presented at the Northeast Pasture Consortium meeting (NEPC) in conjunction with the Maryland Cattlemen's Association Maryland Hay and Pasture Conference on "Evaluation of Fodder Production Systems for Grazing Dairy Farms." The NEPC is attended by farmers, livestock producers, stakeholders, scientists, educators, and agribusiness suppliers. |
| Pasture Systems & Watershed Management Research | University Park, PA | Gave presentation at Northeast Pasture Consortium Meeting (NEPC) in conjunction with the Maryland Cattlemen's Association Maryland Hay and Pasture Conference on "Management Characteristics of Grass-finished Beef Operations in the Northeastern U.S." The NEPC is attended by farmers, livestock producers, stakeholders, scientists, educators, and agribusiness suppliers. |
| Global Change and Photosynthesis Research | Urbana, IL | ARS scientist attended the Illinois Farm Bureau Agribusiness Roundtable at the University of Urbana-Champaign in Urbana Illinois, at the Institute for Genomic Biology. |
| Global Change and Photosynthesis Research | Urbana, IL | ARS scientist met with research leaders from Dow to discuss research on SoyFACE and photosynthetic yield traits. |

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| Gardens Unit | Washington, DC | Participated in the American Boxwood Society Symposium and the American Hemerocallis Society National Convention, which are major stakeholders of the Arboretum. |
| Gardens Unit | Washington, DC | Gave an update and report on the status of the National Bonsai and Penjing Museum to the board of directors of the National Bonsai Foundation (NBF), a stakeholder and partner of the U.S. National Arboretum. NBF helps the U.S. National Arboretum showcase the arts of Bonsai and Penjing to Arboretum visitors. |
| National Soil Erosion Research | West Lafayette, IN | Met with diverse groups of stakeholders, including Federal, State, farmers, and industry, to learn about their science and technology needs. |
| Rangeland and Pasture Research | Woodward, OK | The location held its annual stakeholder meeting on April 13, 2017. The 21 stakeholders in attendance heard presentations on current research and discussed what research they would like to see in the future at the research location. |
| Dairy and Functional Foods Research | Wyndmoor, PA | Met with Angus Johnson, Chair, Northeast Pasture Consortium to discuss industry research needs, which includes milk variants and gut research. |
| Dairy and Functional Foods Research | Wyndmoor, PA | Invited to present a seminar on the progress of the location's gut project and future research at the California Polytechnic State University, Professionals in dairy, Cal Poly 19th ingredient meeting. |
| Dairy and Functional Foods Research | Wyndmoor, PA | Attended the annual meeting of Northeast Pasture Consortium in Hagerstown, Maryland, and presented talk about variations in milk lipids. |

3.8. FY 2017 Technology Transfer Award Winners

3.8.1. ARS Technology Transfer Award

Scientist: Dr. Harvey D. Blackburn, Dr. Phillip H. Purdy, Dr. Carrie S. Wilson, and Scott F. Spiller

Lab: Plant and Animal Genetic Resources Preservation Unit, Fort Collins, Colorado

Title: National Animal Germplasm Program

Award: ARS Outstanding Award

3.8.2. Federal Laboratory Consortium for Technology Transfer (FLC) Awards

Lab: Genetic Improvement for Fruits and Vegetables Laboratory, Beltsville, Maryland

Name: ‘Elkton Potato’

Award: National Excellence in Technology Transfer

Lab: National Laboratory for Agriculture and the Environment, Ames, Iowa

Name: “Development and Transfer of the Agricultural Conservation Planning Framework”

Award: National Technology Focus Award

Lab: Grain Legume Genetics and Physiology Research Unit, Pullman, Washington

Name: “Development and Commercial Licensing of New Lentil and Chickpea Cultivars”

Award: Far West Region, Outstanding Commercialization Success

Lab: Healthy Processed Foods Unit, Albany, California; University of California, Davis

Name: “Development and Commercial Implementation of New Infrared Heating Technologies”

Award: Far West Region, Outstanding Commercialization Success

Lab: Food Safety and Enteric Pathogens Research Unit, Ames, Iowa

Name: “Vaccine to Reduce Salmonella in Food Animals”

Award: Midwest Region, Excellence in Technology Transfer

Lab: Coastal Plain Soil, Water and Plant Conservation Research Unit, Florence, South Carolina

Name: “Novel Anammox Bacterium Isolate for Purification and Recycling Wastewater in Space and Decentralized Wastewater Systems”

Award: Southeast Region, Excellence in Technology Transfer

Lab: Commodity Utilization Research Unit, New Orleans, Louisiana

Name: “Mannitol Measurement to Detect Deterioration in Sugarcane and Sugar Beet Processing and Distilling”

Award: Southeast Region, Excellence in Technology Transfer

Lab: Southeast Poultry Research Laboratory, Athens, Georgia

Name: “Recombinant Highly Pathogenic Avian Influenza Virus Vaccine”

Award: Southeast Region, Excellence in Technology Transfer

Lab: Genetic Improvement for Fruits and Vegetables Laboratory, Beltsville, Maryland

Name: 'Elkton Potato'

Award: Mid-Atlantic, Excellence in Technology Transfer

Lab: Innovation Fruit Production, Improvement and Protection Laboratory, Kearneysville, West Virginia

Name: "Specialty Crop Initiative Coordinated Agriculture Project the BMSB"

Award: Mid-Atlantic Region, Educational Institution and Federal Laboratory Partnership

Lab: The Center for Grain and Animal Health Research, Manhattan, Kansas

Award: Mid-Continent Region, Outstanding Laboratory Award

Lab: Soil Management and Sugarbeet Research Unit, Fort Collins, Colorado

Name: "Sugar Beet Research with High Impact in Colorado, the USA, and the World"

Award: Mid-Continent Region, Excellence in Technology Transfer

3.9. Selected Metric Charts.

Figure 1. Number of new and active Cooperative Research and Development Agreements (CRADAs) and Material Transfer Research Agreements (MTRAs). The decreased number of CRADAs is due to the fact that some collaborative research that was previous carried out under a CRADA is now carried out an MTRA.

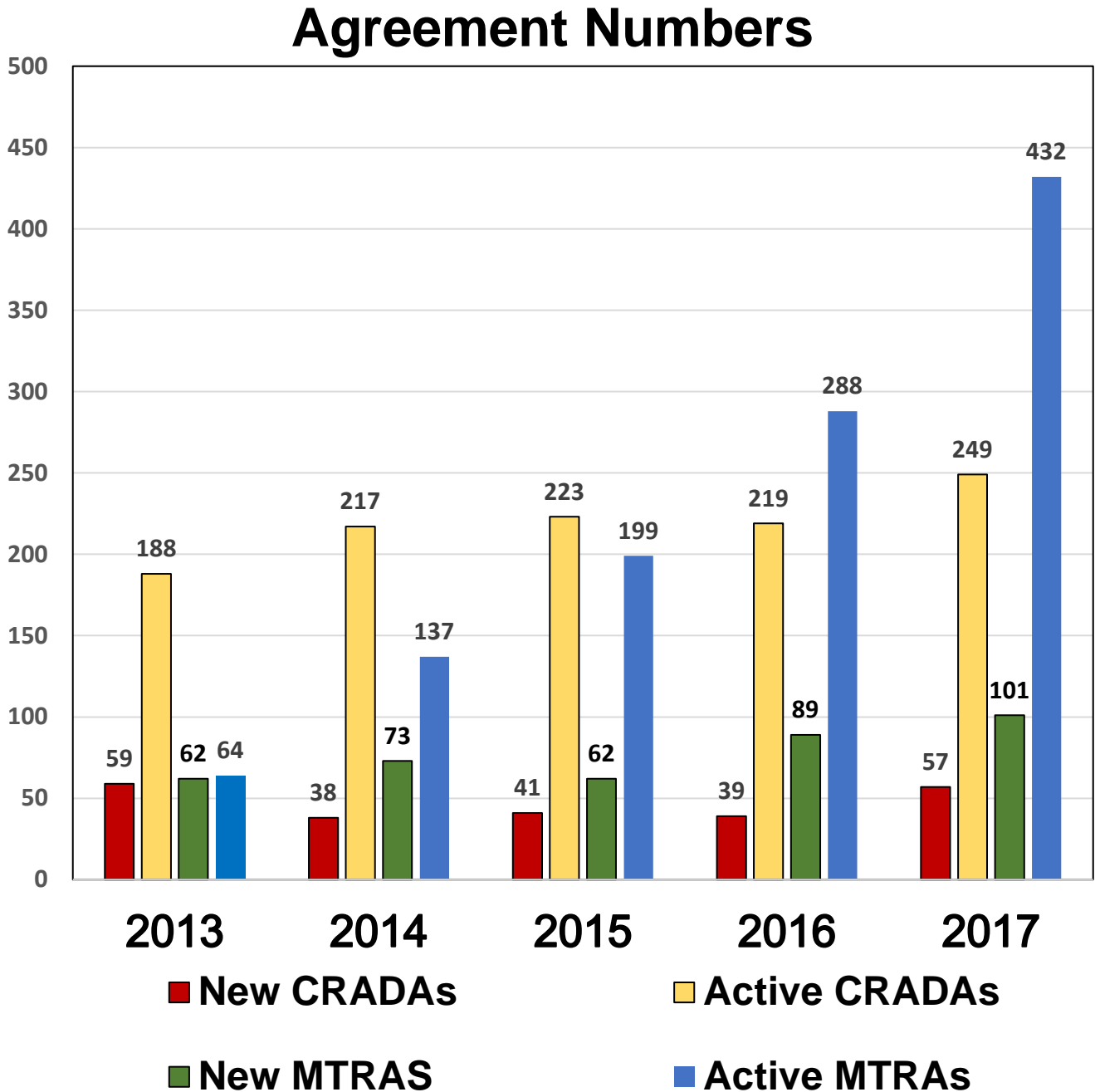
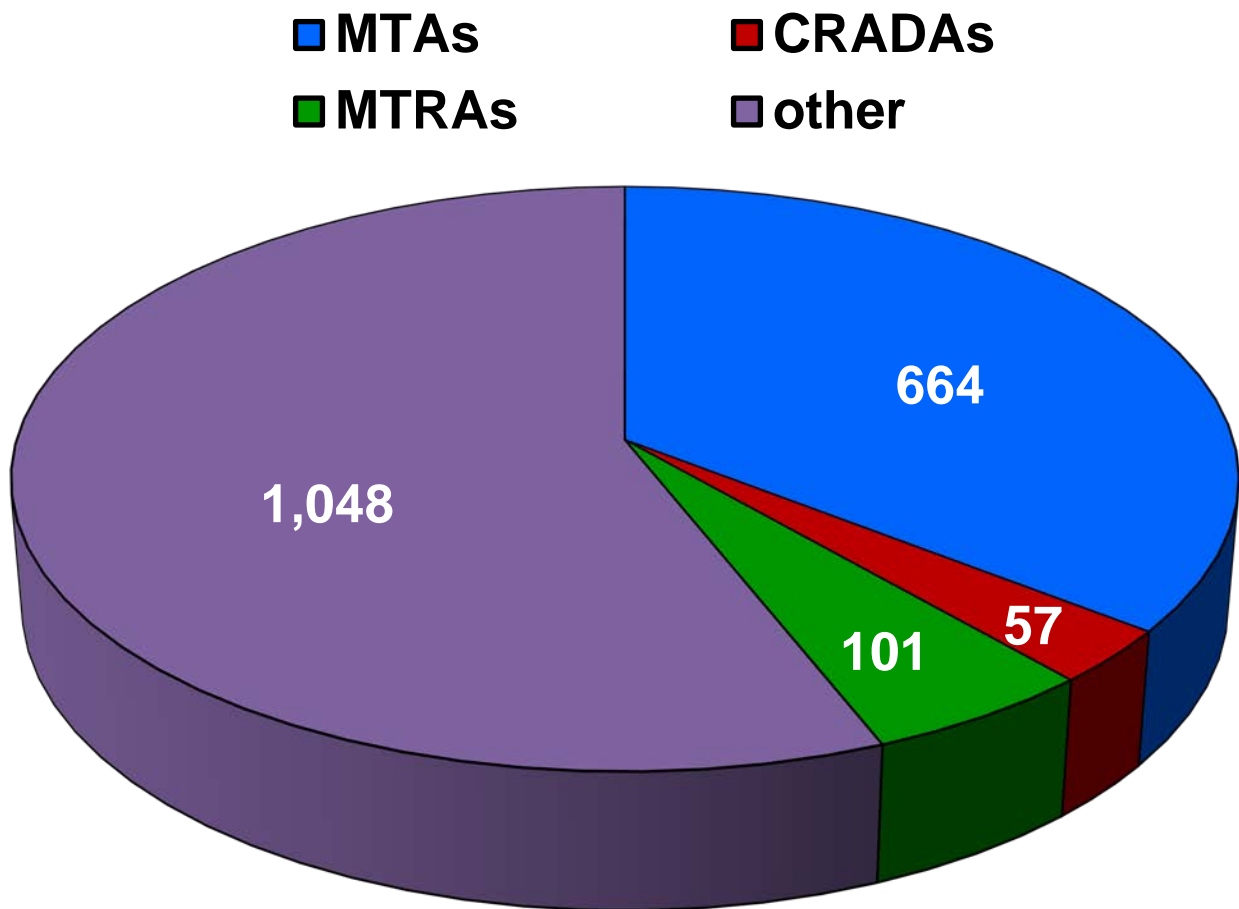


Figure 2. Number of collaborative research agreements (Cooperative Research and Development Agreements [CRADAs], Material Transfer Research Agreements [MTRAs], Material Transfer Agreements [MTAs], and others) executed by type in FY 2017.



SBIR= Small Business Innovation Research
CRADA= Cooperative Research and Development Agreement

Figure 3. Number of National Institute of Food and Agriculture (NIFA) Small Business Innovation Research (SBIR) Phase I proposals submitted and number funded per year for ARS Cooperative Research and Development Agreement (CRADA) partners compared to the number submitted (~500) and approved for funding (~15) by NIFA per year for all applicants. The data of the average for all applicants is transformed to the number of proposals funded per 10 proposals submitted.

SBIR Phase I Proposals

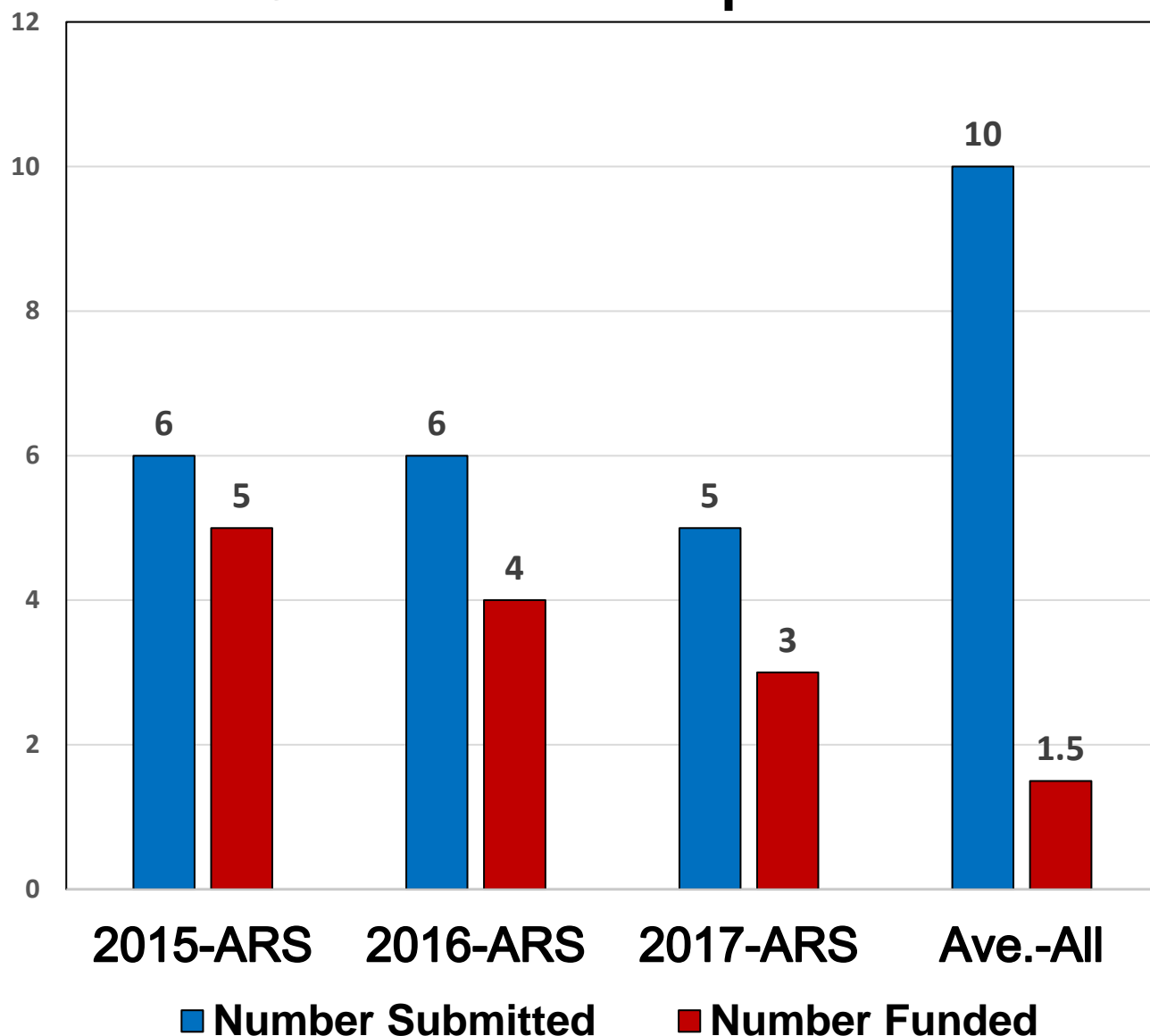


Figure 4. Number of invention disclosures, patent applications filed, and patents issued. The year in which a patent issues is not the year in which the patent is filed. The increase in the number of invention disclosures in FY 2015 was the result of adding biological materials disclosures for the first time.

Patenting Numbers

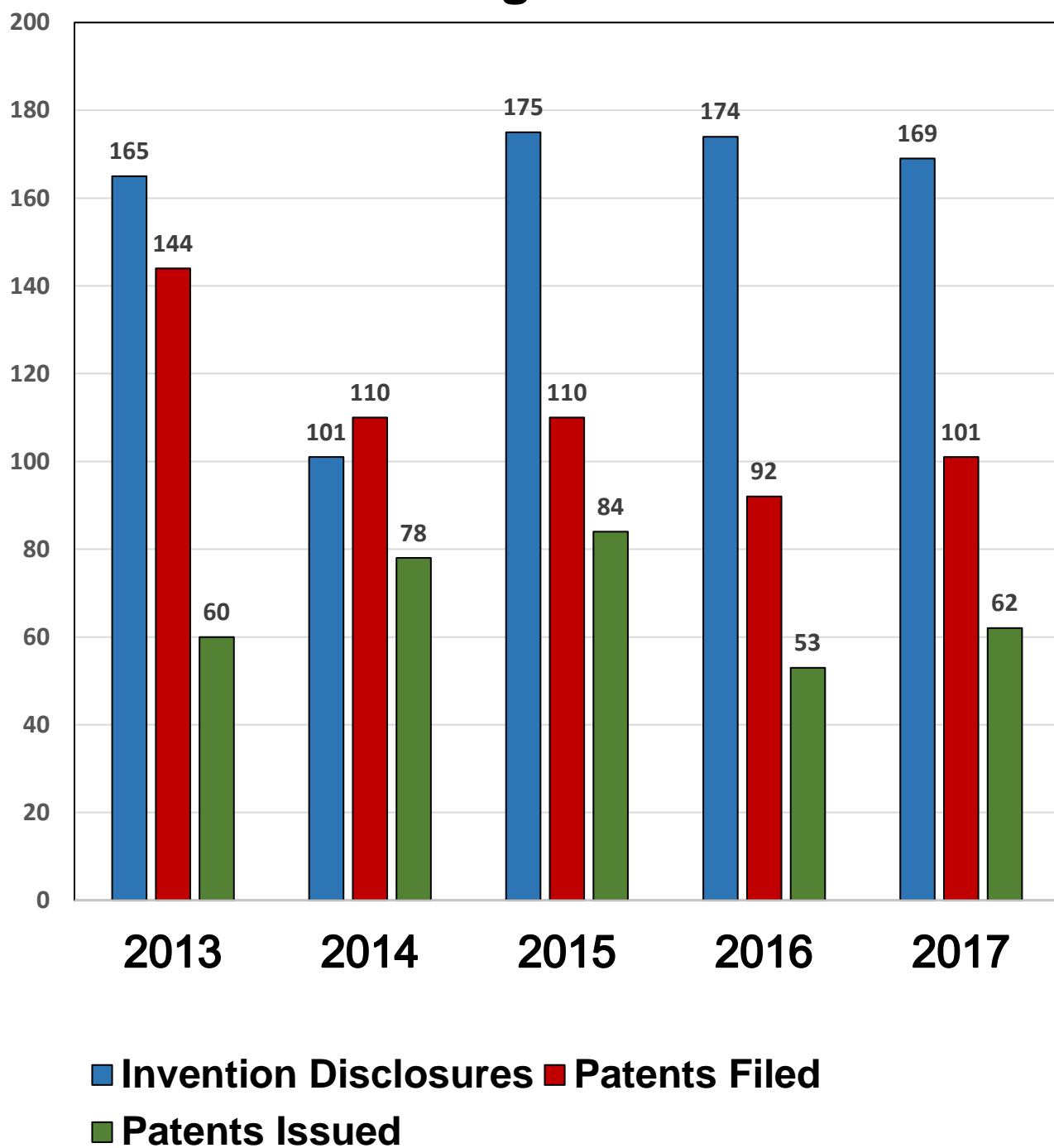


Figure 5. Number of patents issued in FY 2017 by scientific discipline.

- **Life Science**
- **Chemical**
- **Mechanical and Measurements**
- **Plants**

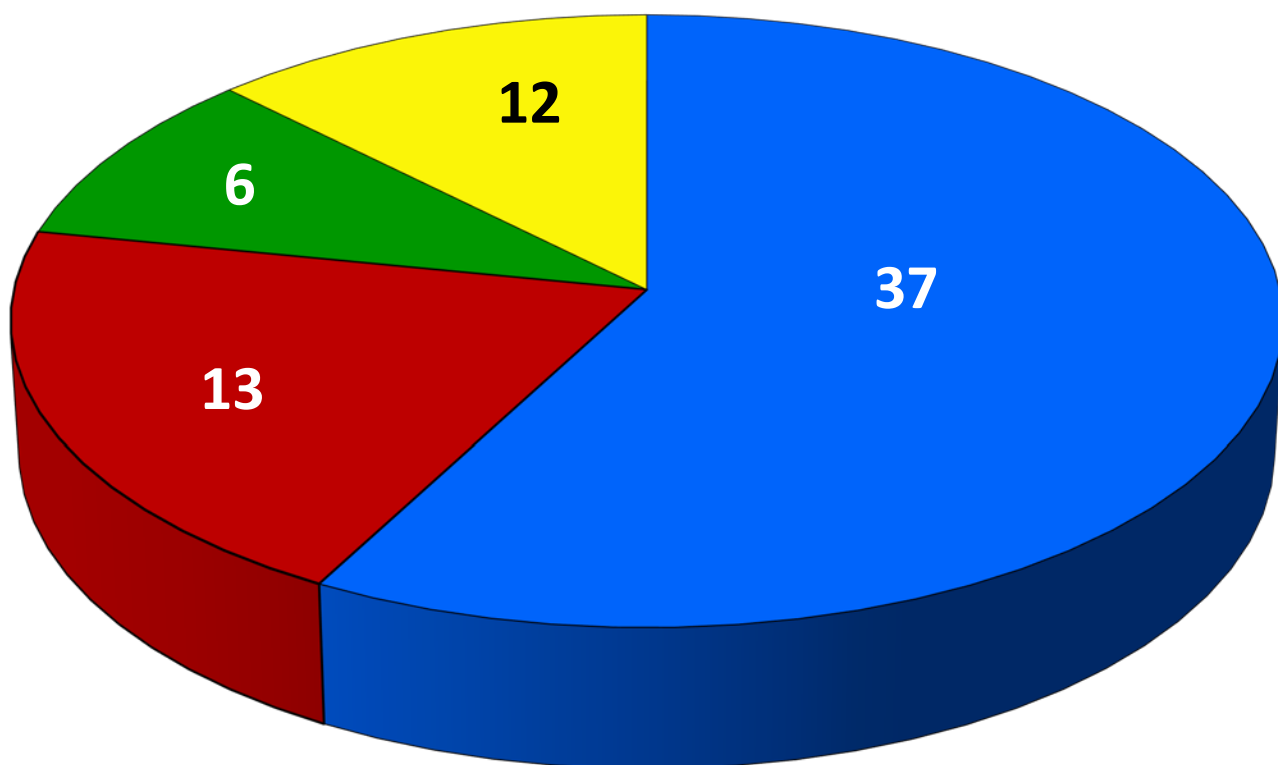


Figure 6. Number of license types per year.

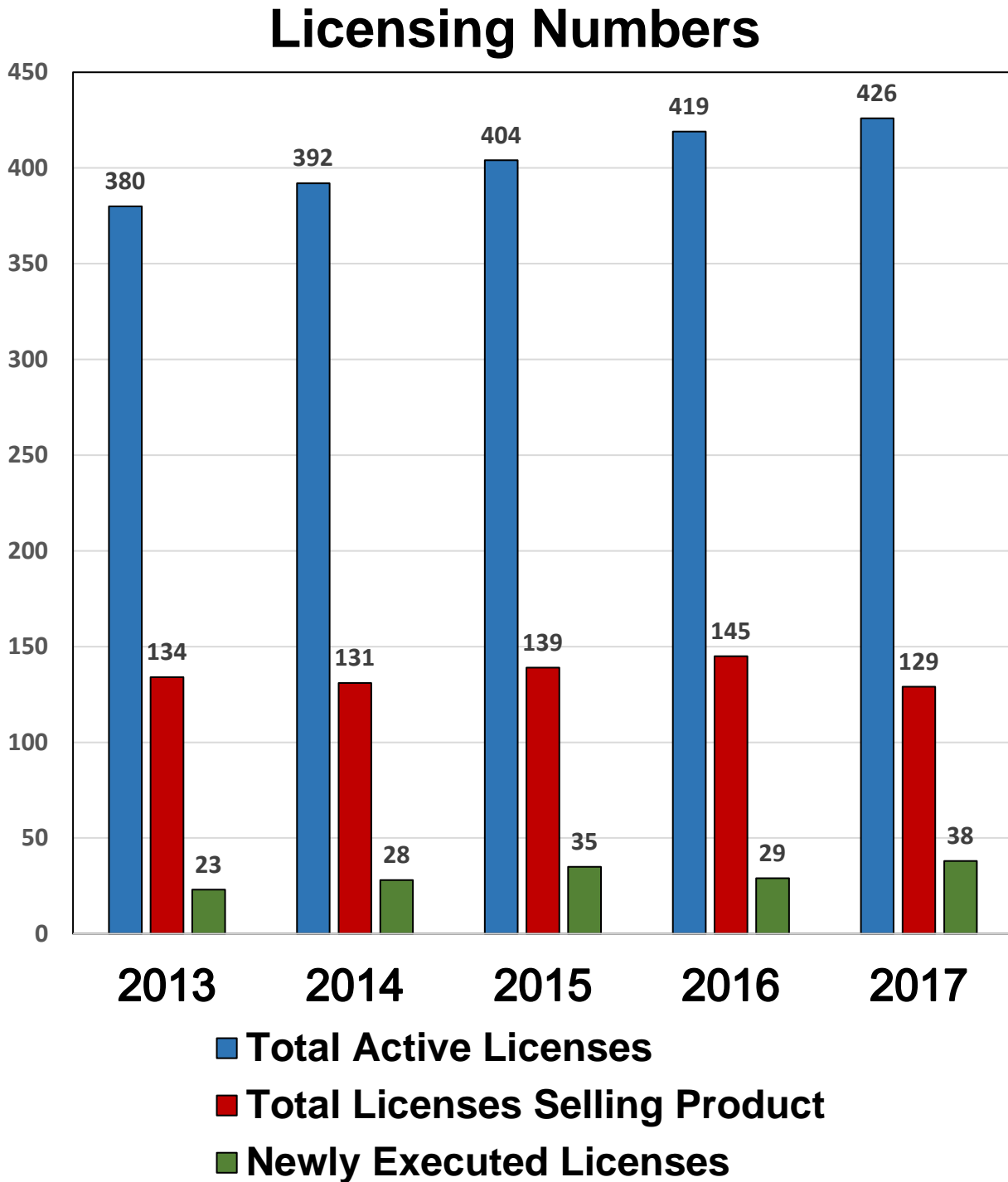


Figure 7. Earned license royalty income (ERI) over time.

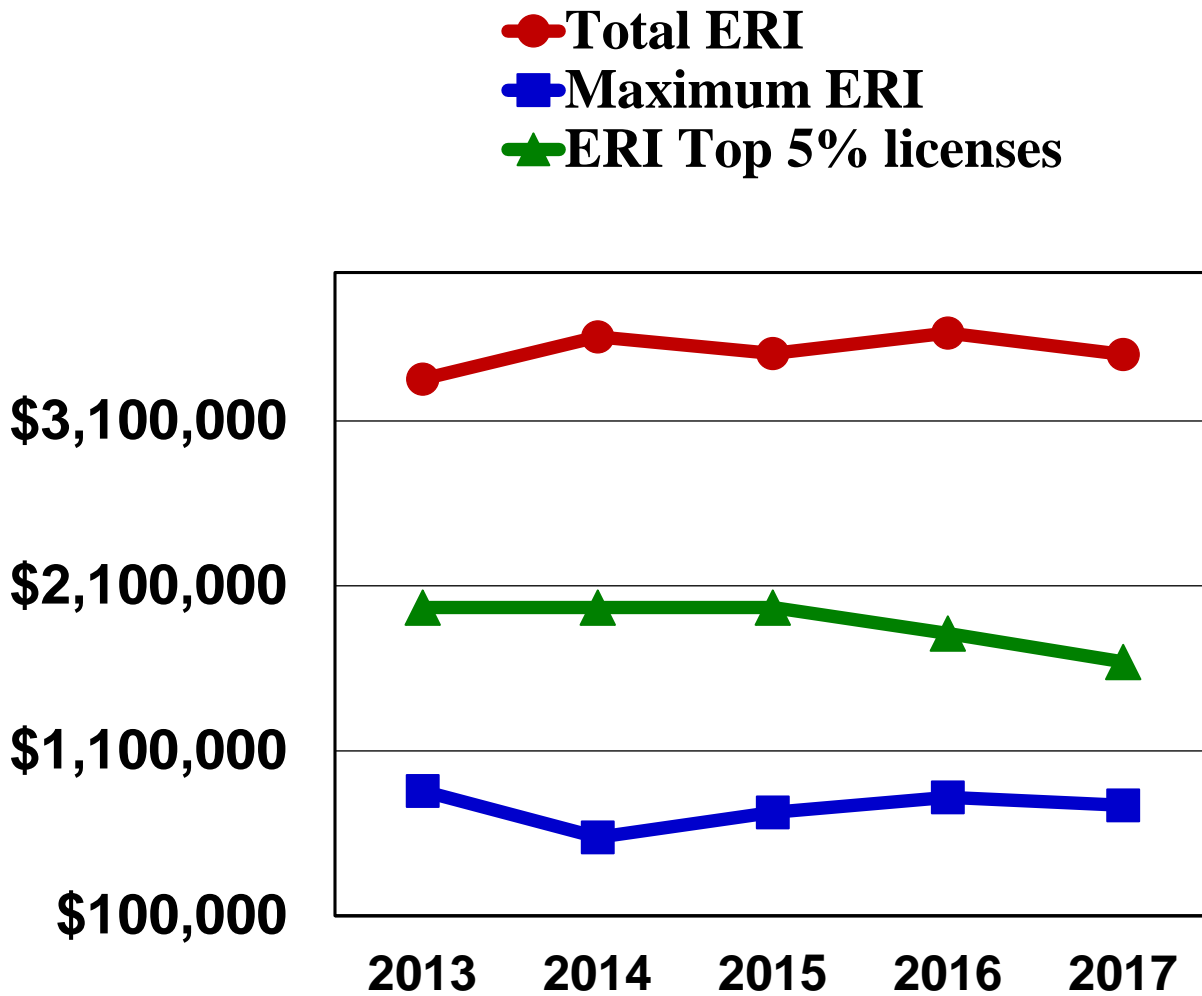


Figure 8. The number of new licenses executed in FY 2017 by business type.

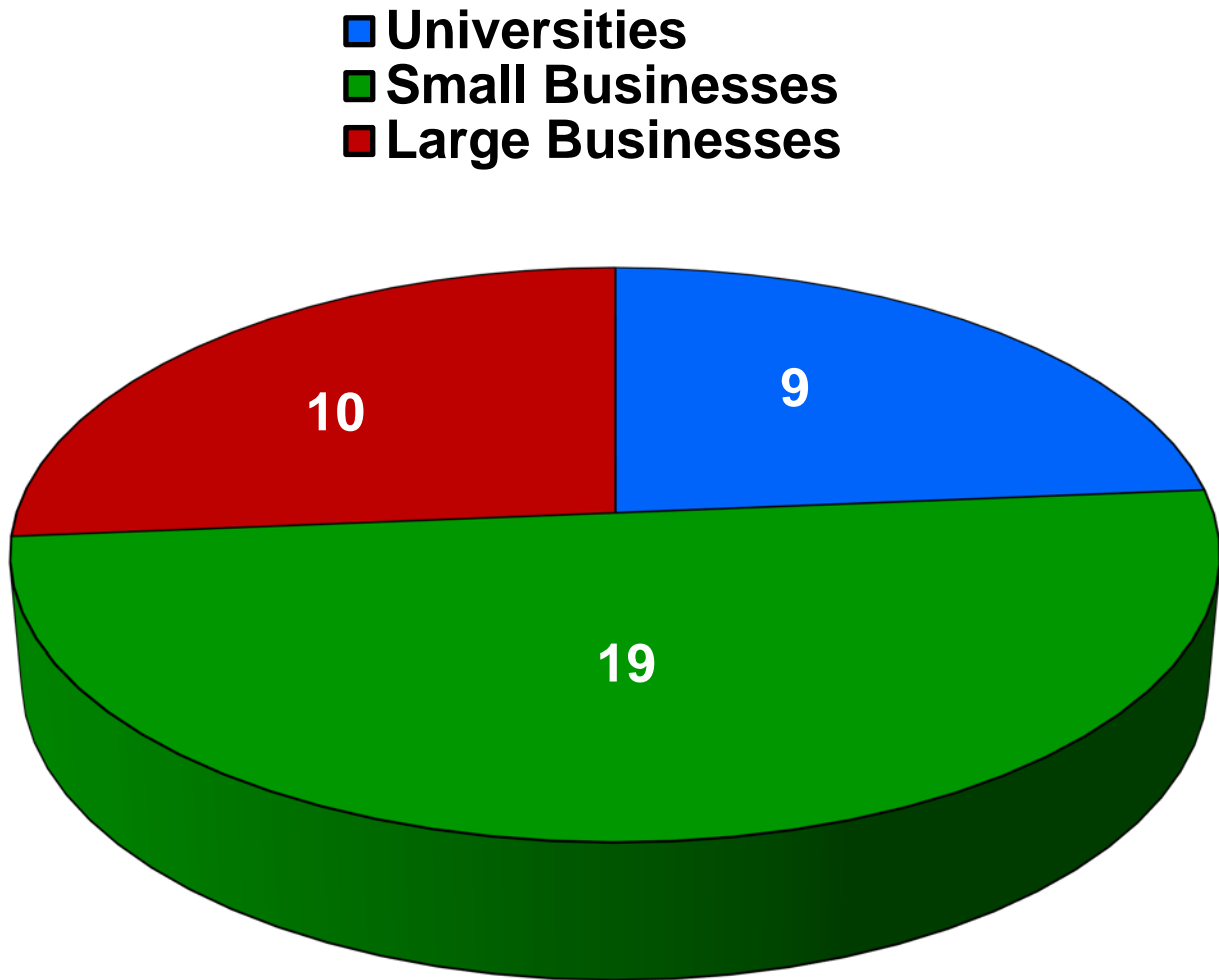
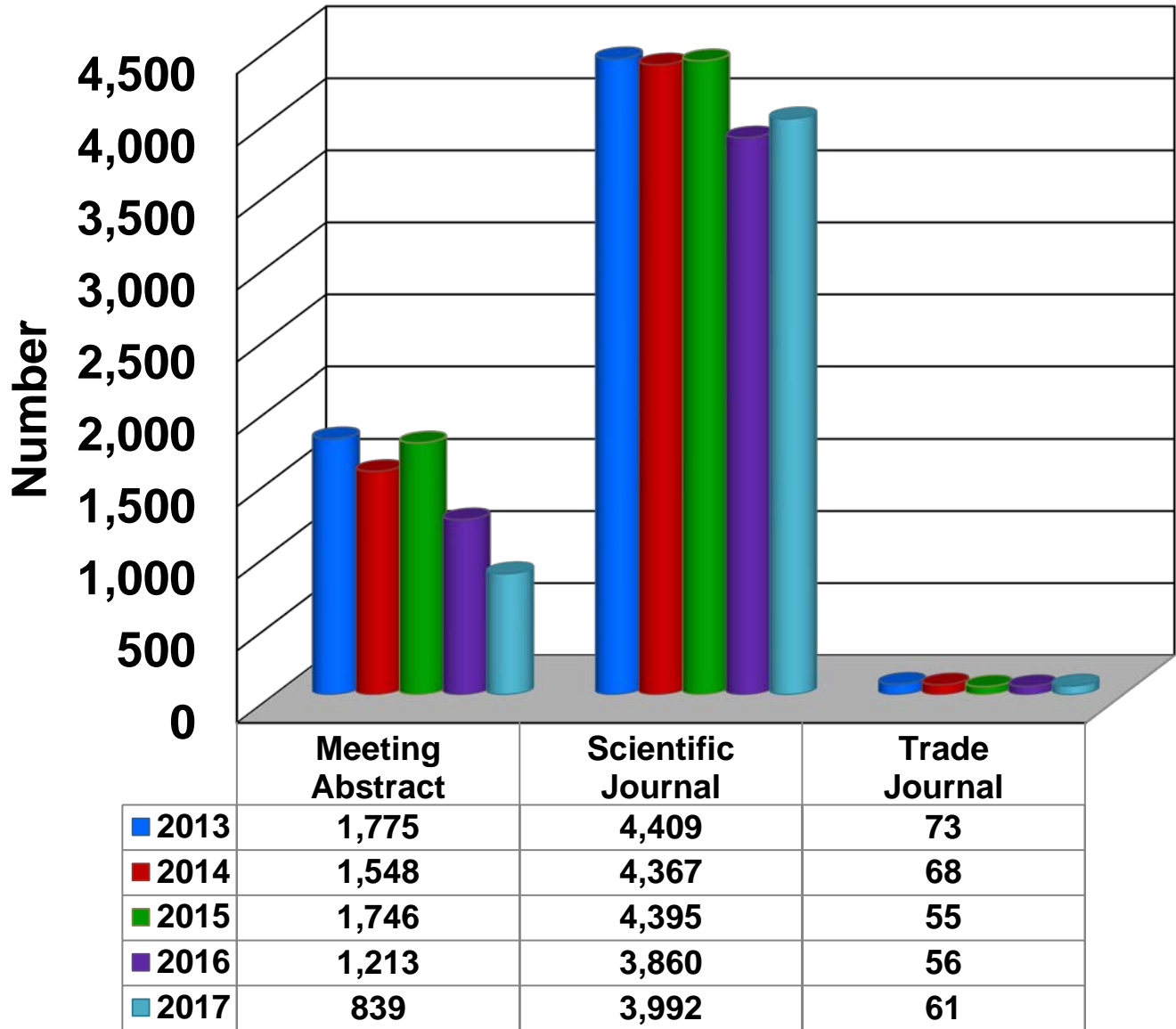


Figure 9. Number of publications per year.



4.0. Economic Research Service (ERS)

<http://www.ers.usda.gov/>

4.1. Mission Statement

ERS's mission is to conduct economic research and develop data and statistics that inform public program and policy decisions related to agriculture, food, the environment, and rural development.

4.2. Nature and Structure of Research Program

ERS follows the general USDA definition of technology transfer as the adoption of research outcomes for public benefit and, to that end, conducts relevant and objective economic research and policy analyses that inform program and policy decisions. ERS designs its research to demonstrate the consequences of taking alternative policy or programmatic pathways. The agency's data and market analysis program provides crucial market and trade outlook information to help farmers and agricultural companies run successful businesses and support jobs.

ERS is the primary source of statistical indicators that, among other things, gauge the health of the farm sector (including farm income estimates and projections), assess the current and expected performance of the agricultural sector (including trade), and provide measures of food insecurity in the United States and abroad. ERS is one of 13 officially designated (by the Office of Management and Budget) Federal Statistical Agencies.

ERS disseminates its research findings, market information, and statistical indicators in a variety of outlets including:

- Its website (www.ers.usda.gov);
- Its online magazine, *Amber Waves*;
- Outlook reports for specific commodity sectors
- [Research and information reports](#);
- [Data products](#), in a variety of forms/formats to suit users' needs; and
- [Refereed journal articles](#), which ensure the professional credibility of findings.

ERS is located in Washington, DC, and has about 225 Federal researchers working on economic and related social science research. Additionally, ERS seeks out academic and private-sector collaborators through contracting and cooperative agreements to leverage external expertise to complement the knowledge of our intramural research staff.

4.3. Current Technology Transfer Goals, Objectives, and Measures of Success (Metrics)

ERS uses a web-centric approach to communication with customers in order to convey clear, objective, and transparent research, data, and analysis to decisionmakers, policy officials, industry, non-governmental organizations, and the general public. All ERS research, data, and other information disseminated by the agency are available through the ERS website.

ERS measures success of the ERS website and its products and services using a variety of web analytics tools and sources to assess performance, quality, reach, relevance, and impact (Adobe Analytics, Google

Digital Analytics Program, Site Improve, Search, Constant Contact, and the Foresee American Customer Satisfaction Index/ACSI survey). The ACSI tracks satisfaction of website users and provides a basis for comparison with similar Government and private-sector websites. The target for this measure is at or above the average rating for Government websites in the Information/News category.

4.4. Strengthening Current Activities

ERS continues to enhance and update its website. Following a recent upgrade, the site is faster and features more intuitive navigation for customers to enhance information delivery. ERS has added features to enhance functionality for mobile users.

4.5. ERS response to Presidential Memorandum on Accelerating Technology Transfer and Commercialization of Federal Research in Support of High-Growth Businesses

In the USDA's implementation plan for the Presidential Memorandum, ERS described an initiative to promote technology transfer and commercialization. The initiative and its implementation in FY 2017 are described below.

USDA 29: ERS is making wider use of social media and new technologies (such as mobile readiness) to widen and expand the reach of our information services to the general public.

ERS's wider use of social media and new technologies (such as mobile-responsiveness and Open Data methodologies) widen and expand the reach of our information services to the general public. ERS has been a leading innovator in support of Open Data initiatives, providing a wealth of products—including data and information—designed to enhance mission delivery. In FY 2017, ERS used several new tools designed to help consumers more easily access critical programs and stimulate further innovation:

- **ERS's Twitter feed** continues to expand the audience for ERS information, growing to nearly 27,000 followers in fiscal 2017—up from 24,000 followers in 2016 and 22,000 in 2015. See https://twitter.com/usda_ers
- ERS also posts highlights synthesizing agency research to **USDA's Facebook and blogs**.
Responsive, Device-Agnostic Design: ERS optimized its website for mobile users, providing fast, mobile-friendly pages that automatically adapt to the user's computer, tablet, and smartphone—without having to pinch or expand—ensuring the website is available anywhere, anytime, from any device. This method also provides internal efficiencies in design/production (versus developing multiple style sheets for individual devices/platforms).
- **Data Visualizations**: ERS continued to offer data visualizations via interactive charts, maps, and graphs to more effectively deliver data in ways that are more meaningful, useful, and easier for customers to use.
- ERS also continued to provide daily **Charts of Note**, with easily digestible research highlights, sent by email to subscribers and posted to the website. ERS updated **Ag and Food Statistics: Charting the Essentials** quarterly, providing the basics of food, farming, and rural America via a series of

charts and maps covering key information about the farm and food sectors, including agricultural markets and trade, farm income, food prices and consumption, food security, rural economies, and the interaction of agriculture and natural resources.

- **Web content APIs** (Application Programming Interface), offering digital professionals dynamic access to and a machine-readable option for accessing publications, charts, and other website content. ERS also provides programming tools (“widgets,” pre-built off the APIs) that enable digital professionals to easily embed charts from the ERS webpage (such as the popular daily Charts of Note) into their websites/projects.
- **APIs for select data and geospatial/mapping applications**, enabling researchers and developers to build applications using ERS data and processes for additional insights.
- **Open Source**, making it easier to share data, improve tools and services, and return value. The [ERS GitHub](#) provides code-sharing and user notification of updates/changes (internally and externally).

The new products and tools/services extend and expand access to ERS research findings, market outlook, and data—making the Agency’s information more readily available to and more easily consumable by the general public. These items enable USDA to meet its Digital Government Strategy goals to ensure high-value services and systems are available anywhere, any time, and on any device.

USDA 30: ERS is exploring new methods for evaluating economic impacts of research collaboration and partnerships between public agricultural research institutions and the private sector.

ERS has developed metrics to quantify the impact of its economic social science research and analysis, including measurement of briefings for senior policy officials, citations of ERS research in Government policy and decision-making documents, technical citations in the scientific literature, media citations, and customer use of information published on the ERS website. These metrics are updated annually and are now a standard component of ERS budget and accomplishments reporting.

4.6. Downstream Outcomes

- ERS has developed a unique database from a survey on food purchases and acquisitions by U.S. households – USDA’s National Household Food Acquisition and Purchase Survey [FoodAPS](#). Originally, to protect individual survey respondents’ privacy, access to the data had been restricted to researchers from academic institutions and government agencies. Now, a public version of FoodAPS masks identities of survey respondents to enable access by all interested parties to the valuable data for research and planning. FoodAPS is designed to fill a critical knowledge gap in support of evidence-based approach to Federal food assistance policies and programs. The data are being used to address a range of questions such as where households acquire food in a typical week, which foods they acquire, how much they pay for the food and how the acquired foods match recommendations for a healthy diet.
- Policymakers and the public are provided with easily accessible data on rural areas and issues through the ERS *Atlas of Rural and Small-town America* (<http://www.ers.usda.gov/data->

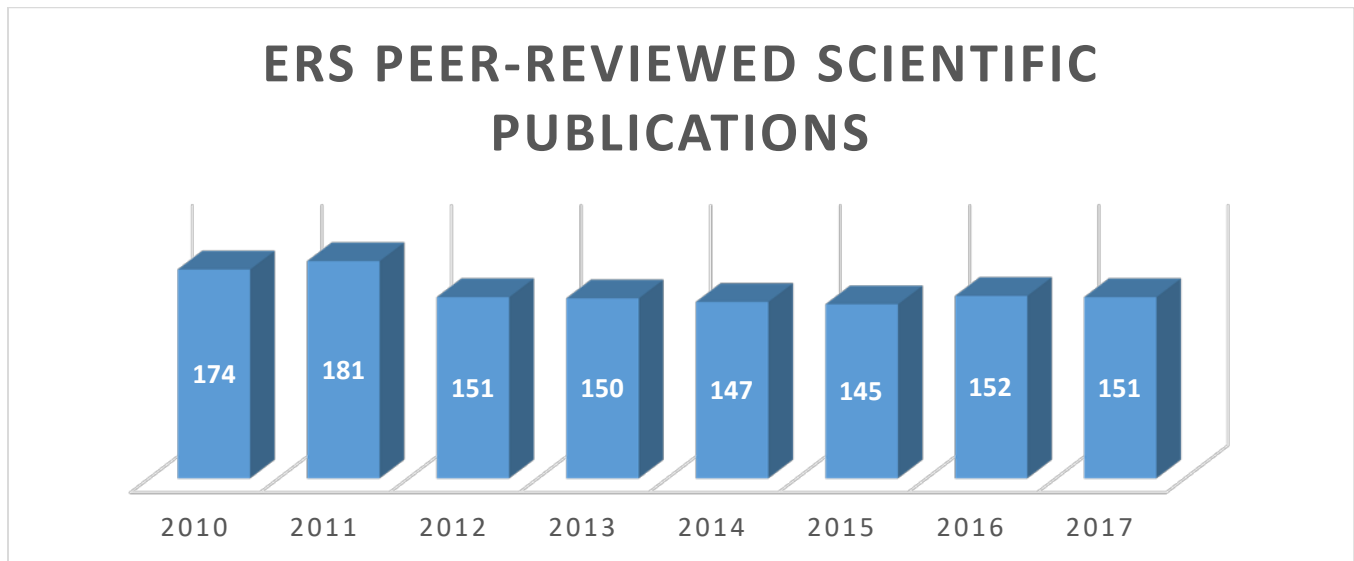
products/atlas-of-rural-and-small-town-america.aspx). The online mapping tool provides county-level information on over 110 statistical indicators on the people, jobs, agriculture, and county characteristics of rural (nonmetropolitan) America. The Atlas helps State and local decision makers pinpoint the needs of particular areas, recognize their diversity, and develop strategies to build on their assets by using location-based data on population, age structure, race and ethnicity, income, employment, indicators of well-being, and other measures. In fiscal 2017, the Atlas was updated with the most recent information on veterans, education, migration, and income from the American Community Survey.

- Local officials throughout the country can easily gauge the characteristics of their food environment and target actions that alleviate problems with the availability of healthy food options for the people in their counties or State using the ERS Food Environment Atlas (<http://www.ers.usda.gov/data-products/food-environment-atlas.aspx>). The Atlas includes over 275 indicators of the food environments in U.S. counties and States – from the number of fast food outlets per capita, to average food prices for various products, and the rate of obesity. Because ERS determined the location and derived the characteristics of neighborhoods that lack access to sources of healthy and affordable food, national, State and local governments can target food access investments so that people with low access will have better choices and better access to healthy, affordable food.
- ERS continued to expand the use of webinars to more directly connect to customers at the time of release of new research and data. As part of the *ERS Insights* Webinar Series, ERS presented 11 webinars in FY 2017 on topics including farm income, rural America, and food security. These webinars both inform ERS audiences about complex topics in an easy-to-understand format and also allow participants to ask questions to ERS economic experts. Audiences typically include media,

agricultural policy staff, agricultural and financial industry analysts, interest groups, nonprofits, and academia. On average, about 100 people participate in each of these webinars. ERS records, close-captions, and transcribes each webinar and posts them on the website for those who want to view them later.

4.7. Publications

The results of ERS research are freely available on the agency website, provided in a variety of forms and formats. In fiscal 2017, ERS produced 151 peer-reviewed research reports and Outlook reports (see publications at <https://www.ers.usda.gov/publications/>).



5.0. Foreign Agricultural Service (FAS)

<http://www.fas.usda.gov/>

5.1. Mission Statement

FAS links U.S. agriculture to the world to enhance export opportunities and global food security.

5.2. Nature and Structure of Program

FAS Washington, D.C., staff and a global network of 93 offices with Foreign Service Officers and locally engaged staff cover 171 countries. FAS supports U.S. foreign policy, identifies problems, provides practical solutions, and works to advance global food security and opportunities for U.S. agriculture. Within USDA, FAS serves as the principle coordinator of international activities, drawing on the broad expertise of USDA and U.S. agricultural organizations. While FAS does not operate a laboratory, conduct research, or license technologies, FAS supports the adoption of USDA innovations for the public benefit.

Trade Policy

FAS expands and maintains access to foreign markets for U.S. agricultural products by providing expertise in international trade policy negotiations and enforcement, and in working to reduce or eliminate technical barriers to trade and sanitary and phytosanitary trade restrictions. FAS works closely with other USDA agencies, Federal and State governments, the U.S. agricultural industry, foreign governments, and international organizations to help ensure a level playing field for U.S. agricultural products in the international marketplace.

Market Development and Export Assistance

FAS partners with more than 75 cooperator groups, representing a cross-section of the U.S. food and agricultural industry, and manages a toolkit of market development programs to help U.S. exporters develop and maintain markets for hundreds of U.S. products. FAS also supports U.S. agricultural exporters through export credit guarantee programs and other types of assistance.

Data and Analysis

FAS's network of global contacts and long-standing relationships with international groups contribute to the agency's unique market intelligence capacity for all major agricultural commodities. FAS collects data and its analysts generate objective intelligence on foreign market opportunities, prepare agricultural production forecasts, assess marketing opportunities for U.S. exports, and monitor changes in policies affecting U.S. agricultural exports and imports.

Capacity Building and Development

FAS leads USDA's efforts to help developing countries and emerging market economies improve their agricultural systems and build their agricultural trade capacities. FAS administers international fellowships and other agricultural science and trade technical assistance, including non-emergency food assistance programs to help meet recipients' nutritional needs and support agricultural development and education.

5.3. Downstream Outcomes

The following summaries illustrate how FAS international trade and capacity building programs supported U.S. technology transfers.

Technical Assistance for Specialty Crops

The Technical Assistance for Specialty Crops Program (TASC) invested in the development and transfer of innovative USDA post-harvest irradiation phytosanitary treatments for U.S. specialty crops, like fruits, tree nuts, vegetables, and greenhouse and nursery crops. In 2017, TASC funded USDA Agricultural Research Service (ARS)-Hawaii to continue working on a project to develop and transfer such irradiation phytosanitary treatments. Their project involves collaborations with grower groups, exporters, the irradiation industry, and relevant university research groups, resulting in treatment protocols for spotted wing drosophila, light brown apple moth, and European grapevine moth and new information on the radiation-tolerance levels of several invasive ants. ARS-Hawaii also received a TASC grant in 2015 to work on the development and testing of a low-cost cabinet X-ray tube machine for phytosanitary irradiation treatments of sweet cherries. The final designs for a packing line scale X-ray tube machine were developed in collaboration with Applied Energy Devices, LLC, (Albuquerque, NM), and a prototype was tested for dose uniformity, dose rate, and treatment efficiency. Once foreign approvals are finalized, the X-ray tube machine will be used to irradiate sweet cherries for export. These TASC investments in ARS research were critical in helping U.S. exporters preserve a \$12 billion annual market for U.S. exports of specialty crops. By collaborating with sister USDA agencies, U.S. universities, and specialty crops industries to develop and commercialize post-harvest phytosanitary irradiation treatments, TASC directly helped to promote the transfer and

commercialization of these new technologies and, overall, expand the variety, quantity and value of U.S. specialty crops for export markets. With TASC's support, the development, transfer, application, and commercial value of irradiation phytosanitary treatments are expected to continue increasing over the coming years.

Norman E. Borlaug International Agricultural Science and Technology Fellowship Program

In FY 2017, the Borlaug International Agricultural Science and Technology Fellowship Program (Borlaug) supported 49 Fellows to help transfer agricultural science and new U.S. technologies to developing countries. Since the Program's inception in 2004, Borlaug provided training to more than 800 Fellows from 69 countries. Many of these Fellows and their U.S. mentors maintain ongoing relationships to promote the adoption or commercialization of U.S. technologies in their respective countries. For example, Borlaug alumni in Turkey, who completed their Fellowships at Michigan State University and Virginia Polytechnic University, recently played key roles in establishing the International Food Biotechnology and Biosafety Research and Extension Center at Hacettepe University, while additional Borlaug alumni drafted technical guidelines for genetically engineered (GE) crops and four "white papers" about GE crops for the Turkish Ministry of Food Agriculture and Livestock. Their ongoing efforts are laying critical groundwork for Turkey's acceptance of agricultural biotechnology. At the University of Georgia (UGA) last year, a Malawian Fellow focused on techniques to detect and minimize aflatoxin in processed peanuts, a major food safety challenge in Malawi. In consultation with UGA's Peanut and Mycotoxin Innovation Lab, the Fellow augmented his research by investigating potential applications of hermetically sealed Purdue Improved Crop Storage (PICS) bags to curtail insect damage, mold growth, and aflatoxin contamination in harvested peanuts. A series of long-term experiments was initiated by the Fellow and UGA collaborators to further clarify

how PICS technology could be applied to protect peanuts and consumers in Malawi and throughout the world. In Thailand, a recent Borlaug Fellow applied her research to help the Ministry of Agriculture and Cooperatives, National Bureau of Agricultural Commodity and Food Standards (ACFS) construct and adopt an analytical tool that standardizes and speeds up the dietary risk assessment process to estimate pesticide dietary exposure, establish pesticide maximum residue levels (MRLs), and register new pesticides. This new analytical tool has reduced the typical registration timeline of new pesticides from 4 months to 1 month and, overall, strengthens Thailand's capacities to ensure food safety and participate in international agricultural trade. These exemplary Fellows, their U.S. mentors, and other Borlaug participants are continuing to learn, disseminate, and apply U.S. technologies to improve agricultural sciences, trade, and food security throughout the world.

Food for Progress Program

Recent developments from USDA Food for Progress Program (FFPr) activities in Ghana (FY 2015), El Salvador (FY 2014), and Honduras (FY 2012) illustrate how the program is supporting transfers of transformative technologies from the United States to partner countries.

Ghana

In collaboration with the American Soybean Association's Assisting Management in the Poultry and Layer Industries by Feed Improvement and Efficiency Strategies (AMPLIFIES) project, FFPr supported the transfer of grain moisture meters to Ghana. Researchers at the USDA/ARS Center for Grain and Animal Health Research in Manhattan, Kansas, initially designed the meters and, through AMPLIFIES, assisted scientists at Ghana's Kwame Nkrumah University of Science and Technology (KNUST) to

establish a laboratory for assembling and testing the meters in Ghana. The Ghana Standards Authority approved the meter and by November, 2017, the KNUST team had produced and delivered at least 50 of the meters to the Ghanaian Grains Council, the AMPLIFIES project, and other local customers to demonstrate. Looking ahead, plans are underway for a Ghanaian entrepreneur to launch a new local business to manufacture and sell these low-cost meters throughout Ghana, where they will help farmers, grain storage operators, and others to reduce post-harvest losses and, overall, improve the management, quality, and value of their grain.

El Salvador

In collaboration with the National Cooperative Business Association's Coffee Rehabilitation and Agricultural Diversification project, FFPr has engaged relevant government agencies, numerous local organizations and private businesses, and over 7,500 coffee producers to support the introduction and dissemination of rust-resistant coffee varieties across El Salvador. The project is largely a response to the 2012 outbreak of coffee rust disease, which quickly destroyed 70 percent of El Salvador's coffee acreage. With the new rust-resistant varieties, developed in part by World Coffee Research (College Station, Texas), and the project's concomitant investments in training and small equipment, USDA and its partners demonstrated how coffee orchards can be affordably rehabilitated and maintained by local cooperatives in El Salvador. Using the project's model and new technologies, participating coffee producers reduced their costs to rehabilitate orchards by approximately 80 percent, and their first harvests of rust-resistant coffee are anticipated following the 2017-2018 growing season.

Honduras

In collaboration with TechnoServe's Sustainable Agricultural Improvement project, FFPr engaged scientists from Michigan State University (MSU), the Honduras Ministry of Agriculture, and the Food and Agriculture Organization of the United Nations to develop, transfer and scale-up production of three improved varieties of common beans. Their effort began with the selection and development of biofortified bean varieties that were well adapted to local growing conditions and were high-yielding in Honduras. The partners then trained 133 local seed producers to begin growing and marketing certified seeds of the new bean varieties throughout Honduras. To date, at least 4,100 Honduran farmers were growing the certified biofortified seeds, and their yields have increased by approximately 54 percent above average bean yields in Honduras.

IR4 Project and Global Partnership for Pesticide Standards

Residue data for establishing pesticide maximum residue levels (MRLs) and Codex Alimentarius food safety standards for fruits and vegetables are mostly generated in the United States and other industrialized nations. Therefore, many tropical crops grown in developing countries lack MRLs, and accordingly, exporters of those products face international trade barriers due to residue violations in destination markets. To help address this problem, FAS is leading a Global Residue Project to strengthen the infrastructure and process to establish MRLs for potential export crops commonly grown in developing countries. The Project is currently working with stakeholders in 20 partner countries in Africa, Asia, and the Western Hemisphere, where national research teams collaborate on joint residue trials, which are based on study protocols and technology models developed by the USDA-funded IR4 Project. In 2017, FAS and the IR-4 Project hosted the third Global Minor Use Summit to review progress, identify additional joint projects and opportunities to expand partnerships, and continue disseminating knowledge and information about safe crop protection. By transferring these policy

concepts and technical skills to foreign partners, the Global Partnership for Pesticide Standards has continued complementing the IR-4 Project by supplementing U.S.-generated data and, in some cases, completely shifting the field trial responsibilities for generating pesticide data to partner countries. In addition to economizing U.S. resources for development and commercialization of pesticides, the Global Partnership continued to promote common standards among the U.S. and foreign agricultural trading partners and, overall, provide modern pest control tools that may be safely used by growers worldwide.

Aflatoxin-Reducing Technologies in Africa.

FAS continued to facilitate vital linkages among the U.S. developers of an aflatoxin-reducing technology. This technology, registered as Aflasafe in Africa by the International Institute of Tropical Agriculture (IITA), is a microbial biological control agent that reduces aflatoxin levels in susceptible crops by inducing native, non-toxin-producing strains of *Aspergillus flavus* fungus that outcompete the toxin-producing strains. Developed by USDA-ARS in collaboration with University of Arizona scientists, Aflasafe was introduced to Africa through a partnership with IITA, where treatments reduce aflatoxin levels by 80 to 99 percent in the harvested product (e.g., maize, groundnut) compared with untreated crops. In FY 2017, Aflasafe products were formally approved for registration in Senegal, The Gambia, and Burkina Faso. Similar products are registered in Kenya and Nigeria and are nearing registration in other African countries. With robust education and marketing, Aflasafe has potential to improve the safety of staple foods consumed by over 126 million people in Africa and, likewise, help African farmers who adopt Aflasafe increase their trade profitability through better compliance with aflatoxin residue trade standards.

6.0. Forest Service (FS)

<http://www.fs.fed.us/>

The USDA, Forest Service Research and Development (FS R&D) is the world's largest forestry research organization. FS R&D conducts ecological and social science research to understand ecosystems, how humans influence those systems, and how to manage for sustained and enhanced benefits.

6.1. Understanding:

Technology Transfer (science delivery) - The application of scientific knowledge for practical purposes.

Technology is also an application of science to solve a problem.

The transfer of new technology from the originator to a secondary user. It is the process of transferring (disseminating) [technology](#) from the places and [in-groups](#) of its origination to wider distribution among more people and places.

R & D - Systematic activity combining both basic and applied research, and aimed at discovering solutions to problems or creating new goods and knowledge.

6.2. Mission Statement

The overall mission of the FS is to “sustain the health, diversity, and productivity of the nation’s forests and grasslands to meet the needs of present and future generations.” Established in 1905, FS is an agency of the U.S. Department of Agriculture (USDA) that directly manages 193 million acres of public land in national forests and grasslands and works with State forestry agencies and other partners to assist in managing 491 million acres of State and private forest lands. **FS is the only land management**

agency in USDA. Gifford Pinchot, the first Chief of the Forest Service, summed up the mission of the Forest Service —“to provide the greatest amount of good for the greatest amount of people in the long run.” FS is composed of four areas: National Forest System (NFS), Research and Development (R&D), State and Private Forestry (S&PF), and Business Operations.

The mission of the FS R&D is to conduct innovative and seminal research that provides sound science, innovative technologies, and practical applications to improve the health and productivity of our Nation’s forest and grasslands, inform natural resources policy and land management decisions, and anticipate emerging natural resource issues. R&D provides this information to landowners, managers, policymakers, and the American people to help inform their decisions and actions.

6.3. Nature and Structure of Research Program

The FS R&D mission area develops and delivers high-quality scientific information, applications, and technology needed by public and private land managers to manage, protect, use, and sustain the natural resources of forests and rangelands. The outcomes of our research include: community protection; multiple environmental and social benefits, such as clean air and clean and abundant water; a great array of recreational opportunities; and a wide range of ecosystem services. Research is conducted by more than 550 scientists and several hundred technical and support staff located at 67 sites across the United States. This structure provides sites for long-term science and management studies of major vegetation types found across the United States. The FS R&D organization includes five research stations (Northern, Pacific Northwest, Pacific Southwest, Rocky Mountain, and Southern), the Forest Products Laboratory, the International Institute of Tropical Forestry in Puerto Rico. There are also two

Technology and Development Centers run by NFS located in Missoula, Montana and San Dimas, California.



The research program is organized into seven Strategic Program Areas: wildland fire and fuels; resource management and use; wildlife and fish; recreation; water, air, and soil; inventory and monitoring; and invasive species. Special emphasis areas are: adaptation to climate change, biomass to energy, watershed restoration, urban natural resource stewardship, and nanotechnology.

Forest Service R&D maintains a vital network of 81 Experimental Forests and Ranges, 29 of which were established in the 1930s. Long-term records from some of these forests can provide unprecedented insights into global climate change, watershed function, disturbance recovery, and many other areas. Major research themes include: developing systems for management and restoration of forests, range lands, and watersheds; investigating forest and stream ecosystems; characterizing plant and animal communities; and observing and interpreting long-term environmental change.



6.4. Role of the National Program Leaders

National Program Leaders (NPL) are advocates for R&D programs and effectively articulate, lead, and promote coordinated national research programs, assisting Forest Service R&D in developing and communicating nationally relevant research priorities, direction, results, and outcomes.

The Washington Office of Research and Development (WO-R&D) serves the Forest Service and R&D-specific missions, advancing and building support for the work of R&D and recognition of the public value that work creates. An important aspect of this is the development and representation of national research programs. Examples of national program needs include: leveraging research and research funding from other Federal agencies (typically in interagency working groups); reporting and promoting R&D to Forest Service leadership and the Department, other agencies, and Congressional staff; fostering cross-station communication and collaboration among scientists; and developing working relationships with national-level nonprofit organizations and professional and technical associations. While National

Program Leaders (NPLs) do not have budgetary or supervisory authority over Station programs and scientists, they coordinate national and Station elements of their research areas and ideally, work with other NPLs and Station leadership and scientists to develop Station research priorities and programs that effectively address national issues as well as local and regional ones. In some cases, NPL's also distribute WO funds to Station scientists and coordinate research inputs and grant programs in accordance with specific WO projects of national scope.

6.5. Current Technology Transfer Goals, Objectives, and Measures of Success (Metrics)

The FS uses many means of technology transfer, including marketing efforts at tradeshow and with universities, patents, webinars, workshops, social media posts, conservation education and citizen science, public outreach, and publications. Many metrics associated with these efforts are currently being tracked, and FS plans to track new metrics such as social media, web hits, and citation indexes within the next 5 years.

The principal contact for technology transfer via intellectual property agreements, patents, and licensing within the FS is the Technology Transfer Coordinator (TTC) who reports to the Washington Office (WO) and is located at the WO and Baltimore field office. The FS Patent Program receives and tracks all invention disclosures, providing guidance to scientists regarding all aspects of intellectual property protection. The goal of the FS patent program is to file provisional patent applications and work with the scientist to find a CRADA partner prior to filing a utility patent. This process includes working with the USDA SBIR program. The Patent Program conducts prior art searches and prepares FS invention disclosures for review by the FS Patent Review Committee (PRC) when needed. The Patent Program also oversees contract law firms that draft utility patent applications (provisional applications are filed

by USDA, Office General Counsel [OGC]), and files and prosecutes applications in the U.S. Patent and Trademark Office. Draft patent licenses are prepared by the FS Patent Program and signed by ARS OTT. FS commercial licenses are royalty based only with a priority toward making the technology available to FS. CRADAs and other technology transfer agreements for the FS are handled by the FS Grants and Agreements Specialists in conjunction with the FS TTC, with patent marketing responsibilities falling to the FS Patent Program. The Forest Service Patent Program is changing the emphasis from utility patent filing to provisional application filing and seeking a development partner and/or extensive marketing prior to a decision to file the utility patent. Reducing the technology to practice under a CRADA greatly increases the opportunity for successful development. If a partner or a successful market plan (this could involve procurement for FS use) cannot be developed, the technology will be published and placed in the public domain. The Forest Service Patent Programs goal is the broadest dissemination of scientific outcomes, and the Patent Program desires to support, not encumber/delay, such dissemination.

6.6. FOREST PRODUCTS LABORATORY (FPL) – Madison, Wisconsin



Mission – To promote healthy forest and forest-based economies through the efficient, sustainable use of our wood resources. The long-term health of our Nation’s forest depends on sound conservation practices, including utilization. Since 1910, the FPL has used science and technology to conserve and extend our Nation’s forests resources. Many everyday products and processes have been improved through FPL research, such as building products (structural and composite), housing, paper, bridges, adhesives, packaging, recycling, biofuels, and wood preservatives, to name a few. Historically, FPL contributed to great improvements in areas such as wood finishes, sawing and drying techniques, prefabricated housing, lumber grading, and many more.

Forest Products Laboratory Research Priorities 2017:

- 1. Advanced Structures:** New technologies referred to as mass timbers provide the means to engineer taller wood buildings and enable much faster assembly of multi-story buildings.
- 2. Nanotechnology:** Woody cell walls can be disassembled into fundamental nano-scale particles that have applications as varied as oil well drilling fluids, barrier films, high-performance composites, and improving cement.
- 3. Forest Biorefinery/Woody Biomass Utilization:** Particle boards, wood pulp, cellulose nanomaterials, and biorefinery are commonly produced from smaller diameter wood and, in some cases, slash and other wood wastes. Increasing the market for smaller diameter trees will increase value sufficiently to pay all logging and transportation costs and increase the rate at which overgrown forests can be treated.

4. **Advanced Composites:** New products like wood-plastic composites and potential products like cellulose nanomaterial-reinforced composites provide new lightweight materials for applications as varied as deck boards, light-weight vehicle parts, and light-weight armor.

Research in Progress:

Development of a Ready-to-Assemble (RTA) Tornado Safe Room Constructed from Cross-Laminated Timber

The growth of the cross-laminated timber (CLT) panel market has made available manufactured wood panels that are ideal for tornado safe rooms and shelters. The thick cross-section of the laminated panels are well suited to resist wind and impact loads produced by tornados (Fig. 1).

Background

The development of a standardized safe room using CLT that is ready to assemble, easy to ship, and quick to fabricate onsite would not only increase the level of safety for our population but also increase the market opportunity for these engineered wood products. This research is an extension of research by the USDA, Forest Service, Forest Products Laboratory, to develop a do-it-yourself safe room constructed from wood that can be incorporated into existing housing and that utilizes commodity wood products.

Approach

CLT panels obtained from a cooperating CLT manufacturer will be tested for impact and wind load resistance. These initial tests will confirm optimal panel thickness and layup configuration. Panels 8 by 8 feet in size will be tested because this size matches existing panel manufacturing capacity. These tests will follow the protocol of International Code Council (ICC-500) and the test setup used by Falk et al. (2015).

A panel connection system is being developed and tested that is similar in design (albeit much more heavy duty) to that used in the furniture industry. These doweled fasteners would be simple to install and allow the butting of panels with little field modification. Full-size lateral load tests will be performed on an assembled safe room (8 by 8 by 8 feet in size) to verify the integrity of the developed connection system and lateral wind pressure resistance of the shelters.

Expected Outcomes

A workable RTA safe room constructed from CLT will be verified to resist the forces of an EF-5 tornado and the requirements of the ICC-500 design standard.

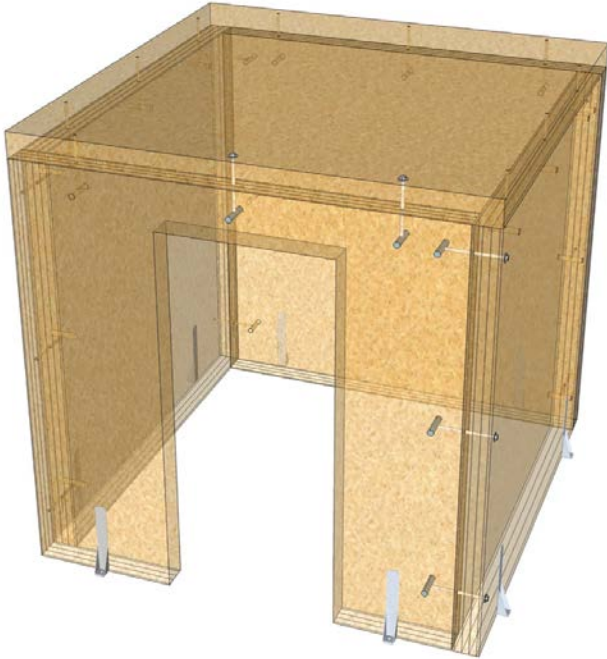


Figure 1. Proposed 8 by 8 ft cross-laminated timber (CLT) ready-to-assemble safe room.

Builder's Guide to Energy-Efficient and Durable Wood-Frame Walls

High-R walls continue to remain an underutilized technology, even among more advanced builders. Results of the Home Innovation Annual Builder Practices Survey showed that in 2013 only 6 percent of homes used 2 by 6 at 24-in. on center framing and only 10 percent of homes used exterior rigid foam over wood structural panels. Yet new model energy conservation codes and various State/local energy and green programs encourage, often mandate, increases in energy efficiency; so builders need practical and actionable construction solutions to help with transitioning to high-R wall systems. General approaches to increasing R-value in walls are available, but their practical implementation is limited by lack of specific details and by concerns over long-term moisture performance and hazard resistance.

Objective

The objective of this project is to develop a Builder's Guide to support and accelerate wider adoption of energy-efficient wall systems in residential construction by providing builders with practical solutions to construction of high-performance walls that (1) can be readily implemented in the field using available methods and materials and (2) can withstand the test of time from environmental and structural loads.

Expected Outcomes

The first installment of the Builder's Guide will focus on two primary wall systems: (1) 2 by 6 walls with optimized framing and (2) 2 by 4 walls with up to 1.5 in. exterior foam insulation, each focusing on aspects most relevant to the transition to high-performance homes. Builders and designers are the primary expected audience searching for standardized solutions to energy-efficient construction. These two wall systems are selected because they represent mainstream energy-efficient options that use standard materials, require a minimal learning curve, are adaptable to system solutions, and contain construction cost implications.

The scope of the Builder's Guide will include all key performance and construction features applicable to transitioning to high-R walls, including (1) optimized framing, including new solutions such as rim headers; (2) cavity insulation; (3) exterior insulation; (4) air sealing; (5) moisture characteristics; (6) cladding attachments; (7) window and door installation; (8) detailing; and (9) whole-house considerations. The developed solutions will be primarily applicable to Climate Zones 3–5.



2×6 wall framing package.

Effect of Multiple Knots in Close Proximity on Southern Pine Lumber Properties

Knots derive from tree branches. When boards are sawn from a log, the sawblade cuts through cross sections of ingrown branches, leaving round, dark-colored masses called knots (Fig. 1). Because the grain of a knot runs more or less perpendicular to the length of a board, it weakens the board, similar to how a hole at that location might weaken the board. Although multiple knots in close proximity are known to weaken lumber performance even further, lumber grading rules used to assess knot groupings in southern pine are somewhat qualitative and subjective.

Background

The southeastern quadrant of the United States includes hundreds of millions of acres of southern yellow pine forest populated with trees worth billions of dollars. Some forest management practices (for example, how trees are spaced or thinned) lead to the development of multiple knots in close proximity when trees are sawn into lumber. From 2010 to 2012, design values (minimum strength values allowed for engineering purposes) of southern yellow pine lumber were reduced, which reduced the utility value of southern pine lumber materials. A better understanding of how knot groupings contribute to reduction of strength properties in boards would allow both lumber manufacturers and silviculturists to better manage and mitigate those effects. This program represents a significant economic opportunity for southern pine producers.

Objective

The objective of this research is to investigate and quantify the effect that different kinds of knot groupings have on strength and stiffness properties of southern pine lumber. Over the long term, this study may also be used to improve lumber valuation practices and overall design performance.

Expected Outcomes

This investigation is expected to reveal what kind of knot patterns affect strength, stiffness, and ultimate performance of southern yellow pine lumber the most. Once these patterns have been identified and classified, results will be shared with grading rule writing agencies, which could lead to the improvement of specific grading-rule writing agencies or valuation techniques. From this work, it will be possible to work with foresters to modify silvicultural practices to reduce the occurrence of knots in

close proximity. The end results could shore up the future value of southern pine materials for the benefit of lumber manufacturers and landowners.



Figure 1. Multiple knots in close proximity found in southern yellow pine lumber.

Blast-Resistant Testing for Loaded Mass Timber Structures

Based on live blast testing done with 2015 Wood Innovations Grant funding, FPL knows that cross-laminated timber (CLT) can compete with light gauge metal, prestressed precast concrete panels, and masonry. However, testing previously completed was on structures carrying only their own weight. This project will provide necessary test data to characterize the response of CLT structures with superimposed dead/live loads under blast loading, establishing the inelastic and ultimate response limits, while also providing documentation needed for design guidance offering an alternative to concrete and steel in military structures.

Objective

The objectives of this project are to develop a design methodology and to demonstrate performance for exterior bearing CLT walls used in buildings subject to force protection requirements. This methodology should be published by U.S. Army Corp of Engineers – Protective Design Center to be used by engineers for designing CLT elements to withstand blast loads as determined by code requirements and specific project conditions.

Expected Outcomes

The outcomes of the quasi-static testing will include

- establishing a resistance function to compare to the resistance function created from previous testing without axial load,
- potentially quantifying residual capacity after bending failure, and
- determining if a ductile failure mode exists when inducing a compression failure in the outer lamination.

Live blast testing outcomes will include

- proving the efficacy of CLT technology in real blast-resistant applications and
- establishing a basis for the design methods recommended for use.



Load tree testing of cross-laminated timber (CLT) panels at Tyndall Air Force Base.



Temporary moisture protection added to cross-laminated timber (CLT) blast testing structures.

6.7. Forest Service Decision Support Tools and Data:

A decision support tool (decision support system (DSS)) is a computer-based [information system](#) that supports business or organizational [decision-making](#) activities. Decision support tools serve the management, operations, and planning levels of an organization (usually mid and higher management) and help people make decisions about problems that may be rapidly changing and not easily specified in advance—i.e., unstructured and semi-structured decision problems. Decision support systems can be either fully computerized, human-powered, or a combination of both. The framework of Decision Support Tools consists of four phases listed below and are developed from: Inputs, User knowledge and Expertise, Outputs, and Decisions:

- Intelligence
- Design
- Choice
- Implementation

Decision support tools are prevalent in [forest management](#) where the long planning horizon and the spatial dimension of planning problems demand specific requirements. All aspects of Forest management, from log transportation, harvest scheduling to sustainability and ecosystem protection have been addressed by modern decision support tools. In this context, the consideration of single or multiple management objectives related to the provision of goods and services that traded or non-traded are often subject to resource constraints and decision problems. The Community of Practice of Forest Management Decision Support Systems provides a large repository of knowledge about the construction and use of forest Decision Support Systems (Community of Practice Forest Management Decision Support Systems, <http://www.forestdss.org/>).

The Forest Service currently reports 92 decision support tools (13 primarily internal use) and 42 databases and maps. Some examples are:

i-Tree - The i-Tree suite of software tools was developed to help users—regardless of community size or technical capacity—identify, understand, and manage urban tree populations.

LANDIS Landscape Disturbance and Succession model - LANDIS is designed to model forest succession, disturbance (including fire, wind, harvesting, insects, global change), and seed dispersal across large (>1 million ha) landscapes.

[ROMI-3 - ROugh Mill simulator](#) - The ROMI 3 rough mill simulator allows users to examine many aspects of rip-first and chop-first processing, including: grade mix, arbor design, optimization, cutting bill, panels, moulding, and much more.

[Invasive Plants in Southern Forests App](#) - This app provides information on accurate identification of the 56 nonnative plants and groups that are currently invading the forests of the 13 Southern States. Recommendations for prevention and control of these species is provided.

[Forest Health Advisory System](#) - The Forest Health Advisory System highlights potential future activities of more than 40 major forest pests and pathogens across 1.2 billion acres of U.S. forestland.

[EFETAC Landcover Maps](#) - View details about landcover across the continental United States or even just in your neighborhood! Kurt Riitters, Eastern Threat Center landscape ecologist, has processed data from the 2001 National Landcover Database to show forest spatial patterns, forest density, and mixtures of land use.

[Aquatic and riparian state and transition models for the Blue Mountains of northeastern Oregon and the northern Oregon Coast Range](#) - These state and transition models simulate the effects of plant succession, natural disturbance, land use, and restoration practices on conditions of riparian forests, channel morphology, and salmon habitat.

[Forest Vegetation Simulator \(FVS\)](#) - Forest Vegetation Simulator (FVS) is a family of forest growth simulation models.

[Fuel Characteristic Classification System, Version 3.0](#) - The system predicts surface fire behavior including reaction intensity, flame length, and rate of spread; and surface fire behavior, crown fire, and available fuel potential using a 9-point index.

[First Order Fire Effects Model \(FOFEM\)](#) - FOFEM (a First Order Fire Effects Model) is a computer program for predicting tree mortality, fuel consumption, smoke production, and soil heating caused by prescribed fire or wildfire.

[FireFamilyPlus](#) - FireFamilyPlus is a software system used to summarize and analyze historical daily fire weather observations and to compute fire danger indices on the basis of the National Fire Danger Rating System (NFDRS) or the Canadian Fire Danger Rating System (CAN).

Data - Research Data Archives

This archive publishes and preserves short- and long-term research data collected from studies funded by: Forest Service Research and Development ([FS R&D](#)), Joint Fire Science Program ([JFSP](#)) and Aldo Leopold Wilderness Research Institute ([ALWRI](#)).

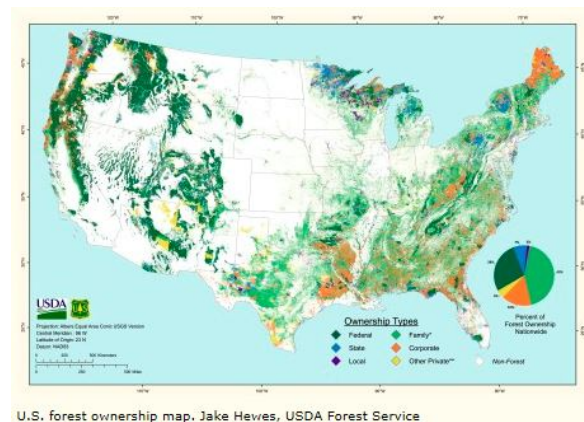
Of special interest, this collection includes data from a number of Forest Service Experimental Forests and Ranges. Each archived data set (i.e., “data publication”) contains at least one data set, complete metadata for the data set(s), and any other documentation the researcher deemed important to understanding the data set(s). The data catalog entries present the metadata and a link to the data. In some cases, the data link is to a different archive.

We encourage you to use our data publications! We just ask that you acknowledge the work of our researchers by using the citation provided with each data publication.

One of the sets of numbers reported is for data publications. There were 65 new data publications in FY 2017; customers accessing data publications rose 20 percent to 4,498. (Session traffic is more impressive: 17,615 customers came into the store; 26 percent more than in FY 2016.)

6.8. Who Owns the Forest?

Contrary to popular belief, nearly two-thirds of forests in the conterminous U.S. are privately, not publicly, owned. The distribution of ownership is 43 percent family, 28 percent Federal, 16 percent corporate, 7 percent State,



and 4 percent other private land (which includes Native American tribal ownerships). By showing the distribution of forest ownership, the [Forest Ownership Map of the Conterminous United States](#) developed by the [Northern Research Station](#) promotes the development of policies that support the conservation and wise management of public and private forests.

6.9. State & Private Forestry (S&PF)

Encompassing two thirds of America's forests, State and privately owned lands provide public benefits such as clean air, clean water, wildlife habitat, outdoor recreation, and the majority of the Nation's wood

supply. These forests face many threats, including wildland fire, invasive species, pests and disease, and the permanent loss of working forest land to non-forest uses. The Forest Service State & Private Forestry (S&PF) division helps ensure that forest landowners have the best technical, educational, and financial assistance available to achieve their unique objectives and to keep forests working for all of us. Below are just a few examples of S&PF Technology Transfer projects carried out in FY 2017.

Wildland Fire:

Wildfire season is all year long and, regardless of where they start, wildfires impact thousands of wildland urban interface communities. Helping communities in fire-prone areas prepare for wildfire reduces impact on those communities, has the potential to reduce suppression needs, and helps protect civilian and firefighter life. Addressing the impacts of wildfire on communities is an all lands/all hands effort.

Community Fire Adaptation: Federal, State, and local governments partner with nonprofits, fire departments, and other stakeholders to reduce wildfire risk locally through the use of mitigation best practices. The Forest Service has developed best practices to enable effective, efficient, and sustainable mitigation efforts locally. Those best practices are based on the best available science, proven by experience on the ground, and shared with communities and partners nationwide.

<https://www.fs.fed.us/managing-land/fire/fire-adaptedcommunities>

Wildland Urban Interface Research: The community wildfire risk reduction work the Forest Service and our partners share and focus on is based on science and verified by experience. Partners like the Joint Fire Sciences Program, the Insurance Institute for Business and Home Safety, the various Forest Service

Research Stations, and Forest Service fire researchers like Sarah McCaffrey and Jack Cohen (retired) form the foundation of best practices. As an example, the Forest Service, States, and partners have long thought messaging through public service advertising, literature distribution, and social media was the route to mitigation actions on the ground. Research supported by experience has shown that's not the case. Messaging may help people become aware of their wildfire risk but it is not a key factor in spurring them to take action to reduce risk. That takes one-on-one, face-to-face engagement at the local level and on building trusted relationships. Sharing that information in an effort to change our approach to community wildfire mitigation is key to accomplishing risk reduction on the ground.

The Community Mitigation Assistance Team (CMAT) concept was piloted in 2015 and is now a standing resource for communities impacted by wildfire. The Teams use the teachable moment of smoke in the air, high fire activity, or high fire risk to work collaboratively with community leaders to share best mitigation practices, help form local mitigation partnerships or coalitions, and plan effective and efficient mitigation programs that can live on in the community long after a wildfire or the deployment of the CMAT. The CMAT has worked with communities and helped mitigation coalitions in association with the Bridger Teton National Forest, Rogue River-Siskiyou National Forest, Pisgah National Forest, Pike San Isabel National Forest, and the Ocanogan-Wenatchee National Forest. The CMAT has also developed a stand-alone Community Mitigation Academy best mitigation practices course, which is available to states or regions at no cost to share the most effective ways to reduce community wildfire risk and how to build a local cadre to accomplish on-the-ground mitigation. See

<http://nrfirescience.org/resource/13555>

Working with Partners: Internal and external partners are key to getting work done in communities and to sharing the latest effective methods to accomplish risk reduction. A long-term important partner has

been the National Association of State Foresters that represents the State. In addition, we continue to increase technology transfer through important partnerships with career and volunteer fire departments nationwide. Work with the National Volunteer Fire Council helps share best practices for assessing homes and communities for wildfire risk and ways to share that information with residents <https://www.nvfc.org/programs/wildland-fire-assessment-program/>. Another important partner, the International Association of Fire Chiefs (IAFC) supports the Ready, Set, Go! program, which focuses on readiness and situational awareness for safe and timely evacuation wildlandfirersg.org. IAFC also supports the pilot Fire Department Exchange (FDX) which allows fire departments to share information about mitigation lessons learned and help each other improve on-the-ground wildfire risk reduction.

The FAC Learning Network, out of which grew the Fire Department Exchange, is a collaborative effort with the Forest Service, The Nature Conservancy, and The Watershed Center. The FAC Learning Network's mission is to connect and support people and communities who are striving to live more safely with wildfire. The Network is a catalyst for spreading best practices and innovations in fire adaptation concepts nationwide. The purpose of FAC Net is to exchange information, collaborate to enhance the practice of fire adaptation, and work together and at multiple scales to help communities before, during, and after wildfires. <https://fireadaptednetwork.org/>

The Fire Adapted Communities Coalition was formed in 2009 and still functions primarily as a technology transfer information-sharing effort between and among partners (and their individual audiences) engaged in community wildfire mitigation efforts (community fire adaptation). Coalition partners share the work they are doing by helping communities reduce risk, increasing their successes, and working to collaborate for effectiveness and innovation across programs. Coalition members use webinars (recorded for later access), social media, videos, face-to-face learning sessions (also recorded),

and workshops to share best practices. FAC Coalition members are the U.S. Forest Service, the National Association of State Foresters, the National Volunteer Fire Council, The Nature Conservancy, The Watershed Center, the Insurance Institute for Business and Home Safety, the National Fire Protection Association, Federal Emergency Management Agency (FEMA), U.S. Fire Administration, U.S. Department of the Interior Bureaus, and the International Association of Fire Chiefs.

Forest Health Protection:

The Forest Health Protection (FHP) Program provides technical assistance on forest health-related matters, particularly those related to disturbance agents such as native and non-native insects, pathogens, and invasive plants. FHP conducts aerial surveys, aerial photography, and aerial application to assist Federal and State partners and the public and to guide forest management actions to improve forest health. This effort makes scientific data available to land managers and States that can reduce the risk and impact of infestations.

We work through partnerships across all lands, providing forest insect, disease, and invasive plant survey and monitoring information, and technical and financial assistance to prevent, suppress, and control outbreaks threatening millions of forested acres across the Nation. Our monitoring program is designed to determine the status, changes, and trends in indicators of forest condition on an annual basis, providing data to guide land managers in maintaining, enhancing, and restoring healthy forest conditions. The FHP program uses data from ground plots and surveys, aerial surveys, and other biotic and abiotic data sources and develops analytical approaches to address forest health issues that affect the sustainability of forest ecosystems. While many of these issues are observed on the ground by trained forest entomologists and pathologists, in FY 2017, two remote sensing methods, where satellite image

analysis was used to survey for both tree mortality and forest defoliation events, stood out as contributing to most of the acres surveyed. These two methods are described below.

The Operational Remote Sensing (ORS) project, utilizing a promising technique based upon massively parallel computing provided by Google®, is designed specifically to model and map pest-related forest disturbance activity in order to augment and enhance the Forest Health Protection and State partners' aerial and ground surveys. This year, much of Massachusetts, Connecticut, and Rhode Island experienced heavy defoliation caused by the gypsy moth, which was visible through satellite data analysis conducted by Forest Health Protection.

Digital Mobile Sketch Mapping (DMSM) is an economical refresh of a formerly implemented technology that supports trained aerial surveyors that sketch forest insect and disease damage on portable computing devices. DMSM uses inexpensive android tablet technology allowing deployment across a range of cooperating agencies and partners. This year, DMSM was implemented in most of the 50 States across the United States and represents almost 500 million acres of forest pest survey.

Urban & Community Forestry:

The Forest Service has a long history, well over three decades, of delivering urban forestry research, technology, and information to our partners, stakeholders, and customers. In FY 2017, the Urban & Community Forestry Program provided technical or financial assistance to more than 8,200 communities across the United States, 35 percent of which were small, rural communities. Sharing Forest Service knowledge and tools is essential to improving the management and long-term sustainability of urban ecosystems. Our partners and customers, including State forestry agencies,

nonprofit organizations, private industry, academic institutions, and municipalities, are asking the Forest Service to continue to provide our much-needed science and technology delivery services. This demand is increasing as our audience and customer base expand to new user groups such as public works, planning, sustainability, and public health and safety professionals. The demand is evolving as we aim to be more effective in reaching a diverse urban audience and as information sharing becomes more essential. Internally and in order to best serve our customers, the Forest Service formed the Urban & Community Forestry Technology and Science Delivery (TSD) Team in 2014. This team is made up of S&PF Urban & Community Forestry program managers and research personnel from around the country. The group's focus is on ensuring our urban forestry staffs are strategic, skillful, creative, and nimble in our science delivery efforts. The team employs a contemporary technology transfer approach in order to reach our diverse audiences and to coordinate across deputy areas, regions, and stations to ensure that we are sharing information that is timely, relevant, and easy to access, understand, and use. For example, in FY2017, the TSD team hosted 10 webinars that showcased the state of the art in urban forestry research and on-the-ground best practices on topics ranging from equitably expanding urban tree canopies to how to best utilize trees to manage stormwater runoff. These webinars had an average of nearly 150 attendees per session during the live webinars and are available for download after the fact, reaching countless more practitioners.

In addition, the team partnered with American Forests and the National Association of Regional Councils to launch the Vibrant Cities Lab, www.vibrantcitieslab.com, to accomplish three goals:

- Give policymakers and municipal executives access to the best available science to inform decisions that impact their urban and community forests. VCL's Make the Case section gives local policymakers the information they need to build support for better tree programs and to

guide decisions in all policies that support and benefit from their tree canopy. With more than 30 case studies covering 11 issue areas and hundreds of carefully vetted research papers already built into the site, VCL isn't simply about education. It's about accelerating action to make communities healthier and more livable.

- Enable urban foresters and planners to assess their program their program against nine categories of best practices. After identifying areas where they'd like to improve, they can use the VCL Assessment Tool to make a persuasive case where change is needed.
- Plan and build better, more effective and efficient urban forestry programs. VCL's Make It Happen section offers a practitioner driven toolkit rooted in best available science that guides users as they work to improve plans and practices from canopy cover and street tree inventory, through staffing, funding, and sustaining their program.

Wood Innovations in Building:

Wood may be one of the world's oldest building materials, but it is also now one of the most advanced, and the Forest Service is playing a critical role in providing assistance to State, Tribal, local, and private entities on how to incorporate wood as a green building material. By building stronger markets for innovative new wood products, we are supporting sustainable forest management, helping to reduce greenhouse gas emissions, and putting rural America at the forefront of an emerging industry. One key avenue for providing technical assistance around the use of wood in building is through our partnership with WoodWorks. WoodWorks, an initiative of the Wood Products Council, provides free, one-on-one technical support to architects and engineers on wood building design. Through partnerships with the

Forest Service, major North American wood associations, and other organizations, WoodWorks promotes the construction of wood buildings. The \$2 million contributed by FS in 2017 leveraged an additional \$4.5 million from the wood industry and Canadian Government, allowing significantly greater impact than could have been achieved independently. WoodWorks provides technical expertise on a wide range of building types including schools, mid-rise/multi-family, commercial, corporate, franchise, retail, public, institutional, and more. WoodWorks hosts yearly conferences across the country and provides workshops and training opportunities on a range of topics to expose architects and engineers to wood design. In FY2017, WoodWorks has directly or indirectly influenced the use of wood in over 500 buildings.

Owner Assistance:

The Forest Service cooperates with researchers to understand landowner behavior and develop technical assistance programs that meet the interests and management needs of America's non-industrial private forest landowners. Through investments in the National Woodland Owners Survey, the Reforestation Nurseries and Genetic Resources program, and the National Agroforestry Center, State & Private Forestry advances technology transfer.

Conservation Education:

Forest Service Conservation Education (CE) helps people of all ages understand and appreciate our country's natural resources and learn how to conserve those resources for future generations. Through structured educational experiences and activities targeted to varying age groups and populations, conservation education enables people to realize how natural resources and ecosystems affect each other

and how resources can be used wisely. Through conservation education, people develop the critical thinking skills they need to understand the complexities of ecological problems. Conservation Education also encourages people to act on their own to conserve natural resources and use them in a responsible manner by making informed resource decisions.

Forest Service Conservation Education is part of the advisory board of the eeWorks project, developed by the North American Association for Environmental Education and Stanford University, and designed to demonstrate the impact and value of environmental education by substantiating powerful anecdotes from across the field with empirical evidence. The project is conducting comprehensive literature reviews that demonstrate the impact of environmental education on key environmental and social outcomes and is translating findings into communication tools to benefit the field.

For more than a decade, Conservation Education has partnered with Prince William Network to bring nature learning to classrooms through technology including webcasts, webinars, and hosting online education materials.

Under the FSNatureLIVE banner are numerous “LIVE” projects, each arranged around a theme and housed in a dedicated website, complete with broadcast links, associated curriculum, and classroom grant opportunities. Recent projects included FreshWaterLIVE, WetlandsLIVE, and GrasslandsLIVE.

The Latino Legacy Youth Leadership in Nature Challenge and Green Ambassador model is an outdoor leadership training program which hosts approximately 20-25 diverse youth per session. The program serves first- and second-generation students of diverse ethnic backgrounds. This week-long connection with nature and natural resource career opportunities has provided visits and one-on-one networking

with major Hispanic Serving Institutions, State universities, agricultural colleges, and Governmental agencies.

The Natural Inquirer publications focus upon STEM education; targeting 5-8th grade students.

Hardcopy and digital publications are available to students and educators. These publications educate students about research generated by the Forest Service, engage youth in STEM education, and inspire youth to pursue science-driven careers. Scientist cards present information on specific Forest Service scientists from many different backgrounds, and many of the cards, which inspire young conservation leaders in the pursuit of natural-resource-related careers, are translated into Spanish.

Partnering with the National Environmental Education Foundation, the Forest Service reaches underserved children and their families through health care providers with prescriptions to recreate in parks and forests near their homes, with an emphasis on underserved areas of the country. Over 880 health care providers have been trained about the health benefits of nature and have written over 1,000 Prescriptions for Outdoor Activity. They have also created digital applications (Apps) for Outdoor Activity to help motivate technology bound children to get outside.

6.10. WATER

National forests are the most important source of water in the United States. The annual value of water flowing from agency lands has been estimated to be \$7.2 billion. More than 60 million Americans—including residents of cities such as Atlanta, GA; Denver, CO; and Portland, OR—rely on drinking water that originates on national forests. In a sense, the Forest Service is the Nation's largest water regulator.

Forests provide people with clean, reliable drinking water. But these waters are at risk due to the needs of growing human populations, continued conversion of forests to other land uses, and anticipated changes in climate conditions. Given such threats, it is important to understand how much drinking water originates in forests, what populations and communities are served, and how to best regulate water quality through proper watershed management.

- [A Rocky Mountain Research Station study](#) published in 2015 showed that forests yield 46 percent of the mean annual water supply but occupy only 26 percent of the land area of the continuous United States.
- [A 2014 report](#) published by the [Southern Research Station](#) showed that clean water begins in national forests for over 19 million people in the South—roughly the population of Florida. The report provides information at a level not previously available on the amount of surface drinking water provided by national forest lands to communities in the South. This information can help support partnerships among State, Federal, and nongovernmental organizations that work to conserve the forest cover that provides the area’s clean, dependable water supplies.

How Forests Provide Clean Water

Small headwater streams determine the water quality of the larger rivers, lakes, and reservoirs that they flow into. Researchers used data from Hubbard Brook Experimental Forest to study the pathways water takes from the time it lands as rain until it reaches a headwater. By tracing water isotopes, they found that the median time it takes rain water to reach a headwater stream ranges from 50 days during wet

periods to 190 days during dry periods. The team took it one step further and also measured changes in the concentrations of dissolved substances that naturally occur in water, such as calcium, and are often what make water “hard” or “soft.” They found that not only does the amount of time water spends flowing through forest soils, but also what path the water takes through the ground determines how much a forest filters the water and removes dissolved substances, thereby impacting water quality. Research like this could potentially help land managers target specific areas of a forest that provide the most filtration services for restoration or conservation to improve a forest’s water filtering capabilities.

Best Management Practices Improve Water Quality and Save Money

Whether developing camp sites for visitors or restoring stream habitats, work on national forests often involves disturbing the ground, which creates opportunities for sedimentation and other negative water quality impacts. Best management practices are techniques that help control and reduce water pollution and protect aquatic ecosystems.

Forest Service scientists pioneered the first national program to strengthen implementation and monitoring of [best management practices \(BMP\) used to protect water quality](#) from the diverse range of ground-disturbing and management activities that occur on national forest system lands. The national BMP monitoring program provides consistency for evaluating BMP implementation and effectiveness across all national forest system units, which in turn allows the Forest Service, for the first time ever, to report national performance results to regulatory agencies, States, Tribes, other stakeholders, and the public. The consistency of the monitoring program is expected to result in improved water quality and millions of dollars of savings through simplified and streamlined monitoring approaches that contribute to the success of both local and national adaptive management strategies.

6.11. FIRE

Protecting Homes From Wildfires

Forest Service research by the [Rocky Mountain Research Station](#) shows that a home's ignitability during extreme wildland fires depends on the characteristics of the structure and the 100 feet immediately surrounding it, including the presence and types of vegetation and outbuildings.

Forest Service research also shows that—surprisingly—[most home destruction from wildland fires is associated with burning embers](#) and low-intensity surface fires, not the big flames of intense wildfires. A shower of firebrands lofted into the air ahead of the wildfire can land on a home or its surroundings and result in its destruction. Property owners can use this information to reduce the risk of structure ignitions during wildfires by clearing small debris around their homes.

Explaining How Wildfire “Spreads Like Wildfire”

Large wildfires of increasing frequency and severity threaten local populations and natural resources. Although wildfires have been researched and modeled for decades, until recently no verifiable physical theory of how fire spreads has been available to form the basis for the precise predictions needed to manage fires more effectively and reduce their environmental, economic, ecological, and climate impacts.

In 2015, the Forest Service [Missoula Fire Sciences Laboratory](#) received an award for its research in [buoyant flame dynamics](#) in wildfire spread. Forest Service researchers discovered that convection—hot gases bursting rapidly forward from the flames and contacting the unburnt fuel—is the primary mode of

heat transfer that causes wildfires to spread. Before this discovery, most scientists considered radiation—the heat we feel from the sun or a fire—to be the key heat transfer mechanism in wildfires. This research will help scientists construct better fire models, which in turn will help fire fighters keep people, property, and themselves safer while battling a big blaze.

A Clear Picture of Smoke

Severe fires produce heavy smoke—a risk for sufferers of asthma and other respiratory problems. To help understand real-time smoke dispersal, the Forest Service [Pacific Northwest Research Station](#) developed [BlueSky](#), a smoke-modeling framework that forecasts smoke concentrations and behavior based on factors like fire, weather, and terrain.

In 2015, BlueSky was used across the country during one of the worst fire seasons on record. It was accessed more than 20,000 times a day during particularly bad smoke events in Washington and Oregon. This effort helped mitigate the harmful effects of smoke for thousands of people across the United States. BlueSky has also been used to support decision-making about when to start and stop prescribed fires, thereby minimizing harmful impacts to air quality in nearby communities.



Researchers prepare to launch a balloon into a smoke plume to measure emissions during an operational scale fire. USDA Forest Service.

Fighting Fire With Fire: Prescribed Burns

A [prescribed fire](#) is “applied in a skillful manner, under exacting weather conditions, in a definite place, to achieve specific results.” The right fire at the right place at the right time reduces hazardous fuels and can thereby reduce the risk or severity of future wildfires.

- The [Rocky Mountain Research Station](#) and [Pacific Northwest Research Station](#) completed a landmark study—the [Prescribed Fire Combustion and Atmospheric Dynamics Research Experiment](#) (RxCADRE)—that helps predict how wildland fires spread and smoke behaves. These predictions support decision-making on wildland fire fighting and on prescribed burns by reducing impacts to air quality and soil.
- An updated edition of [The Guide to Prescribed Fire in Southern Ecosystems](#), which was published by the [Southern Research Station](#) in 2016, is designed to help resource managers plan and execute prescribed burns in southern forests and grasslands. This publication reviews the history and ecology of fire; reasons for using prescribed fire in the South; weather and fuel conditions that are key to controlling fire; meeting burn objectives; and techniques for firing and evaluating burns. It also reviews research aimed at increasing the precision of smoke management, which is particularly important as human populations expand into areas where prescribed burning is needed.

Data for Decision Making on Firefighting

As the world's premiere firefighting agency, the Forest Service develops cutting-edge firefighting resources. These resources include the [Wildland Fire Decision Support System](#) (WFDSS) developed at the agency's Missoula Fire Sciences Laboratory in Montana. WFDSS is the primary system used by fire managers and analysts to make strategic and tactical decisions that maximize firefighter safety and minimize community risk to save lives and property.

WFDSS accesses and integrates national weather data and forecasts, fire behavior predictions, economic assessments of values at risk, smoke management assessments, and landscape into a database. Easy-to-use and web-based, it is responsive to changing fire conditions.

[The Missoula Fire Sciences Laboratory](#)

The internationally renowned Missoula Fire Sciences Laboratory in Missoula, MT, addresses the complicated, dynamic issues associated with wildland fire. The Lab's cutting-edge, uniquely applicable wildland fire research advances our understanding of fire and increases the safety and effectiveness of fire, fuel, and smoke management. The lab produced the [Wildland Fire Decision Support System](#) and scientific [breakthroughs on flame dynamics](#) and designation of the [Home Ignition Zone](#).

6.12. Science Delivery by the R&D Washington Office and Field Research Stations

WASHINGTON OFFICE (WO)

R&D's Washington Office provides leadership, conducts strategic planning, and ensures scientific integrity. Washington Office R&D program staffs also develop national research policy priorities and directions and communicate them to resource planners and land managers within the agency, as well as to other Government agency employees, academics, personnel from nonprofit organizations and industry, and the public.

Inventory, Monitoring and Assessment Research (IMAR)

Mission: To lead the official U.S. Government inventory of the status, trends, use, and health of the Nation's diverse forest lands and projections of natural resource conditions and use into the future to provide the scientific basis for natural resource management and decision making at multiple spatial scales in boreal, temperate, and tropical forest eco-systems. This authoritative information also guides forest investments by governments and the private sector and is key for determining forest sustainability.

Key elements

- Leads the Forest Inventory and Analysis (FIA) program which is delivered through five stations and internal and external partners. This program inventories and reports the attributes of U.S. forest resources based on measurements collected every 5 to 10 years. FIA data support Federal, State, and private decision makers (e.g., in siting forest product facilities); evaluating the sustainability of management practices to maintain the health and productivity of forested lands, identifying policy options to keep forest land forested, analyzing invasive species, and conducting wildlife modeling. FIA data also provide the foundation for many research studies.
- Assesses cutting-edge developments in monitoring, remote sensing, and geospatial analysis and helps set priorities for other activities within R&D. This work involves partnering with the Office of the Chief Information Officer and Esri, Inc., to develop a secure, dedicated, and massive, fast processing environment for analyzing dense, remote sensing, time-series observations and for performing other data analyses that require enormous processing.

- Leads production of the Resource Planning Act (RPA) Assessment, a national, renewable resource assessment mandated by the Forest and Rangeland Renewable Resources Planning Act. The RPA Assessment examines how the interaction of socioeconomic and biophysical drivers affects the productivity of forest and rangeland ecosystems and their ability to meet increasing demands for goods and services, including analyses of forests, rangelands, wildlife and fish, biodiversity, water, out-door recreation, wilderness, and urban forests.
- Leads production of the National Report on Sustainable Forests, which provides a comprehensive picture of forest conditions in the United States as they relate to the ecological, social, and economic dimensions of sustainability using the Montreal Process criteria and indicators for sustainable forest management.
- Provides leadership and coordination for international monitoring and assessment activities in partnership with International Programs. This partnership effort helps lead the United Nations Food and Agriculture Organization's Global Forest Resource Assessment, Economic Commission for Europe Committee on Forests and the Forest Industry, and various U.S. agencies for international development activities.
- Develops and implements science, technology, and decision-support systems for land management planning.
- Produces quality assurance and statistics policy and review, setting policies for quality-assurance and quality-control strategies and tactics and conducting oversight to ensure national consistency in implementing quality assurance and quality control.

Recent achievements

1. Published Assessing the Sustainability of Agricultural and Urban Forests in the United States. The latest sustainability assessment report supplements the National Report on Sustainable Forests series by focusing on agricultural and urban forest resources within the context of national forest sustainability reporting.
2. Published Future of America's Forests and Rangelands: Update to the Forest Service 2010 Resources Planning Act Assessment in 2016. This report summarizes the status and trends of forests, rangelands, wildlife, biodiversity, water, outdoor recreation, and urban forests.
3. Provided forest monitoring data used for forest management. For example, forest staff on the Idaho Panhandle and Kootenai National Forest used FIA data to develop their recently completed forest plans. Such data typically track status and trends in forest growth, mortality, and overall health.
4. Produced an Engagement Portfolio website that delivers geospatial data on varied subjects in interactive, eye-catching formats. Topics covered include white-nose syndrome among bats, wildfire, forest communities, and the southern forest products industry.

Sustainable Forest Management Research (SFMR)

Mission: To build a solid scientific foundation for natural resource management and policymaking at multiple spatial scales in forest and rangeland ecosystems. Methods used include conducting leading-edge research, synthesizing existing research, and improving access to and highlighting field research.

Key elements

- Investigates natural disturbances, stressors, and threats caused by insects, diseases, and invasive species; fire; weather (hurricanes, ice storms, droughts); and physical phenomena (avalanches, landslides, volcanoes) that impact forests and grasslands.
- Studies human-caused disturbances, stressors, and threats related to fragmentation of forests and rangelands and changing weather patterns (temperature and precipitation), atmospheric deposition, air quality, and soil health.
- Researches sustainable production of forest and rangeland resources.
- Manages systems, practices, and policy options for restoring forests, rangelands, and agroforestry systems.
- Researches and manages landscape ecology issues at national, regional, and local levels.
- Researches meteorology and the effects of climate variability on living organisms.
- Conducts vulnerability and risk assessments.
- Conserves biological diversity using methods such as genetics, gene conservation, and species conservation.
- Develops reforestation and revegetation methods and materials.
- Manages experimental forests and ranges, research natural areas, and demonstration areas.

Recent achievements

1. Partnered with the U.S. Department of Energy on the 2016 Billion-Ton Report: Advancing Domestic Resources for a Thriving Bioeconomy, Volume 1, providing wood fuel-availability projections. This product is critical to ensuring that up-to-date information is available to guide policy and investment decisions related to biotechnology and America's energy-secure future.
2. Published Effects of Drought on Forests and Rangelands in the United States: A Comprehensive Science Synthesis. This report provides a first-of-its-kind national assessment of the impacts of drought on U.S. forests and rangelands and establishes the scientific foundation for managing resiliency and adaptation to drought.
3. Produced a precision agriculture tool for designing conservation buffers (strips of vegetation planted along streams, lakes, or wetlands) that filter agricultural runoff for maximum water-quality benefits.
4. Published Effects of Climactic Variability and Change on Forest Ecosystems: A Comprehensive Science Synthesis for the U.S. Forest Sector—the technical report for the U.S. Global Change Research Program National Climate Assessment. This publication also provided the foundation for an award winning book, Climate Change and United States Forests, which was edited by Forest Service researchers and serves as a comprehensive science-based assessment of the effects and variability of a changing climate on U.S. forests.

Pending publications

- Agroforestry: Enhancing Resiliency in Agricultural Landscapes Under Changing Conditions
- State of Science for Non-Native Invasive Species
- Non-Timber Forest Products in the United States

Landscape Restoration and Ecosystem Services Research (LRESR)

Mission: To research conservation and restoration strategies that promote ecological resilience in the face of environmental change, discern how changing social and economic conditions impact forests and the goods and services they provide, and ensure a continuous supply of forest-based products to sustain the livelihood of our citizens through innovative new technologies.

Key elements

- Conducts research to help improve management practices and inform policy options for restoring watersheds and wildlife and fish habitats, including those of threatened, endangered, and sensitive species.
- Advances understanding of the effects of environmental change on fish and wildlife and identifies key threats, stressors, and limiting factors that affect the abundance and population viability of fish and wildlife.
- Develops innovative protocols to inventory and monitor fish and wildlife populations and habitats.
- Develops science-based strategies to meet growing demands for water, energy, and other forest-based commodities while ensuring the sustainability and diversity of fish and wildlife.

- Conducts research that supports the adoption of innovative new uses of wood in nanotechnology, the engineering of functional systems at the molecular scale. These uses for wood include, but are not limited to, “green” buildings, biorefineries, electronics, bio-medicine, automobiles, oil drilling, and construction.
- Conducts research that supports sustainable community economic development and employment.
- Responds to Presidential Memorandum, “Incorporating Ecosystem Services into Federal Decision Making,” by making resources and information available to forest managers.

Recent achievements

1. Developed fast, easy, cost-effective, and noninvasive environmental deoxyribonucleic acid (eDNA) technology to detect multiple species rapidly and inexpensively from a single water sample. This technique involves filtering water samples to capture trace amounts of cells shed by organisms, which are then analyzed to identify the presence of a species of interest. Testing with eDNA can identify the presence of threatened and endangered species in ecosystems and species vulnerable to invasive species.
2. Created a monitoring program to support the implementation of the National Best Management Practices for Water Quality Management on National Forest System Lands.
3. Developed technology that enabled a history-making, coast-to-coast commercial airline to use alternative jet fuel in November 2016. The alternative fuel was made from the limbs and branches

that remained on harvested Tribal lands and private forests in the Pacific Northwest. This type of post-harvest debris is often burned as waste. The alternative jet fuel was produced by the Washington State University-led Northwest Advanced Renewables Alliance (NARA), and Sulfite Pretreatment to Overcome Recalcitrance of Lignocellulose (SPORL)— a technique for pretreating woody biomass for conversion to aviation fuel that was developed through Forest Service research.

4. Created NorWeST+ClimateShield, a comprehensive database of stream temperatures for Western States. This tool forecasts changes in stream temperatures and predicts associated changes in cold-water fish habitat under climate change scenarios.

Knowledge Management and Communications (KMC)

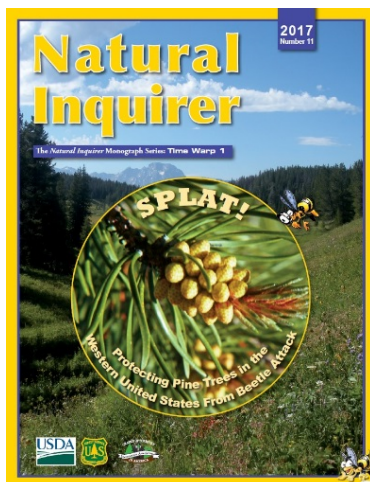
Mission: The Knowledge Management and Communications (KMC) staff's mission is to disseminate results of the agency's research to varied audiences—including the scientific community, land owners/managers, academics, policymakers, the public, and students—and to provide the information technology needed to disseminate results. KMC is responsible for leadership, development, oversight, and delivery of communications, performance accountability, science applications, science education, data quality, peer review, tech transfer and licensing activities, and information management for Forest Service Research & Development. KMC also defines, develops, and maintains the national information architecture and content of databases essential to managing the strategic information flow and messaging about Forest Service research.

Key elements

- Plays a leadership role in the Forestry Research Advisory Council (FRAC) Federal Advisory Committee. Consisting of up to 20 members appointed by the U.S. Secretary of Agriculture from Federal, State, university, industry, and nongovernmental organizations, the FRAC meets annually and presents recommendations to the Secretary on the Forest Service R&D program.
- Provides information technology resources for communicating research, including the R&D website, which provides public access to about 50,000 scholarly publications by R&D scientists and collaborators.
- Maintains databases of research and archives information.
- Develops and disseminates science applications.
- Manages R&D data quality, peer review, and performance accountability.
- Manages R&D patents, licensing, and technology transfer.
- Manages the Forest Service History Program.
- Produces the Natural Inquirer, a free science education journal for students.
- Manages R&D's science delivery and communications program, which produces products and services that target varied audiences, including the scientific community, land managers, policymakers, the public and other stakeholder groups; this work involves overseeing the strategic planning and production of web and hard copy communications products, new outreach products, communications promoting the rollout of major R&D initiatives, and the translation of technical information into reader-friendly language.

Recent achievements

1. Created the R&D monthly online newsletter, which has more than 9,000 subscribers.
2. Designed and led the implementation of the communication plan for Effects of Drought on Forests and Rangelands in the United States: A Comprehensive Science Synthesis, which was covered in many national publications including the San Francisco Chronicle, Scientific American, The Christian Science Monitor, and Greenwire.
3. Delivered about 200,000 downloads of R&D scholarly publications from the R&D website during a recent approximately 12-month period.
4. Developed and distributed more than 100,000 new Forest Service scientist cards and historic Centennial Deputy Chief's cards. Distributed almost 70,000 Fresh-water and Citizen Science issues of Natural Inquirer. More information about this important science education program is presented below.



The *Natural Inquirer* program creates and distributes reusable science journals and materials written for K-12 students. In FY 2017, 92,323 of these products were distributed to classrooms and homeschools across the country. FS website had 142,466 unique visitors in FY 2017, a 95 percent increase over FY 2016. All work is done with our nonprofit partner, the

Cradle of Forestry in America Interpretive Association, and the University of Georgia.

<http://naturalinquirer.org>

WO R&D KMC, Barbara McDonald, Ph.D., Education Program Manager, 706-559-4224

Important FY 2017 Program Accomplishments

- 92,323: *Natural Inquirer* products distributed (excludes scientist cards)
- 168,940: *Natural Inquirer* scientist cards, featuring Forest Service scientists, were distributed
- 673 “Women in Science” scientist card packs distributed (20,190 cards)
- 3,207 total packs of scientist cards distributed
- 26 new cards created (13 of those were women)
- *Natural Inquirer* social media: 12 percent increase in followers on Facebook, and 10 percent increase on Twitter
- **New products:** Time Warp Monograph Series 1: *SPLAT!*, Time Warp Monograph Series 2: *Full Throttle Model*, *NSI: Nature Science Investigator* (as a National product), 26 new scientist cards, Forest Service Historical Cards

***Natural Inquirer* products distributed at:**

- Women of Color in Science, Technology, Engineering, and Mathematics (STEM) Conference
- Dia De la Madre
- Atlanta Science Festival
- Athens Tree Fair (Athens, GA)
- Capitol Christmas Tree event

- ACES (A Community on Ecosystem Services) conference
 - Girl Scouts events
 - Water Education Day, Oregon
 - Columbia Outdoor Classrooms
 - LatinoFest
 - Project Learning Tree workshops
 - Teacher Conservation Institute
 - California State Fair
 - Experience UGA (University of Georgia outreach event for K-1 students)
 - Minorities in Agriculture, Natural Resources, and Related Sciences (MANRRS) Annual Conference
 - Cradle of Forestry in America Interpretative Association campgrounds
-
- **Partnerships:**
 - USGS (Citizen Science edition)
 - United Nations Food and Agriculture Organization (World's Forest 3 edition)
 - Forest Service Conservation Education (*NSI* as a national product & Spanish language partnership for cards and *NSI*)
 - Forest Service Southern Research Station (Hidden Figures partnership)
 - Forest Service Northern Research Station (Production of Time Warp monograph series)

NATIONAL AGROFORESTRY CENTER

The National Agroforestry Center advances the health, diversity, and productivity of working lands, waters, and communities through agroforestry. The Center provides science-based information for integrating trees and agriculture on farms, forests, and ranchlands across the United States, to improve water quality, enhance crop and livestock production, create wildlife habitat, and sequester carbon.

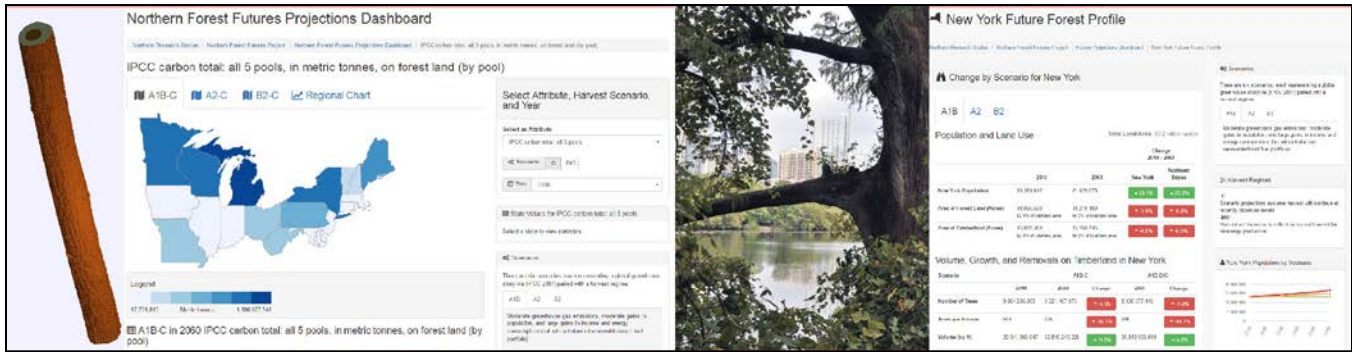
Work at Center includes research and/or outreach on agroforestry systems that include:

- **Windbreaks and shelterbelts**, to shelter crops, people, animals, buildings, and soil from wind, snow, dust, and odors,
- **Riparian forest buffers** that filter farm runoff and reduce soil erosion,
- **Silvopasture**, to increase the efficiency of land use and diversify farmer incomes,
- **Alley cropping** to augment landowner income before the trees are mature enough to harvest and/or produce fruit, berries, or nuts.
- **Forest farming, or multi-story cropping**, to produce food, herbal, botanical, or decorative crops under the protection of a managed forest canopy.

The USDA, National Agroforestry Center was established in the 1990 Farm Bill. It is administered by the [Forest Service's, Washington, DC, Office of Research and Development](#) and is located in Lincoln, Nebraska. Outreach is accomplished through an extensive national network of public and private

partners including NRCS conservationists, forestry and agriculture extension agents, and many more. Together, we conduct [research](#), develop technologies and [tools](#), coordinate demonstrations and [training](#), and provide useful information to natural resource professionals.

NORTHERN RESEARCH STATION (NRS)



The Northern Research Station’s science is complex, but the need for the research is simple. Land managers, city planners, and policymakers need sound science on all aspects of the natural world and its complex connections with people to achieve decisions resulting in a healthy and sustainable future for present and future generations of Americans. In a region extending from Maine to Minnesota and from Missouri to Maryland, Northern Research Station science aims to understand all of the elements of forests and related landscapes. Part of the [Forest Service Research and Development program](#), the Northern Research Station is one of seven Forest Service research units conducting research within all 50 States as well as in U.S. territories and commonwealths.

Northern Research Station scientists reach these audiences in a variety of ways, including:

- Publishing in peer-reviewed journals and Station General Technical Reports; over 15,000 publications authored or co-authored by Northern Research Station scientists.
- The Station develops [web-based tools](#) that deliver sound, peer-reviewed science in a format that is convenient for land managers and others.

The Northern Research Station's Forest Inventory and Analysis group is responsible for inventory and monitoring in 24 States. We provide extensive data through Forest Inventory Data Online (FIDO), giving our stakeholders in State agencies, private industry, and other Federal agencies alternatives for generating tables and maps.

The Station manages 22 of the 80 [experimental forests](#) that are part of the Forest Service Experimental Forest Network; most of these long-term research sites lie within National Forests. The ability to conduct scientific research in-house, to apply research findings on National Forest System lands, and to transfer these findings to others for use on all of the Nation's forest land sets the Forest Service apart as a natural resource agency.

Science priorities include:

- Forest health and disturbance
- Forest restoration and management

- Water, wildlife, and fish conservation
- Resilient communities and economies
- Inventory, monitoring & assessment

NRS SCIENCE DELIVERY

How Declining Size of Private Forest Land Holdings Impact Benefits From and Management of Public Forest Lands

What happens to neighboring public forest lands when a piece of privately held forest land gets split into multiple ownership pieces—a process that scientists refer to as parcelization? Northern Research Station social scientist, Stephanie Snyder, along with colleagues at the University of Minnesota, explored this question by gathering information from natural resource managers who work for public agencies in the Lake States of MI, MN, and WI.

Across the Lake States, most public natural resource managers told us they have witnessed an increasing frequency of forest land parcelization (i.e., the private forested landscape getting split up into smaller units with more owners). They consider development potential of the land and closeness to population centers to be the most likely factors that lead to ownership splits of private forest lands. They also helped us identify important linkages between private forest land parcelization and public land management in areas such as increased conflict on, decreased access to, and increased recreation demand on public land. In addition, managers also identified higher costs of managing neighboring

public lands as a consequence of having to devote greater amounts of resources and time to fostering relationships and negotiating access arrangements with neighboring private landowners to maintain cross-boundary trails and right-of-way access. Decreased timber supply on private forest land may also impact the demand for these services on public forest land. These are important findings and trends for public land managers to be aware of as they consider future management for public forest lands and how best to meet society's needs for the important goods and services that our Nation's forests provide.

Resident and user support for urban natural areas restoration practices

Residents and visitors believe that a given restoration practice such as controlled burning at a site can be a powerful predictor of support for that practice.

Public support is important to the success of natural areas restoration programs. Support can be especially critical in urban settings where stakeholders recreate in or reside near natural areas but may lack familiarity with practices for managing ecological processes. Surveys of onsite recreationists and nearby residents (N= 888) of 11 Chicago metropolitan natural areas were used to assess support for 8 different practices commonly used in oak woodland restoration. Support generally ranged in relation to the level or intensity of management intervention, from more than 90 percent of the sample supporting the planting of native seeds and plants to just 32 percent supporting the use of herbicides to control undesired vegetation. Onsite users and nearby residents who believed that a restoration practice was being used at the site they visited and/or lived near were much more likely to support the use of that practice than those who did not believe or did not know whether it was being used.

Preserving timber values after wildfires requires immediate action

Drought has set the stage for many unusually large and hot fires in the forests of the Southern and Central Appalachian Region. Immediately after intense wildfires in November 2016 were extinguished, National Forest managers requested decision support for dealing with anticipated timber losses. NRS scientists delivered that support in less than 1 month. As a result, salvage timber sales were put in place in less than a year, which will retain the value of those mature trees and help the economies of nearby rural communities that were devastated by the fires.

Dozens of wildfires occurred during October and November of 2016 in western North Carolina, eastern Tennessee, northeast Georgia, and northwest South Carolina. Most of these were associated with a period of extreme drought. On the Nantahala Ranger District of the National Forests of North Carolina alone, 27 wildfires burned approximately 28,000 acres—several of those were extremely intense. Forest Service managers in the region were frustrated in their inability to find information to help them understand how to deal with the results of the moderate to extremely intense fires that burned in mature upland hardwood timber stands. Guidance on the most effective management practices for conducting salvage timber sales was a key need. Where rapid implementation of salvage removal appeared plausible and needed, discerning which of the damaged trees were at greatest risk of suffering deterioration and losing value had to be addressed quickly. Jan Wiedenbeck, a Forest Products Technologist in the Northern Research Station, quickly compiled and synthesized the most relevant and credible information available concerning hardwood damage, deterioration, mortality, and value depreciation for National Forest managers in North Carolina. After phone and in-person consultations, the team developed guidelines for marking trees for removal, and the salvage sale contract was written just 9 months after the fire damage occurred. The expeditious, informed teamwork between the National Forest System and

the Northern Research Station is allowing recovery of this timber before major losses in its value occur, thereby providing economic benefit to rural families and communities still recovering from the devastating fires.

Re-establishing pollinator habitat on mined lands using the forestry reclamation approach

Many pollinator species are threatened worldwide for many reasons, including habitat loss. In Appalachia, native forests serve as critical pollinator habitat. Thoughtful reclamation can help provide habitat and protect these important insects and the ecosystem services that they provide.

Coal mining in the Appalachian region has changed as many as a million acres of diverse, productive hardwood forest into shrubby fields and grasslands. These fields stubbornly resist becoming forests, and exist in a state of “arrested” ecological succession. Such lands don’t provide the same ecosystem services and values as the former forests. One particularly important ecosystem service is that of pollination of plants by a variety of insects. Reforestation of mined lands using the Forestry Reclamation Approach (FRA) can provide important pollinator habitat and may help support pollinator populations in the Appalachian coal fields. We recommend that the FRA be applied in a manner that will produce soil conditions on mine sites similar to those of unmined forests. We also recommend establishing a diverse community of seeded and naturally invading native plants; and re-establishing native plant species that will provide a continuous bloom cycle throughout the growing season. The information in this Advisory presents mine reforestation strategies that can encourage and support pollinator conservation in the eastern U.S. Such activities can also lead to wonderful teaching moments with school children

Economic benefits from violence reduction associated with remediation of abandoned buildings and vacant lot greening

A study by a Northern Research Station scientist and partners found that, in an urban area, remediation of abandoned buildings and vacant lots can be a cost-beneficial solution to firearm violence. We performed quasi-experimental analyses of the impacts and economic returns on investment of urban remediation programs involving 5,112 abandoned buildings and vacant lots on the occurrence of firearm and nonfirearm violence. Abandoned building remediation significantly reduced firearm violence by 39 percent, as did vacant lot remediation by 4.6 percent. Taxpayer and societal returns on investment for the prevention of firearm violence were \$5 and \$79 for every dollar spent on abandoned building remediation and \$26 and \$333 for every dollar spent on vacant lot remediation. Abandoned buildings and vacant lots are structures seen daily by urban residents and may create physical opportunities for violence by sheltering illegal activity and illegal firearms. Urban remediation programs can be cost-beneficial strategies that significantly and sustainably reduce firearm violence.

During the last 150 years, hundreds of forest insects have accidentally been introduced to the United States and many of these have caused substantial damage.

Over time, these introductions have actually depleted the number of potentially invasive species, but increases in imports have compensated for the effect of this depletion. A model incorporating sizes of source species pools and trade volumes allows us to make predictions about numbers of new forest insect species likely to invade in the future.

During the last 150 years, hundreds of forest insects have accidentally been introduced to the United States and many of these have caused substantial damage. Predicting how increasing rates of global trade will result in new establishments of potentially damaging invasive species is a question of critical importance to the development of national and international policies aimed at minimizing future invasions. Here we develop a model that predicts future numbers of new species invasions based upon the abundance of species within invasion pathways. In this model the most abundant species are likely to invade first, while the many rare species are likely to invade only under high pathway (import) volumes. This mechanistic model is applied to make predictions of numbers of bark beetles likely to invade the United States from Europe over the next century, but the model is widely applicable for predicting future invasions of all taxa and provides insights into how increases in rates of imports counteract the species-pool-depletion effect, resulting in the continued establishment of new species.

Why Ice Storms Aren't Cool: New Research at the Hubbard Brook Experimental Forest Targets Impacts of These Events on Northern Hardwood Forest Ecosystems

Extreme weather events are becoming increasingly common, creating dangerous disturbances to forests, towns, and cities. Scientists are pioneering new approaches to study these hazardous events with the long-term goals of making future forests and communities more resilient.

Ice storms are a common disturbance that can cause massive damage to north temperate and boreal forests worldwide. Because of the stochastic nature of ice storms and difficulties in predicting their occurrence, most past investigations of the ecological effects of ice storms have been based on case studies following major storms. During the winters of 2016 and 2017, scientists at the Hubbard Brook Experimental Forest, NH, took a novel approach and created a suite of experimental ice storms in a

northern hardwood forest. The icing treatments included targets of one-fourth, one-half, and three-fourths inch radial ice thickness sprayed in winter 2016 (to evaluate the impacts of different intensities of ice storms), and one-half inch sprayed again in winter 2017 (to evaluate impacts of consecutive ice storms). Early results show that the ice storm created gaps in the canopy and deposited large amounts of woody debris to the forest floor, and had surprisingly little impact on soil processes. The ultimate goal of this study is to provide information to stakeholders, such as utility companies, forest managers, and arborists, so that they will be better prepared to respond to big storms.

PACIFIC NORTHWEST RESEARCH STATION (PNW)



The Pacific Northwest (PNW) Research Station is one of seven research centers that are part of the USDA, Forest Service. We develop and deliver knowledge and innovative technology to improve the health and use of the Nation’s forests and rangelands—both public and private. Since 1925, the PNW Research Station has been dedicated to understanding forests and rangelands. We believe that resilient forests are a promise to generations to come—a promise to replenish the air we breathe and the water we drink and use to grow food. Forest trees store carbon from the roots to the tops. Trees supply wood for homes, biomass for fuel, and fiber for paper. From remote mountains to bustling cities, forests provide habitat for fish and wildlife. Wherever they grow, forests are places of beauty, renewal, and solace.

Land managers understand more than ever just how important forests are to people from every walk of life. The PNW Research Station is in the unique position to offer scientific knowledge—built on decades of research—that can be used now to ensure that future generations enjoy the same benefits from forests that we do today. As part of the USDA, Forest Service, Research and Development, the station has access to national forests and an experimental forest system that hold the keys to new understanding of forests and rangelands.

The PNW Research Station has strong partnerships with universities, national forests, State agencies, nonprofits, private industry, and other Federal agencies. With these partners, we address key questions associated with climate change, imperiled species, human health and well-being, and other topics. We have the honor of bringing science to the table as people make often difficult choices about managing land.

The Pacific Northwest Research Station is a leader in the scientific study of natural resources. We generate and communicate impartial knowledge to help people understand and make informed choices about natural resource management and sustainability.

PNW Science Deliveries

Managing fire-prone forests in multi-ownership landscapes

Study reveals many new insights into this social ecological system. For example, Federal forests that adopt more of a live-with-fire strategy rather than an exclude-all-fire strategy often have more fire-resilient forests than forests whose owners who try to exclude all fire, including prescribed fire.

Fire-prone landscapes present many challenges for both managers and policymakers. A multi-disciplinary team of scientists with the Pacific Northwest Research Station recently completed a study of the social and ecological dimensions of a multi-ownership, fire-prone landscape in Oregon's eastern Cascade Range.

The study was designed to address the following questions: (1) How do current forest management approaches differ among ownerships across forests of central Oregon? (2) How are social networks that focus on fire structured and how might they influence adaptation to fire? (3) How does resilience to fire vary by ownership and environment? (4) How do different management strategies affect fire outcomes and ecosystem services? The work was unique in bringing together social, ecological, and computer scientists to conduct integrated research to apply an "agent based" landscape model to help understand how ecological and social variability, fire, and management interact across millions of acres of dry, fire-frequent forests.

The results and the landscape modeling tool are being used to inform stakeholders with the Deschutes and Fremont-Winema National Forests about strategies to adapt to fire and alternative approaches to forest restoration.

Pacific Northwest Research Station supports Washington State's forest resiliency burning pilot project

Researchers characterize fuel before and after prescribed burns in eastern Washington and assess post-fire tree mortality. The State is using these findings to develop a forest resilience burning program. After the large wildfire seasons of 2014 and 2015 in Washington, the State legislature tasked the Washington Department of Natural Resources to conduct a forest resiliency burning pilot project to monitor and evaluate the benefits of forest resiliency burning on air quality and to investigate means of increasing the use of prescribed burns in forests across the State. This large-scale, interagency effort involved approximately 15 prescribed burns sites on State and national forest lands. The Pacific Northwest (PNW) Research Station was specifically asked by the State to provide science support for this pilot project.

Roger Ottmar, a research forester with the PNW Research Station, led the effort to characterize the pre- and post-fire fuels and assess post-fire tree damage and mortality. Data from this project was used to evaluate the model "Consume," developed at the PNW Research Station, and currently used in Washington's smoke management program.

The followup reports presented to the State legislature will help the state develop a forest resiliency burning program that will maintain healthy forests and limit uncontrolled wildfires while protecting ambient air quality.

Rapid forest health assessment to aid forest restoration

Fuels-reduction treatments are an opportune time to remove trees in poor health and significantly increase the proportion of high-vigor trees remaining in the stand after treatment. Having a tool that helps identify clusters of trees in poor health could help prioritize restoration activities the following

year and reduce the probability of a landscape-level insect outbreak. The Western Wildland Environmental Threat Assessment Center (WWETAC) collaborated with The Nature Conservancy and the Fremont-Winema National Forest to develop such a tool.

Researchers developed a rapid-assessment tool for identifying and prioritizing removal of western yellow pine in poor health. It is based on canopy and whole-tree attributes that can be assessed within a minute on the ground. It is scalable to the landscape level by correlating ground-based attributes to spectral signatures developed for two tree-health classes (poor, and average or above average) from high-resolution remote sensing that the National Forest System Regions currently can request annually from The Nature Conservancy or WWETAC. This approach also can be used to assess the effect of different fuels treatments on stand health through time in stands dominated by western yellow pines (ponderosa pine, Jeffrey pine, washoe pine).

The Chemult and Silver Lake Ranger Districts the Fremont-Winema National Forest are very interested in using the iPad-based tool to identify and locate trees in poor health.

Revealing the economic benefits of outdoor recreation in national forests

Research provides updated data and technical guidance for computing the economic benefits of recreation at national, regional, and individual national forest levels. Analyses of recreation trends and associated spending helps national forests plan and allocate resources for recreation management along with other forest uses.

Outdoor recreation is a major use of national forests. It is highly valued by the public, generates substantial public health benefits, and generates more economic activity nationally than all other uses of National Forest System land. Managing for recreation alongside other forest uses, such as timber production, depends on an accurate understanding of present and future recreation patterns and the economic values associated with recreation activities. National forest staff, scientists, decisionmakers, and other clients use recreation data and analyses to inform planning, allocate resources, and evaluate the economic benefits associated with outdoor recreation.

Forest Service's National Center for Natural Resource Economics Research enlisted scientists with the Pacific Northwest Research Station to lead efforts to update data and analyze recreation economic benefits and economic activity in the United States. The research is providing data and technical guidance of the computation of recreation economic benefits at national, regional, and individual national forest levels. For example, economic benefits to people recreating on national forests range from \$63 per person in the Pacific Southwest Region (Region 5), to \$103 per person in the Alaska Region (Region 10). The data generated by this effort enable national forest analysts to meet their analysis, monitoring, and reporting requirements.

A strategy for ecosystem services

The Forest Service is poised to be a leader in the integration of ecosystem services concepts for forest land managers. This report demonstrates the breadth of opportunity available to the agency.

The ecosystem services concept describes the many benefits people receive from nature and highlights the importance of managing public and private lands sustainably to ensure these benefits continue into

the future. The National Ecosystem Services Strategy Team was chartered in 2013 to collaboratively develop national strategy and policy around ecosystem services and integrate them into Forest Service programs and operations; a product of this effort is a report published by the Pacific Northwest Research Station in 2017.

The report, titled “Integrating Ecosystem Services into National Forest Service Policy and Operations,” identifies focus areas that can be used to help the agency identify opportunities for taking advantage of ecosystem services and areas in which these benefits are needed. It also summarizes ongoing efforts to integrate ecosystem services into Forest Service policy and operations at both the national and local scale. Additionally, the report articulates existing Forest Service policy in order to help the agency consider a broad suite of services in the future when it is making decisions and setting priorities, communicating benefits to the public through measurement and reporting, and connecting providers and beneficiaries of ecosystem services through partnerships and investments.

Decision support for Northern Region’s integrated restoration and protection strategy

The Regional Office and national forests in Region 1 are using the decision-support system to develop priorities for restoration and protection of subwatersheds across the region.

The Pacific Northwest Research Station collaborated with the Forest Service Northern Region (Region 1) to develop a decision-support process that the region can use to assess management opportunities as part of an ecosystem-based approach to management that emphasizes ecological resilience. The decision-support system implements the Region’s Integrated Restoration and Protection Strategy, and was developed to allow the region (1) to assess ecosystem resilience using a more consistent, efficient,

and effective process; (2) to identify priority restoration opportunities; and (3) to manage resources and ecosystem services being affected by various disturbance processes.

Quantifying fire effects on soil

Severe heating alters soil microbial communities and soil chemistry, slowing recovery of vegetation. Environmental change and fire suppression throughout the 20th century in the Western United States have created conditions that facilitate high-intensity forest fires. When large downed wood burns, the soil beneath the log is exposed to prolonged, intense heat. This alters soil properties and kills soil microbes. The amount of large downed wood influences the extent of extreme soil burning. In areas that contain large amounts of large downed wood from previous wildfires, the extent of severe soil burn can be a concern.

To better quantify the effects of soil heating, scientists conducted an experiment in the Pringle Falls Experimental Forest in central Oregon. The study team led, by Jane E. Smith, a botanist with Pacific Northwest Research Station, found that the composition of soil microbial communities varied with burn severity. The greatest differences were apparent in the early time-points following the fire and decreased over 4 years. Severely burned soils had a fewer nutrients which slowed the recovery of vegetation for at least 4 years. These findings provide a foundation for ongoing studies investigating the effects of soil-burn severity on tree-seedling growth, soil fungi, and nutrients. Continuing this work, the scientists are investigating soil fungal-community recovery and succession using next-generation DNA sequencing.

Forest managers and members of the public are concerned about the lingering environmental effect of extreme soil heating. Findings from this study were used to address public comments to Forest Plans for

the Deschutes National Forest. As burned areas continue to increase across Western United States forests, incorporating previously burned areas into management plans and understanding the temporal fuel dynamics following high-severity fire will be essential. Increased understanding of biogeochemical processes in soils following low or high burn intensity will contribute to best management practices aimed at mitigating the potentially negative effects of large patches of high-intensity soil burning.

PACIFIC SOUTHWEST RESEARCH STATION (PSW)



The Pacific Southwest Research Station represents FS R&D in the States of California and Hawaii and the U.S.-affiliated Pacific Islands. The region has the lowest, driest desert in the country, the highest elevations within the 48 contiguous States, and the wettest tropical forests. It is home to an abundant diversity of native plants and animals and nearly half of the Nation's threatened and endangered species. PSW scientists are engaged in research across a network of 14 experimental watersheds, ranges, and forests and 8 research facilities. PSW scientists conduct a broad array of natural resources research to achieve our mission to "develop and communicate science needed to sustain forest ecosystems and their benefits to society." Research is organized into five research units: conservation of biodiversity, ecosystem function and health, fire and fuels, urban ecosystems and social dynamics, as well as Pacific Islands forestry. For more information, visit fs.fed.us/psw.

PSW SCIENCE DELIVERY

Greenstrips in Hawaii – Can they be used to protect high-value ecosystems from fire?

The purpose of the greenstrip study was to test a tool that has been used in parts of the arid continental United States to protect high-value ecosystems from fire. In our case, we wanted to identify species for restoration that would not only reduce the incidence of invasive grasses, and thus fire in dryland ecosystems, but would also resist invasion once in place. We hypothesized that greenstrips with established native species would deter the reinvasion of fountain grass due to the preemption of space and resources, and thus reduce the maintenance required to remove grass fuels.

A component of our work towards restoration of dryland ecosystems in Hawaii is to design fire-reduction measures to protect remaining dry forest fragments within grass-dominated landscapes. Throughout leeward Hawaii, extensive areas of former dry forest have been completely converted to non-native grasslands. Approaches are needed that can enhance other fire-reduction measures already in place to reduce the spread of large fires across these landscapes. Greenstrip techniques have been used widely in arid landscapes of the Intermountain West to limit the spread of large fires in grasslands invaded by fire-promoting alien grasses. This practice is based on using species with fire-resistant characteristics (e.g., high water content, low levels of volatile compounds, large leaves) to produce areas of non-flammable vegetation that disrupt fuel continuity and limit production of fire-promoting grasses. Green strips that grade into native dominated protected areas can also serve as sites of passive restoration, restoration of key ecosystem services (i.e., carbon, nutrient, and water cycling), and as corridors between forest fragments. Despite successes in the continental United States, this novel

approach to fuels management has not been attempted in Hawaii or the tropical Pacific. To test this concept we seeded fountain grass into plots of native species that differed in their fuel traits. Our study revealed that these native species plots significantly reduced fountain invasion compared to the controls. Plots containing the native species *Chenopodium* had the lowest levels of invasion. Further, *Chenopodium* had the highest moisture content and lowest heating value—both important traits in reducing the spread of fire. *Chenopodium* grows quickly, grows large, and occupies space-limiting reinvasion making it an excellent species to use for greenbreaks in Hawaii.

Evaluating habitat restoration plans with a novel fish population model

The ability to forecast the consequences of alternative habitat-restoration plans for highly valued resources is a critical need of the Forest Service and other resource management agencies. This project included development and application of a novel model of anadromous fish that addresses this need.

Resource management agencies worldwide seek to efficiently restore habitat—identification of effective restoration designs is a key step in this process. This collaborative project included evaluation of alternative restoration plans for a large site on lower Prairie Creek in Redwood National Park, northwestern California. Prairie Creek is a critical regional hotspot for Coho Salmon (a threatened species) and for aquatic biodiversity in general. Conservation of fish is a primary goal of this restoration project. FS scientists and their collaborators formulated and applied a spatially explicit, individual-based model of Coho Salmon. One key feature of the model is its ability to explicitly incorporate temporal heterogeneity in environmental conditions: effective restoration projects provide habitats where animals can be continuously successful over lengthy timespans. Key advances by PSW this year included development of methods to assign model-specific habitat parameters in spatially explicit

simulations of restoration alternatives. Results from these simulations are informing the selection of a specific restoration plan and contributing to its design. This project is important because of the weakness of current approaches to forecasting restoration consequences, which rely on simplistic conceptual models with hidden assumptions that focus on static conditions rather than environmental regimes.

ROCKY MOUNTAIN RESEARCH STATION (RMRS)



RMRS researchers work in a range of biological, physical, and social science fields to promote sustainable management of the Nation's diverse forests and rangelands. The Station develops and delivers scientific knowledge and innovative technologies with a focus on informing policy and land-management decisions. Our researchers work in collaboration with a range of partners, including other agencies, academia, nonprofit groups, and industry. The Rocky Mountain Research Station serves the Forest Service as well as other Federal and State agencies, international organizations, Tribes, academia, nonprofit groups, and the public.

Research has been part of the Forest Service mission since the agency's inception in 1905. The Rocky Mountain Research Station (RMRS) is an integral component of USDA, Forest Service Research and

Development (R&D), which is the most extensive natural resources research organization in the world. Forest Service R&D is comprised of five regional research stations (RMRS, Pacific Northwest Research Station, Pacific Southwest Research Station, Southern Research Station, and Northern Research Station), the Forest Products Laboratory, and the International Institute of Tropical Forestry.

RMRS maintains 12 research locations throughout a 12-state territory encompassing the Great Basin, Southwest, Rocky Mountains, and parts of the Great Plains. The Station employs over 400 permanent full-time employees, including roughly 100 research scientists. The RMRS footprint includes four Forest Service Regions: Northern Region (Region 1), Rocky Mountain Region (Region 2), Southwest Region (Region 3), and Intermountain Region (Region 4).

RMRS administers and conducts ecological research on 14 experimental forests, ranges, and watersheds over the longterm. Some of this research dates back over a century and offers invaluable insight into how forests change over time, particularly as we face a changing climate and new disturbance regimes.

We also oversee activities on several hundred research natural areas, a network of ecosystems set aside to conserve biological diversity. These areas represent a wide variety of habitats and ecosystems from alpine ecosystems to lowlands; and from coniferous forests of the Northern Rockies to semiarid deserts of the Southwest and prairie ecosystems of the Great Plains.

RMRS SCIENCE DELIVERY

Conservation and restoration of the sagebrush biome

Land management agencies face the need for effective strategic conservation actions for the conservation and restoration of sagebrush ecosystems. For nearly a century, the U.S. Department of Agriculture, Forest Service Research and Development (USDA-FS R&D) has studied sagebrush ecosystems and sagebrush obligate species such as sage-grouse with a focus on threats such as invasive annual grasses and wildfire, and management strategies, including conifer removal and restoration. In 2014, the USDA-FS R&D became part of a synergistic interagency collaboration for conservation and restoration of sagebrush ecosystems that began with development of two General Technical Reports published by the Rocky Mountain Research Station on using resilience and resistance concepts to manage threats to sagebrush ecosystems and sage-grouse.

The Science Framework for Conservation and Restoration of the Sagebrush Biome (Science Framework) provides a strategic, multiscale approach for prioritizing areas for management and determining effective management strategies across the sagebrush biome that exists in 11 Western States. A geospatial process is used in which sagebrush ecosystem resilience to disturbance and resistance to nonnative, invasive plant species are linked to information on the habitat requirements of sagebrush obligate species. The predominant ecosystem and land use and development threats are assessed, and a habitat matrix is used to help decision makers evaluate risks and determine appropriate management strategies at regional and local scales. The Science Framework provides a new and valuable approach that helps to ensure conservation and restoration actions are implemented where they will have the greatest benefits.

RMRS Research Ecologist Jeanne Chambers is first author and led the team of scientists and managers who developed the Science Framework. The team included individuals from the U.S. Department of

Agriculture Forest Service and Natural Resources and Conservation Service; U.S. Department of the Interior Geologic Survey, Bureau of Land Management, and Fish and Wildlife Service; the University of Wyoming; the Western Association of Fish and Wildlife Agencies; and individuals from the departments responsible for wildlife in the states of Idaho, Nevada, Montana, Wyoming, and Colorado.

Forest soil resilience following biomass thinning and repeated prescribed fire

The soil organic horizon, or forest floor, is vital to the function and health of most conifer forests. As a source of soil carbon and nutrients, this surface layer also moderates soil temperature and moisture extremes, limits soil erosion, and contributes to wildfire hazard. We examined 25-year changes in forest floor depth, amount, and ecological function following biomass thinning and prescribed burning in ponderosa pine forests. The findings revealed a high level of resilience to thinning and a relatively rapid recovery of the organic layer following burning. More importantly, key ecological functions of the forest floor were not compromised by either fuel-reduction practice during the quarter-century study.

We measured long-term forest floor accumulation in young, central Oregon ponderosa pine forests and asked whether selected ecological functions of the surface organic layer were altered by thinning and prescribed burning. Experimental treatments included (1) thin-only in 1989, (2) burn-only in 1991 and 2002, (3) thin and repeated burn, and (4) control—no thin or burn. Without fire, there was little change in forest floor accumulation for thinned or unthinned stands, indicating balanced litterfall and decay rates in these young forests regardless of tree density. The repeated burns each consumed most of the forest floor, yet post-fire accumulation rates were comparatively rapid, with forest floor depth matching pre-burn levels within 15 to 20 years of treatment. We detected only modest treatment effects on forest floor functions by the end of the study (total carbon and nitrogen pools, litter decay rate, restrictive layer

limiting plant emergence, erosion protection, and surface fire behavior) despite the temporal differences in forest floor depth and mass. This study highlights a quarter-century of forest floor development and suggests that thinning and burning pose limited risk to the properties and functions of surface organics in these dry, pine forests.

SnowEx: partnering with NASA to better understand snow in forested areas

More than one-sixth of the world's population relies on seasonal snow for water. In the Western United States, nearly three-quarters of the annual streamflow that provides the water supply arrives as spring and summer melt from the mountain snowpacks. SnowEx is a NASA-led science campaign that combines on-the-ground measurements with aerial and remote sensing to improve measurements and techniques for identifying the amount of water in snow. Forest Service scientists are playing a key role in the SnowEx ground campaign.

Background seasonal snow melts and provides water for more than one-sixth of the world's population. Knowing how much water will be provided to streams from snow is important. Ranchers and farmers depend on this water for their livelihoods. Cities depend on this information to know how much water they will have for their citizens. It is also important to know this for determining risk of flooding and water available for wildlife and fish. Snow is also important to climate, as it reflects sunlight, and loss of snow cover will mean the earth will absorb more light, accelerating warming. Right now, predictions of the snow-water equivalent, or how much water from the seasonal snowpack will melt into streams, vary widely, which makes accurate planning difficult. To address this, scientists and resource managers have come together under the leadership of NASA to launch a campaign, SnowEx, to better understand the snow-water equivalent.

For decades, satellites have monitored how much snow covered the Earth's surface. Scientists have also been on the ground monitoring snow depth in an attempt to best estimate the snow-water equivalent. For this intensive campaign, scientists from across the world came together for 1 month in Colorado to see if new sensors on aircraft and improved ground techniques could provide accurate estimates. NASA enlisted RMRS Research Hydrologist and Snow Scientist, Kelly Elder, to lead the ground campaign. Elder coordinated over 100 research volunteers to collect data on the ground during the course of the campaign. This data would allow the team to validate the information collected via the air campaign. NASA used 5 different types of aircraft that carried 10 types of sensors, like thermal infrared cameras, imaging spectrometers, and lasers for measuring snow depth through tree cover.

Key Findings

- Ground equipment was installed in September 2016.
- The SnowEx campaign took place over the month of February 2017. During this time, researchers were positioned at various ground sites and in airplanes to collect data.
- Data is being stored at the National Snow and Ice Data Center and is currently being evaluated by participating scientists. The data will be available to the public at no cost.
- For more information, please visit NASA's SnowEx website.

SOUTHERN RESEARCH STATION (SRS)



The Southern Research Station (SRS) is part of the network of forest and range research facilities that comprise the Research and Development program of the Forest Service. Stationed mainly in the 13 Southern States, our diverse and highly trained employees are committed to developing the science-based knowledge and technology needed to help inform decisions about natural resource management, use, and sustainability. To accomplish this charge, SRS's internal capacity for scientific research is enriched and extended through 19 experimental forests and networks of partnerships with other researchers, practitioners, and volunteers from a variety of groups and organizations.

Formed by the merger of the Southeastern and Southern Forest Experiment Stations, SRS celebrated its 20th anniversary in 2015. Today, existing long-term studies combined with 21st century innovations provide the foundation of a responsive, forest-based research program that continues to expand into new fields and address emerging challenges, including how forces such as climate and land-use change, population growth, invasive plants and pathogens, and fire affect the provision of timber, wildlife, clean air and water, recreation, and many other ecosystem services.

Knowledge generated by SRS applies to millions of people across the Southern United States, and serves urban, suburban, and rural communities across the country and even around the world. Designed for a broad range of audiences, the research program of SRS focuses on both expanding basic scientific knowledge and translating this science into practical applications. This dual mission provides a credible foundation for forest policy and management and provides science-based information about the forest ecosystems of the South.

Whether it's related to projected climate change, forest economics, ecosystem restoration, endangered species, silviculture practices, invasive plants, forest products, the dynamics of soil fungi, or the relationships between society and natural resources, the science we produce helps people make informed decisions, craft effective policies, and manage land sustainably.

SRS is focused on delivering the research and products that address the diverse needs of our stakeholders and partners. Communication with and feedback from Federal, State, Tribal, and local agency forest managers and policymakers, nongovernmental organizations, family forest landowners, private industry and investment companies, university academics, outdoor enthusiasts, small business owners, teachers and students, and many others shapes the direction of SRS research programs.

Today, the South is considered the wood basket of the world. No other nation produces as much industrial roundwood as the 13 Southern states, which contain almost a third of all forested lands and net annual timber volume growth in the United States. This was certainly not the case a century ago, when exploitive lumbering, poor agricultural practices, resource extraction, and wildfires devastated the forests of the Southeastern United States. The degrading, eroding, and increasingly unproductive landscapes contributed to impoverished and declining communities. Fortunately, pioneering visionaries

in government, industry, and the general public recognized the potential of southern lands to sustainably grow forests for timber, clean water, recreation, and economic development. This recognition spurred numerous rehabilitation and restoration programs designed to return this diminished region to environmental and economic vibrancy.

Yet little was known about the best way to proceed with this ambitious forest restoration goal—nationally, a serious lack of forest science capacity existed in the early 1900s. Forest Service research and development, itself only a few years old, helped fill this gap with the establishment of the Appalachian (later, Southeastern) and Southern Forest Experiment Stations in 1921. The efforts of our researchers, in partnership with universities and forestry professionals developed the technology and strategies for restoring the forests of the South. Research resulted in advances in many areas of forestry: the control and use of fire, tree planting, production, harvesting, and utilization; water quality protection; wildlife habitat management; and regulation of insects and diseases.

These advances led to emergence of the South's vital timber sector. In particular, the long-term research and demonstration projects on our experimental forests, many of which continue into the present, formed the basis for new questions and provided a means to respond to challenges as they appeared. In addition, new research directions also arose, as the public identified concerns regarding the sustainability of a broader suite of ecosystem services. Understanding where we are is the key to moving forward.

SRS SCIENCE DELIVERY

Shortleaf pine genetics, hybridization, and restoration

Shortleaf pine is a priority species for restoration in the Eastern United States. Understanding the genetics of the species is important for restoration planning and implementation, as recent genetics work has shown increased rates of shortleaf x loblolly pine hybridization as a potential restoration issue. DNA testing of orchard and nursery stocks for hybridity can ensure purer shortleaf pine planting stock to meet the needs of natural resource managers who are restoring shortleaf pine ecosystems.

To continue to address the genetic information needs of the Shortleaf Pine Initiative (shortleafpine.net), we completed a study looking at hybridity of shortleaf pine (*Pinus echinata*) orchard and nursery stocks across the Southeastern United States. Our study sampled both Forest Service and State agency facilities. We found none to limited amounts of first-generation (F1) hybrids with loblolly pine (*Pinus taeda*) in the orchards and nurseries; however, there was evidence for an appreciable amount of later generation hybridity. This may reflect bias in selecting shortleaf pines with some hybrid character for initial orchard establishment. Our previous research showed that shortleaf x loblolly pine hybrids have many desirable (strong competitive) characteristics under fire-excluding conditions, but not when fire is frequent. Establishing and maintaining shortleaf pine with frequent fire will greatly reduce or even eliminate hybrids regenerating and developing into the overstory. In addition to this research, we surveyed the literature on shortleaf pine genetics and prepared a review that can be used to guide further research and restoration planning activities. The work will be invaluable to natural resource managers across the southeast.

Quantifying Urban Forest Effects on Stormwater Runoff

Clean drinking water is vital to human existence, and forests provide the majority of potable water to the public. Urbanization of water-providing forests impacts water quality, as traditional urban development practices eliminate tree canopy cover, remove existing ground cover and pervious soils, and compact the remaining soil to better accommodate impervious surfaces. Green Stormwater Infrastructure (GSI) practices in municipalities are becoming viable strategies for managing stormwater runoff for less money, in many cases, compared to conventional stormwater conveyance practices. However, little is known about the benefits of urban forest systems as a GSI practice for stormwater volume control and water quality. Current research has provided valuable information that stormwater professionals can use to mitigate urban stormwater runoff. The Forest Service worked with civil engineers to compile research regarding urban trees and stormwater benefits. These manuscripts reviewed the most current research regarding the volume of rainfall retained by tree canopy; the impacts of foliar detention on stormwater runoff lag time, peak flow, and velocity; water volume removed from the soil through transpiration; and nutrient uptake by trees. These functions assist in “pre-treating” stormwater, helping to remove pollutants before it enters our drinking water supply. This research quantified the stormwater runoff reduction function of trees and discussed a method for estimating tree function and equating to best management practices (BMP) design capacity. The information gives stormwater and other natural resource professionals a way to quickly estimate tree impacts on stormwater and equate to the function of engineered systems. Ultimately, this gives them a basis for including urban forest systems in their stormwater management plans and design projects.

Sustainability of water and nutrient use in short-rotation forest crops for biofuels and bioproducts

Purpose-grown trees can be part of the bioenergy solution in the Southern United States where plantation forestry is prevalent and economically important. Short-rotation woody crops (SRWC) are

potentially an environmentally acceptable and economically sustainable method of producing wood for of bioenergy, biofuels, and bioproducts, as well as for traditional solid wood and fiber. However, production of SRWC will likely be located on marginal sites that may face challenges from nutrient management, water resource availability, and climate change.

There is renewed effort in examining a variety of SRWC including Pinus, Populus, and Eucalyptus for bioenergy production in the Southern United States. An economically viable and ecologically resilient bioenergy industry will require SRWC that can tolerate climate extremes such as multi-year droughts or tropical storms and appropriately apportion nutrient and water resources. Traditional forest management focused on wood products and fiber. These crops require long rotations of 10 to 100 years depending on species, site, and management. However, SRWC typically have short rotations – less than 10 years.

Management of nutrients, water, and competition will differ from traditional silvicultural systems and could result in environmental changes onsite such as changes in nutrient and water availability. There could also be off-site effects such as reduced water yield. For example, our results suggest that young Eucalyptus plantations have greater water-use efficiency than pine; however, because of greater growth, the potential total water use will be higher. Furthermore, Eucalyptus will be managed on shorter rotations (6 to 8 years) and will have greater cumulative water use over successive rotations compared to pine with longer rotations (15 to 25 years).

Thus, species conversion from pine to Eucalyptus may adversely affect offsite water yield. This could have implications for ground water reserves in ecologically sensitive areas. Our research will focus on management practices that maximize the sustainability potential of SWRC, including productivity and ecosystem services such as nutrient use, water use, and water quality.

Wilderness areas contribute to economic health of rural communities

Wilderness areas attract millions of tourists who spend significant amounts of money in nearby communities, according to new Forest Service research. Because wilderness areas are typically located in the most remote and inaccessible regions, income and jobs resulting from visitor spending contribute to local economies that may have limited alternatives for economic growth. New Forest Service research showed that nearly 10 million people per year visit wilderness areas and spend about \$500 million in adjacent communities. Annual visitor expenditures generate about 5,700 jobs, resulting in over \$700 million in total economic output. Maintaining the character and supporting the ecological health of wilderness areas are key management goals and, because of the relative permanence of this land use, wilderness areas support the economic sustainability of rural areas.

Burning Forests Can Impact Water Supplies

The number of wildland fires and burned areas in the United States is on the rise as a result of a warming climate, drought, and increasing human ignitions. Though forests and rangelands provide more than half of U.S. water supplies, the long-term impacts of both wildland and prescribe fire on water supplies have not been previously measured nor factored into water management strategies. Researchers developed a practical framework to evaluate fire impacts on water resources by synthesizing 30-year records of wildland fire, climate, and river flow for 162 locations across the United States.

The number of wildland fires and burned areas in the United States is on the rise as a result of a warming climate, drought, and increasing human ignitions. Wildland fires alter the watershed hydrologic cycle by modifying soil and forest cover properties, but the effects vary widely across the continental U.S. due to differences in fire severity and burned area, background climate, and watershed conditions. Climate variability such as drought may mask the effects of wildland fire on water supplies. Though forests and rangelands provide more than half of United States water supplies, the long-term impacts of wildland and prescribed fire on water supplies have not previously been measured nor factored into water management strategies. Eastern Forest Environmental Threat Assessment Center researchers developed a practical framework to evaluate fire impacts on water resources by synthesizing 30-year records of wildland fire, climate, and river flow for 162 locations across the United States. They discovered that wildland fires enhanced annual river flow in Western regions with a warm temperate or humid continental climate (the semi-arid Lower Colorado River in particular). In contrast, repeated prescribed burns did not significantly alter river flow in the subtropical Southeast. These outcomes offer new insights into the potential role of wildfire and prescribed fire in water supply augmentation, flood control, and landslide hazard mitigation under a changing climate. Results can help land managers consider local watershed conditions and design effective forest management practices, including prescribed burning, that reduce fire risk and strengthen forest resilience to drought and diseases.

TECHNOLOGY AND DEVELOPMENT CENTERS

Missoula & San Dimas



History

The Missoula Technology and Development Center (MTDC) began as the support facility for Forest Service fire management in the late 1940s, when a small group started developing techniques for parachuting men and cargo. In the early 1960s, the center's role was expanded to a Forest Service-wide technical center with a nationwide program that now encompasses all Forest Service equipment needs. Today, MTDC works with Federal and State agencies, universities, private firms, and research groups to meet its responsibilities to resource managers.

What is MTDC?

MTDC is one of four detached units of the Engineering Staff in Washington, DC, and serves Forest Service Regions and cooperating Federal and State agencies. MTDC makes equipment, information, concepts, and ideas available so Federal and State agencies can better manage the millions of acres of public land.

The Center:

- Interviews Forest Service personnel to help identify real needs.
- Surveys commercial markets and tests promising products.
- Designs, builds, and tests prototype equipment.
- Cooperates with private industry to develop commercial sources.
- Maintains specifications and standards for fire and safety equipment.
- Disseminates publications, fabrication drawings, project films, and audiovisual programs.

Personnel

Wide-ranging problem solving in resource management demands varied skills. Equipment specialists, engineers, writers, foresters, draftsmen, technicians, illustrators, and photographers all work as project team members to accomplish goals.

Staff members have worked on projects in fire and aviation, timber, occupational safety and health, engineering, forest pest management, range and disturbed land rehabilitation, watershed, wildlife, cooperative forestry, forest residues, recreation, and law enforcement.

The team approach has resulted in these recent accomplishments:

- Tree nursery pickup system
- Chunkwood chipper for utilizing slash
- Audiovisual on crew supervision and safety
- Satellite navigation and position locating system
- The Salmon Blade scarifier
- Improved firefighter's clothing and equipment



- Improved aircraft restraint system for cargo and smokejumpers
- Electronic tree measurement devices
- Placement guide for traffic control devices
- Orchard netting retrieval machine
- Audiovisual showing how to order and inspect Forest Service signs
- Improved aerial ignition equipment
- Disk chain for range improvement
- Fire shelter training facilitator's guide
- Sign maintenance guide for Forest Service signs.

History

The San Dimas Technology and Development Center (SDTDC) was established in 1945 to standardize fire equipment. At that time the Center—known as the Arcadia Fire Equipment Development Center—was located in Arcadia, California. It consolidated all Forest Service fire equipment problem-solving efforts into a "laboratory sufficient to serve the fire control requirements of the Western Regions."

Southern California was selected due to the large fire activity in the area, its evolving industrial and academic centers, and the availability of space in an existing Los Angeles County Forest Service facility.

Additional program sponsors brought new work to the Center, and its name was changed to Arcadia Equipment Development Center. In 1965, a new facility, 13 miles east of Arcadia, was designed and constructed to house the Center. In conjunction with the move, the Center's name was changed to the

San Dimas Equipment Development Center. For the past 10 years, the Center has been known as the San Dimas Technology and Development Center.

Who We Are

SDTDC is a national program of the Forest Service Engineering staff in Washington, DC, and serves emerging technological requirements of the Forest Service and its cooperators.

Personnel

To support the Technology and Development program's mission of resource management problem solving, the Center has a cadre of personnel with far reaching skills. Engineers, technicians, foresters, draftsmen, writers, and desktop publishers all work as project team members to support the problem-solving goals of the Center. Program areas include fire and aviation, recreation, engineering, watershed, and timber. The Center's team approach to creative problem solving has resulted in some unique and innovative projects.

Projects

These projects include the development of:

- A "Scenic Byways Roadside Improvement Guidebook" to help managers develop successful scenic byways.
- The only spark arrester qualification facility in the world.

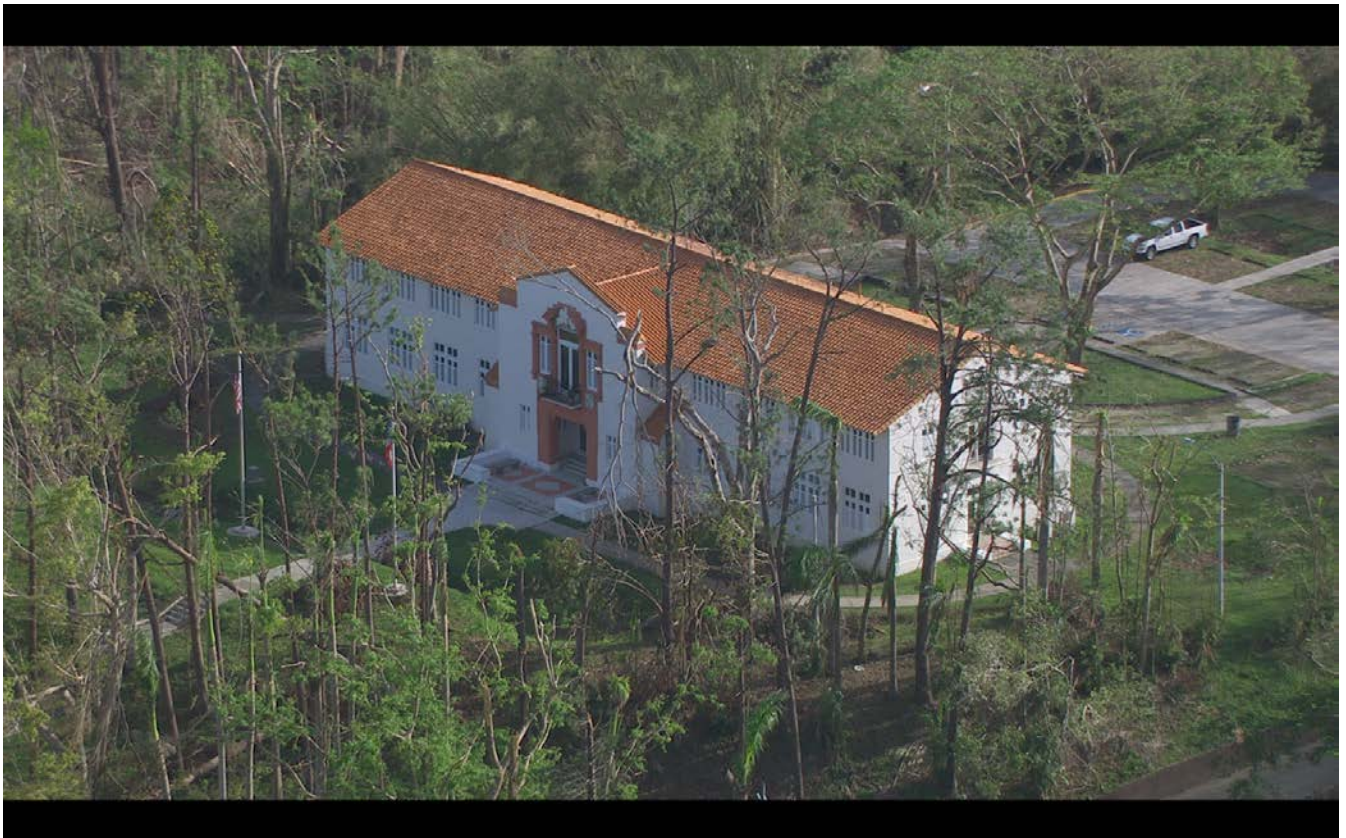


- Self-monitoring water treatment systems for remote sites.
- A new series of publications entitled "Water/Road Interaction" to provide guidance in all aspects of the ways roads affect the hydrology of forested watersheds.
- Re-engineered chemical toilets that do not smell.
- Bear-proof food lockers for forest campsites.
- Soil hardeners that stabilize trails for universal access.
- A digital tally meter for estimating timber yields.
- Biological odor-control filters.
- The "Plastic Road" for crossing wet sites on soils of low bearing capacity.

Other projects

- Qualification testing for fire chemicals, water-handling fire equipment, general purpose and locomotive spark arresters, and multiposition small-engine exhaust systems.
- Field demonstrations of "Mobile Rock Crusher" technology to determine the capabilities of road reconditioning equipment.
- Demonstrations of the "Soil Nail Launcher" to expand this technology nationally.
- The use of transponders for marking timber boundaries.
- Composting as an alternative method of waste disposal.
- Noise control on National Forest lands.

INTERNATIONAL INSTITUTE OF TROPICAL FORESTRY



The International Institute of Tropical Forestry (Institute) is housed in San Juan, Puerto Rico where it serves people from Puerto Rico, the US, Virgin Islands, the Caribbean, and central and south America. The Institute has an international mission as well as Research and Development and State and Private Forestry missions. It has been a unit of the Forest Service since 1939, and it specializes in tropical forestry, a specialty which is globally known for its level of excellence and continuity of its programs. As an example, the Institute pioneered tropical forestry in this hemisphere and developed the field at a time when there was no professional tropical forestry being practiced in the region. Today, the programs of the Institute support the Forest Service mission in the only tropical forest in the National Forest System, the El Yunque National Forest. This forest is also an experimental forest in its entirety (unique in the agency) and is the most studied tropical forest in this hemisphere. The results of the Institute's research program are broadly transferred to a diverse network of collaborators including non-governmental organizations, municipal and State governments, landowners, land management practitioners, international organizations, and other scientists, to name a few. Through electronic media, the Institute now reaches millions of people.

Recent outcomes of Institute programs include:

- Comprehensive understanding of the effects of hurricanes on tropical forests, including uncovering invisible effects through microbial action that may prove key to processing enormous quantities of debris produced by hurricanes and other extreme events.

- Established the first experiment dealing with the response of tropical forests to increases in air temperature. Experiments on the effects of droughts and fire on tropical forests are also underway and yielding information relevant to forest conservation.
- How do cities think? How can cities be made more adaptive and resilient to extreme events? These questions are being addressed through networks of tropical and temperate cities. Research shows that tropical cities are different from temperate cities in terms of their green infrastructure and social-ecological responses to extreme events.

The Institute transfers the results of its research to collaborating communities and landowners through programs that include tree cities, forest stewardship management plans, urban councils, land acquisition for conservation purposes, and new eco-tourism enterprises; all are programs that provide jobs and economic development.

The Institute also has a conservation education program that reaches underrepresented populations from kindergarten to postdoctoral levels.

6.13. Metric Tables.

TABLE 1. Collaborative Relationships for Research and Development.

ND= no data available. CRADA= Cooperative Research and Development

Agreement. MTA= Material Transfer Agreement.

| Forest Service (FS) | FY 2013 | FY2014 | FY2015 | FY2016 | FY2017 |
|--|---------|--------|--------|--------|--------|
| Total number active CRADAs | 20 | 44 | 79 | 73 | 74 |
| Number newly executed CRADAs | 10 | 16 | 20 | 33 | 34 |
| Newly executed amendments ¹ | 6 | ND | 13 | 12 | 3 |
| Newly executed traditional CRADAs | 10 | 9 | 7 | 9 | 30 |
| Newly executed non-traditional CRADAs | 0 | 7 | 13 | 24 | 4 |
| Newly executed CRADAs with small businesses | 0 | 0 | ND | ND | ND |
| Total number active MTRAs² | 0 | 0 | 4 | 7 | 1 |
| Newly executed MTRAs | 0 | 0 | 4 | 5 | 1 |
| Total number of active other agreements³ | 3,179 | 2,550 | 1,083 | 1,274 | 1261 |
| Newly executed other agreements | 1,380 | 701 | 261 | 322 | 642 |
| Number newly executed MTAs | 8 | 7 | 3 | 5 | 3 |
| Newly executed outgoing MTAs | 8 | 7 | 3 | 5 | 3 |
| Total number of analysis publications | 3,460 | 2,083 | 2,013 | 2,022 | |
| Peer-Reviewed Scientific Publications ⁴ | 3,014 | 1,285 | 1,151 | 1,169 | 1,214 |
| Trade Journal Publications ⁵ | 446 | 798 | 862 | 853 | 824 |
| Abstracts ⁶ | ND | ND | ND | ND | ND |
| Total number of data publications | 37 | 34 | 63 | 37 | 65 |
| Customers Accessing Data Publications | 997 | 1,547 | 2,500 | 3,874 | 4,498 |
| Percentage Increase in Customers Served | 179% | 55% | 61% | 55% | 26% |

1. Amendments extend existing CRADAs for additional years to a maximum of 5 years, and/or change Statements of Work, and/or change funding levels.
2. Material Transfer Research Agreements. Involves collaborative research on a specific material.
3. Includes mostly Trust Fund Cooperative Agreements, Reimbursable Agreements, Material Transfer Research Agreements, Specific Cooperative Agreements and Non-Funded Cooperative Agreements, Challenge Cost-Share Agreements, Collections Agreements, Cooperative Agreements, Inter-agency & Intra-agency Agreements, Joint Venture Agreements, Participating Agreements, Research Cost-Reimbursable Agreements, Research Joint Venture Agreements.
4. In 2014 the definition of this metric and the means of accounting for publications was changed and these factors can explain the large reduction in number of publication accomplishments for 2014 and beyond compared to FY2013 and earlier. This category is considered "Formally Refereed Publications" and is defined as "Documents, usually in journal or similar quality outlet, that are the result of material support from FS R&D, and on which the decision to publish is based on the results of a formal peer review and independent editorial decision."
5. The definition for this metric changed in FY14 to "Informally Refereed Publications" and is defined as "scientific papers or similar documents that are the result of material support from R&D, and on which the decision to publish is made after peer reviews that are not independently commissioned (reviewers are selected by author or line officer). In past years, these publications may have been counted as journal publications, but from FY2014 onward the new definition applies.
6. The Forest Service does not count Abstracts as accomplishments.

TABLE 2. Invention Disclosure and Patenting

| Forest Service (FS) | FY 2013 | FY2014 | FY2015 | FY2016 | FY2017 |
|---|---------|--------|--------|--------|--------|
| Total number new invention disclosures¹ | 24 | 13 | 24 | 20 | 10 |
| University co-owned | 7 | 4 | 2 | 7 | 1 |
| Total number patent applications filed² | 13 | 9 | 12 | 11 | 7 |
| University co-owned | 9 | 6 | 7 | 6 | 0 |
| Total number patents issued | 4 | 4 | 9 | 5 | 5 |
| University co-owned | 1 | 1 | 4 | 4 | 4 |

1. Inventions arising at the Federal lab.
2. Includes U.S. patent applications, foreign patent applications filed on cases for which no U.S. application was filed, divisional applications, continuation-in-part applications, and provisional applications.

TABLE 3. Profile of Active Licenses

| Forest Service (FS) | FY 2013 | FY2014 | FY2015 | FY2016 | FY2017 |
|---|---------|--------|--------|--------|--------|
| Total number active licenses | 19 | 21 | 19 | 19 | 9 |
| Executed to small businesses ¹ | 1 | 3 | 2 | 2 | 0 |
| Executed to startup businesses ² | 2 | 1 | 1 | 1 | 0 |
| Executed to universities | 14 | 17 | 16 | 16 | 0 |
| Invention licenses³ | 19 | 21 | 19 | 19 | 9 |
| Executed to small businesses | 1 | 3 | 2 | 2 | 0 |
| Executed to startup businesses | 2 | 1 | 1 | 1 | 0 |
| Executed to universities | 14 | 17 | 16 | 16 | 0 |
| Other IP Licenses⁴ | 0 | 0 | 0 | 0 | 0 |
| Executed to small business | 0 | 0 | 0 | 0 | 0 |
| Executed to startup businesses | 0 | 0 | 0 | 0 | 0 |
| Executed to universities | 0 | 0 | 0 | 0 | 0 |
| Total number newly executed licenses | 2 | 2 | 0 | 2 | 0 |
| Executed to small businesses | 0 | 0 | 0 | 0 | 0 |
| Executed to startup businesses | 1 | 0 | 0 | 0 | 0 |
| Executed to universities | 1 | 2 | 0 | 2 | 0 |
| Invention licenses | 19 | 21 | 19 | 19 | 9 |
| Executed to small businesses | 1 | 3 | 2 | 2 | 0 |
| Executed to startup businesses | 2 | 1 | 1 | 1 | 0 |
| Executed to universities | 14 | 17 | 16 | 16 | 0 |
| Other IP Licenses | 0 | 0 | 0 | 0 | 0 |
| Executed to small businesses | 0 | 0 | 0 | 0 | 0 |
| Executed to startup businesses | 0 | 0 | 0 | 0 | 0 |
| Executed to universities | 0 | 0 | 0 | 0 | 0 |

1. A small business, together with its affiliates, must not have more than 500 employees.
2. For the purpose of this report, a startup company is a privately-held, U.S., for-profit company operating for less than five years and actively seeking financing to commercialize a federal scientific work product.
3. Invention licenses refer to licenses resulting from a patent.
4. Other intellectual property (IP) licenses included biological materials licenses and plant variety protection licenses.

TABLE 4. Characteristics of Income-Bearing Licenses

| Forest Service (FS) | FY 2013 | FY2014 | FY2015 | FY2016 | FY2017 |
|--|---------|--------|--------|--------|--------|
| Total number of income-bearing licenses | 18 | 21 | 19 | 19 | 9 |
| Exclusive | 17 | 20 | 18 | 18 | 9 |
| Partially exclusive | 0 | 0 | 0 | 0 | 0 |
| Non-exclusive | 1 | 1 | 1 | 1 | 0 |
| Invention licenses¹ | 18 | 21 | 19 | 19 | 9 |
| Exclusive | 17 | 20 | 18 | 18 | 0 |
| Partially exclusive | 0 | 0 | 0 | 0 | 0 |
| Non-exclusive | 0 | 1 | 1 | 1 | 0 |
| Other IP Licenses² | 0 | 0 | 0 | 0 | 0 |
| Exclusive | 0 | 0 | 0 | 0 | 0 |
| Partially exclusive | 0 | 0 | 0 | 0 | 0 |
| Non-exclusive | 0 | 0 | 0 | 0 | 0 |
| Total number royalty-bearing licenses | 18 | 21 | 19 | 19 | 9 |
| Invention licenses | 18 | 21 | 19 | 19 | 9 |
| Material transfer licenses | 0 | 0 | 0 | 0 | 0 |

1. Invention licenses refer to licenses resulting from a patent.

2. Other intellectual property (IP) licenses included biological materials licenses and plant variety protection licenses.

TABLE 5. Income from Licensing

ND= no data available.

| Forest Service (FS) | FY 2013 | FY2014 | FY2015 | FY2016 | FY2017 |
|---|-----------|-----------|-----------|-----------------------|---------|
| Total income all active licenses | \$3,763 | \$2,230 | \$2,878 | \$2,634 | \$3,122 |
| Invention licenses | \$3,763 | \$2,230 | \$2,878 | \$2,634 | \$0 |
| Biological materials licenses | 0 | 0 | 0 | 0 | \$0 |
| Total earned royalty income (ERI) | \$1,763 | \$230 | \$878 | \$634 | \$1,122 |
| Median ERI | \$340 | \$230 | \$439 | \$317 | ND |
| Minimum ERI | \$256 | \$230 | \$256 | \$11 | ND |
| Maximum ERI | \$827 | \$230 | \$623 | \$623 | ND |
| ERI from top 1% of licenses | \$827 | \$230 | \$623 | \$623 | ND |
| ERI from top 5% of licenses | \$827 | \$230 | \$623 | \$623 | ND |
| ERI from top 20% of licenses | \$827 | \$230 | \$623 | \$623 | ND |
| Total income distributed | \$10,788 | \$2,230 | \$2,878 | \$2,634 | \$1,122 |
| Inventors | \$10,788 | \$2,230 | \$2,878 | \$2,634 | \$1,122 |
| Salaries of some technology transfer staff | \$194,496 | \$194,496 | \$194,496 | \$194,496 | ND |
| Patent filing preparation, fees, & annuity payments | \$15,144 | \$15,600 | \$13,500 | \$63,053 ⁴ | ND |
| Other technology transfer expenses (plaques) | \$665 | \$910 | \$1,158 | \$320 | ND |



FSIS applies the latest technologies to assure the safety of meat, poultry, catfish, and egg products.



FSIS employs a variety of techniques to communicate safe food handling practices to consumers.



FSIS activities lead to safer food for consumers.

7.0. Food Safety & Inspection Program

<http://www.fsis.usda.gov>

7.1. Mission Statement

The Food Safety and Inspection Service (FSIS) is the public health agency in the U.S. Department of Agriculture responsible for ensuring that the Nation's commercial supply of meat, poultry, Siluriformes fish, and egg products is safe, wholesome, and correctly labeled and packaged.

7.2. Nature and Structure of the Program

FSIS applies the latest advances in food safety technologies to monitor chemical and microbial hazards in meat, poultry, Siluriformes fish, and egg products. FSIS also facilitates the application of new food safety technologies to food production by industry. In addition, the agency uses various strategies and

technologies to conduct educational outreach to consumers throughout the year (examples provided in section 7.3).

The FSIS Research Priorities Review Panel routinely identifies and prioritizes research that assists the agency in its mission to protect public health. The list of current FSIS research priorities includes:

- Developing analytical methods to increase the efficiency of laboratory analyses
- Identifying and understanding emerging chemical and microbial hazards
- Identifying and evaluating hazard mitigation techniques (e.g., pathogen interventions for food processing establishments)
- Improving the transfer of food safety knowledge to consumers.

Although FSIS is not a research agency, FSIS addresses its scientific information and data needs through partnerships with a variety of Federal agencies, universities, and industry. The agency prioritizes and communicates its needs to our partners and stakeholders during meetings with agency leadership and scientists, seminars at universities and scientific conferences, and postings on the FSIS website. In FY 2017, the FSIS Research Priorities and Food Safety Research Studies pages on the FSIS website were each accessed on more than 5,000 occasions. About 70 percent of page views were by new visitors. About 90 percent of visitors were referred by search engines or partner agency websites. During FY 2017, FSIS added one new research priority (Identify or develop approaches to facilitate humane handling of FSIS regulated livestock species) and seven new priority associated study suggestions.

7.3. Activities in FY 2017

Adoption of New Technologies To Facilitate Information Transfer to FSIS Inspectors and Industry

- FSIS launched 360-degree video and virtual reality segments in the classroom and job fairs, depicting authentic operations to train inspection personnel and orient prospective job applicants. Touchscreen tablets deliver the video via a customizable, open-source platform, and cellphone-powered goggles deliver the virtual reality.

Facilitating the Application of New Food Safety Technologies to Food Production

- FSIS encourages continued improvement and innovation in food safety technologies. During FY 2017, FSIS evaluated new technologies aimed at enhancing food safety, including new commercial pathogen interventions, process innovations, and the use of new ingredients proposed by industry. If the evaluation indicates that the technology is consistent with agency regulations and will not adversely affect product safety, inspection procedures, or the safety of FSIS inspectors, the agency issues a “no objection” letter. In an effort to increase public and industry awareness of available new technologies, FSIS posts brief summaries of the technology on the [FSIS New Technology Information Table](https://www.fsis.usda.gov/wps/portal/fsis/topics/regulatory-compliance/new-technologies/new-technology-information-table)¹. In FY 2017, FSIS evaluated 132 new technology submissions. Of these submissions, FSIS issued 76 “no objection” letters.

¹ <https://www.fsis.usda.gov/wps/portal/fsis/topics/regulatory-compliance/new-technologies/new-technology-information-table>

Facilitating the Application of Food Safety Research Findings To Produce Safe Food and Compliance With FSIS Guidance and Regulations

In FY 2017, FSIS released seven guidance documents to assist industry with identifying and applying relevant scientific findings to produce safe meat, poultry, Siluriformes, and egg products, including:

- FSIS Compliance Guideline for Minimizing the Risk of Shiga Toxin-Producing *Escherichia coli* (STEC) in Raw Beef (including Veal) Processing Operations. This guideline assists establishments in understanding the adulterant status of STEC in beef products and how to design supportable control measures for STEC.
- Compliance Guideline for Minimizing the Risk of Shiga Toxin-Producing *Escherichia Coli* (STEC) and *Salmonella* in Beef (including Veal) Slaughter Operations. This guideline provides beef and veal slaughter establishments with practices that prevent, eliminate, or reduce levels of microbiological contamination.
- FSIS Guidance for Importing Meat, Poultry, and Egg Products into the United States. This guideline is designed to help importers, customs brokers, official import inspection establishment plant management, and the general public understand U.S. import regulatory requirements.
- FSIS Compliance Guidance for Label Approval. This guide provides information about the types of labels and statements that need agency approval.

- FSIS *Salmonella* Compliance Guidelines for Small and Very Small Meat and Poultry Establishments That Produce Ready-to-Eat (RTE) Products and Revised Appendix. This guidance assists small and very small meat and poultry establishments understand the regulatory requirement for RTE products.
- FSIS Compliance Guideline for Stabilization (Cooling and Hot-Holding) of Fully and Partially Heat-Treated-Ready-to-Eat and Not-Ready-to-Eat Meat and Poultry Products Produced by Small and Very Small Establishments and Revised Appendix B. This guidance assists establishments in understanding the requirements for product stabilization, identifying scientific documents to develop safe processes, and identifying correction actions for cooling deviations.
- FSIS Compliance Guideline for Establishments That Slaughter or Further Process Siluriformes Fish and Fish Products. This compliance guideline is to assist establishments that slaughter or further process Siluriformes fish and fish products in understanding and implementing their regulatory responsibilities.

FSIS Uses Science-Based Food Safety Information To Educate Consumers and Other

Stakeholders

- Expanded Hotline Hours: The USDA Meat and Poultry Hotline is staffed by food safety specialists with backgrounds in home economics, nutrition, and food technology who personally answer food safety questions on weekdays year-round. The majority of calls come from consumers regarding how to properly handle their food, including food safety

during power outages, food manufacturer recalls, foodborne illnesses, and the inspection of meat, poultry, and egg products. The hotline staff responded to more than 52,000 consumer inquiries via the Meat and Poultry Hotline and 7,709 email inquiries during FY 2017. In April 2017, the Meat and Poultry Hotline expanded its hours to accommodate consumers in the Pacific Time Zone and provide them with better access to the toll-free phone, chat, and email system designed to address food safety questions from consumers. By expanding the hours from 10 a.m.–6 p.m. ET (originally 10 a.m.– 4 p.m. ET), the number of calls answered by the hotline increased by 34 percent, total chats answered in Ask Karen increased by 24 percent, and total engagements increased by 31 percent.

- **Ask Karen:** “Ask Karen” is FSIS’ food safety virtual representative, an automated system with answers to thousands of typical USDA Meat and Poultry Hotline-type questions. Live chat is available during specified weekday hours. The “Ask Karen” database received 3,704 email questions and 2,792,351 answers were viewed in FY 2017. The “Ask Karen” chat feature allows consumers to chat online with a hotline food safety specialist. The “Ask Karen” chat received 3,296 chat requests in FY 2017.
- **Food Safety Discovery Zone:** The Food Safety Discovery Zone (FSZD) is FSIS’ mobile classroom and provides consumers with science-based, interactive, and hands-on food safety learning experiences that help protect them and their families from foodborne illness. The interior of the Food Safety Discovery Zone (FSDZ) was redesigned to be more digitally interactive with touchscreen televisions and videos that explain the importance of food safety. The entryway to the interior also includes a laser counter to track the number of consumers visiting the exhibit. The FSDZ had more than 20,000 direct connections with consumers while

exhibiting at 15 events. The marquee event of FY 2017 was the California State Fair, where the FSDZ had over 9,000 direct connections with consumers, including with California Department of Food and Agriculture Secretary Karen Ross.

- Twitter & Facebook: The @[USDAFoodSafety](#) Twitter account and the FoodSafety.gov Facebook account continued to see growth throughout the year due to the ongoing strategy of using non-traditional topics to communicate food safety messages. FSIS has seen outstanding success in Twitter followers, reaching a new total of 1,178,459 followers. This makes FSIS the second public health Federal agency with more than 1 million followers. In an effort to educate the Hispanic community about safe food handling, FSIS continued posting messages in Spanish on Facebook. This year, the FSIS Spanish language Twitter account achieved a total of 317,078 impressions and 789 new followers.
- Foodkeeper App: The Foodkeeper app is a relevant, useful, and effective tool to educate consumers about proper food storage and its relationship to safe food-handling behaviors. It is tri-lingual (Spanish, Portuguese, and English) and available for Android and Apple platforms. It has been downloaded more than 150,000 times. Version 7 of the app was published in August 2017, and allows users to receive food safety recall notifications immediately when they're announced or select to receive them daily or weekly. The update also adds instructional videos on proper handling and storage of food, and expands the list of food and beverage products from about 400 to more than 500 items.

Transferring Analytical Methods Development Research and New Technologies to FSIS

Laboratories for Monitoring Hazards in Meat, Poultry, Siluriformes, and Processed Egg Products

FSIS laboratories deploy new technologies to better monitor hazards in meat, poultry, Siluriformes, and egg products and to minimize human exposure to foodborne hazards. In FY 2017, FSIS validated and adopted four new or revised laboratory methods. These methods improve the agency's ability to monitor potentially hazardous concentrations of chemicals (e.g., antibiotics, pesticides, environmental contaminants, growth promoters) and microbial pathogens (e.g. Shiga-Toxin Producing *E. coli*, *Salmonella*, *Listeria monocytogenes*, and *Campylobacter*) in food. These new FSIS methods include:

- **Screening and Confirmation of Animal Drug Residues by UHPLC-HRMS-MS.** Multi-residue methods to detect veterinary drug and pesticides are used by the Agency to ensure that FSIS regulated products do not contain unsafe levels of chemicals. An ultra-high performance liquid chromatography–tandem high resolution mass spectrometry (UHPLC-HRMS-MS) method was developed by the USDA, Agricultural Research Service. The method was subsequently validated and implemented in FSIS laboratories. This method is suitable for screening a variety of animal drugs in bovine and porcine muscle and kidney. Results from these methods may be used both for regulatory enforcement purposes and for FSIS, U.S. Food and Drug Administration, and U.S. Environmental Protection Agency consumer chemical exposure and risk assessments.
- **FSIS Procedure for the Use of a Polymerase Chain Reaction (PCR) Assay for Screening Salmonella in Meat, Poultry, Egg, and Siluriformes (Fish) Products and Carcass and Environmental Sponges.** This method is used to screen ready-to-eat (RTE) meat and poultry products, egg products, raw meat, carcass and environmental sponges, whole bird and parts rinses, and raw and RTE Siluriformes (fish) products for *Salmonella*. FSIS Laboratories

extended a previous method to include RTE Siluriformes (fish). The FSIS Laboratories modified the existing method to render improved performance for the detection of *Salmonella* in RTE products.

- **Isolation and Identification of *Listeria monocytogenes* From Red Meat, Poultry, RTE Siluriformes (fish), Egg Products, and Environmental Samples.** FSIS Laboratories expanded previous methodology by validating RTE siluriformes (fish) as a matrix for the isolation and identification of *Listeria monocytogenes* method. The new method is broadly applicable to raw or cooked RTE red meat, poultry products, egg products, RTE siluriformes (fish) and environmental sponge samples.
- **FSIS Procedure for the Use of a *Listeria monocytogenes* Polymerase Chain Reaction (PCR) Screening Test.** This PCR based method is used to screen-test processed meat, poultry, RTE siluriformes (fish), and egg products and environmental sponge samples for the presence of *Listeria monocytogenes*. All samples identified as presumptively positive for *Listeria monocytogenes* are subject to cultural confirmation.

8.0. Grain Inspection, Packers and Stockyards Administration (GIPSA)

Note: As a result of a reorganization that occurred at the end of fiscal year 2017, the activities previously carried out by GIPSA are now carried out by Agricultural Marketing Service (AMS). For background information, please see <http://www.ams.usda.gov/>

8.1. Mission Statement

To facilitate the marketing of livestock, poultry, meat, cereals, oilseeds, and related agricultural products, and promote fair and competitive trading practices for the overall benefit of consumers and American agriculture.

8.2. Strategic Plan

GIPSA's Strategic Plan serves to ensure fair and transparent markets free from deceptive and fraudulent practices, combined with recognized and reliable descriptors of crop quality and value, to promote economic health and prosperity in American agriculture. U.S. farmers produce a wide variety of agricultural products, and the vast American infrastructure permits these products to be processed and distributed throughout the United States and international markets effectively and efficiently. In FY 2017, the grain markets serviced by GIPSA represented an approximate value of \$113 billion, with exports contributing about 44 billion to the U.S. economy.

8.3. Nature and Structure of Research Programs

GIPSA maintains a strong presence, domestically and internationally, in the development, evaluation, and implementation of practical grain quality assessment and inspection methods. Our laboratories work with the latest technologies, and through these technologies and our ongoing efforts, we are helping to improve the quality of U.S. grain available to the global market. To enhance marketing of grain into the future, we are also conducting internal research and participating in development and collaborative efforts with other governmental entities, laboratories, and private business. The research and analysis we conduct is in response to clear and widespread market needs. In general, GIPSA research is highly “applied,” in that GIPSA’s successful projects result in direct and immediate use by the U.S. grain industry. GIPSA also develops written information for customers and stakeholders, including scientific publications, publications in trade journals, and reports to stakeholders.

As agricultural crops evolve and varieties with enhanced traits are developed, reliable tests must be developed to detect and quantify the quality traits important to the market. GIPSA conducts an evaluation program to assess the performance of rapid test kits that are designed for detecting and/or quantifying the presence of mycotoxins in grain and for detecting the presence of specific genetically engineered (GE) traits in grain. GIPSA research results in new applications of existing technologies, such as near infrared spectroscopy and nuclear magnetic resonance, and improvements in those technologies to meet identified market needs for grain quality assessments.

8.4. Current Technology Transfer Goals, Objectives, and Measures of Success (Metrics)

8.4.1. Current Technology Transfer Initiatives

Visually identifying quality factors within grain and other commodities requires specific lighting

characteristics to appropriately illuminate the sample being graded. GIPSA has identified a need for light emitting diode (LED) lights as an alternative to the fluorescent lights currently used within the official inspection system. GIPSA conducted a study of three commercially available LED lights to identify the appropriate specifications that equate to the current fluorescent lighting requirements.

Test weight per bushel is a critical component for the marketing of grains and commodities that is currently assessed using a manual method. In FY 2017, GIPSA investigated the feasibility of the two approved dielectric moisture meters to provide official test weight per bushel determinations, which would reduce the time required for this measurement. Both meters have received Certificates of Conformance issued by the National Conference on Weights and Measures (NCWM) as legal for trade for test weight and moisture.

Using technology that can provide an objective measurement of quality factors currently measured by visual assessment can result in increased consistency between measurements. Reducing the amount of time required to complete the assessment adds additional value to the measurement process. GIPSA is exploring how use of imaging and near infrared technology (NIR) can be effectively integrated into the official grain inspection system.

In FY 2017, GIPSA conducted a field study of three near infrared transmittance (NIRT) instruments that have NCWM Certificates of Conformance to evaluate if they provide equivalent results for protein, oil, and starch compared to the approved NIRT, which also has a NCWM Certificate of Conformance. Evaluating instruments for equivalency to current approved models allows the introduction of new technology while maintaining the consistency between measurements. One instrument was approved as providing equivalent results with no additional modifications needed to the instrument and its

calibrations. GIPSA continues to review the data and work with the participating manufacturers to determine if other NIRT models may provide equivalent results and potentially be approved for official protein, oil, and starch determinations.

GIPSA continues work with manufacturers to evaluate and certify rapid test kits that detect mycotoxins and approved GE traits in grain. GIPSA also approves the use of mycotoxin test kits for use within the official inspection system. GIPSA provides a monthly update of all approved rapid test kits on its public website. GIPSA has approved 36 rapid test kits for the detection of mycotoxins in grain including, aflatoxins, deoxynivalenol, fumonisins, ochratoxin A, and zearalenone. GIPSA has approved 12 rapid test kits for detection of specific GE traits in corn and soybeans.

8.4.2. CRADA Activities

GIPSA has a CRADA with QualySense AG to assess how the use of imaging and NIR technology can be effectively integrated into the official grain inspection system. GIPSA's Technology and Science Division (TSD) and QualySense AG have entered into a Cooperative Research and Development Agreement (CRADA) to collaborate on research and development of innovative technologies for accurate, consistent, and efficient assessment of grain quality. QualySense is a Swiss-based company providing equipment for high-speed inspection and sorting of grains, seeds, and beans using biochemical and/or geometrical properties. The purpose of the collaboration is to support scientific advances in testing and measurement of grain quality by means of high-speed kernel imaging and NIR technologies. The collaboration is research oriented and is intended to:

- Evaluate imaging and NIR technologies for potential applications in grain inspection;

- Explore the development of novel inspection standards using high-speed, single-kernel imaging and NIR technologies for measuring one or more quality traits that can be used to characterize the biological and commercial value of a commodity;
- Identify and resolve limitations, issues, and concerns with the technologies to improve their performance and suitability; and
- Identify and address issues and concerns related to specific crops and/or applications, sampling processes, inspection procedures, and other factors that may impact the accuracy, consistency, or efficiency of grain quality assessments.

The initial research focus is on specific applications for rice and wheat inspections. Other commodities and applications may be assessed in subsequent years. The CRADA protects proprietary or confidential information brought to the effort by QualySense. Information arising from the CRADA that is owned or co-owned by the U.S. Government may be made available to others by GIPSA for bona fide research or commercial purposes provided (1) confidentiality is not breached and (2) patent or copyright rights are not compromised. This CRADA is not an evaluation of the QualySense instruments and technology for adoption in the official grain inspection system.

8.4.3. Measures of Success

GIPSA measures its success in terms of the percentage of market needs provided, which are grain and commodity quality factors assessed through official inspection services. GIPSA currently provides tests

that address 98 percent of current market needs as identified by the grain exporting industry. GIPSA continues to review all market needs in order to ensure that emerging quality factors critical to marketing grain are addressed. Another metric used is the number of quality and weight complaints we receive from our customers each fiscal year. In FY 2017, GIPSA received no complaints that would indicate that there are issues with the official methods used to assess any quality factors.

8.5. Downstream Outcomes

- **Harmonizing Biotech Reference Methods.** There is a need for highly specific and accurate tests for the various GE crops grown in the United States. GIPSA has developed intra-laboratory-validated, real-time polymerase chain reaction (PCR) methods and has evaluated the accuracy, reliability, and proficiency of publicly available methods used to detect and identify GE grains and oilseeds. GIPSA participated on a scientific panel of experts engaging U.S. stakeholders and influencing outcomes on issues related to testing of GE traits in grains with the goal of developing global scientific consensus regarding the analysis of transgenic events.
- Through the Corn and Soy Proficiency Program, GIPSA seeks to improve the overall performance of testing for GE grains and oilseeds. The GIPSA proficiency program report contains inter-laboratory comparisons to determine the performance of individual laboratories' ability to detect and/or quantify transgenic traits in corn or soy as well as to monitor laboratories' continuing performance. The program does not assess the effectiveness of different detection methods for GE traits, nor does it determine the characteristics of fortified samples to a particular degree of accuracy. However, the GIPSA Proficiency Program helps organizations identify areas of concern and take corrective actions to improve testing precision, capability, and reliability.

- GIPSA continues to collaborate with international organizations such as Codex Alimentarius, International Organization for Standardization (ISO), American Association of Cereal Chemists, American Oil Chemists' Society, and the Canadian Grain Commission to harmonize testing technologies for GE grains and oilseeds.
- **Export Wheat, Soybean and Corn Quality Surveys.** GIPSA provides testing services for grain through annual export survey programs in collaboration with U.S. Wheat Associates, U.S. Soybean Export Council, and the U.S. Grains Council. GIPSA organizes the surveys by collecting samples and performing a range of analytical tests, including tests for pesticide residues and heavy metals. GIPSA has assisted with the wheat survey for over 20 years and the corn and soybean surveys periodically for over 9 years. The purpose of the survey programs is to assess the quality of grain and grain-related commodities in order to facilitate the U.S. Grain market. The market development organizations use the data to advise importers worldwide on what is available for sale, the cost, and the advantages that U.S. wheat, corn, and soybeans have over the competition.

8.6. Outreach Activities

8.6.1. Domestic Outreach

- GIPSA met with stakeholders from the canola, dry pea and lentil, and sorghum producer associations to discuss potential quality factor assessments utilizing current technology that could be of benefit to the industry.

- GIPSA met with members of the USA Rice Federation to discuss the need for official inspection services for the analysis of arsenic in rice.

8.6.2. International Outreach

- A GIPSA scientist participated in the Asian Pacific Economic Cooperation's (APEC) Regional Workshop on Measurement and Standards for Grain Food Safety and Free Trade in Da Nang, Vietnam. The objective of this workshop was to create an action plan for developing measurement standards and capabilities in APEC economies relating to grain food safety and for international cooperation and collaboration, particularly in the area of testing for mycotoxins and heavy metals in grain. More than 24 countries participated in the workshop and were informed on the GIPSA mycotoxin and heavy metal testing programs.
- A GIPSA scientist served as a member (alternate delegate) of the U.S. delegation to the Codex Committee on Methods of Analysis and Sampling meeting held in Budapest, Hungary. The U.S. delegation actively participates in continuing discussions on methods and standards for food safety testing, the uncertainty of sampling, and processes for the resolution of disputes.
- Two GIPSA scientists served as members (delegates) of the U.S. Technical Advisory Group (US TAG) to the ISO Committee on Horizontal Methods for Molecular Biomarker Analysis. The meeting was held in Washington, DC. The US TAG seeks to engage in dialog on harmonizing methods of detection for GE products, defining terms related to GE technology, and standardizing terminology related to low-level/adventitious presence of GE traits.

- In FY 2017, GIPSA responded to customers' needs for technical assistance in foreign markets. Exporters, importers, and end-users of U.S. grains and oilseeds, as well as other USDA agencies, USDA cooperator organizations, and other governments ask for GIPSA expertise. GIPSA provides grain-marketing and grain-grading seminars, meets with foreign governments and grain industry representatives to resolve grain-quality and weight discrepancies, helps other countries develop domestic grain and commodity standards and marketing infrastructures, assists importers with quality specifications, and trains local inspectors in U.S. inspection methods and procedures. In FY 2017, two GIPSA grain marketing specialists spent 30 days in Southeast Asia presenting onsite seminars with foreign grain buyers and end users, explaining both objective and visually based grain quality measurement processes, instruments, and equipment used by GIPSA. Such activities are funded through various programs administered by the Foreign Agricultural Service (FAS) or directly by GIPSA. Outreach activities serve to strengthen the U.S. reputation for being a reliable supplier of high-quality grain, to reinforce the integrity of GIPSA as an independent quality-inspection authority, and to minimize discrepancies in inspection results between GIPSA and importers.
- GIPSA personnel frequently meet with delegations visiting from other countries to brief them on the U.S. grain marketing system, our national inspection and weighing system, U.S. grain standards, and our mission. Many of these delegations are sponsored by USDA Cooperator organizations like the U.S. Wheat Associates and U.S. Grains Council, who arrange visits to grain production areas, GIPSA field offices, onsite laboratories at export grain elevators, and our National Grain Center in Kansas City, Missouri. At the National Grain Center, delegations sometimes receive technical training on analytical testing procedures and grain inspection methods and procedures.

- Briefings are tailored to address each group's interests and concerns. Presentations include explanations of the various services available from GIPSA, our use of the latest technology to provide grain traders with accurate and reliable inspection and weighing information, and information on GIPSA services that importers can use to contract for the quality they desire. These briefings foster a better understanding of the entire U.S. grain marketing system and serve to enhance purchasers' confidence in U.S. grain. Ultimately, these efforts help move our Nation's harvest to end-users around the globe. During 2017, GIPSA personnel met with 40 teams from 26 countries.

8.7. Publications

8.7.1. Internet Publications

- The GIPSA Performance Verified Mycotoxin Rapid Test Kits matrix is located on GIPSA's website at:
https://www.gipsa.usda.gov/fgis/metheqp/GIPSA_Approved_Mycotoxin_Rapid_Test_Kits.pdf.
The matrix is updated on a monthly basis.
- The GIPSA Performance Verified Biotech Rapid Test Kits matrix is located on GIPSA's website at: https://gipsa.usda.gov/fgis/metheqp/GIPSA_Approved_Biotech_Rapid_TestKits.pdf. The matrix is updated as new tests are approved.
- The GIPSA Biotechnology Proficiency Report is located on GIPSA's website at:
https://www.gipsa.usda.gov/fgis/biotech/quarterly_reports/April_2017_Proficiency_Report.pdf

9.0. National Agricultural Statistics Service (NASS)

<http://www.nass.usda.gov/>

9.1. Mission Statement

“The National Agricultural Statistics Service provides timely, accurate, and useful statistics in service to U.S. agriculture.” The statistics NASS compiles are used by agricultural producers and businesses to ensure an orderly flow of goods and services among agriculture’s production, processing, and marketing sectors. Reliable, timely, and detailed crop and livestock statistics help to maintain a stable economic climate and minimize the uncertainties and risks associated with the production, marketing, and distribution of commodities.

NASS data are also vital to policymakers, researchers, and scientists in the agriculture community who depend on reliable and unbiased facts. The Census of Agriculture, conducted every 5 years, provides comprehensive, county-level data about agricultural communities across the United States. NASS statistical data are essential to both the public and the private sector for making effective policy and for production and marketing decisions.

9.2. Nature and Structure of Research Program

NASS primarily conducts applied research to improve and enhance the agency’s census and survey programs. Research strives to increase the efficiency, accuracy, and quality of official estimates by improving statistical and survey methodology.

NASS's Research and Development Division is located in Washington, DC, and has about 34 permanent Federal researchers working on various statistical, methodological, and geospatial research projects. Additionally, NASS augments its research capacity by seeking input from academics by contracting with them or entering into cooperative agreements.

NASS does special tabulations of its data in response to requests and makes unpublished data available in Data Labs to other government agencies and university researchers. Advanced security technology allows such access to data, which is tightly controlled and monitored to ensure all output retains the confidentiality of the farmers' individual information.

9.3. Downstream Outcomes

- **Estimation Enhancements:** NASS is examining model-based estimation techniques to improve the statistical reliability of published forecasts/estimates and to provide accurate measures of uncertainty. Estimates of yield for corn, soybean, wheat, and cotton yields derived from Bayesian hierarchical models are now being produced in parallel with NASS operational survey processes, and the results are provided to the Agricultural Statistics Board for their consideration in producing reports. Small area models are being developed to improve the county-level estimates of acreage, yield, and production as well as county-level cash rental rates. Research to produce remote sensing, county-level estimates for more regions of the United States is also being conducted. A decision-support application, which should eventually lead to crop phenology being more explicitly accounted for in the yield models, was developed for the State of Nebraska and is being extended to other states. An effort has been initiated to incorporate a disruption in the system, such as a disease outbreak, to the livestock time series models,

beginning with the model for hogs and pigs. NASS has worked collaboratively with outside consultants to develop the methodology for some of these endeavors.

- **Automated Stratification for Construction of Area Frame:** NASS uses its area frame both as a stand-alone frame to estimate numbers of farms and a wide variety of commodities, and as a measure of incompleteness for its list surveys—including the quinquennial Census of Agriculture. To date, new area frames for Oklahoma, Arizona, New Mexico, Georgia, South Dakota, Alabama, North Carolina, Wisconsin and Nebraska were created using a hybrid stratification approach that uses automatic stratification with manual editing. The new frames have more uniform strata than those based on the traditional manual stratification, leading to more precise estimates at no additional cost.
- **Sampling Frames and Web Scraping:** For most NASS surveys, the sampling frame is the NASS list frame, which is ideally a complete and up-to-date list of all U.S. agricultural operations. However, as is the case with all list frames for complex populations, the NASS list frame is not complete; that is, not all farms are on the list. This lack of completeness has significant implications for the quality of survey data and the official estimates. NASS is examining the practice of web scraping or web crawling techniques to identify farms, especially the non-traditional agricultural operations, to measure the undercoverage of the NASS list frame. NASS is collaborating with an external partner to create data-sharing partnerships across the Federal Government, to harvest open source information and develop web-scraped lists of agricultural operations currently underrepresented on the NASS list frame. This could potentially improve coverage of entities such as urban farms, operators of farmers markets, and local food producers. NASS's primary objective is to explore the feasibility of using web-

scraped lists of farms to measure the undercoverage of the NASS list frame for each of the NASS surveys. In FY17, NASS began a pilot study in the State of Washington to assess the feasibility of using a web-scraped list account for undercoverage of hard-to-survey groups in the Census of Agriculture.

- **Geospatial Products:** NASS completed its 48-state Cropland Data Layer (CDL) in 2017 for the 2016 crop year, making 9 years of national CDL's available. This layer provides information on the crops planted and is useful in land cover, animal habitat, and watershed monitoring; soils utilization analysis' agribusiness planning; addressing biodiversity, crop intensity, and agricultural sustainability concerns; environmental research; and the remote sensing and GIS value-added industry. NASS continued to provide its 48-State VegScape, which is a geospatial data service offering automated updates of vegetative condition at daily, weekly, and biweekly intervals. The 48-State Crop Frequency Layers were released in 2017 for the 2016 crop season. The Crop Frequency Layers identify crop specific planting frequency and are based on land cover information derived from the 2008 through 2016 CDL. Currently, these are produced for corn, soybeans, wheat, and cotton.
- **Improved Calibration Process:** After the capture-recapture weights are associated with each Census of Agriculture record, the weights are calibrated to known commodity targets. During the 2012 Census of Agriculture, it became evident that the calibration process could be improved. Improved methods for calibration and rounding (so that only whole numbers of farms are reported) have been developed, and better measures of uncertainty have been derived. These new methods have been integrated into NASS processes for use in the 2017 Census of Agriculture.

- **New Imputation Methodology Used for the 2016 Certified Organic Survey:** Fully Conditional Specification (FCS) is a multivariate imputation method, providing flexible model specification for missing survey responses and the ability to handle both qualitative and quantitative data. This methodology was implemented for the 2016 Certified Organic Survey using IVEware. IVEware is a stand-alone or statistical analysis system (SAS) callable product from the University of Michigan that implements FCS while incorporating simple edit constraints. The methodology improved the quality of imputed data over the prior conditional means imputation approach. Micro-data quality was improved by preserving relationships between variables, and the uncertainty in the survey indications were reflected more accurately.
- **Prototype Data-Collection Application Built:** NASS, working cooperatively with a university, built a prototype data-collection application to collect data for the June area survey. The Geographic Information System (GIS) tools initially gave the field enumerators the ability to delineate field maps and collect information on the utilization of the land in hand-held devices. Testing in the summer of 2014 found that field enumerators could not delineate the fields in a reasonable amount of time, resulting in too much of an increased burden for the respondent. Thus, for 2015 and 2016 testing, the fields were delineated in advance, and the enumerators were asked only to correct the boundaries. This new tool was finalized in 2017; plans are to incorporate the tool once other enhancements are made to the mobile data-collection environment.
- **Data-Collection Enhancement for Computer Assisted Personal Interviewing Tool (MOST):** NASS implemented a new Launch Page for its MOST platform in fiscal year 2017. The

enhancement uses free Google software that allows for NASS staff to have instant communication with field interviewers through the form of announcement pages and system status pages. This enhancement has helped to reduce the time and resources NASS's Regional Field Offices (RFOs) have to dedicate on a daily basis to answering phone calls from interviewers. This allows field interviewers more time to work with farmers and ranchers who have been sampled for NASS surveys.

- **Data-Collection Enhancement for Census of Agriculture:** NASS implemented a new, responsive, web data collection system for the Census of Agriculture and other surveys. This new system provides an enhanced web experience for agricultural producers responding to NASS surveys. NASS worked with a contractor to develop the prototype system for producing this responsive instrument and will use the new system to produce all NASS survey web instruments beginning in spring 2018. The goal is to provide an enhanced experience for the respondent that reduces burden while also improving data quality.
- **Survey Management Services (SMS):** In 2015, NASS implemented its Survey Management Services (SMS), an enterprise-level, centralized database with a thin-client application service system designed to prepare survey samples for data collection, including activities such as interviewer assignments, mail file and label generation, survey coordination, check-in, and historical data manipulation. SMS provides an interface for authorized users to develop an overall data collection strategy for a survey while having access to and using available historical response/non-response data. The data collection strategy provides the general parameters or information needed to distribute the sample to the selected modes of data collection (mail, Computer Assisted Self Interview (CASI), Computer Assisted Personal Interview (CAPI),

Computer Assisted Telephone Interview (CATI) in the data collection preparation phase. NASS recently created a Response Rate Research Team to review a number of inhibitors affecting response rates. The team gathered feedback from NASS's Regional Field Office (RFO) staff regarding the sample review process and several new features were added to SMS in fiscal year 2017 to increase efficiency and better evaluate data collection strategies. The first feature allows RFO statisticians to view aggregate and detail-level response history data on sampled records within SMS. Details include data such as preferred mode of completion, number of overall survey contacts, and 1-to-5 year completion percentages. The second feature added to SMS in fiscal year 2017 was the Response Burden Index (RBI). This feature includes summary fields that quantify the total number of surveys, contacts, and time it will take for a producer to complete NASS surveys within the present year. NASS staff can click on these RBI summary fields to view a detailed information window on each survey producers have been sampled in. These new features allow NASS personnel to streamline the sample review process and more accurately set the most effective data collection procedures for each sample. These enhancements will have a positive impact on the farmers and ranchers that NASS contacts to complete surveys by reducing burden.

9.4. Outreach Activities

- **Data User Input:** NASS holds an annual data-users meeting to gather input to ensure the agency statistical program is meeting the needs of our user community. The 2017 Data Users Meeting was held in Kansas City, Missouri, on October 24, 2017. It featured representatives from NASS as well as other USDA agencies and provided an open forum for data users to ask questions about the entire USDA statistics program. From a customer service perspective, the

meeting provided an excellent opportunity for NASS to learn about data users' concerns and desires for improvements or changes to the statistics and economics programs.

- **Expert Panels on Farm Operator Demographics:** Following the 2012 Census of Agriculture, NASS received feedback that the manner in which it measured farm operators may not be fully capturing the role of women and new/beginning farmers. In response to this, NASS asked the National Institute of Statistical Sciences (NISS) to convene an expert panel to provide recommendations on how to improve reporting of women and new/beginning farmers. NASS modified the operator characteristics section to reflect the panel recommendations. Since the demographic section for the 2017 Census of Agriculture was significantly changed from the previous census cycle, NASS also needed to determine how to publish data collected from this new section. Additionally, NASS needed guidance on whether and, if so, how data from 2017 can be bridged to data from 2012 while taking into account the panel recommendations. To help address these challenges, NASS again reached out to NISS to convene an expert panel to provide recommendations for publishing and bridging the data. Through the outreach to expert data users, statisticians, and methodologists, NASS will be able to better capture the role of women and beginning farmers within the diverse organizational structure of modern farms.

9.5. Publications

Peer-Reviewed Scientific Publications 13 entries

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Trade Journal Publications.....0 entries

10.0. National Institute of Food and Agriculture (NIFA)

<http://www.nifa.usda.gov/>

10.1. Mission and Vision Statements

NIFA's mission is to "Invest in and advance agricultural research, education, and extension to solve societal challenges." NIFA's approaches its mission with the following vision, "Catalyze transformative discoveries, education, and engagement to address agricultural challenges."

10.2. Nature and Structure of Research Program

NIFA's two key mechanisms for accomplishing its mission are:

- National program leadership. NIFA helps States identify and meet research, extension, and education priorities in areas of public concern that affect agricultural producers, small business owners, youth and families, and others.
- Federal assistance. NIFA provides annual capacity grants to land-grant universities and competitively granted funds to researchers in land-grant universities, other universities, and other partner organizations.

NIFA collaborates or has formal working partnerships with many institutions and individuals. Our key partners are the institutions of higher learning making up the Land-Grant University System. However, we also partner with other Federal agencies, within and beyond USDA; non-profit associations;

professional societies; commodity groups and grower associations; multistate research committees; private industry; citizen groups; foundations; regional centers; the military; task forces; and other groups.

NIFA and its partners focus on critical issues affecting people's daily lives and the Nation's future. The advanced research and educational technologies NIFA supports empower people and communities to solve problems and improve their lives on the local level.

Among the many programs NIFA leads, many are currently focusing efforts on the following societal challenges:

- Advance our ability to provide global food security and fight hunger
- Create a resilient and environmentally sustainable agricultural system responsive to climate change
- Enable U.S. energy independence through the development of sustainable bioenergy feedstocks and value-added, bio-based industrial products
- Combat childhood obesity by ensuring the availability of affordable, nutritious food and providing individuals and families science-based nutritional guidance
- Reduce the incidence of food-borne illness and provide a safer food supply

NIFA does this not only through its research and higher education programs, but also through an extensive network of state, regional, and county extension offices in every U.S. State and territory. These offices have educators and other staff who respond to public inquiries and conduct informal, noncredit workshops, and other educational events. Extension education for all citizens is also provided

nationally online through eXtension.org. Moreover, with support from more than 500,000 volunteers, 4-H–USDA's 115-year-old youth development program administered through NIFA—engages more than 6 million young people every year and teaches them life skills through hands-on learning and leadership activities.

10.3. Current Technology Transfer Goals, Objectives, and Measures of Success (Metrics)

Applicants or recipients of NIFA grants that support basic research and integrated projects are encouraged to explore potential commercialization through the Small Business Innovation Research (SBIR) program. Conversely, small business owners or other grant recipients are encouraged to use NIFA-funded basic research programs to enhance innovation and competitiveness in their commercial operations.

Each land-grant university funded by NIFA has a university technology transfer office to promote, support and improve technology transfer from academic and nonprofit institutions. They often manage and license innovations derived from research at their universities (including research funded by NIFA) and are a good source to link small businesses with university faculty. Moreover, the Cooperative Extension System Offices are a nationwide, non-credit educational network. These offices are staffed by one or more experts who provide useful, practical, and research-based information to agricultural producers, small-business owners, youth, consumers, and others in rural areas and communities of all sizes.

10.4. Strengthening Current Activities and New Initiatives

The National Institute of Food and Agriculture (NIFA) administers the USDA Small Business Innovation Research (SBIR) program. In FY 2017, NIFA promoted SBIR funding opportunities to USDA intramural research Cooperative Research and Development Agreement (CRADA) partners through a partnership between NIFA's SBIR program and the Agricultural Research Service (ARS) Office of Technology Transfer (OTT).

Through this partnership with ARS, NIFA informs potential SBIR applicants of partnership possibilities and benefits working with ARS scientists. If ARS and a small business identify an opportunity to partner together, the small business would submit an SBIR application and would address this partnership. The partnership is generally developed under a CRADA or through a licensing agreement between ARS and the small business. NIFA in turn uses the knowledge of an ARS CRADA or license as a tie-breaker in the application selection process. Some of the benefits a small business can employ when partnering with ARS is joint intellectual property potential. In this case, ARS can file patent applications for CRADA partners and only charges the partner for filing fees; patent application and prosecution completed by registered USDA patent agents are provided free of charge, saving small businesses substantial costs.

10.5. Response to Presidential Memorandum on Accelerating Technology Transfer and Commercialization of Federal Research in Support of High-Growth Business

USDA 27: New Metrics (beginning FY 2014) on NIFA outcomes:

Efforts to develop procedures for requesting information from NIFA awardees are in progress. A survey of past SBIR Phase II winners from 1994 through 2015 will be conducted later this winter 2018.

Information will be collected on: (1) number of new jobs created by a small business as the result of

receiving SBIR grant funds; (2) increase in sales of technology or services developed by a small business as the result of receiving SBIR grant funds; and (3) sale to other businesses of licenses to technology developed by a small business as the result of receiving SBIR grant funds.

The data on the patents issued based upon Competitive NIFA Funding has been collected for FY2016 and is now being reported (see Table 1).

Table 1. Patents Issued in FY 2016 based upon Competitive NIFA Funding.

| Institution Name | Award Number | Patent Number | Issue Date | Invention Description |
|-----------------------------------|------------------|---------------|------------|---|
| North Carolina A&T University | 2010-33100-08912 | 9,474,272 | 10/25/2016 | Micropropagation of Alexandrian laurel (<i>Danae racemose</i> L) |
| Penn State University | Hatch | 9,456,539 | 10/4/2016 | Row Crop Side Dress Applicator and Cover Crop Seeder |
| University of Missouri – Columbia | 2008-38814-04727 | 9,486,747 | 11/8/2016 | Nanocomposite Membranes with Advanced Antifouling Properties Under Visible Light Irradiation |
| University of Wisconsin – Madison | 11-CRHF-0-6055 | 9,487,712 | 11/8/2016 | Methods for Producing Liquid Hydrocarbon Fuels Directly from Lignocellulosic Biomass |
| Auburn University | 2012-38500-19665 | 9,492,521 | 11/15/2016 | Live Attenuated Vaccines for Control of Epidemic <i>A. hydrophila</i> Generated by Markerless Gene Deletion |
| University of Georgia | Hatch | PP27392 | 11/15/2016 | Bermudagrass Named ‘DT-1’ |
| University of Minnesota | 2006-55606-16629 | PV201600163 | 11/28/2016 | Bolles |
| North Dakota State University | 2003-31100-06038 | PV201600264 | 11/28/2016 | ND-Genesis Two-Rowed Barley formerly 2 ND25276 |
| University of Wisconsin - Madison | 2001-35204-10184 | 9,505,836 | 11/29/2016 | H3 Influenza A Virus |
| Penn State University | Hatch | 9,540,415 | 1/10/2017 | Inhibitors of the Farnesoid X Receptor and Uses in Medicine |

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| | | | | |
|-----------------------------------|------------------|-----------|-----------|--|
| North Dakota State University | 2007-38202-18597 | 9,567,422 | 2/14/2017 | Novel Acetoacetoxy and Enamine Compounds and Coatings Therefrom |
| University of Wisconsin – Madison | 13-CRHF-0-6055 | 9,585,870 | 3/7/2017 | Compositions and Methods for Improving Lactation |
| University of Wisconsin - Madison | 13-CRHF-0-6055 | 9,587,247 | 3/7/2017 | Plants with Altered Phytochromes |
| University of Missouri – Columbia | 2011-67015-20025 | 9,594,077 | 3/14/2017 | Method for Determining Fertility in Boars |
| Mississippi State University | Hatch | 9,624,270 | 4/18/2017 | Engineering the Production of a Conformational Variant of Occidiofungin that has Enhanced Inhibitory Activity Against Fungal Species |
| Michigan State University | 00-52104-9663 | 9,644,222 | 5/9/2017 | Methods for Pretreating Biomass |
| Cornell University | 2007-35504-05381 | 9,650,652 | 6/16/2017 | Production of Carboxylates and Methane from Biomass Waste |
| University of Wisconsin – Madison | 14-CRHF-0-6055 | 9,663,758 | 5/30/2017 | Global Gene Regulators (GGR) as Vaccine Candidates Against Paratuberculosis |
| Iowa State University | 2004-35605-14197 | 9,683,021 | 6/20/2017 | Identification of Protective Antigenic Determinants of Porcine Reproductive and Respiratory Syndrome Virus and Uses Thereof |
| Mississippi State University | 2004-35204-14211 | 9,700,611 | 7/11/2017 | Live Attenuated Catfish Vaccine and Method of Making |
| Auburn University | 2010-34605-20651 | 9,746,443 | 8/29/2017 | Magnetoelastic Resonator Biosensor System Apparatus, Methods, Composition |

USDA 28: Partner with ARS and the Animal and Plant Health Inspection Service (APHIS) at USDA on the National Plant Diagnostic Network, and the National Animal Health Laboratory Network

There are two goals for NIFA in this area.

- (1) Develop competitive funding opportunities to include ARS scientists in the development of diagnostic assays and validation protocols that are needed to support APHIS regulatory surveillance efforts for foreign and emerging plant and animal diseases.

- (2) Coordinate APHIS regulatory and ARS research efforts with relevant components of the Cooperative Extension Service in order to better identify producer needs and the transfer of relevant technology.

10.6. Downstream Outcomes

Hazel Technologies is located in Chicago, IL, and has received support from the SBIR program. It developed FruitBrite™ sachets that are the size of a sugar packet and can be tossed in alongside packed produce. This is a patent-pending technology that actively emits an ingredient that is an ethylene inhibitor. Ethylene is a natural plant-ripening hormone. Inhibiting its production keeps produce looking and tasting better for a couple of weeks versus a couple of days. The active ingredient in Hazel Technologies' FruitBrites packets is 1-methylcyclopropene (1-MCP), which mimics the effects of ethylene but blocks ethylene receptors in the produce. This technology has been tested on 20 different commodities from tomatoes to mushrooms to avocados. This technology will allow producers to ship over greater distances and reduce food waste. Near the end of the Phase I award, the company raised \$800,000 to ramp up manufacturing through a seed round led by Rhapsody Venture Partners and joined by the donor-advised fund VentureWell and Valley Oak investments. The company recently received a 2017 USDA SBIR Phase II award to conduct research needed to optimize the sachet. Hazel Technologies was 1 of 6 AgTech Companies selected to compete for equity investment through the Western Growers New AgSharks™ Competition. It pitched the company and the SBIR-supported technology to the AgSharks October 31, 2017, in Las Vegas. Hazel Technologies won the competition and received a \$2M equity investment from Seed 2 Growth Ventures (S2G). The company is now expanding to a second office space in the Western Growers Association Innovation Center in Salina California to be closer to the producers and shippers.

Hedin Environmental is located in Pittsburgh, PA, and received support from the SBIR program to treat polluted coal mine drainage water. In many abandoned coal mines in Pennsylvania, water that drains from the mines has an alkaline pH. This water typically contains high levels of iron oxides that cause significant pollution of surface waters. In this project, the mine drainage water was diverted to constructed wetlands where the iron oxides are allowed to precipitate out at the rate of 2-3 inches per year. These iron oxides can then be collected and used as pigments. Hedin Environmental is selling over 300 tons of iron oxides each year to a company in North Carolina to be used as wood stain. The original constructed wetland was on a tributary of the Youghiogheny River, and at that time the river had significant levels of pollution from iron oxides. Today, the river is cleaned up, and it even has fishing tournaments on it.

Harris Vaccines is located in Ames, IA, and received several SBIR grants from 2009 to 2014 for the purpose of developing vaccines against important diseases affecting livestock and aquaculture species. The critical technology developed by Harris Vaccines was the replicon particle vaccine platform. The viral genome includes both viral structural genes and several non-structural genes that can be removed and replaced by appropriate foreign genes that code for antigenically active proteins from the virus of interest. These foreign genes are the “replicon” that is produced in large amounts and used to make the vaccine. The system is completely safe since the replicons cannot replicate and become infective. Using this system, Harris Vaccines was able to respond to an outbreak of Porcine Epidemic Diarrhea (PED) virus and produce a vaccine within 4 months. The vaccine was very effective, and the company was able to sell millions of doses and help to control this disease outbreak. In 2015, Harris Vaccines was acquired by Merck Animal Health and became a division of Merck Animal Health focused on developing various animal vaccines.

Trellis Growing Systems is located in Fort Wayne, IN, and received SBIR support to develop an innovative new trellis system for production of blackberries. Prior to this work, blackberries were not grown commercially in the upper Midwest because the vines were often killed by harsh winter conditions. Trellis Growing Systems developed a trellis system that supports the main shoots during the growing season. In the fall, the entire trellis is lowered to the ground with the vines still attached and the vines are covered and thus protected from the winter conditions. In the spring, after the secondary shoots, which bear the flowers and the fruit, start to grow, the trellis is rotated back to the original position. With this system, not only are the vines protected from winter conditions but the fruit all appear on one side of the trellis for more efficient harvest. As a result of this grant, there are over 60 farms in the upper Midwest with a combined production of over 300 acres now producing blackberries.

Soojin Jun and colleagues at the **University of Hawaii** have been working on ways to extend the shelf life of perishable food items. Their method is based on “supercooling” which consists of dropping the temperature of an item below its normal freezing point. **Jun Innovations** was formed to commercialize this technology. The company received support from SBIR to develop a supercooling device that preserves perishable foods far below their freezing points while retaining their freshness. The company combined pulsed electric field and an oscillating magnetic field to supercool foods, decelerating the rate of spoilage without compromising the sensory quality and nutrient composition of foods. The developed supercooling device can be best applied to home appliance manufacturers, in particular the refrigerator and freezer industry. In addition, this device can be integrated into food storage and transportation processes anywhere starting from the point after harvest or manufacture, to distribution, down to the food retailer level. A reliable cold-storage preservation device was fabricated and tested to maintain the metastable nature of supercooled foods. The supercooling unit is designed to maintain temperature-sensitive foods in a supercooled state far below their equilibrium freezing points while upholding their

original freshness. The fabricated device was successfully demonstrated to LG Electronics, one of the largest home appliance companies which showed great interest.

Matthew Wallenstein of **Colorado State University** received an Agriculture and Food. Research Initiative (AFRI) Exploratory Research Grant during the first year of the program in 2015. The goal of this program is to fund high-risk, high reward research. The project was focused on developing an artificial directed selection approach to engineer a microbial consortia that could be applied to the soil to make more phosphorus available for plants. This proof-of-concept research resulted in a new platform to develop targeted microbial biostimulants by determining a consortia of phosphorus-solubilizing bacteria. Extensive plant testing demonstrated increased yields for many plants. Based on the success of early plant trials, postdoc Colin Bell commercialized the product and co-founded a startup company called Growcentia, Inc., In 2016, Growcentia, Inc. received a Phase I USDA SBIR award to create plant biostimulants for controlled environment agriculture. Growcentia is developing a patent-pending microbial biostimulant to increase the availability of phosphorus and micronutrients to plants. While the AFRI ERP grant focused on live microorganisms, the controlled environmental agriculture industry is resistant to using live beneficial organisms in production systems. To reach this industry, Growcentia's Phase I project is evaluating non-living formulations through rigorous plant trials in a controlled greenhouse. If successful, their product will enhance plant production while meeting the needs of producers.

4-H National Headquarters staff within Division Youth and 4-H, USDA NIFA are active on the White House Maker initiative and fostering making and inventing in 4-H programming. A growing number of States have been developing maker experiences within 4-H clubs, afterschool programs, camps, and military 4-H partnership programs. The 4-H science, technology, engineering, and

mathematics (STEM) National Program Leader serves on the National Science and Technology Council (NSTC) Maker Interagency Working Group and gave a presentation about 4-H Maker programs on an internal Federal webinar. National and State 4-H program staff representatives coordinated the National 4-H Geographical Information System/Global Positioning System (GIS/GPS) Leadership team composed of teens and adult mentors from four States. This past year, the team developed a map showing the correlation of selected health factors with obesity. They presented their work at the National Youth Healthy Living Summit and the Environmental Systems Research Institute (ESRI) International GIS conference plenary session in 2017 (view video at <https://www.youtube.com/watch?v=-cr686Wh-is>). NASA and 4-H National Headquarters staff are collaborating on the NASA GLOBE Observer citizen science program where youth and adults can use mobile apps to learn about and collect data on clouds, mosquitos, land cover, soil, and other subjects to contribute to NASA earth science data collections. A guide for State 4-H staff and volunteers is being developed. University of Nebraska-Lincoln, 4-H National Headquarters, and National 4-H Council collaborated on the 2017 4-H National Youth Science Day project “Incredible Wearables.” In events across the country, youth learned about wearable technology. They built and tested their own health fitness monitor that measures pulse and activity levels when paired with a personal mobile device.

Operating as a team, **State Extension leaders from the 12 North Central 1862 land-grant** universities developed common indicators for reporting the impacts of community development educational programs. The States collectively developed this report based on in-state action. Each partner university selected a subset of the indicators for reporting. Over \$122 Million in impacts and 14,344 jobs were created or saved. The impacts stem from innovative, science-based approaches developed in partnership with stakeholders. The programming associated with these impacts varies according to

community needs and the creativity of university-based and other partners. Full details broken down by State, are available at http://ncrcrd.msu.edu/ncrcrd/state_extension_leader_section1.

In administering the **New Technologies in Ag Extension funding, eXtension** expanded the Impact Collaborative (<https://www.extension.org/impact-collaborative/>) model reaching 273 educators through 115 projects. Of these educators, 83 percent were exposed to new or different ideas and/or viewpoints, 50 percent gained significant new ideas that moved their projects forward, 82 percent interacted with other Extension professionals outside their normal professional circle, and 68 percent felt they could influence either their institution and/or their professional field in new ways after participating in the Collaborative.

The **Western Rural Development Center** led an effort to help determine the importance of sustainability outreach to Extension educators in the West. Results are explored in an article summarizing a nationwide survey on Extension sustainability programs by authors Roslynn Brain McCann, Mark Apel, and Paul Lachapelle. The article was first published in *Rural Connections* Fall 2017 and can be accessed directly at <http://wrdc.usu.edu/files-ou/publications/Sustainability-Apel-rcfall2017.pdf>.

The **University of Nebraska** is leading a Coordinated Agricultural Project (CAP) project to reduce foodborne illnesses from Shiga toxin-producing *Escherichia coli* (STEC) through research, education and extension activities. Shiga toxin-producing *Escherichia coli* (STEC) are major pathogens of humans, most commonly acquired through the consumption of contaminated food or water, with about 29 percent of the cases in the U.S. attributable to beef. There are a number of tech transfer activities.

Here are a few examples:

- A proprietary commercial ground beef manufacturing system was validated in a 2-week plant trial. The system utilizes chlorinated acidic nanobubble water in a recirculating process over 6 continuous production run days to antimicrobially treat high-fat-level (e.g. 50/50 lean/fat) beef trimmings resulting in lean tissue for final grinding. Using USDA-approved *E. coli* surrogates, the system achieved a 1.6 log CFU/g microbial reduction, while demonstrating that a nightly chlorinated water concentration change maintained microbiological control for recirculating water and in-line equipment for extended run periods. The findings of this study will support the start-up company's Food Safety and Inspection Service (FSIS) technology approval petition.
- Antimicrobial interventions applied at the fed-cattle carcass level are foundational pathogen control points for the beef processing industry; however, full-scale validations of these technologies against actual pathogens are very limited. A STEC-inoculated whole-carcass study was completed to quantify the pathogen-reducing capacity of ambient temperature high-volume water washing, hot water washing, and final food-grade chemical application when applied using a 3-stage commercial Chad cabinet. Ambient water washing reduced STEC populations by 1.0-1.5 log CFU/cm² from top to bottom of the carcasses, and 180°F water provided an additional reduction of approximately 2.5 log CFU/100 cm². A final chemical spray of carcasses using 200 ppm peracetic acid, 4.5 percent lactic acid, or pH 1.1 Centron™ prior to entering chilling was beneficial in further reducing small populations of surviving STEC. This study provides commercial beef processors scientific validation of commonly used carcass interventions at simulated commercial scale to control STEC-7 serogroups.

- Over 700,000 veal calves are slaughtered and processed annually in the United States, and recent national microbiological surveys of fabricated veal indicate a substantially higher incidence of Shiga toxin-producing *E. coli* presence in raw veal than beef. A void in scientifically validated and USDA-approved antimicrobial interventions exists; thus, processors have not instituted such control measures appreciably into their processes. Two large-scale veal studies were completed to validate antimicrobial interventions for veal; three antimicrobial sprays (CitriLow, BeefXide, and 4.5 percent lactic acid) for application on dehided veal carcasses prior to chilling and a novel hot water/lactic acid “scalding” process for hide-on bob veal carcasses. Approximately 1.5 log CFU/cm² reductions in *E. coli* surrogate populations were observed for dehided carcasses, while >5 log cfu/100 cm² reductions were observed with hide-on bob veal carcasses. These published results will likely influence more veal processors to incorporate pre-rigor carcass interventions into their commercial processes.
- Wastewater streams from two slaughterhouses were examined. For slaughterhouse 1, the normalized total solids, volatile solids, biological oxygen demand (BOD₅) and carbonaceous biochemical oxygen demand (COD) loads in the overall wastewater were 15.6, 11.1, 4.7, 13.2 kg/1000 kg LW, respectively. For Slaughterhouse 2, the corresponding values were 18.0, 8.8, 4.7, 11.8 kg/1000 kg LW. Wastewater streams from antimicrobial interventions have low pH and high organic content due to the use of organic acids, and therefore they are a potential source of shock loading to a wastewater treatment facility. Viscera and offal processing has the highest impact on wastewater streams, and any improvement in these processes is expected to positively impact the sustainability of the cattle processing industry.

- The environmental and economic implications of three scenarios of antimicrobial systems currently applied in the commercial U.S. beef packing industry were investigated. Findings revealed that antimicrobial systems utilizing chemicals result in higher detrimental impacts on human health, ecotoxicity, and eutrophication impacts, while antimicrobial systems featuring steam or hot water pasteurization lead to higher global warming and energy depletion. Revenue loss from discolored products in antimicrobial systems applying pasteurization result in higher operating costs. This study can be helpful for guiding the industry in strategic process optimization and for providing baseline profiles to allow comparison with newly established antimicrobial systems in the future.

At **North Carolina State University**, researchers investigated the molecular basis of the interactions between *Listeria monocytogenes* and fresh produce. They have filed an Invention Disclosure on a novel bacterial strain from fresh cantaloupe with inhibitory activity against *Listeria monocytogenes*. The strain was identified as *Exiguobacterium* sp. and was isolated from freshly harvested cantaloupe prior to processing or storage at the packing shed. In addition to anti-*Listeria* activity in laboratory media, the novel strain also inhibited biofilm formation by *Listeria monocytogenes*. The team also optimized and validated protocols utilizing ampicillin selection to enrich for mutants that fail to grow on fresh produce. Protocols for testing *Listeria* strains and mutant constructs in the insect *Galleria melonella* virulence model were refined and validated. Seedling models (turnip seeds, wheat berries) were developed to assess *Listeria* persistence and growth in roots and shoot portions of the seedlings. A simple washing protocol that can be employed for temporary reductions of *Listeria* populations on rind of cantaloupe was developed and published. This work will improve the safety of produce.

Researchers at the **University of California, Davis**, have been studying the fate and transport of engineered nanoparticles (NP) in soil and crop systems to enhance our understanding of any potential threats to food safety. Investigating the fate of engineered nanoparticles in environmental and agricultural systems is complicated by the heterogeneity of natural systems (e.g., soil minerals, organic matter, plants, etc.), the widespread existence of naturally occurring nanomaterials, and the low concentration of engineered nanoparticles in such systems. This research has provided important insight into the dissolution of engineered copper oxide nanoparticles and how the presence of natural organic matter influences their environmental fate in the environment. Additional information on the transport of nanoparticles in carrots and lettuce was also a key outcome of this research. Through collaboration with biomedical engineers, radiolabeling technologies to trace nanoparticle transport in plant and soil systems was developed as a novel approach for tracking NPs in these complex environmental matrices. It is anticipated that these technologies will serve as an inspiration to industry to further develop methods to trace particles in real time through porous media such as soils, filtration systems, and size-permeable barriers. Additionally, the development of a method for the “in-situ” attachment of radiolabels to nanoparticles in porous media may serve as a method to attach other customizable labels, including sensors, to nanoparticles embedded in porous media. Although this research was directed at addressing food safety issues, the technologies which enabled the research may be adapted for a number of different applications.

Foodborne contamination is a serious public health issue and causes a substantial economic burden. Fresh produce, such as spinach, lettuce, cabbage, and tomato fruit, have been identified as causes for viral infection. Researchers at the **University of Illinois** have developed effective produce sanitation methods to minimize the risk associated with viral infections. In an extensive study using 24 cultivars of leafy vegetables and tomato fruits and a strain of rotavirus, a diarrhea-causing virus, Illinois researchers

found that the three-dimensional crystalline wax structures on the produce epicuticular surfaces significantly impacted the inhibition of viral adsorption to the produce surfaces. The growers and consumers can use the appearance of the leafy green as an indicator for the tendency of viral attachment and the efficacy of sanitation. Specifically, if the leaf appearance is non-waxy, more careful sanitation should be used. Results of a comprehensive study on sanitation efficacy of a common sanitizer, peroxyacetic acid (PAA), and a newly formulated sanitizer containing a mixture of surfactant TDS and malic acid showed that the peroxyacetic acid had low efficacy on viruses attached to the non-waxy leaves, while the surfactant-based sanitizer was effective for both types of leaves. Longer sanitation time is recommended for non-waxy produce to reduce the infectious risk. These findings were published in an open-access peer-reviewed journal PLOS ONE. The University of Illinois team has also developed artificial surfaces that mimic both the topographical and epicuticular characteristics of two of the most consumed fresh produce commodities in the United States (i.e., “Romaine” lettuce and “Carmel” spinach). Testing results with the artificial surfaces and the fresh produce surfaces confirmed that the artificial surfaces can be used as a tool to screen commercially available sanitizers. In addition, we will present these data in workshops and webinars organized for growers and consumers through the University of Illinois Extension Service and funded by another NIFA-integrated grant on water reuse.

Commercial agriculture contributes to water quality and quantity concerns in many complex ways, including nutrient contamination of surface and groundwater, and contributions to climate change from greenhouse gas emissions. In fact, persistent agriculture-derived pollution concerns are increasingly gaining prominence as concerns with other sources are being more effectively addressed. Better tools are needed to equip farmers and society to improve current water quality and quantity concerns and to prepare for future water-resource challenges related to climate change. **Cornell University’s** integrated project combines applied stakeholder-driven research with a high-impact extension and education

program that empowered farmers with effective tools and solutions while training the next generation of problem solvers using innovative technologies. The goal of this project was to research, develop, and facilitate the adoption of practical decision tools related to precision nitrogen management and soil health management to improve water quality and quantity in the face of extreme precipitation and drought events. Van Es et al. advanced research and development of the Adapt-N tool and the new comprehensive Cornell Soil Health Test (CSHT), both developed at Cornell University, using a network of on-farm research collaborators and increasing the expanding base of involved stakeholders with these tools across the Northeast and Midwest to test and further advance these new tools.

They kept the Adapt-N and Soil Health websites up to date. The **Cornell Soil Health Website** continues to provide up-to-date content on soil health testing available to the public at

<http://soilhealth.cals.cornell.edu>, and a blog, e-list, and social media presence were established ([facebook.com/soilhealth1](https://www.facebook.com/soilhealth1); twitter.com/soilhealth1). The webinar workshops that were provided (<http://adaptn.cals.cornell.edu/webinars/index.html>) as well as other webinars and educational materials on the effective use of Adapt-N for precision nitrogen management in corn are available at <http://adaptn.cals.cornell.edu/pubs/index.html>. The commercial version of Adapt-N is available at the company's website <http://www.adapt-n.com/>. The Cornell Institute for Climate Change and Agriculture's website displays both of our tools available to stakeholders:

<http://climatechange.cornell.edu/tools-resources/agriculture-resources/>. Finally, through New York State funding, a New York State Soil Health Initiative was created to serve as a central hub for information and networking related to soil health in New York State. A website has been created to serve as a clearing house to distribute to stakeholders. It is available at:

<https://blogs.cornell.edu/soilhealthinitiative/>. The website has provided educational programming (under training opportunities above) to enable certified crop advisers (CCAs), conservation agencies, and

farmers to use these tools effectively. Notably, with increasing interest from service providers and growers across the Northeast and Midwest, Cornell University's Soil Health Lab provided intensive Adapt-N workshops and webinar trainings on Adapt-N in the springs of 2013 and 2014 that drew around 200 people each year. They also planned and hosted an intensive Soil Health 1-day workshops, as well as two, week-long Train the Trainer Soil Health Workshops in 2014 and 2015 attended by extension, non-profit, private, and governmental agricultural stakeholders from across the U.S. and several other countries. In all, they have reached nearly 8,000 growers, industry professionals, and members of the public through 118 presentations given at field days, winter meetings, regional trainings, scientific meetings, workshops, and webinars. Nineteen articles were published in extension newsletters, five manuscripts were accepted into peer-reviewed journals, two training manuals were published, two websites were significantly updated and two social media accounts have been maintained with project-related content. In all, they have provided over 250 hours of instruction and activities for over 14,000 person-hours of training. The Soil Health Lab has trained undergraduate and graduate students, post docs, visiting scientists, and external stakeholders in the methods used and rationale for these. The team has also contributed materials toward multiple courses.

The **Northwest Potato Variety Development Program (Tri-State Program)** is a critical program, serving a region that produces over half (57 percent) of all United States potatoes on 51 percent of total acres devoted to potatoes. This region also accounts for the majority of United States potato exports. The program (University of Idaho, Washington State University, University of Oregon, and USDA, Agricultural Research Service) entails a comprehensive research effort that crosses State and institutional boundaries and is an excellent example of the cooperative research approach visualized by writers of the original Farm Bill. The objectives are to develop, release, and commercialize new potato varieties that will directly benefit all segments of the Northwest potato industry and indirectly benefit all

United States producing regions. The strategy is to identify traits, make crosses, and apply selection pressures that will increase the probability of developing varieties that can be produced more efficiently and sustainably than existing varieties. Breeding goals include high yield, improved processing quality, genetic resistance to major pests and diseases, resistance to stresses, increased nutrient use efficiency, improved nutritional value, and high tuber quality. Environmental benefits come with reduced use of pesticides, water, and fertilizers. The majority of the potato clones and cultivars evaluated in this project come from the USDA, Agricultural Research Service breeding programs located at Aberdeen, ID, and Prosser, WA. Impact of the program is revealed by the extent of adoption and commercialization of new and improved varieties. ‘Ranger Russet’, ‘Umatilla Russet’, ‘Alturas’, ‘Bannock Russet’, and ‘Clearwater Russet’ are examples of russet cultivars released from the Tri-State program that have greatly benefited the U.S. and Northwest potato industry. In 2016, these cultivars ranked as the 3rd, 4th, 7th, 9th, and 10th most widely grown cultivars in the United States, respectively, with Tri-State varieties representing 33.5 percent, or 309,000 acres, of the fall crop nationally (NASS, Crop Production, December 2016). ‘Ranger Russet’, ‘Umatilla Russet’, and ‘Alturas’ were the 3rd, 4th, and 5th most widely grown cultivars in the Northwest (ID, OR, WA) in 2016, respectively, and accounted for 27 percent of Northwest planted acreage. Varieties recently released by the Tri-State program are now produced on more than 143,000 acres in the Pacific Northwest with value to growers estimated at approximately \$620 million. In the past 10 years, the United States farm-gate value of Tri-State varieties has increased by approximately \$190 million. With the acceptance in 2016 of ‘Clearwater Russet’ and ‘Blazer Russet’ for processing by McDonald’s, we expect the acreage of these varieties to increase significantly, further displacing the less efficient standard variety, ‘Russet Burbank.’ McDonald’s is the largest purchaser of potatoes nationally and worldwide. Four of the seven varieties McDonald’s accepts for their gold-standard signature French fry have come from the Tri-State program.

Genome editing to increase wheat genetic yield potential. Together with the negative impact of climate change, diminishing natural resources, and competition for land, the nearly stagnant gain in yield potential has been challenging global wheat production. Funding from the NIFA-International Wheat Yield Partnership (IWYP) to a team of scientists at **South Dakota State University** and **Iowa State University** aims to improve wheat genetic yield potential using a genome-editing approach, and has identified and mapped 45 candidate genes for grain size regulation in the wheat genome and established a CRISPR/Cas9 platform to target the negative regulators of grain size. Using this new technology is expected not only to better our understanding of genetic control of grain size but also to deliver a set of novel germplasm with enhanced yield potential. Applying a similar genome-editing system to improve resistance to fungal diseases broadened the resistance spectrum in wheat.

Microbes colonize every natural and artificial surface on Earth. In some cases, these microbial communities (known as “biofilms”) can be benign. However, most biofilms are undesirable: they corrode colonized surfaces, clog pipes, and serve as a refuge for pathogens. Learning to prevent or disrupt biofilms, and thus minimize biofouling, remains a “holy grail” of industrial microbiology. NIFA-funded researchers at the **University of Hawaii at Manoa** and their colleagues have come a step closer to this goal. They learned that tiny nanopillars formed on aluminum surfaces discourage microbes (including pathogens) from settling on surfaces and biofouling them. To build the nanopillars, the scientists first treated aluminum surfaces with oxalic acid to create nanopores, then etched them with phosphate and coated the resulted structured with a nano-thick layer of Teflon. The resulting nanopillars were conical spikes, 1 micron tall, spaced a micron apart. These spikey surfaces were effective in dissuading microbes from settling in. Under the static conditions, the reduction in microbial settlement was approximately 100-fold, even further reduction was observed under flow.

While there is no shortage of pathogen-detection kits on the market, their usefulness can be limited by sensitivity, efficiency, or cost. A team of researchers in the Food Science Department at **Cornell University** is a few steps closer to achieving the goal of designing a sensitive, efficient, and cheap method for the identification of pathogens in drinking water, milk, and juices. Their discovery builds on the ability of phages (viruses that infect bacteria) to capture and infect their bacterial prey. Once inside bacteria, engineered phages take control of the bacterial gene expression machinery and force the cell to produce a specific enzyme. Once enough enzyme is produced within 3-7 hours, a substrate for it is mixed into the sample. The substrate is then cleaved by the enzyme, generating an electroactive molecule that can be easily detected. This approach can detect as few as a thousand bacterial cells in a milliliter of water, apple juice, or milk, and is specific to only the target pathogen after 7 hours (or approximately a million cells after 3 hrs). While not yet ideal, this method is a significant improvement on the existing pathogen detection technology.

With the ever-growing public desire for safe, high-quality, clean-label foods, **Washington State University's** (WSU) microwave-based sterilization and pasteurization food processing technologies offer a unique way to meet consumer needs. Currently in its second year, the AFRI-funded Center of Excellence for Food Safety Using Microwave Energy has been working to move the food industry forward in the scale-up and commercialization of the Microwave Assisted Pasteurization System (MAPS) which produces virus and pathogen free, clean-label, refrigerated or frozen meals. With a main emphasis on helping innovative small- and medium-sized companies, the work includes finalizing system design, packaging research, nutritional analysis, and consumer acceptance studies to help move microwave food processing into a mainstream technology. Five recently graduated Ph.D. students have been recruited to work for three startup companies and one global food company to lead breakthrough innovations.

In addition, WSU has hosted numerous lab visitors and tours from food companies, offering several on-site workshops, boot camps, and outreach events to the food processing community. In November 2017, WSU's microwave research was selected as one of the top 20 projects to be showcased at the inaugural University Innovation and Entrepreneurship Showcase during the Association of Public and Land Grant Universities (APLU) Annual Meeting, sponsored by the National Academy of Inventors. The showcase projects were also featured at the Capitol Hill Reception and Exhibition at the Rayburn Office House Building in Washington, DC, on November 14, 2017. These events were attended by top research university administrators and Government representatives from across the Nation and successfully highlighted the partnership between federally funded research activities and their impact on the economy and workforce development.

The technology, Microwave Sterilization or Pasteurization, was granted a U.S. Patent (No. 9,642,385 B2) on May 9, 2017, and subsequently licensed to 915 labs. Additionally, the patent was filed in 11 countries, including China, Japan, Australia, among others for worldwide protection.

10.7. Outreach Activities

- On March 29, 2017, the SBIR program and the USDA, Office of Technology Transfer presented a webinar titled "Partnership Pays: Building a Research Partnership with USDA, Agricultural Research Service (USDA-ARS) to Enhance Your USDA SBIR Proposal" in an effort to encourage more small business firms to enter into CRADA agreements with ARS prior to submitting proposals to the SBIR program. Results of this webinar indicated an increase in small

businesses contacting ARS to explore CRADA or licensing opportunities in preparation for USDA SBIR Phase I application.

- A number of NIFA's National Program Leaders attended National SBIR Conferences in Washington, DC, and Austin, TX, with formal presentations on the USDA SBIR program, which included information about the USDA-ARS, Office of Technology Transfer. Additionally, the USDA SBIR program staff conducted one-on-one meetings with over 25 small business entrepreneurs at each conference and discussed opportunities for both SBIR and USDA-ARS, Office of Technology Transfer. In addition, the USDA SBIR program participated in webinars for New Mexico and Iowa. Site visits were conducted with 19 SBIR companies in the following States, AL, CA, IA, IL, MA, MD, NY, OH, and PA.
- In FY 2017, the USDA SBIR program in conjunction with the Small Business Administration (SBA) had staff participate in 3 SBIR Road Tours and participate in 10 regional SBIR-focused conferences, which included two SBIR National Conferences. The focus of these tours and regional conferences was to conduct outreach to potential small businesses found in underrepresented States. In each case, a presentation was provided on the USDA SBIR program and included information and opportunities for the USDA-ARS, Office of Technology Transfer. The road tours provided outreach to approximately 1,800 attendees in total, provided on average 20-30 one-on-one meetings with small business entrepreneurs at each meeting, and covered the following States: AZ, CA, HI, IA, ID, IN, KY, MI, MN, NV, OH, UT and WI. In FY 2018, the USDA SBIR program will participate in National SBIR Conferences in Anaheim, CA, and Tampa, FL, five SBA Road Tours, and several regional meetings, primarily in rural States.

- During the week of May 8th, two National Program Leaders (NPLs) visited Puerto Rico in an effort to do outreach and promote the SBIR program and get a better understanding of the agricultural challenges and opportunities the island is facing under its current economic crisis. Both NPLs met with several stakeholders including faculty from the University of Puerto Rico in Mayaguez, farmers, small businesses, and Federal and State agencies and attended the AgroHack conference, a unique agriculture innovation summit in Puerto Rico. Puerto Rico's agricultural sector is experiencing a rebirth with the emergence of new farms, farmer's markets, and innovative ideas and technologies in this sector; this is an opportunity for USDA, NIFA to continue its support to small businesses, research, education, and extension.

11. Rural Development (RD)

<http://www.rd.usda.gov/>

11.1. Mission Statement

USDA, Rural Development (RD) is committed to helping improve the economy and quality of life in rural America. RD provides loan and grant financing as well as technical assistance to develop housing, community facilities, businesses, infrastructure, and renewable energy ventures in rural areas. In addition to providing direct loan and grant assistance, USDA, Rural Development also partners with private-sector lenders and development organizations to carry out local community development projects. Rural Development's more than 40 financial assistance programs, in addition to its ability to leverage private-sector resources, give USDA the flexibility to invest in a wide range of projects that are reinvigorating rural towns and building strong and economically robust communities.

With a total portfolio of more than \$220 billion and investments upwards of \$33.8 billion in 2017 alone, Rural Development is making lasting investments in rural communities. The mission area has a tremendous set of business, utilities, housing, and community development programs designed to ensure that rural Americans have access to safe, affordable homes and community facilities, jobs and business capital, and the benefits of drinking water, broadband, electricity and other essential services.

11.2. Nature and Structure of Program

RD is a program-oriented organization that provides a vast array of grant, loan, loan guarantee, and technical assistance programs to rural Americans. RD financial programs support such essential public

facilities, services, and infrastructure as water and sewer systems, housing, health clinics, emergency service facilities, and electric, broadband, and telephone service. We promote economic development by supporting loans to businesses through banks and community-managed lending pools. We offer technical assistance and information to help agricultural and other cooperatives get started and improve the effectiveness of their member services. And we provide technical assistance to help communities undertake community empowerment programs.

Rural Development achieves its mission by helping rural individuals, communities, and businesses obtain the financial and technical assistance needed to address their diverse and unique needs. Rural Development works to make sure that rural citizens can participate fully in the global economy and plays a lead role in improving the economic climate of rural areas through creating and preserving business opportunities and jobs. Through our partnerships with other public and private-sector businesses, our programs help close the opportunity gaps between under-served rural and productive metropolitan areas.

Although RD does not have a formal technology transfer program in place, the agency does oversee the Biorefinery, Renewable Chemical, and Biobased Product Manufacturing Assistance Program (Section 9003 of the Farm Security and Rural Investment Act of 2002 (7 U.S.C. 8103), as amended), which assists in the development, construction, and retrofitting of new and emerging technologies for the development of advanced biofuels, renewable chemicals, and biobased-product manufacturing by providing loan guarantees for up to \$250 million.

The purpose of the program is to assist in the development of new and emerging technologies for the development of advanced biofuels, renewable chemicals, and biobased-product manufacturing. This is

achieved through guarantees for loans made to fund the development, construction, and retrofitting of commercial-scale biorefineries using eligible technology and of biobased-product manufacturing facilities that use technologically new commercial-scale processing and manufacturing equipment and required facilities to convert renewable chemicals and other biobased outputs of biorefineries into end-user products on a commercial scale. RD's Rural Business-Cooperative Service has the responsibility for administering the program.

RD's rural energy programs help increase American energy independence by increasing the private sector supply of renewable energy and decreasing the demand for energy through energy efficiency improvements. Over time, these investments can also help lower the cost of energy costs for small businesses and agricultural producers.

RD also oversees the Alternative Technology Transfer for Rural Areas (ATTRA) project carried out by the National Center for Appropriate Technology (NCAT). The ATTRA project works to provide information to farmers and other rural users on a variety of sustainable agricultural practices that include both cropping and livestock operations. Additionally, ATTRA encourages agricultural producers to adopt sustainable agricultural practices which allow them to maintain or improve profits, produce high quality food, and reduce adverse impacts to the environment.

Work for the ATTRA project takes place at all seven NCAT office locations. The ATTRA project is staffed by more than 20 NCAT agricultural specialists with diverse backgrounds in livestock, horticulture, soils, organic farming, integrated pest management, and other sustainable agriculture specialties. The ATTRA project supports a nationally recognized, virtual resource center (www.attra.org) that is accessible by farmers, ranchers, market gardeners, Extension agents, researchers,

educators, farm organizations, and others involved in agriculture, especially those who are economically disadvantaged or belong to traditionally underserved communities. ATTRA provides technical assistance through publications and/or customized resource packets.

ATTRA receives funding through the annual appropriations bill which directs Rural Development to administer the funding through a cooperative agreement. The annual funding for ATTRA is administered by Rural Business-Cooperative Service.

11.3. Current Technology Transfer Goals, Objectives, and Measures of Success (Metrics)

While RD did not have any specific goals related to technology transfer, RD programs support entrepreneurs and rural businesses implement technology through an array of loan, loan guarantee, grant, and technical assistance programs. RD works to support technology transfer by creating linkages and supporting partnerships and collaborations with other Federal agencies, universities, and other organizations that can improve access and deployment of proven technology in rural areas. For example, through various programs, RD investments support connecting rural communities to the future through broadband and e-connectivity projects. Other examples include advanced manufacturing, business incubators, renewable energy systems, and energy efficiency improvements. Examples of how producers and small businesses are using RD programs to implement technology advances include: distance learning and telemedicine; lighting; refrigeration; high efficiency heating; ventilation and air conditioning systems; cooling or refrigeration units; electric, solar or gravity pumps for sprinkler pivots; and replacement of energy-inefficient equipment. Additionally, RD funds are being used to support new technology in the processing and marketing of value-added food products that are contributing to the development of a more robust local and regional food system.

11.4. Strengthening Current Activities

Through a diverse portfolio of programs and a network of State offices, RD achieves its mission by helping rural individuals, communities, and businesses obtain the financial and technical assistance needed to address their diverse and unique needs. Rural Development works to make sure that rural citizens can participate fully in the global economy and plays a lead role in improving the economic climate of rural areas through creating and preserving business opportunities and jobs. Through our partnerships with other public and private-sector businesses, our programs help close the opportunity gaps between under-served rural and productive metropolitan areas.

RD continues to enhance its Web presence to make information and programs more accessible to the public as well as to concentrate outreach efforts to ensure that businesses and communities in greatest need have access to the necessary resources to be competitive.

12. The Natural Resources Conservation Service (NRCS)

<http://www.nrcs.usda.gov>

12.1. Mission Statement

The Natural Resources Conservation Service (NRCS) is not generally considered a research agency—the thrust of its mission is to help private landowners address natural resource concerns on their lands. NRCS conservation experts help landowners develop conservation plans and often provide opportunities for financial assistance to implement conservation practices. To carry out this mission on a broad scale (NRCS’s discretionary and mandatory annual budget is approximately \$4 billion), NRCS has become perhaps the country’s premier agency for transfer of natural resources conservation approaches and technology. NRCS maintains 169 National Conservation Practice Standards. These standards and supporting documents are NRCS’s principle vehicle for transferring the latest science and technology directly to America’s farmers and ranchers.

12.2. Nature and Structure of Programs

Once NRCS conservation planners identify resource needs on private farms and ranches, the agency works closely with the Agricultural Research Service and numerous universities to develop and fine tune the science and technologies needed to help farmers conserve, protect, and enhance their natural resources. NRCS in-house research and technology development programs include the Soil Science Division and the Plant Materials Centers. The NRCS also conducts conservation field trials to strengthen NRCS technology when formal research is not available. As appropriate, NRCS conducts these trials on working farms and ranches in cooperation with other agencies and organizations. A field trial is a study

designed to examine the adequacy or adaptability of a conservation practice, technology, procedure, or material. Field trials also introduce promising conservation practices or technologies into areas where they are not now accepted as a solution to a local soil, water, or related natural resource problem or condition. Field trials can be useful to transfer technology, to update the local technical guide, or identify the need for formal research.

12.3. Soils Research and Technology Transfer

The NRCS Soil Science Division (SSD) is authorized by the U.S. Secretary of Agriculture to conduct research on the use and behavior of soils to facilitate soil classifications and distribution of information through the Web Soil Survey and other vehicles of data dissemination. Below are some current research and technology transfer efforts that are currently underway.

Rapid Assessment of U.S. Soil Carbon for Climate Change and Conservation Planning

Soils are the largest global storehouse of terrestrial carbon and have potential for mitigation of anthropogenic atmospheric carbon dioxide. Additionally, many other important processes, including water infiltration, nutrient cycling and loss, and soil erodibility, are strongly influenced by the amount of carbon in soils. To aid land managers, policymakers, and conservationists to make sound recommendations for management options to increase the amount of carbon in soils, scientists with the SSD, in cooperation with scientists from multiple universities, completed a nationwide inventory of soil carbon. This inventory from 6,000 sites provides a statistically reliable estimate of the amount of carbon in U.S. soils for global carbon accounting and will enhance model-based conservation planning.

National Wetland Condition Assessment Hydric Soil Analysis

The Nation's wetlands are important landscape components and perform important ecosystem services including flood mitigation, regulation of carbon and nutrient dynamics, and sediment and contaminant sequestration. Many important wetland functions are mediated by hydric soils that are a key component of wetlands. SSD soil scientists are cooperating with the U.S. Environmental Protection Agency (EPA) in a nationwide project spanning FY 2016 through FY 2018 to sample and evaluate the condition of the Nation's wetlands. The project entails field evaluations and soil sampling at 1,000 wetland sites. The NRCS SSD's Kellogg Soil Survey Laboratory (KSSL) has nearly completed quantitative measurements on the approximately 5,000 samples collected by this project. Quantitative soil data forms the basis for wetland assessment throughout the United States.

Soil Enrichment and Sustainable Agricultural Practices Outreach to Turkmenistan and Uzbekistan

The arid areas of the Southwestern United States share similar cropping, climate, and soil conditions that can undermine agricultural efforts in other arid countries. Working through a Cochran Fellowship with the University of Arkansas at Pine Bluff, soil scientists from Texas provided a tour to agricultural scientists from Turkmenistan and Uzbekistan through the arid areas of Texas. The tour demonstrated NRCS programs and management strategies for dealing with irrigated farming operations and salt affected soils, similar to what occurs in Turkmenistan and Uzbekistan. These scientists will be able to implement best management practices in their respective countries for dealing with salt-affected soils and irrigation management based on the NRCS approach.

Ecological Site Information

Ecological site information is integral to conservation planning, practice implementation, and program assessment. In 2015, NRCS implemented the Provisional Ecological Site Initiative to assign all the areas with completed National Cooperative Soil Surveys to ecological sites. Ecological sites are the basic component of a land-type classification system that describes ecological potential and ecosystem dynamics of land areas. Information and data pertaining to a particular ecological site is organized into a reference document known as an Ecological Site Description (ESD). State and transition models are the key component of ESDs, as they depict and organize information regarding the ecological dynamics of an ecological site. Practical application (spatial and temporal relevance) is dependent on the development of the Ecological Dynamics Interpretive Tool (EDIT) database. Currently, all existing ecological site information resides in the EDIT database. The objective is to open EDIT to public access by late FY 2018 and establish connections to other NRCS planning tools. This new tool will allow for the direct application of existing soil, vegetation, and management information. It will also provide a predictive capacity for developing new conservation planning information at the practice level. This is a collaborative project with USDA, Agricultural Research Service (ARS).

NRCS National Soil Survey Center

The SSD, National Soil Survey Center (NSSC) in Lincoln, Nebraska, is a world-renowned facility for soils research, soil interpretation development and soil data development, as well as information delivery, soil policy and procedure development, and extensive training. One section of the NSSC supports the Web Soil Survey, which delivers soils data and interactive soils information to over 550,000 people annually who are preparing customized soil reports, over 3 million interested viewers

per year, and over 350,000 downloads of soils data annually. The NSSC also houses the Kellogg Soil Survey Laboratory (KSSL), which is the most comprehensive soil laboratory in the world; the KSSL achieved a major milestone in 2017, when the 250,000th soil sample was received and processed. During FY 2017, the KSSL staff analyzed 24,454 soil samples from 8 countries (including the United States); with a total of 493,723 chemical, physical, and biological analyses conducted on these samples. All laboratory data are freely distributed via the web.

NRCS Investments in University Research

The SSD has invested more than \$650,000 in research agreements with 7 universities in 2017 through the Cooperative Ecosystem Studies Units Network (CESU). CESU is a national consortium of Federal agencies, Tribes, academic institutions, State and local governments, nongovernmental conservation organizations, and other partners working together to support informed public-trust resource stewardship. Provisions of the funded research includes student and NRCS scientists' involvement and focuses on key research priority areas. Funded research topics in 2017 included change responses to soil biological properties from human management, development of soil geography teaching tools, investigation into soil carbon stocks in Northeastern United States vernal pools, and soil moisture and temperature research.

Mapping Soil Habitat for *Coccidioides* Using Soil Survey Data

“Valley fever” or coccidioidomycosis is caused by the soil-borne fungi *Coccidioides immitis* and *Coccidioides posadasii* which are endemic to the southwestern United States and a few other places in Central and South America. Data from the Center for Disease Control and Prevention (CDC) show that

the number of reported cases of valley fever has increased rapidly in recent years. Increased understanding of habitat suitability for *Coccidioides* is important as a marker of geographic risk for public health and healthcare providers. Collaboration between the SSD, the CDC, and other public health officials has allowed for verification of likely *Coccidioides* soil habitats and the production of spatially explicit maps that identify these areas. This information will help the public and industries mitigate risk when conducting soil-disturbing activities, as well as inform healthcare providers to aid in improving diagnosis and treatment of people exposed to coccidioidomycosis.

National Commodity Crop Productivity Index

The National Commodity Crop Productivity Index (NCCPI) is a tool for arraying the soils of the United States based on the soils' ability to foster the production of commodity crops. Typically, soils with a lower index can be risky to farmers. The SSD developed and supports the NCCPI. NCCPI is used by other USDA agencies in their programs.

- The NRCS, Farm Service Agency (FSA), and Risk Management Agency (RMA) recognize that by sharing program data they can effectively ensure compliance with existing Federal statutes and USDA directives and regulations, heighten program integrity, reduce program costs, eliminate the need for duplication of effort, and enhance and improve their agency's capability to successfully complete their assigned mission.
- Typically, soils having a lower index are less profitable to farm production and thus command a lower Conservation Reserve Program (CRP) rental rate. The Farm Service Agency (FSA) has updated the soil productivity factors that are applied to county-average rates to obtain soil rental

rates using NRCS's publicly available NCCPI. As a result, virtually all soil rental rates have changed, regardless of whether the associated county-averages changed.

Planning for Resilience: Hurricane-Related Catastrophic Soil Interpretations Through National Cooperative Soil Survey Data

The recent and devastating hurricanes (Harvey, Maria, and Irma) that threatened large portions of the Eastern sea board, Gulf States, and Puerto Rico resulted in a greater need for coastal catastrophic-level interpretations of spatial soil survey data for planning with communities and Federal programs. There is a tremendous need for the modification of existing interpretations, development of new interpretations, identification and repair of data-population issues, and development of new GIS models to better meet customer needs for catastrophic hurricane-related interpretations. Currently, there are 18 catastrophic interpretations related to hurricanes available through the NRCS Web Soil Survey. These interpretations assist users in identifying suitable areas for animal mortality disposal, contaminated plant material isolation, rubble and debris disposal, sites for composting facilities, and clay liner material. A multidisciplinary team has convened in NRCS to address modification of existing interpretations and development of new interpretations such as debris burial, storm surge inundation, coastal erosion, barrier island erosion, potential remediation due to flooding and storm surge for chemical/oil leaching, mosquito habitat suitability, and soils that pose a health threat by harboring soil-borne respiratory pathogens.

Fragile Soil Index

A Fragile Soil Index (FSI) developed by the SSD is available on the Web Soil Survey for landowners

and land managers to use. Fragile soils are those that are most vulnerable to degradation with low organic matter and potentially unstable or weak soil aggregates. The FSI can be used in conservation and watershed planning to assist in identifying soils and areas with greater vulnerability to degradation.

Soil Health Interpretations on the Web Soil Survey

Six new soil interpretations developed by the SSD are available via the Web Soil Survey for landowners and land managers to consider the potential of their ground's soil health. These soil interpretations are based on the major soil health resource concerns of soil susceptibility to compaction, soil susceptibility to organic matter depletion, soil susceptibility to surface salts, soil susceptibility to surface sealing, soil susceptibility to subsidence (agricultural organic soils), and suitability for soil organism habitat (aerobic).

NRCS Soils Data Webinar to the American Society of Agronomy

The USDA soil survey program, led by the NRCS, has been collecting spatial and laboratory data for over 100 years. However, this large database is very much underutilized by agricultural and resource management communities. To help increase awareness about this database, a webinar presented by SSD staff to the American Society of Agronomy explained what data exists, how and when it was obtained, how it can be accessed, and how this information may be used.

National Ecological Observatory Network

The National Ecological Observatory Network (NEON) is a 30-year, National Science Foundation-

funded endeavor, designed to gather and synthesize data on the influence of climate change, land use change, and invasive species on natural resources and biodiversity. Ecological, biological, air, and soil data will be collected from 47 terrestrial sites across the United States (including Alaska, Hawaii, and Puerto Rico) using sophisticated instrument measurements and field sampling. The sites have been strategically selected to represent 20 regional biomes. NEON will combine site-based data with remotely sensed data and existing continental-scale data sets (e.g., satellite data) to provide a range of scaled data products that can be used to describe changes in the Nation's ecosystem through space and time. The SSD is collaborating with NEON to characterize, sample, and analyze soils at each of the 47 sites to develop a better understanding of the dynamics soil plays in the ecological environment.

12.4. Plant Materials Centers

The NRCS Plant Materials Program includes 25 Plant Materials Centers (PMCs) operated by NRCS to service all 50 States and territories. Each PMC addresses the high-priority conservation concerns within unique ecological areas. When appropriate, PMCs have the ability to coordinate among locations to evaluate vegetative technology and solutions that influence large regions of the United States. This program has been a function within NRCS since the mid-1930s. PMC activities include:

- Developing technology and information for the effective establishment, use, and maintenance of plants for a wide variety of natural resource conservation uses to improve the establishment of conservation practices and success of farm bill programs.
- Evaluating new plant materials and releasing promising materials to the public for the commercial production of plant materials to protect and conserve natural resources.

- Testing and demonstrating plant materials for specific conservation practices, applications, and purposes to advance agency initiatives/priorities (e.g., soil health, nutrient management, wildlife habitat improvement, and renewable energy systems).
- Providing appropriate training and education to NRCS staff, partners, farmers, ranchers, and the public.

Technology Development and Transfer

The PMC program develops vegetative solutions to natural resource concerns such as soil stabilization, soil health and productivity, forage production for livestock, water quality, and enhancement of wildlife and pollinator habitat. PMCs provide scientifically sound plant information and tools used by conservation planners and partners.

- Plant Materials Program staff develop technology and methods for both the commercial growers who produce NRCS conservation plants and the landowners, land managers, and conservationists who utilize NRCS plants in conservation plantings. Technology transfer is a core component of the Plant Materials Program to ensure that NRCS field staff, partners, and other customers have the information they need to establish vegetation for conservation purposes. Plant Materials Program information is integrated into over 30 NRCS conservation practices to support the technical integrity of these practices and provide a direct application to agency conservation activities.

- The Plant Materials Program website consists of over 2,900 technical documents downloaded more than 1.5 million times per year. Plant Materials studies resulted in the addition of over 120 new technical documents to the Plant Materials website in 2017.
- Plant Materials staff conducted 56 technical training sessions for over 1,150 field staff and conservation partners in 2017. Training topics included selecting, planting, and managing cover crops; improving soil health; selecting and establishing conservation plants; plant identification; planning a conservation planting; enhancing pollinator habitat; improving the productivity of range and pasture land; restoring riparian areas; importance of vegetative covers for preventing erosion; and use of farm equipment. The PMCs also conducted 40 field days and tours to inform and educate field staff, farmers, ranchers, and the public on current plant materials activities and new technology.
- PMC plant materials, plant technology, and management practices are key products used by field staff for the successful implementation of USDA conservation programs such as the Environmental Quality Incentives Program, Conservation Stewardship Program, and Conservation Reserve Program.

Conservation Plants

PMCs have released over 750 conservation plants to the public over their 80-year history. Commercial growers of conservation seeds and plants, many who are in rural communities, grow about 600 of these NRCS conservation plant releases, and produce enough seeds and plants each year to plant over 2.5 million acres. The seeds and plants have an estimated \$100 million annual commercial value. In 2017,

PMCs released three new conservation plants to the public and commercial growers. These plants support NRCS conservation activities on private lands as well as the National Seed Strategy, a Federal interagency effort to select appropriate plants for restoration and conservation.

- Wynia germplasm indiagrass (*Sorghastrum nutans*), released by the Booneville, Arkansas PMC, is a native perennial warm-season grass used for livestock forage, improving wildlife habitat, stabilizing critical areas, and for cover in other conservation plantings in eastern Oklahoma and western Arkansas.
- Soda Springs germplasm parsnipflower buckwheat (*Eriogonum heracleoides*), released by the Aberdeen, Idaho PMC, is a native perennial wildflower used to improve pollinator and other wildlife habitat and for increasing diversity in range plantings in southern and eastern Idaho.
- Stucky Ridge germplasm silverleaf phacelia (*Phacelia hastata*), released by the Bridger, Montana PMC in cooperation with the Montana and Wyoming Agricultural Experiment Stations and the Deer Lodge Valley Conservation District (Montana), is a native perennial wildflower used for reclamation and stabilization of acidic soils with heavy metals, as well as on other sites for pollinator and wildlife habitat, and adding diversity to rangeland plantings in the foothills and intermountain valleys of the Northern Rocky Mountains in Montana and Wyoming.

12.5. Snow Survey and Water Supply Forecasting

The National Water and Climate Center (NWCC) has three contracts that provide valuable assistance to the Snow Survey and Water Supply Forecasting Program (SSWSF) for hydrologic forecasting. Through

a Cooperative Ecosystem Studies Unit (CESU) agreement with Colorado State University, the NWCC is advancing the infrastructure to support simulation modeling using the Precipitation Runoff Modeling System (PRMS). This contract is expanding development of operational hydrologic, Ensemble Streamflow Prediction, also known as “ESP”-based, forecasting. Another CESU agreement with Portland State University support the parameter input to PRMS. The NWCC has a cooperative agreement with the USDA, Agricultural Research Service (ARS) in Boise, Idaho, to develop a physically based, distributed snowmelt model. Advanced work includes integrating NASA’s new Airborne Snow Observatory flight data into the ARS model. These contracts improve the NWCC’s ability to forecast water supplies.

Notable application and outreach efforts include:

- In Idaho, the Data Collection Office (DCO) united with the Idaho Water Resources Board on a network analysis project to identify data gaps in snowpack and water forecasting.
- In Oregon, the DCO collaborated with the National Weather Service, other NRCS offices, and emergency management authorities to provide weekly snowpack updates in preparation for potential flooding.

12.6. Soil Health

NRCS launched its Soil Health Initiative in 2012 to refocus agency efforts on improving the physical, chemical, and biological characteristics of soil on private-lands and, shortly after that, established a Soil Health Division. NRCS’s soil health activities have expanded greatly, and interest in soil health has

spread rapidly to partners and stakeholder groups. Adoption of soil health practices has positive impacts on weather and pest resilience, risk, production economics, yields, crop quality, nutrient cycling, water quality, and climate change adaptation and mitigation.

In fiscal year 2017, NRCS performed soil-health-related outreach and tech transfer to over 50,000 people through presentations, workshops, technical assistance, staff and partner trainings, and demonstrations. NRCS's Science of Soil Health videos, available on YouTube, have been viewed over 125,000 times, and a National Public Radio interview reached 2 million people. Nearly 70 soil health webinars are posted on the NRCS Science and Technology Training Library and are available to the public.

The Science of Soil Health is collaborative across the Science and Technology, Soil Science and Resource Assessment, and Programs Deputy Areas; USDA, Agricultural Research Service and USDA, National Institute for Food and Agriculture; university partners; and other research and implementation organizations to enable rapid integration of the newest soil-health science into the NRCS' processes and services. One outcome of these cooperative efforts has been the formation of three additional Cover Crop Councils in the Northeast, Southeast, and West, which along with the Midwest Cover Crops Council, now cover the Nation. These councils provide structure for compiling the practical science from across the cover-cropping community and transferring it to farmers, ranchers, and other landowners.

12.7. Watershed and Dam Protection

The Emergency Watershed Protection Program (EWPP) helps local communities relieve imminent

hazards to life and property caused by floods, fires, windstorms, and other natural occurrences that cause watershed impairments. EWPP has two distinct options for assisting landowners in affected areas: EWP-Recovery and EWPP-Floodplain Easements. The EWPP Tool is a software application designed to help NRCS staff create and manage Emergency Watershed Protection (EWP) projects more efficiently. The EWPP Tool follows the EWP process from the designation of a State disaster and submission of the electronic disaster report (EDR), through damage survey report (DSR) preparation and submittal, to project and funding approval.

WinDAM—NRCS collaborated with scientists at the USDA-ARS, Hydraulic Engineering Research Unit and Kansas State University to develop WinDAM (i.e., Windows Dam Analysis Modules) for predicting embankment erosion due to overtopping and/or internal erosion. Engineers and other practitioners use the software to evaluate the potential for dam breach associated with overtopping or internal erosion as well as to route floods through the reservoir when dam breach does not occur. Features include the capability to route flows through multiple spillways, over the top of the dam, or through the dam. The software provides the outflow hydrograph for practitioners to examine the impact that dam breach and non-breach events may have in relationship to the dam.

NRCS DamWatch®—DamWatch is a web-based application developed for the USDA, Natural Resources Conservation Service (NRCS) by USEngineering Solutions Corporation (USES) to assist watershed project sponsors to monitor and manage 11,800 NRCS-assisted dams. This tool provides real-time monitoring of rainfall, snowmelt, stream flow, and seismic events that could pose potential threats to dam safety. DamWatch also forecasts rainfall events to allow NRCS personnel and project sponsors prepare for potential events at the dams. DamWatch alerts essential personnel via email, fax, or text message when dams experience one or more of the potentially hazardous monitored conditions. This

allows for the coordinated deployment of personnel and resources at the right time and place.

DamWatch provides a “one-stop” source for accessing critical documents, databases, onsite electronic monitoring devices, and geospatial information through a secure interactive web interface. This allows NRCS and watershed project sponsors to manage a proactive response. Important project dam information includes as-built plans, operation and maintenance agreements, emergency action plans, inspection reports, photos, videos, and assessment reports. DamWatch offers project sponsors an effective means for managing watershed projects. Although NRCS personnel may elect to receive DamWatch alerts, the project sponsor maintains responsibility for monitoring the dams and notifying authorities during an emergency.

12.8. National Technology Support Centers

NRCS has three National Technology Support Centers (NTSCs)—Greensboro, NC, Fort Worth, TX, and Portland, OR. NTSCs have two primary functions:

- To provide direct assistance and technology transfer (including collaboration with others for technical training) to NRCS States and the Pacific Basin and Caribbean Areas, and
- To acquire and develop new science and technology to provide cutting-edge technological support.

The NTSCs are also charged with developing and maintaining national technical standards and other technological procedures and references.

The NTSCs are a critical vehicle for technology transfer from NRCS scientists down to State, area, and field offices. Conservation implementation partners, such as conservation districts and State departments of agriculture, frequently participate in NTSC training sessions alongside NRCS employees. Over 13,000 individuals participated in over 200 training sessions in 2017.

NTSCs also provide critical support to the models and tools used by NRCS for conservation plantings.

A few examples include:

- The Rangeland Hydrology Erosion Model (RHEM) guides users in predicting runoff and erosion rates on rangelands, based on fundamentals of infiltration, hydrology, plant science, hydraulics, and erosion mechanics. RHEM assists in determining the conservation practice effects of brush management, prescribed grazing, and other rangeland management practices.
- Pasture State Interpretations and Ecological Site Descriptions provide ecosystem interpretations through ecological site descriptions for ranchers and farmers needing guidance on adapted forage species and seeding mixtures for pasture planning.
- NRCS is updating its suite of erosion prediction tools, including Integrated Erosion Tool version 2 (IET2), Wind Erosion Prediction System (WEPS), and developing Water Erosion Prediction Project (WEPP) for NRCS use. These tools are being developed in cooperation with ARS and will improve the efficiency and effectiveness of field-level predictions of wind and water erosion during the conservation planning process.

12.9. Science and Technology Training Library

NRCS's National Technology Support Centers work with partners including the Forest Service, land-grant universities, and the extension service to make available to conservation planners and natural resource managers up-to-date training webinars on a wide diversity of topics (including forestry, climate change, bioenergy, wildlife, soil health, conservation planning, organic agriculture, etc.). Some of the webinars are developed by NRCS staff, others by partners. These webinars may be viewed live or on-demand. In fiscal year 2017, these webinars were viewed by over 39,600 individuals, including both NRCS and non-NRCS participants. More than 18,700 continuing education unit (CEUs) were issued to maintain professional certifications for NRCS employees, partners, and other participants. More than 10,000 conservation-planner CEU certificates were awarded.

12.10. Phytoremediation Data

The NRCS Plant Data Team cooperated with Brooklyn College to update an existing database of over 1,130 plant species used to remediate contaminants, based on research published in the past decade. The database is being finalized and made available online, and will allow users to search by plant species and contaminant. Scientific references used for documentation are searchable as well on the database. The database also provides a listing of NRCS Conservation Practice Standards which can be used in conjunction with phytoremediation processes. Brooklyn College presented this work at the 14th International Phytotechnologies Conference in Montreal, Canada, in September 2017.

12.11. Conservation Innovation Grants (CIG)

Another important vehicle for development of conservation technology that NRCS will then transfer to

farmers and ranchers is Conservation Innovation Grants. CIG, a component of NRCS's Environmental Quality Incentives Program (EQIP), is a voluntary program intended to stimulate the development and adoption of innovative conservation approaches and technologies while leveraging Federal investment in environmental enhancement and protection in conjunction with agricultural production. Under CIG, EQIP funds are used to award competitive grants to non-Federal governmental or nongovernmental organizations, Tribes, or individuals.

CIG enables NRCS to work with other public and private entities to accelerate technology transfer and adoption of promising technologies and approaches to address some of the Nation's most pressing natural resource concerns. CIG will benefit agricultural producers by providing more options for environmental enhancement and compliance with Federal, State, and local regulations. NRCS administers CIG. Much of what NRCS learns from CIG is incorporated into conservation practice standards used by the field conservationists and technicians to address resource concerns on private farms and ranches.

Since CIG's inception in 2004, NRCS has awarded over 600 national-level CIG grants. There is also a State-level component that NRCS State offices may use to award smaller grants for State-specific resource concerns. A sample of results for recently completed projects is provided below. Lists and brief summaries of funded projects are available on the CIG website:

<http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/cig>.

Solar Irrigation Pumps

Water quantity is a significant issue in many parts of the country, particularly in the arid Southwest.

Many producers on Navajo Nation work their land beyond the reach of the energy grid, so they must choose from diesel-generated power or renewable energy options for irrigation. Tó Łání Enterprises (TLE) received a 2012 CIG award to conduct a 3-year national pilot project to demonstrate the environmental, agricultural, economic, and sociocultural effectiveness and benefits of solar energy systems for pumping irrigation water. The project was designed to encourage and facilitate adoption of such systems among Navajo, Hopi, and other Tribal conservation districts, farmers, and ranchers in the arid and semiarid Southwest. Results have been so promising that the solar powered system has already been adopted by many Navajo farmers.

A Tool for Tailoring Cover Crops for Water Quality and Weather Resilience

Cover crops can dramatically reduce nutrient losses to surface and ground water, provide nutrients for the next crop, and enhance water infiltration, all of which improve resilience to extreme weather. Through a CIG award and other contributions, the Midwest Cover Crops Council developed a Cover Crop Decision Tool that incorporated expert knowledge across several States into a decision-support system for farmers. As a result of this project, producers throughout the Midwest United States can evaluate their options and receive cover crop recommendations, such as species and seeding rates, tailored to their local conditions, soils, and management goals. This not only helps farmers be profitable, but also contributes public value through benefits to the environment.

A Cloud-based Tool for Nitrogen Management

Nitrogen is required for plant growth, but loss of excess nitrogen can contribute to water quality impairments and greenhouse gas emissions. Determining the right rate to apply is difficult because

weather influences how much nitrogen is needed. With funding from a CIG and others, Cornell University developed and tested a publicly available, cloud-based nitrogen recommendation tool, Adapt-N, on farms over 3 years. The tool models local weather, soil, and management to provide better nitrogen recommendations. Results showed that Adapt-N saved producers \$30 an acre and decreased nitrogen inputs by 44 pounds an acre, without decreasing yield. The model has been successfully tested throughout the Northeast United States and is now being evaluated in the Midwest.

Generating Greenhouse Gas Credits Through Nutrient Management on Cropland

In 2011, NRCS awarded a CIG grant to the Delta Institute to develop a protocol that would allow farmers to generate greenhouse-gas-reduction credits arising from voluntary implementation of more efficient nitrogen fertilizer management techniques. The Delta Institute engaged a variety of partners in the project, including American Farmland Trust, Conservation Technology Information Center, Environmental Defense Fund, and agricultural retailers. The result was a methodology approved by the American Carbon Registry that allows for the generation of carbon credits (converted nitrogen oxide credits) on cropland. In a first-of-its-kind transaction, the Climate Trust purchased credits developed using the methodology in early 2014, providing a new income stream for those farmers generating the credits. This demonstrates how improving nitrogen management can be used to generate marketable credits that improve the environment and provide additional income for producers.

Rebuilding Pollinator Habitat

People depend on pollinators for about 30 percent of their food supply; however, habitat for pollinators has declined in recent years. A 2009 CIG award to the Xerces Society developed new NRCS guidelines

for improving native bee habitat. The project demonstrated that establishing native pollinator habitat in previously abandoned agricultural areas significantly increased native bee populations. The project was carried out in California, where most of the Nation's fruit and vegetable crops are located. The guidelines developed led to publication of an NRCS bee habitat improvement reference guide. NRCS is now providing funding to establish bee habitat on previously unused farm areas across the Nation.