United States Department of Agriculture

# FY 2018 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), 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 2014 | FY 2015 | FY 2016 | FY 2017 | FY 2018 |
|---|---|---|---|---|---|---|
| | **Invention Disclosures** | | | | | |
| 1 | Number of new inventions disclosed | 117 | 222 | 244 | 166 | 320 |
| | **Patents** | | | | | |
| 2 | Number of patent applications filed | 119 | 125 | 109 | 111 | 120 |
| 3 | Number of patents received | 83 | 94 | 60 | 68 | 67 |

**Table 2:** Income-bearing licenses from Animal and Plant Health Inspection Service, Agricultural Research Service (ARS), and Forest Service. Since most of the licenses were from ARS (459), the Elapsed Amount of Time to Grant Licenses data is from ARS.

| | | FY 2014 | FY 2015 | FY 2016 | FY 2017 | FY 2018 |
|---|---|---|---|---|---|---|
| | **Income-bearing Licenses** | | | | | |
| 4 | Number of income-bearing licenses | 412 | 421 | 439 | 437 | 471 |
| 5 | Exclusive licenses | 299 | 292 | 307 | 302 | 324 |
| 6 | Partially exclusive licenses | 15 | 11 | 9 | 6 | 7 |
| **7** | Non-exclusive licenses | 98 | 118 | 120 | 129 | 140 |
| | **Elapsed Amount of Time to Grant Licenses** | | | | | |
| 8 | Average (months) | 5.9 | 2.8 | 4.9 | 6.1 | 6.3 |
| 9 | Minimum (months) | 0.9 | 0.5 | 0.9 | 1.3 | 0.9 |
| 10 | Maximum (months) | 21.5 | 10.0 | 16.0 | 13.7 | 24.1 |

**Table 3:** Licensing income from Agricultural Research Service. 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.

| | | FY 2014 | FY 2015 | FY 2016 | FY 2017 | FY 2018 |
|---|---|---|---|---|---|---|
| | **Earned Royalty Income** | | | | | |
| 11 | Earned Royalty Income from top 1% of licenses | N/R | N/R | N/R | N/R | N/R |
| 12 | Earned Royalty Income from top 5% of licenses | $2,048,317 | $1,756,460 | $1,811,637 | $1,639,557 | $1,218,975 |
| 13 | Earned Royalty Income from top 20% of licenses | $3,103,143 | $2,856,924 | $3,043,395 | $2,933,342 | $2,227,058 |
| 14 | Minimum Earned Royalty Income | $32 | $13 | $5 | $15 | $21 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 15 | Maximum Earned Royalty Income | $575,753 | $728,017 | $818,537 | $769,167 | $265,844 |
| 16 | Median Earned Royalty Income | $3,232 | $3,525 | $3,966 | $3,698 | $3,056 |
| | **Disposition of Earned Royalty Income** | | | | | |
| 17 | Total amount earned royalty income received | $3,610,774 | $3,509,904 | $3,633,239 | $3,503,866 | $2,715,861 |
| 18 | Percent of Earned Royalty Income distributed to inventors | 25% | 25% | 25% | 25% | 25% |
| 19 | Percent of Earned Royalty Income distributed to the agency or laboratory | 0% | 0% | 0% | 0% | 0% |
| 20 | Licenses terminated for cause | 0 | 0 | 0 | 0 | 0 |

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

**Table 4:** Cooperative Research and Development Agreements (CRADA) and other research collaborations. CRADA are from Agricultural Research Service, Animal and Plant Health Inspection Service, Forest Service and Agricultural Marketing Service. Most of the CRADA numbers (189 out of 219) are from Agricultural Research Service.

| | | FY 2014 | FY 2015 | FY 2016 | FY 2017 | FY 2018 |
|---|---|---|---|---|---|---|
| | **CRADAS** | | | | | |
| 21 | Number Active CRADAs | 267 | 301 | 238 | 330 | 212 |
| 22 | Total Newly Executed CRADAs | 60 | 80 | 79 | 91 | 61 |
| 23 | Active CRADAs with small businesses involvement | 102 | 106 | 76 | 68 | 81 |
| 24 | Number of small businesses involved in active CRADAs | 102 | 106 | 76 | 68 | 81 |
| | **Traditional CRADAs** | | | | | |
| 25 | Active traditional CRADAs | 193 | 188 | 161 | 296 | 182 |
| 26 | Newly executed traditional CRADAs | 39 | 52 | 43 | 77 | 57 |
| | **Non-Traditional CRADAs** | | | | | |
| 27 | Active non-traditional CRADAs | 74 | 113 | 77 | 34 | 30 |
| 28 | Newly executed non-traditional CRADAs | 21 | 28 | 36 | 14 | 4 |
| | **Other Collaborative Research Agreement[1]** | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Active other collaborative research agreements | 5,629 | 4,730 | 5,628 | 6,125 | 3,369 |
| | Newly executed other collaborative research agreements | 1,535 | 1,383 | 2,316 | 1,968 | 694 |

[1] The types of other agreements reported this year are different from previous years. This year the agreements reported are: Trust Fund Cooperative Agreements, Reimbursable Agreements, Material Transfer Research Agreements, Specific Cooperative Agreements and Non-Funded Cooperative Agreements, Cooperative Agreements, Inter-agency & Intra-agency Agreements. In addition, only the Agricultural Research Service and Animal and Plant Health Inspection Service provided numbers this year.

# 1.0. AGRICULTURAL MARKETING SERVICE (AMS)

## 1.1. Mission Statement

The mission of the Agricultural Marketing Service (AMS) is to facilitate the strategic marketing of agricultural products in domestic and international markets, while ensuring fair trading practices and promoting a competitive and efficient marketplace to the benefit of producers, traders, and consumers of U.S. food and fiber products.

AMS carries out a wide range of programs under the authorization of the Agricultural Marketing Act of 1946 as well as over 50 other statutes. More than half of the funds needed to finance AMS activities (excluding commodity purchase program funds) are derived from voluntary user fees. AMS also provides services for private industry and State/Federal agencies on a reimbursable basis. In addition, AMS conducts several appropriated program activities through cooperative arrangements with State Departments of Agriculture and other agencies.

In a Memorandum dated November 14, 2017, the Secretary of Agriculture eliminated the Grain Inspection, Packers, and Stockyards Administration (GIPSA) as a standalone agency. All activities formerly part of GIPSA are now organized under AMS.

## 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 are handled

through the separate business units and divisions within AMS. Still, the agency oversees several 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. Market News Service:**

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. Examples of improved reports and services include: additional local and regional

livestock, grain, and food market prices and volumes, and new and/or enhanced reports on traditional products with specific attributes. AMS is developing a modern data management solution that allows 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). In FY 2018, MARS and its public facing website, My Market News, was introduced to the public. Developers expect all voluntary Market News reporting data products to be collected and publicly disseminated through MARS by the end of FY 2019. At that time, customers will have access to market data from over 3,600 markets and considerably more market information, better data access, and more distinct content. Customers can also access the MARS Application Programming Interface (API), which allows users to automatically download data in custom formats. After a one-time setup, the API continues to deliver the requested information right to the user without the need to do anything else. MARS has improved reporting speed, reliability, and flexibility for the commodities in production. Improvements in data quality and management have been completed including the creation of a report scheduler and file repository, and better cooperator relationship management tools have been implemented.

### 1.4. Market Information Organization of the Americas (MIOA)

AMS continues to serve in a leadership role for the MIOA, which is 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, as they have since 2004. With the support of IICA and the Foreign Agricultural Service (FAS), MIOA is working on several key projects that will assist all the institutions and member countries. These projects

include: An agricultural products dictionary for the Americas, known as Wiki; technology improvement for selected member nations including new mobile applications for information collection and dissemination, 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. All these aligned efforts are designed to expand the availability of reliable price information, which facilitates international trade and allows for greater market transparency.

The latest effort is a self-evaluation process for the members of MIOA. The process is known as Methodological Proposal for the Auto-evaluation of the Agricultural Market Information Systems (MIS) of MIOA Member Countries. The detailed information should allow MIOA to better align system improvement and training efforts among like-countries to enhance the effectiveness and efficiency of capacity building efforts.

### 1.5. National Organic Program

The organic market continues to grow worldwide, providing new export and import opportunities for organic farms and businesses. Rapid organic growth has increased the complexity of supply chains that carry organic products from farm to table. Through its Agricultural Marketing Service (AMS) National Organic Program (NOP), USDA protects the integrity of the products displaying the USDA organic seal around the world and facilitates international trade for U.S. organic farms and businesses.
Import and export systems are important tools for tracking products coming into and out of different countries. The USDA is currently working with the U.S. Customs and Border Protection agency to

establish ways to better identify organic products coming into the United States. AMS has taken actions to increase the transparency and availability of data for other countries involved in organic trade. The Organic Integrity Database has significantly increased the visibility of organic businesses, and directly advances our compliance and enforcement work. AMS also launched a new organic export certificate system to provide electronic certificates about organic shipments. This system can either be accessed by other governments, or our data can feed into other countries' import systems.

Investment in organic systems directly advances AMS goals related to organic integrity, technology modernization, and customer service. The USDA is currently considering foundational needs for a global organic oversight system. The goal is to develop technologies that would allow organic certifiers to approve transactions along an organic supply chain in real-time, enabling them to conduct mass balance checks and to detect fraudulent activity across the supply chain. A comprehensive system would allow government oversight bodies to audit across supply chains, fulfilling the goal of tracing product from farm to market and back. The system would create an inter-connected network, where data can be exchanged between different government oversight systems and existing corporate supply chain systems. Such technology investments are key to protecting organic integrity and facilitating access to international organic markets.

### 1.6. Laboratory Approval & Testing Division

The National Science Laboratories (NSL) provide analytical testing service for a fee. Analytical services include microbiological, chemical, physical, and bio-molecular analyses on a wide variety of food products and agricultural commodities. NSL primarily supports AMS commodity programs with analytical and scientific support for voluntary grading, commodity purchases, and export certification

programs. NSL also serves other USDA and federal government agencies, commercial enterprises, academic and research institutions, and private individuals.

NSL provides technological benefits to the agricultural community and consumers via testing of a wide variety of products for diverse stakeholders. For example, NSL provides microbiological and nutritional testing of operational rations purchased by the U.S. military. In FY 2018, there was an uptick in ration purchases so NSL experienced a prolonged surge in testing for the wide variety of food products purchased for the military and warfighters. Also, NSL is a go to laboratory for the testing of honey bee related samples for pesticide residues in support of pollinator research and protection. In FY 2018, NSL expanded its capabilities in testing for adulteration and authenticity, which provides critical information on quality and safety parameters for compliance of products such as citrus juice, honey, and olive oil.

NSL also routinely supports the vast missions of AMS by testing for quality and safety parameters of commodities procured for the School Lunch Program and other USDA buying programs, pesticide residues in organic commodities for compliance to organic standards; and pesticide residues in specialty products for the Pesticide Data Program which helps to monitor pesticide residue levels in U.S. food. The Laboratory Approval Service (LAS) approves, or accredits, other laboratories to perform testing services in support of domestic and international trade. At the request of industry, other Federal agencies, or foreign governments, AMS develops and administers laboratory approval programs to verify that the analysis of food and agricultural products meet country or customer-specific requirements and is performed by qualified laboratories. In FY 2018, LAS continued the improvement its documented policies, procedures, and program management tools to ensure transparent and consistent program administration; refined the requirements for the Laboratory Approval Program for Aflatoxin Analysis in Almonds, Peanuts, and Pistachios, and monitored implementation in the 34 participating laboratories;

and introduced the official program requirements for the Laboratory Approval Program for Federal Milk Marketing Orders. The program improvements have created greater consistency across participating laboratories and the administrative improvements have created greater efficiency in the services provided by LAS.

### 1.7. Monitoring Program Division

The Pesticide Data Program (PDP) is a national pesticide residue monitoring program and produces the most comprehensive pesticide residue database in the U.S. Since 1991, PDP has tested 122 different commodities for over 640 different pesticide residues. In FY 2018, PDP tested over 10,000 samples and generated over 2.5 million data points. All data are available to the public electronically by way of the PDP website and customized reports are generated when requested. The Environmental Protection Agency uses the data to assess dietary risks from pesticide exposure and determine which pesticides can continue to be used in domestic agricultural production. It also uses the data to harmonize U.S. pesticide tolerance levels with international levels. The Food and Drug Administration uses the data to enhance its surveillance of imported foods. State public health and environmental agencies use the data to fulfill their consumer protection commitments. Growers and distributors use the data to resolve trade issues. PDP data was also submitted to the Codex Alimentarius Committee to assist in benchmarking international Maximum Residue Levels (MRLs) as real-life data (in place of theoretical data), contributing to more accurate MRL estimates.

### 1.8. Plant Variety Protection Office

The Plant Variety Protection (PVP) Act provides legal and intellectual property rights protection to developers of new varieties of plants that are sexually reproduced or tuber-propagated. This voluntary program is funded through application fees for certificates of protection. Currently, more than 140 species of plants are protected under the PVP Act and more than 8,340 certificates of protection are in force. In FY 2018, the Plant Variety Protection Office (PVPO) received 536 applications of new seed and tuber propagated agricultural and ornamental plant varieties, conducted examinations on 336 applications to determine if plants were a new variety, and issued more than 280 certificates of protection. In FY 2018, in addition to carrying out its mission, PVPO moved the electronic PVP system (ePVP) from the testing phase, in which it was used on a limited basis, to official, wide-use. One upgrade to ePVP implemented in FY 2018 was the connection to the customer-friendly payment system, pay.gov. Customers can now submit payments for fees using e-check, Amazon pay, PayPal, debit card, or credit card.

### 1.9. Seed Regulatory & Testing Division

The Seed Regulatory and Testing Division (SRTD) administers the Federal Seed Act and other marketing programs to facilitate the trade of agricultural and vegetable seed in domestic and international markets. These activities ensure that seed buyers can make informed choices when purchasing seed and American seed businesses are able to market their seed on a level playing field. SRTD partners with 50 state departments of agriculture and several industry organizations to leverage its limited resources into a broad network of regulatory and marketing activities that stabile and support the robust 12 billion-dollar U.S. seed market.

One critical activity for SRTD is the enforcement of State noxious weed-seed laws. Each year, invasive species cause an estimated $137 billion dollars in damages annually in the US. SRTD offers a weed seed identification service which allows unknown seeds to be compared to the SRTD seed herbarium which houses approximately 30,000 seed samples. This service helps keep the public informed of potentially noxious seeds before they are planted. To expand its service, SRTD has partnered with the Canadian Food and Inspection Service to develop an online seed identification tool (www.IDseed.org) that allows users to compare seeds using descriptive characteristics. The website tool was launched in October 2018. Eventually, the online tool will contain images of all Federal and State regulated weed seeds and images of restricted or prohibited seeds from our international trading partners.

### 1.10. Federal Grain Inspection Service (FGIS)

FGIS 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 2018, the grain markets serviced by FGIS represented an approximate value of $104 billion, with exports contributing about 42 billion to the U.S. economy.

FGIS 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, FGIS research is highly "applied," in that FGIS's successful projects result in direct and immediate use by the U.S. grain industry. FGIS 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. FGIS 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. FGIS 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.

### 1.10.1 Nature and Structure of FGIS Research Programs

FGIS maintains a strong presence, domestically and internationally, in the development, evaluation, and implementation of practical grain quality assessment and inspection methods. FGIS laboratories work with the latest technologies, and through these technologies and ongoing efforts, FGIS is helping to improve the quality of U.S. grain available to the global market. To enhance marketing of grain into the future, FGIS is also conducting internal research and participating in development and collaborative efforts with other governmental entities, laboratories, and private business. The research and analysis conducted is in response to clear and widespread market needs. In general, FGIS research is highly

"applied," in that FGIS's successful projects result in direct and immediate use by the U.S. grain industry. FGIS 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. FGIS 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. FGIS research has resulted 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.

### 1.10.2 Current Technology Transfer Goals, Objectives, and Measures of Success (Metrics)

**Current Technology Transfer Initiatives**

Visually identifying quality factors within grain and other commodities requires specific lighting characteristics to appropriately illuminate the sample being graded. FGIS has identified a need for light emitting diode (LED) lights as an alternative to the fluorescent lights currently used within the official inspection system. FGIS conducted a study of three commercially available LED lights to identify the appropriate specifications that equate to the current fluorescent lighting requirements. One LED light was equivalent to the current fluorescent lights used for official inspection. In FY 2019, FGIS plans to conduct a study of additional commercially available LED lights to refine the appropriate specifications.

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. FGIS is exploring how use of imaging and near infrared technology (NIR) can be effectively integrated into the official grain inspection system.

FGIS continues work with manufacturers to evaluate and certify rapid test kits that detect mycotoxins and approved GE traits in grain. FGIS also approves the use of mycotoxin test kits for use within the official inspection system. FGIS provides a monthly update of all approved rapid test kits on its public website. FGIS has approved 29 rapid test kits for the detection of mycotoxins in grain including, aflatoxins, deoxynivalenol, fumonisins, ochratoxin A, and zearalenone. FGIS has approved 3 rapid test kits for detection of specific GE traits in corn and soybeans.

The Falling Number test measures the effect of alpha-amylase activity in wheat. Increased alpha-amylase activity associated with sprouting, causes breakdown of starch and adversely affects the end use quality of wheat. As a result, the Falling Number test result is an important factor in the domestic and international trade of wheat. In FY 2018, FGIS identified two changes to the Falling Number test that would reduce overall variation of Falling Number test results, including using correction of test results to sea level based on the barometric pressure of the testing location and requiring the use of the Shakematic, a robotic shaker used in sample preparation. FGIS plans to implement these changes for official Falling Number tests in FY 2019.

**CRADA Activities**

FGIS has a Cooperative Research and Development Agreement CRADA with QualySense AG to assess how the use of imaging and NIR technology can be effectively integrated into the official grain inspection system. FGIS' Technology and Science Division (TSD) and QualySense AG have entered into a 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 FGIS 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. The CRADA concludes on January 31, 2019.

**Measures of Success**

FGIS measures its success in terms of the percentage of market needs provided, which are grain and commodity quality factors assessed through official inspection services. FGIS currently provides tests that address 98 percent of current market needs as identified by the grain exporting industry. FGIS 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 2018, FGIS received no complaints that would indicate that there are issues with the official methods used to assess any quality factors.

**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. FGIS 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. FGIS 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, FGIS seeks to improve the overall performance of testing for GE grains and oilseeds. The FGIS 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 FGIS Proficiency Program helps organizations identify areas of concern and take corrective actions to improve testing precision, capability, and reliability.

- FGIS 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. FGIS 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. FGIS organizes the surveys by collecting samples and performing a range of analytical tests, including tests for pesticide residues and heavy metals. FGIS has assisted with the wheat survey for over 20 years, the soybean survey for

10 years, and the corn survey for the last two 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.

**Outreach Activities**

**Domestic Outreach**

FGIS 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.

**International Outreach**

- A FGIS scientist participated in the Asian Pacific Economic Cooperation's (APEC) Regional Workshop on Capacity Building of Measurement Standards and Technologies for Grain Food Safety and Free Trade in Beijing, China. The objective of this workshop was a capacity building and knowledge transfer program, and the goals were to improve regional mutual recognition on measurement standards and technology for the analysis of mycotoxins and heavy metals in grain. FGIS presented its sampling, testing, and methods development programs for mycotoxins in grain.

- A FGIS scientist participated in the Africa Food Safety Workshop in Pretoria, South Africa. The objective of this workshop was to improve measurement standards, expand food safety networks, and strengthen capacity of food safety testing and control in Africa.

- A FGIS 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.

- A FGIS Scientist participated in the 5th Global Low-Level Presence Initiative Meeting (GLI) in Natal, Brazil. The objective of the workshop was to address low level presence of genetically modified (GM) traits in grains which remains a global issue for importers and exporters of both genetically modified and non-GM crops.

- Two FGIS 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 2018, FGIS 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 FGIS expertise. FGIS 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 2018, one FGIS grain marketing specialist 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 FGIS. Such activities are funded through various programs administered by the Foreign Agricultural Service (FAS) or directly by FGIS. Outreach activities serve to strengthen the U.S. reputation for being a reliable supplier of high-quality grain, to reinforce the integrity of FGIS as an independent quality-inspection authority, and to minimize discrepancies in inspection results between FGIS and importers.

- FGIS 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, FGIS 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 FGIS, our use of the latest technology to provide grain traders with accurate and reliable inspection and weighing information, and

information on FGIS 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 2018, FGIS personnel met with 21 teams from 13 countries.

**Publications**

**Internet Publications**

- The FGIS Performance Verified Mycotoxin Rapid Test Kits matrix is located on FGIS'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 FGIS Performance Verified Biotech Rapid Test Kits matrix is located on FGIS'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 FGIS Biotechnology Proficiency Report is located on FGIS's website at:
  https://www.gipsa.usda.gov/fgis/biotech/quarterly_reports/April_2017_Proficiency_Report.pdf
- The FGIS approved moisture calibrations is located on FGIS's website at:
  https://www.gipsa.usda.gov/fgis/moisture.aspx
  The calibrations are updated May 1 and August 1.

### 1.11. Packers and Stockyards Division (PSD):

AMS provides impartial third-party regulatory overview of electronic grading evaluation being used in the sale of livestock, meat, and poultry. In 2001, PSD began working with the livestock and poultry industries through ASTM International by developing voluntary consensus standards for livestock, meat and poultry grading devices. Acting within its regulatory framework, PSD amended regulations promulgated under the Packers and Stockyards Act by referencing three (3) standards developed by ASTM International. To ensure fair business practices, PSD continually conducts trade practice investigations of packers' electronic grading evaluation practices to determine compliance with the Act and regulations. Today, PSD continues to participate in ASTM International F10 activities exploring new instrument grading standards for lamb and pork tenderness. PSD is committed to working with our ASTM partners in the industry to not only meet challenges but to succeed in creating an industry that provides quality meat and poultry products to consumers and increased producer returns.

### 1.12. Warehouse and Commodities Division (WCMD)

The Warehouse and Commodity Management Division (WCMD) supports the agricultural community through a variety of programs which are essential to promoting agricultural production and food security. WCMD administers the U.S. Warehouse Act of 1916 and certain provisions of the Commodity Credit Corporation (CCC) Charter Act of 1933. WCMD's mission is to oversee the formulation of national policies and procedures to administer a nationwide warehousing system, establish posted county prices for major farm program commodities, and manage CCC commodity inventories and cotton economic assistance programs. WCMD acquires, barters, sells and manages CCC-owned inventories; routinely analyzes locations, conditions and quantity of the stocks as part of its quality

assurance processes; and, establishes the Posted County Prices (PCPs) that are used to determine alternative loan repayment rates for CCC marketing assistance loans and loan deficiency payments. In accordance with Secretary Perdue's USDA Strategic Goal 1 to work efficiently, effectively, with integrity and a focus on customer service, WCMD intends to modernize its present infrastructure. Modernization efforts are intended to align with the Department security requirements and create efficiencies within the portfolio for the removal of stovepipes, strengthening internal control, and eliminate conflicting functionality.

Modernizing the many legacy applications within WCMD's activity and technology portfolio will result in a cost-effective method for linking field offices with headquarters as well as securely sharing applications and information with our employees and stakeholders through digital government services. We initiated a comprehensive modernization effort of the current Warehouse Examination System (WES) to a centralized operational platform/portal that encompasses all warehouse program functions from Licensing/ Reinstatement, Examinations, and Invoicing capability. A modernized system is anticipated to be self-contained and interdependent representing one comprehensive platform. Overall, the updates will improve accessibility/data collection, improved query systems, real-time transparency, and departmental security compliance). WES supports the United States Warehouse Act and Commodity Credit Corporation (CCC) Examination Programs.

As part of the comprehensive approach, updates will include streamlining and automating procedures for gathering, evaluating, improve data security, and posting prices to meet the required availability service level agreement, providing for access to commodity pricing data without exception. A modernized application will provide remote secure VPN access for multiple concurrent users, enable reporting, and automate manual tasks.

### 1.13. Perishable Agricultural Commodities Act Program

This Program is 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. AMS has been developing a modernized data management platform, ePACA, that will include an online self-service portal through which members of the produce industry can apply for or renew a PACA license, file complaints when they have not been paid in full by their buyers and pay PACA fees. The ePACA system will reduce the time it takes AMS to approve and issue a license, shorten the complaint process, and facilitate faster payment of outstanding debts to farmers and produce sellers. The ePACA system also will provide enhanced search capabilities of PACA licensees with 24-hour access to real-time information that produce sellers can use to make informed business decisions.

### 1.14. 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 2018, AMS specialists reviewed commodity standards to ensure their accuracy in describing current products, including 21 for cotton products; 30 for fruit and vegetable products; 36 for meat and poultry products (beef, lamb, and pork); and 13 for tobacco. Of note were revisions for beef and chickens, canned plums, cucumbers 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. AMS updated 6 CIDs, including for refried beans, dehydrated peppers, and snack foods, and created 1 new CID for frozen fruit purees in FY 2018.

### 1.14.1 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 United States 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 through direct outreach and interventions. Much of the work in international standardization involves developing and validating methods of analysis, establishing specialized characteristic descriptions, developing interpretative literature and capturing and analyzing increasingly large datasets.

### 1.15. 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.

### 1.16. 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. In FY 2018, AMS conducted 2,168 inspections to ensure that only eggs fit for human consumption are marketed in consumer outlets.

### 1.17. ACE and CEMS Implementation

Beginning July 23, 2016, U.S. Customs and Border Protection (CBP) began requiring that all importers submit their entry filings through the Automated Commercial Environment (ACE). The ACE electronic

interface accelerates the processing of entry filings for all importers by automating clearance processes by all Government agencies, including AMS. Since that time, AMS has launched its Compliance Enforcement Management System (CEMS) for 16 imported products for which grade and quality inspection is required. CEMS communicates product and inspection information with ACE and has enabled AMS to reduce the time necessary to investigate and close cases of non-compliant imports from several months to an average of 3 weeks of the entry being filed.

### 1.18. International Food Procurement:

AMS procures foods for international food aid programs for overseas use to meet USDA and USAID program requirements. USDA international food procurement activities are governed by the following legislation: Emergency Food Assistance Act of 1983, as amended; Agricultural Trade Development and Assistance Act of 1954 (Public Law 83-480, Title II), as amended; Food for Progress Act of 1985, as amended; the Food, Conservation, and Energy Act of 2008, and the Agricultural Act of 1949, Section 416(b), as amended.

### 1.19. Additional Programs within AMS not contacted for technology transfer update during this cycle.

#### 1.19.1. 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). A majority of the currently active Federal marketing order programs for fruits and vegetables include minimum grade requirements. The standards used by our programs include characteristic qualities as well as criteria related to food safety (e.g., lack of mold, insects, foreign material, etc.). Presently, there are 38 active specialty crop marketing agreement and order programs covering 28 commodities, and 11 milk marketing orders. Proposed orders are subject to approval by producers of the regulated commodity. Section 32 funds authorized annually through the appropriations bill, are used by AMS for administering the Marketing Agreements and Orders Program at the national level, and to conduct public hearings and referenda to determine producer sentiment concerning new programs and proposed revisions of marketing orders already in effect. Program activities and administration at the local level are financed through handler assessments.

### 1.19.2. Country of Origin Labeling (COOL)

The Agricultural Marketing Act (Act) requires retailers to notify their customers of the country of origin of covered commodities. Labeling requirements for fish and shellfish became mandatory during FY 2005, and AMS established an audit-based compliance program the following year to ensure that the public receives credible and accurate information on the country of origin of the fish and shellfish they purchase. In January 2009, USDA issued a final rule on mandatory COOL for all other covered commodities that became effective on March 16, 2009. The FY 2016 Omnibus Appropriations Act amended the Act to repeal the mandatory labeling requirements for beef and pork. The Act 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, macadamia nuts, 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. AMS trains Federal and State employees on enforcement responsibilities; responds to formal complaints; conducts supply chain audits; and develops educational and outreach activities for interested parties.

### 1.19.3. Commodity Research and Promotion Programs

AMS provides oversight and direction to industry-funded and managed commodity research and promotion programs. The various research and promotion acts authorize the collection of an assessment from identified segments of the marketing chain which is used to broaden and enhance national and international markets for various commodities. Assessments to producers are most common; however, some programs assess processors, feeders, packers, handlers, importers, exporters, or other entities. These assessments are used to carry out research and promotional activities for cotton, dairy, fluid milk, beef, lamb, pork, soybeans, sorghum, eggs, highbush blueberries, Hass avocado, honey, mango, mushrooms, peanuts, popcorn, potatoes, softwood lumber, watermelon, Christmas trees, paper and paper-based packaging. AMS is entrusted with oversight of research and promotion boards to ensure fiscal accountability, program integrity, and fair treatment of participating stakeholders. AMS reviews and approves commodity promotional campaigns – including advertising, consumer education programs, and other materials – prior to their use. AMS also approves the boards' budgets and

marketing plans and is invited to attend meetings. Each research and promotion board fully reimburses AMS for the cost of implementing and overseeing its program.

### 1.19.4. Sheep Production and Marketing Grant Program

The 2014 Farm Bill amended the Agricultural Marketing Act of 1946 (7 U.S.C. 1621 et seq.) to establish a competitive grant program to strengthen and enhance the production and marketing of sheep and sheep products in the U.S. The Farm Bill made funding available for a grant to one or more national entities whose mission is consistent with the purpose of the program. The grant was awarded in 2015.

### 1.19.5. Federal-State Marketing Improvement Program (FSMIP)

FSMIP is authorized by the Agricultural Marketing Act of 1946, which gives USDA the authority to establish cooperative agreements with State departments of agriculture or similar State agencies to improve the efficiency of the agricultural marketing chain. AMS provides matching funds on a competitive basis to State departments of agriculture, State agricultural experiment stations, and other State agencies, to assist in exploring new market opportunities for U.S. food and agricultural products, and to encourage research and innovation aimed at improving the efficiency and performance of the agriculture commodities marketing system. State agencies may perform the work or contract with others but must contribute at least one-half of the cost of the projects. This program has funded many innovative projects, such as electronic marketing and agricultural product diversification.

### 1.19.6. Specialty Crop Block Grant Program (SCBGP)

Section 101 of the Specialty Crops Competitiveness Act of 2004 (7 U.S.C. 1621) authorized USDA to provide State assistance for specialty crops, and the 2014 Farm Bill funded the SCBGP through 2018. 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 provides guidance and assistance to States in developing plans; submitting applications; and meeting the administrative, reporting, and audit requirements involved in managing a funded project. AMS also establishes internal review and evaluation procedures for applications and State plans, and participates in workshops, conferences, and other forums to facilitate interaction among States, USDA representatives, and industry organizations. AMS established standardized national outcome measures to demonstrate the program's performance toward fulfilling its statutory purpose. After a grant is awarded, AMS reviews annual performance reports, final reports, audit results, and final financial statements; posts final performance reports on the SCBGP website; and disseminates project findings at appropriate meetings and conferences.

### 1.19.7. Transportation and Marketing:

**Transportation and Market 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 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.

**Farmers Market and Local Food Promotion Program**

This program was created through amendments of the Farmer-to-Consumer Direct Marketing Act of 1976. The 2008 Farm Bill made resources available for the Farmers Market Promotion Program to provide grants targeted to help improve and expand domestic farmers markets, roadside stands, community-supported agriculture programs, agritourism activities, and other direct producer-to-consumer market opportunities. The 2014 Farm Bill expanded the program to assist in the development of local food business enterprises and funded the expanded program through 2018. 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.

**Bioengineered Disclosure and Labeling Program**

The Agricultural Marketing Act of 1946 (7 U.S.C. 1621 et seq.) was amended in 2016 by P.L. 114-216, which added Subtitle E—National Bioengineered Food Disclosure Standard. The National Bioengineered Food Disclosure Law charges AMS with developing a national mandatory system for disclosing the presence of bioengineered material in foods or ingredients to increase consumer confidence and understanding of the foods they buy and avoid uncertainty for food companies and farmers. AMS will ensure an open and transparent process for effectively establishing this new program.

**Strengthening Agricultural Markets and Producer Income (Section 32):**

Section 32 of the Act of August 24, 1935, (7 U.S.C. 612c) made available an appropriation equal to 30 percent of gross customs receipts collected during each preceding calendar year to encourage the domestic consumption or exportation of agricultural commodities. An amount equal to 30 percent of receipts collected on fishery products is transferred to the Department of Commerce's National Marine Fisheries Service. Section 14222 of the 2008 Farm Bill established an annual amount that can be retained from these funds for Section 32 activities, with the remaining funds transferred to the Food and Nutrition Service (FNS) for Child Nutrition Programs.

### 1.19.8. 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 pursuant to Section 32, and in support of entitlement program needs within USDA. The 2002 and 2008 Farm Bills established minimum levels of specialty crop purchases. All purchased commodities are distributed by FNS to schools, as part of the entitlement for the National School Lunch Program, or to other domestic nutrition assistance programs. AMS also provides purchasing services to FNS to supply food to recipients in nutrition assistance programs and is reimbursed for the administrative costs associated with these purchases (Economy Act, 31 U.S.C. 1535) and contract management of the national warehouses serving USDA's Food Distribution Programs on Indian Reservations (FDPIR) and the Commodity Supplemental Food Program (CSFP).

Section 32 of the Act of August 24, 1935, authorizes the Secretary of Agriculture, through payments or indemnities, to encourage the domestic consumption of agricultural commodities or products by persons in low income groups, and to re-establish farmers' purchasing power in connection with the normal production of agricultural commodities. In addition to commodities purchased for distribution, support to growers and producers may also be accomplished through commodity diversion. The diversion program under Section 32 provides an alternative means of support to markets that are experiencing adverse economic conditions. Section 32 authority also allows USDA to finance the removal of defective commodities and to purchase foods for disaster relief (in Presidentially-declared domestic disasters under the Stafford Act).

# 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 2018.

## 2.0.2. Combined Metric Tables

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

| **Wildlife Services (WS)** | **FY 2014** | **FY 2015** | **FY 2016** | **FY 2017** | **FY 2018** |
|---|---|---|---|---|---|
| ● **CRADAs**, total active | 9 | 11 | 9 | 6 | 7 |
| - New, executed | 1 | 1 | 2 | 0 | 1 |
| ▪**Amendments[1], total active** | 9 | 8 | 7 | 6 | 4 |
| - New, executed | 3 | 3 | 2 | 2 | 0 |
| ▪ **Traditional CRADAs, total active** | 9 | 11 | 9 | 6 | 7 |
| - New, executed | 1 | 1 | 2 | 0 | 1 |
| ▪ **Small Business Cooperators, total active** | 6 | 8 | 6 | 6 | 7 |
| - New, executed | 1 | 1 | 2 | 0 | 1 |
| ▪ **Foreign Cooperators, total active** | 5 | 3 | 2 | 1 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| - New, executed | 0 | 0 | 0 | 0 | 0 |
| ● Other Collaborative R&D Relationships | | | | | |
| ▪ **Confidentiality Agreements**[3] | 59 | 69 | 74 | 33 | 40 |
| - New, executed | 9 | 10 | 7 | 5 | 9 |
| ▪ **Material Transfer Agreements**[3] | 71 | 93 | 106 | 75 | 89 |
| - New, executed | 18 | 34 | 17 | 7 | 12 |
| **- Material Transfer Research Agreements** | 0 | 0 | 7 | 11 | 26 |
| - New, executed | 0 | 0 | 7 | 6 | 15 |
| ▪ **Other Agreements**[2], total active | 203 | 269 | 320 | 185 | 154 |
| - New, executed | 107 | 147 | 127 | 77 | 73 |
| ● **Publications** | 147 | 99 | 107 | 128 | 198 |
| -Peer-Reviewed Scientific Publications | 142 | 91 | 99 | 108 | 175 |
| -Non-Indexed Publications | 5 | 8 | 8 | 20 | 23 |
| **Veterinary Services (VS)** | **FY 2014** | **FY 2015** | **FY 2016** | **FY 2017** | **FY 2018** |
| ● **CRADAs,** total active | 0 | 0 | 0 | 0 | 0 |
| ● Other Collaborative R&D Relationships | | | | | 0 |
| ▪ **Confidentiality Agreements** | 1 | 0 | 0 | 17 | 20 |
| - New, executed | 1 | 0 | 0 | 17 | 3 |
| ▪ **Material Transfer Agreements** | 9 | 63 | 64 | 62 | 67 |
| - New, executed | 9 | 22 | 16 | 17 | 31 |
| **Material Transfer Research Agreements** | | 0 | 0 | 5 | 0 |
| - New, executed | | 0 | 0 | 5 | 0 |
| ▪ **Other Agreements**[2], total active | 58 | 89 | 170 | 154 | 104 |
| - New, executed | 23 | 86 | 91 | 84 | 61 |
| ● **Publications** | 35 | 29 | 46 | 33 | 22 |
| -Peer-Reviewed Scientific Publications | 35 | 29 | 40 | 32 | 22 |
| -Trade Journal Publications | 0 | 0 | 0 | 0 | 0 |
| **Plant Protection and Quarantine (PPQ)** | **FY 2014** | **FY 2015** | **FY 2016** | **FY 2017** | **FY 2018** |
| ● **CRADAs, total active** | 0 | 0 | | 1 | NR |
| ● Other Collaborative R&D Relationships | | | | | NR |
| ▪ **Confidentiality Agreements** | 0 | 1 | | 2 | NR |
| - New, executed | 0 | 1 | | | NR |
| ▪ **Material Transfer Agreements** | 1 | 9 | | 24 | NR |
| - New, executed | 1 | 8 | | 6 | NR |
| **Material Transfer Research Agreements** | | 4 | | 6 | NR |
| - New, executed | | 4 | | 2 | NR |
| **ARS Letter of Intent**[3] | | 2 | | 1 | NR |
| ▪ **Other Agreements**[2,4], total active | 380 | 389 | | | NR |
| - New, executed | 147 | 132 | | 2 | NR |
| ● **Publications** | 68 | 54 | | | |
| -Peer-Reviewed Scientific Publications | 39 | 30 | | | |
| -Trade Journal Publications | 29 | 20 | | | |

Footnotes for Table 1

[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] Includes Trust Fund Agreements, Interagency Agreements, Cooperative Agreements, Cooperative Service (Reimbursable) Agreements, Non-Funded Cooperative Agreements and MOUs.

[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 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 2014 | FY 2015 | FY 2016 | FY 2017 | FY 2018 |
|---|---|---|---|---|---|
| **● New invention disclosures in FY** | 2 | 4 | 3 | 4 | 4 |
| **● Patent applications filed in FY, total** | | | | 3 | 5 |
| ▪ Non-Provisional | 0 | 0 | 3 | 1 | 4 |
| ▪ Provisional | 0 | 3 | 2 | 2 | 1 |
| | | | | | |
| **● Patents issued in FY** | | | | | |
| ▪ Life Sciences | 1 | 1 | 2 | 1 | 0 |
| ▪ Chemical | 0 | 0 | 0 | 0 | 0 |
| ▪ Mechanical & Measurement | 0 | 0 | 0 | 0 | 1 |
| **APHIS-Veterinary Services (VS)** | **FY 2014** | **FY 2015** | **FY 2016** | **FY 2017** | **FY 2018** |
| **● New invention disclosures in FY** | 1 | 0 | 1 | 0 | 0 |
| **● Patent applications filed in FY, total** | | | | 0 | 0 |
| ▪ Non-Provisional | 0 | 1 | 0 | 0 | 0 |
| ▪ Provisional | 0 | 0 | 1 | 0 | 0 |
| **● Patents issued in FY** | | | | 0 | 0 |
| ▪ Life Sciences | 1 | 1 | 0 | 0 | 0 |
| ▪ Chemical | 0 | 0 | 0 | 0 | 0 |
| ▪ Mechanical & Measurement | 0 | 0 | 0 | 0 | 0 |

**TABLE 3. Licensing: Profile of Active[1] Licenses**

| APHIS-Wildlife Services (WS) | FY 2014 | FY 2015 | FY 2016 | FY 2017 | FY 2018 |
|---|---|---|---|---|---|
| ● All licenses, total active in the FY | | | | | |
| ▪ **Patent licenses**, total active in FY | 1 | 1 | 3 | 3 | 3 |
| **APHIS-Veterinary Services (VS)** | **FY 2014** | **FY 2015** | **FY 2016** | **FY 2017** | **FY 2018** |

| | | | | | |
|---|---|---|---|---|---|
| ● All licenses, total active in the FY | | | | | |
| ▪ **Patent licenses**, total active in FY | 1 | 1 | 0 | 0 | 0 |

[1]Active 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 IP licenses.

**TABLE 4. Income Bearing Licenses[1]**

| APHIS-Wildlife Services (WS) | FY 2014 | FY 2015 | FY 2016 | FY 2017 | FY 2018 |
|---|---|---|---|---|---|
| **● All royalty bearing licenses[1]** | | | | | |
| ▪ Patent licenses | 1 | 0 | 2 | 3 | 3 |
| **APHIS-Veterinary Services (VS)** | **FY 2014** | **FY 2015** | **FY 2016** | **FY 2017** | **FY 2018** |
| **● All royalty bearing licenses[1]** | | | | | |
| ▪ Patent licenses | 1 | 0 | 0 | 0 | 0 |

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

**TABLE 5. License Income. Veterinary Services had no licensing income.**

| APHIS-Wildlife Services (WS) | FY 2014 | FY 2015 | FY 2016 | FY 2017 | FY 2018 |
|---|---|---|---|---|---|
| ▪ Patent licenses | 1 | 0 | 3 | 3 | 3 |
| **● Total Earned Royalty Income (ERI)[1]** | | | | | |
| **▪ Patent licenses, total ERI** | $0 | $0 | $17,500 | $5,000 | $87 |

**TABLE 6. Disposition of License Income**

| APHIS-Wildlife Services (WS)[1] | FY 2014 | FY 2015 | FY 2016 | FY 2017 | FY 2018 |
|---|---|---|---|---|---|
| ● Income distributed, total | | | $17,500 | $5,000 | $87 |
| - To Inventors | $0 | $0 | $6,625 | $2,750 | $87 |
| ▪ Patent licenses, total | $0 | $0 | $17,500 | $5,000 | $87 |
| - To inventors | $0 | $0 | $6,625 | $2,750 | $87 |

## 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. NWRC is the only Federal Laboratory devoted to resolving problems caused by the interaction of wild animals and society.

NWRC is headquartered on the Foothills Research Campus of Colorado State University in Fort Collins, CO. The NWRC employs more than 140 scientists, technicians, and support personnel at its Fort

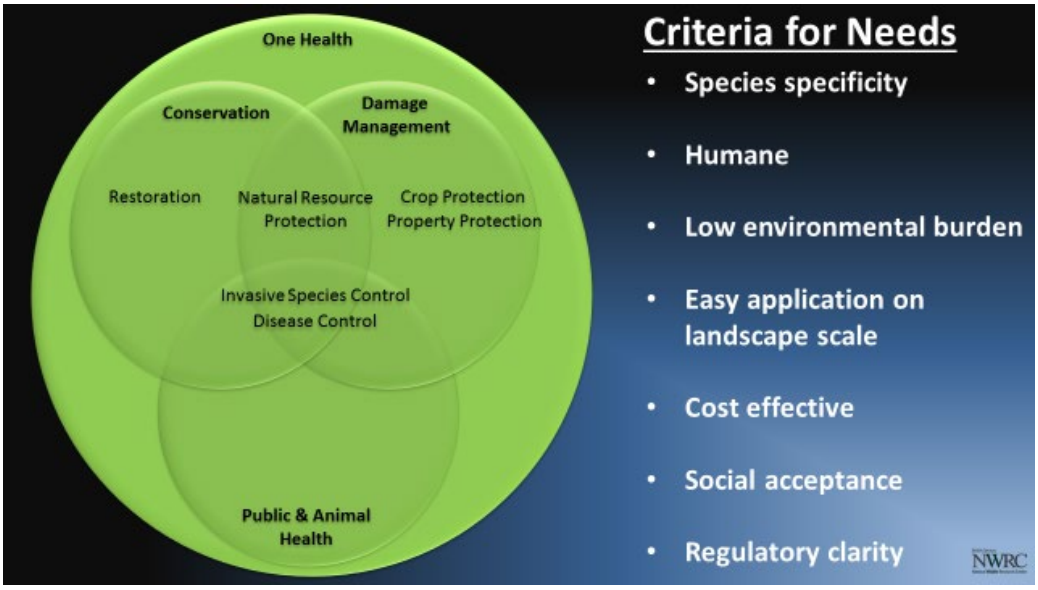
Collins, CO, headquarters and at the 8 field stations located throughout the United States. Five field stations are co-located with Universities (University of Florida, Oregon State University, Utah State University, North Dakota State University, and Mississippi State University). One field station is located at the Monell Chemical Senses Center in Philadelphia, PA. The range of geographic locations facilitates a unique ability to address regional wildlife damage management issues. Further, NWRC routinely conducts international consultations in this specialized area.

Scientists at 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, 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.

NWRC works within three general focus areas, Damage Management, Conservation, Public and Animal Health, which complement the USDA One Health initiative. 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 as little environmental impact when employed, are cost effective and when appropriate, 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' work flow paradigm, originating with ideas from NWRC scientist, WS Operations

field staff, or outside entities 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.

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

Scientists at NWRC produce methods, technology, and materials for reducing animal damage. Through the publication of results and the exchange of technical information, 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, 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

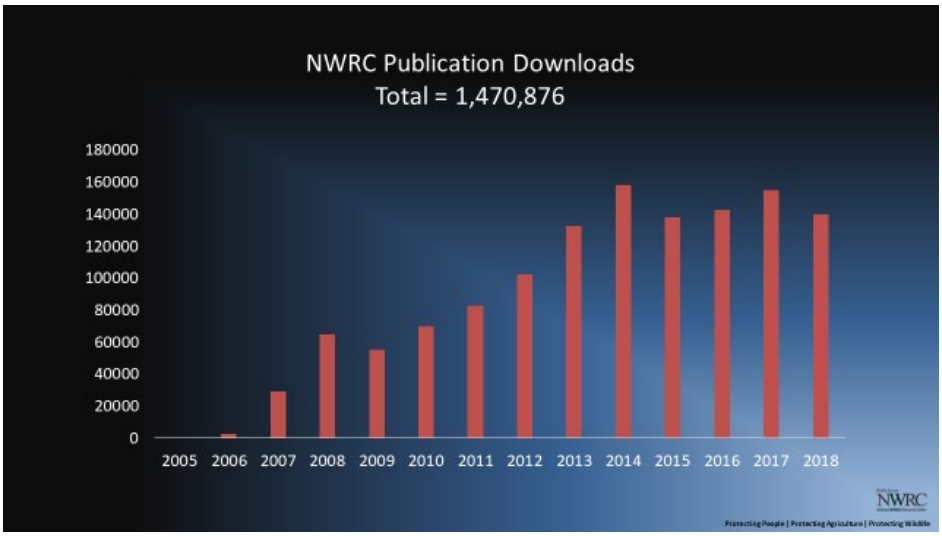
methods development, creating economic activity, jobs, and sustaining economic development. WS uses formal instruments of technology transfer, including Confidentiality Agreements (CA), Material Transfer Agreements (MTA), Material Transfer Research Agreements (MTRA), and Cooperative Research and Development 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 (USFS) 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 USFS 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 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 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 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 their publication success. In FY18, NWRC scientist published 175 peer-reviewed manuscripts in 85 scientific journals, 7 manuscripts in conference proceedings and 16 book chapters. Even more impressive though is the rate at which publications have been downloaded by external audiences, especially 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 113,000 per year. Between 2005 and 2008, 1,470,876 NWRC publications were downloaded.




Another measure of the NWRC's technology transfer and research development efforts are the number of individual organizations our scientists and support staff collaborate with annually. In 2018, NWRC partnered or otherwise collaborated with 368 individual institutions, an impressive number given the size of the Center's research staff (Table 1). 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 26 foreign governments or institutions. It is expected that NWRC's external collaborations remained at this level in FY19.

Table 1. Number of unique institutions NWRC collaborated with in FY18.

| Institution Type | Number of Unique collaborations |
|---|---|
| Wildlife Services State Operational Programs | 50 |
| Federal Agencies | 57 |
| State/Local Governments | 44 |
| Non-Government Organizations | 32 |
| Private Institutions | 47 |
| Universities | 112 |
| Foreign Governments or Institutions | 26 |
| Total | 368 |

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. 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 FY18, NWRC was actively involved in 162 intellectual property protection and/or development agreements, 37 of which were initiated in FY18. An additional 69 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% of the annual budget and has remained steady during the last 6 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 and $2.7 million in 2018.

### 2.1.4. Downstream Outcomes

#### 2.1.4.1. Birds Don't Always Like What They See

Birds and rodents damage agriculture by eating newly-planted, maturing, ripening, and stored crops, as well as livestock feed. Their feces may also contaminate crops, feed, and equipment. European starlings, blackbirds and crows are abundant and widely distributed in the United States, with their winter populations estimated between 750 million and 1 billion birds. They cause $150M in direct damages to agriculture. Annually, blackbirds damage more than $15M in sunflower, $15-25M in ripening corn, $20-50 million in seeded corn, $6 million in sorghum, and more than $20M in rice. Annual losses to U.S. crops and stored produce from rats is estimated to be $19B.

Scientists at the NWRC have long-standing partnerships with private companies and industry groups to investigate bird and rodent repellent compounds, formulations, and application strategies for reducing wildlife damage. One such partnership with Arkion Life Sciences (Arkion) has resulted in five co-owned patented technologies and associated repellent products that are cost effective, practical, environmentally safe and socially responsible, and are currently marketed and sold nationally and internationally. Recent advances have also led to the development of a new repellent application strategy that takes advantage of both visual cues and post-ingestive consequences (e.g., an unpleasant taste or sickness in the birds that eat it).

Technology Partnership

Since the early 1990s, Arkion and the NWRC have collaborated under Cooperative Agreements, Cooperative Service Agreements, and Cooperative Research and Development Agreements (CRADA) to develop bird repellent products based on a naturally occurring, plant-based compound called anthraquinone (AQ). AQ was first patented as a bird repellent in 1944 to reduce bird damage to agricultural crops. At that time, the assumed mode of action was post-ingestive stress. Recent NWRC-Arkion research has shown that AQ can also cause avoidance behaviors in birds and mammals through visual cues related to the compound's absorption of the ultraviolet (UV) spectrum. As a consequence, repellent products and application strategies have been designed that 'trick' birds and mammals into overlooking food items or deter them from sitting or perching on items. NWRC research has also shown that if birds first come into contact with AQ, other less expensive compounds with similar UV spectral characteristics can be substituted for AQ or subsequent applications of AQ can be made at lower application rates.

The NWRC-Arkion collaboration has led to a suite of co-owned patents being issued or under review by the U.S. Patent and Trade Office, as well as foreign governments (Table 2). Arkion has since been issued an exclusive license to the visual cue technology.

Table 1. Intellectual property suite resulting from the collaboration between Arkion Life Sciences and the USDA National Wildlife Research Center.

| **Patent Title** | **U.S. Patent or Application No.** | **Foreign Patents or Applications** |
|---|---|---|
| Ultraviolet Strategy for Avian Repellency | 9,131,678 | 13 countries |
| Method for Repelling Rodents | 9,999,220 | 7 countries |
| Use of Visual Cues to Enhance Bird Repellent Composition | 14/910,099 | n/a |

| | | |
|---|---|---|
| Repellent and Attractant Composition for Dichromatic Animals | 15/398,060 | n/a |
| Wildlife-Repellent and Wildlife Attractant feed formulations for Animal Agriculture | 62/420,273 | n/a |

Impact

With the growing knowledge of how AQ repels birds, Arkion has developed a range of products. Currently marketed products include a spray application to turf to reduce usage by Canada geese (Flight Control® and Stop the Drop®); a surface application to inhibit perching behavior (Airepel®); and pre-planting seed treatments to reduce bird damage to newly planted corn and rice (Avipel® and AV-1011®). Arkion also has registration applications under review at the U.S. Environmental Protection Agency (EPA) for AQ-based foliar treatments for ripened crops.

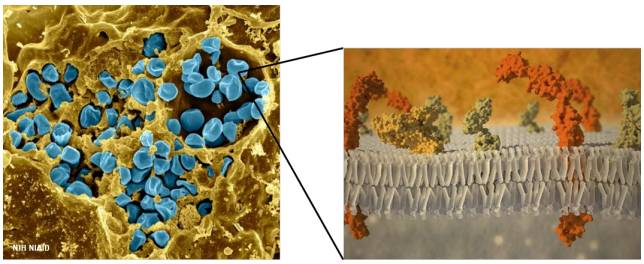
The results of the NWRC-Arkion partnership not only impact wildlife conservation and crop and disease protection in the United States, but also food production in lesser developed countries. For example, an AQ-based product used as a seed treatment on upper Midwest corn crops has significantly reduced sandhill crane damage to newly planted corn seed, thus reducing the need to lethally remove cranes. Rice seed treatments significantly reduce blackbird and grackle damage to newly planted rice, and foliar applications to emergent soybeans reduce damage caused by grazing geese. Furthermore, applications made to perch sites on the outside of poultry facilities cause wild birds to avoid those areas, thereby reducing the threat of wild birds transmitting diseases to domestic poultry flocks. Most recently, Arkion announced a product registration in the Republic of Ghana for an AQ-based repellent for rice seed.

Rice is a major food staple for Ghana and 85% of its rice is grown in small, 5 to 7-acre plots. Initial repellent field trials on Ghana rice have doubled its yield, representing changes from subsistence to cash

crop farming and allowing children to go to school rather than scaring birds away from rice fields. Across Ghana, the increase in rice could total more than $460M per year. Arkion and the Republic of Ghana are promoting the treatment of 7,000 acres of rice in the fall of 2018 through a program called 'Reclaim the Grain.' As part of the program, the Ghana government will purchase and provide Arkion's repellent to farmers. In return, the farmers will help cover the cost of the repellent by giving the government 4 of the 30 extra bags of harvested rice per acre expected from treated fields. By 2025, Africa's population is expected to exceed 1.5B people, thus the demand for rice will continue to grow and an increase in rice production will be essential for economic stability in West Africa. Ghana represents 1% of the potential use of Arkion's AQ-based repellent product in West Africa. It is expected that the repellent will help boost Ghana's rice production and reduce the amount of imported rice needed.

Future NWRC-Arkion research efforts are focused on developing AQ-based products intended for foliar applications to crops; topical application to fruit and nut trees; structural applications in poultry, beef and dairy facilities; and incorporated or topical applications to rodenticide baits. Applications of this repellent technology are expected to increase throughout the U.S. and internationally, saving farmers money and helping to protect a wide variety of resources.

#### 2.1.4.1. Improving Disease Detection and Diagnostics



Wildlife can carry and spread pathogens that infect poultry, livestock, and people, as well as threaten our Nation's food safety and security. For example, avian influenza viruses (AIV) can spill-over from wild birds and other wildlife into poultry operations

and become highly pathogenic resulting in the loss of poultry and embargos on poultry products. Pathogenic and anti-microbial resistant (AMR) bacteria can be introduced into agricultural operations through wildlife feces causing illness in livestock and contaminating food products harvested and prepared for human consumption. The ability to detect and diagnose diseases is key to monitoring and preventing their spread. Accordingly, working with a variety of collaborators, NWRC researchers have developed multiple diagnostic tools and monitoring systems for pathogens affecting wildlife, people, and livestock.

Paper-based Immunoassay System for Environmental Pathogens

Researchers at Colorado State University and NWRC have developed a paper-based immunoassay system for detecting pathogens of agricultural and zoonotic importance. This novel device provides a simple system for field analysis of environmental samples, saving time and money incurred when samples are sent to laboratories for analysis. A provisional patent application on this technology was submitted to the US Patent and Trade Office by Colorado State University in August 2018.

Detecting Plague and Tularemia Exposure in Wildlife

WS routinely monitors wildlife for the presence of plague and tularemia. Sylvatic plague and tularemia are diseases that affect people, domestic animals, and many other mammals. They are caused by the bacteria, *Yersinia pestis* and *Francisella tularensis*, respectively. Working with the U.S. Centers for Disease Control and Prevention and Colorado State University, NWRC scientists developed a new method for sample analysis that uses a semi-automated, bead-based flow cytometric assay called the F1 Luminex plague assay. This system was shown to be 64x more sensitive than traditional plague

monitoring methods and 99.7% accurate. It is able to detect *Y. pestis* exposure in coyotes (key sentinel species), as well as felids and raccoons. The F1 Luminex plague assay is being evaluated as the primary tool for plague monitoring by the WS National Wildlife Disease Program to replace the passive hemagglutination assay.

Detecting Contaminated Water

Fecal contamination of water by wildlife poses a significant public health risk. Male-specific F+ RNA (FRNA) coliphages (i.e., viruses that parasitize *E. coli* bacteria) are microbial indicators of fecal contamination. Different genotypes of these coliphages are associated with specific animal hosts, making FRNA coliphages useful for identifying and tracking sources of fecal contamination. Working with U.S. Environmental Protection Agency, Colorado State University, University of Wyoming, McGill University, and TechLaw, Inc., NWRC scientists developed a simple, sensitive and reliable method for detecting fecal contamination in water. The method uses a resin-based anion exchange which concentrates and detects FRNA coliphages from water samples. The new system performs equally or better than existing methods in smaller volumes of water. This tool may be useful for frequent or continuous water testing and identifying sources of wildlife-associated fecal contamination.

Identifying Antimicrobial Resistance

Wildlife are increasingly recognized as carriers of antimicrobial resistant bacteria and for their abilities to disseminate the pathogens across agricultural landscapes. This can negatively impact agriculture, public health, and food safety. Traditional microbial identification and typing techniques are laborious and expensive, and often cannot identify microbes down to the strain level. Methods, such as Matrix-

Assisted Laser Desorption Ionization Time-of-Flight mass spectrometry (MALDI-TOF MS) biotyping, can significantly reduce costs and accelerate the time to detection of antimicrobial resistant pathogens. The tool compares and contrasts bacteria that have different phenotypes and looks for differential properties or abundances of the bacterial components. Working with the University of Wyoming, NWRC scientists developed a MALDI-TOF MS technique to characterize antimicrobial resistance in *E. coli* strains commonly found in wildlife and livestock. So far, the tool has identified over 80 different biomarkers that are predictive of certain types of antimicrobial resistant *E. coli*.

Detecting Aerosolized Avian Influenza Viruses

Biocontainment and emergency response measures related to the 2014-2015 outbreak of highly pathogenic avian influenza highlighted the important role of aerosols in virus transmission within and between poultry facilities. Accordingly, aerosol sampling has been suggested as a surveillance tool to monitor influenza viruses in agricultural production systems. Working with Colorado State University, University of Wyoming and McGill University, NWRC scientists developed and tested a system to effectively sample and detect aerosolized influenza viruses. The novel method pairs liquid impingement (a widely used system in which aerosolized viruses are deposited into a liquid substrate) with anion exchange resin-based virus concentration, and improves the detection of type A and B influenza virus by more than 6x and 3x, respectively. The new technique is simple to perform, adaptable to existing methods, and cost-effective, and will likely prove valuable in future influenza emergency response efforts.

## 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 science-based regulatory framework to ensure the safe importation, interstate movement, and environmental release of regulated 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 a GE organism at different stages in the development of a product. This can facilitate efficient development of the appropriate information necessary for regulatory review. The BRS guide for new users illustrates how to efficiently use its system https://www.aphis.usda.gov/aphis/ourfocus/biotechnology/permits-notifications-petitions/petitions/ct_new_users_petitions.

BRS provides compliance assistance to organizations involved in biotechnology research and development, including small businesses and academic researchers, to facilitate compliance with APHIS regulations (7 CFR part 340) for the import, interstate movement, and field release of regulated genetically engineered (GE) organisms. Compliance assistance is provided to the regulated community

through a variety of mechanisms including education, template procedures and forms, and the Biotechnology Quality Management Support (BQMS) Program. 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. The BQMS Program provides participants with the tools and guidance needed to develop a BQMS that is tailored to their organization's needs and to better maintain compliance with APHIS regulations for GE organisms. Information regarding compliance assistance can be found at https://www.aphis.usda.gov/aphis/ourfocus/biotechnology.

## 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 and international organizations 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 empowers 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 trade 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, including Veterinary Services (VS), Plant Protection and Quarantine (PPQ), Biotechnology Regulatory Services (BRS), Wildlife Services (WS) and other headquarters staffs, to ensure that its 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 bonds 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 collaborates 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), The Pan American Health Organization (PAHO), and the International Regional Organization for Agricultural Health (OIRSA) as well as with our international trading partners to help prepare and implement appropriate technologies to control or eliminate sanitary and phytosanitary (SPS) threats to the safe trade of agricultural products.

**Examples of International Services Action Programs**

- IS has organized and led several pest control and eradication 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.

- The Medfly Program (Moscamed) transfers Sterile Insect Technique (SIT) and other related technologies and the area-wide integration of pest management through many interactive trainings and by hosting international fruit fly training courses sponsored by FAO and the IAEA. Highly specialized Moscamed program staff also advise on fruit fly management to interested countries. Through international partnerships, technicians from over 40 countries worldwide have been trained and research and development of SIT and related technologies has been advanced during the program's history.

- 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's Agricultural Research Service. IS' ability to move quickly to respond to pest threats and outbreaks was demonstrated by the Medfly outbreak in the Dominican Republic in 2015-2017. Through collaboration with IS' Latin America/Caribbean region, Action Programs, and PPQ, a local Medfly program was developed and quickly brought up to date in the latest control and monitoring techniques. Of particular note was the establishment of an emergence and chilled release facility using aerial release and state-of-the-art GIS technology that resulted in successful eradication. Assistance continues to ensure the area is prepared for additional outbreaks of exotic fruit flies.

**Mexico**

- 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 has been essential to the success of this initiative. WS and IS collaborated during 2018 to formalize the collaborative plan with all involved Mexican agencies, and two field studies on feral swine will be conducted in 2019. One of them is a national multimedia survey to identify the presence and type of damage that feral swine is generating in the country and create a map of priority areas. The second is a regional project for identifying diseases of feral swine in Mexico's northern border region, initially focused on Chihuahua State. The initial goal is to collect 200 samples of serum and tissues of feral swine and to run the diagnostics of Swine Influenza, Epidemic Porcine Diarrhea, Porcine Reproductive and Respiratory Syndrome, Salmonellosis, Porcine Circovirus 2, Tuberculosis (TB), Brucellosis, Pseudorabies, and Classical Swine Fever (CSF). We are also working to prepare and conduct two workshops in Baja California, Chihuahua and the Mexican Border States region to formalize plans for coordinated activities of feral swine damage management.

- WS, with IS' collaboration, also conducts various activities for rabies and other wildlife diseases throughout Mexico, focusing on strategic planning and coordinating and implementing cooperative programs. During 2018, 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 in Hidalgo State and the first workshop of vampire bats capture in Texas, 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 2018 include:

    - IS-Mexico and VS participated in several bilateral meetings among APHIS and Mexican authorities to continue discussions on animal health protocols to open and maintain trade of animal and animal products between both countries. IS continues its support of releasing stuck shipments of animal and animal products at the U.S.-Mexico border due to misinterpretation of negotiated terms by border inspectors or other issues.

    - Other important collaborations include participating in risk analysis processes and evaluation team site visits to determine presence or absence of animal foreign diseases in both countries. Examples include Mexico's site visit to the American Midwest to evaluate BSE (Bovine Spongiform Encephalopathy) measures applied in the U.S., in order to resume U.S. exports of ruminant meals for animal feeding to Mexico.

    - Additionally, IS-Mexico supported the training of two Mexican federal veterinarians in Emergency Preparedness Response for Poultry Disease and Quality Control for Laboratory Diagnostics.

    - IS-Mexico and VS continue to coordinate with Mexican federal agencies and the State Governments of Chihuahua and Sonora as well as with their industries on the Mexican Electronic Tag (RFID) and Export Certification program for their cattle. This new technology is being tested to develop a substitute for the current metallic export ear tags. The change will facilitate trade and improve the accuracy of the information, the

inspection process, and tracking Mexican cattle throughout the U.S. In addition, IS and VS have provided Mexico with technical information of the electronic system for the import/export of cattle, to make the process more practical for users and port veterinarians.

- APHIS has provided technical information and validated protocols to Mexico for approving and certifying donors of semen in cervid collection centers. This will allow Mexico to export cervid semen to the U.S.

- IS continues to facilitate the transfer of technology to Mexico for the whole genome sequencing of the *Mycobacterium bovis*. This tool has greatly enhanced the accuracy of epidemiology investigations in the U.S. since 2013, and Mexico has begun to implement this technology in its TB program.

- IS also helped Mexico send its federal veterinarians to the U.S. for training in brucellosis epidemiology and the laboratory diagnostic technique on Fluorescence Polarization Assay. This test has improved diagnostic testing in Mexico and compliance with USDA requirements for Sonora's recognition as being free of *Brucella abortus*.
- IS also participated in the first seminar on zoonosis, providing updated information on the zoonotic tuberculosis *(Mycobacterium bovis*). Attendees from several southern Mexican states attended the training in Tuxtla Gutierrez, Chiapas, Mexico.

**Central America**

- IS' Guatemala City office delivered presentations for Ministry of Agriculture officials in Guatemala and Honduras on various sanitary and phytosanitary (SPS) topics, as requested by OIRSA. These ministries have delegated their inspections and fumigation treatments to OIRSA. These opportunities have allowed APHIS to present their standard operating procedures and discuss how biological risks are assessed and managed. Presentations were also delivered at the Schools of Agriculture and Veterinary Medicine of San Carlos University in Guatemala on broad animal and plant health topics and on specific pests, diseases, and local export programs.

**Caribbean**

- Collaboration to address the exotic Teschen disease outbreak continues with FAO, the Inter-American Institute for Cooperation on Agriculture (IICA), the Haitian and Dominican national veterinary services, APHIS-VS' diagnostic laboratories, and IS. This disease remains a serious problem, especially for Haiti, and IS and VS worked with their national laboratory to improve diagnostic and vaccination programs. Samples continued to be collected through 2018 in coordination with VS and the Dominican Ministry of Agriculture and shipped for analysis to strengthen APHIS' library on the evolution of the virus.

- In 2018, VS also worked with the Dominican national laboratory to update their standard operating procedures and develop new DNA sequences to identify a local outbreak of Avian Influenza, as well as support Haiti's ongoing diagnostics and vaccination for Classical Swine Fever (CSF) and Teschen disease. Additional APHIS-funded animal health technology transfer trainings in the Caribbean (in coordination with the regional animal health organization CaribVET) included providing funding for the International Air Transport Association (IATA)

infectious substances shipping protocols for suspect material and subject matter expert sessions. This training addressed the increased interest in disaster risk reduction and management given the volume of animal health concerns after Hurricanes Irma and Maria in 2017.

- Examples of plant health-related technology transfer in the Caribbean included sending a group of Dominican plant health officials to Miami to discuss their respective Giant African Snail (GAS) eradication plans and inviting two APHIS identifiers from the Port of Miami to present training on enhanced pest inspection techniques and port inspection procedures to members of academia and officials in the Ministries of Agriculture and Customs.

- IS' office in Trinidad and Tobago provided plant health capacity building activities in 2018 and coordinated a visit of two Trinidadian Ministry of Agriculture officials to visit Fort Pierce, Florida and learn about the prevention and management of citrus greening disease. The Trinidad office serves as the central coordinator/Secretariat for the Caribbean Plant Health Directors' Forum (CPHD) and hosted the annual Caribbean Regional Plant Quarantine Principles and Procedures Training Course with participants from 15 countries.

- The office also facilitated a Caribbean Pest Diagnostics Network & Working Group with participants from 8 countries and several international organizations to discuss improvements to area-wide pest identification techniques. It also hosted the Annual Meeting of the CPHD, including technical sessions on irradiation for market acceptance, next-generation sequencing applications, invasive species assessment tools, pest risk assessment methods, pest prioritization methods, export certification case studies, field eradication programs, and fruit fly monitoring methods.

**South America**

- In 2018, IS' Brasilia office organized a regional workshop on logistics for emergency response for highly pathogenic avian influenza (HPAI) with the goal of transferring the Incident Command System approach to the countries of the Southern Cone of South America.

- IS' long-standing support of Foot-and-mouth disease (FMD) eradication from the Western Hemisphere is another example of technology transfer from the U.S. to foreign counterparts. APHIS continues to be an active partner in this 35+ year effort involving multiple treaties and agreements between the United States and our Western Hemisphere trading partners. The strategies rely on several different technologies that the U.S. is usually the leader in developing. The campaign to eradicate FMD from the Hemisphere is nearly complete and could not have been accomplished without the United States' active participation to transfer technologies essential to the program.

- LAC worked closely with PPQ's Phytosanitary Issues Management staff (PIM) to organize the first APHIS outreach webinar to educate industry and government counterparts on the use of irradiation as a phytosanitary treatment for exports to the United States, reaching over 75 participants from Ecuador, Colombia, and Peru. Peru is the first country in South America to use this treatment for market access to the United States, shipping figs and pomegranates to Gulfport, Mississippi for irradiation treatment. 2018 shipments totaled 700 tons for pomegranates and 72 tons of figs, which doubled 2017's shipment amounts. The trend will continue with Peru into 2019, while Colombia and Ecuador are on track to expand access of a variety of products using this treatment as an alternative to Methyl Bromide.

- In 2018, IS' Lima office held a regional workshop on Logistical Responses to Avian Health Emergencies for South American Countries, with 47 participants from 11 Latin American countries and PANAFTOSA – PAHO providing regional representation.

- The national laboratories of USDA and Peru's SENASA ministry continued a collaborative effort to study and characterize the circulation of CSF in Peru, improve Peru's diagnostic capabilities, and develop new control strategies. As a follow-up to this collaboration, VS' diagnostic laboratory shared standard operating procedures for diagnostic tests. VS imported 40 historic and recent CSF positive field samples from Peru to bolster the U.S. national collection and also imported the attenuated viruses used as vaccine. This will foster the development of a differential diagnostic test between field and vaccine strains isolated from infected animals. VS plans to host one SENASA laboratory technician at the Plum Island diagnostic facility for training in CSF sequencing, typing, and molecular characterization in 2019.

### 2.3.3. Downstream Outcomes

**International Technical and Regulatory Capacity Building (ITRCB)**

The ITRCB, a unit of IS, acts as a clearinghouse to review requests for APHIS technical assistance. The resulting courses, workshops, and technical meetings are key to bringing new and innovative techniques and technology to our foreign counterparts. When appropriate, it supports Agency efforts by facilitating technical cooperation activities with trading partners and developing countries. The training, including the use of new technology of foreign counterparts, comprises a significant part of ITRCB's mission. However, technology transfer is limited.

# 2.4. PLANT PROTECTION AND QUARANTINE

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

### 2.4.1. Mission Statement

APHIS' Plant Protection and Quarantine (PPQ) program safeguards U.S. agriculture and natural resources against the entry, establishment, and spread of economically and environmentally significant pests, and facilitates the safe trade of agricultural products.

### 2.4.2. Nature and Structure of Program

PPQ's technology development is facilitated and implemented through cooperation between its three divisions; Policy Management (PM), Field Operations (FO), and Science and Technology (S&T)**.** PPQ Science and Technology (S&T) provides scientific analysis and support for PPQ regulatory decisions and operations, and develops practical tools for plant pest exclusion, identification, detection, and management for PPQ.

PPQ S&T is headquartered on the campus of North Carolina State University in Raleigh, North Carolina. The broader S&T system consists of approximately 240 scientists, analysts, and support staff at 7 principal laboratories, 2 stations, and additional satellite locations. S&T 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. S&T also administers the National Clean Plant Network (NCPN),

an 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/).

In FY 2018, S&T continued planning the expansion of operations for construction of a new laboratory 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, ARS labs, and industry will fill a major need for additional science and technology support for west coast pest programs and agricultural trade.

S&T activities are primarily focused on providing scientific support for PPQ needs and decision making, but also support stakeholders such as State plant regulatory programs and the agricultural and nursery industries. S&T 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. We also directly transfer technology and scientific knowledge through hands-on training at our labs, presentations at technical or professional conferences, publications in proceedings, trade publications, and by providing direct technical assistance to the public, stakeholders, and industry through various outreach activities and events.

S&T provides training to stakeholders in technical areas that involve pests of regulatory concern (i.e., diagnostic testing, pest risk assessment, treatments) and also provides information and training on quality management and accreditation. For example, the Beltsville Lab provides hands-on training on molecular diagnostics for regulated plant diseases to diagnosticians from the National Plant Diagnostic Network (NPDN), State and Federal laboratories, and in FY 2018, conducted 6 training workshops for 54 diagnosticians in four technical subjects. The 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. 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 2018, APHIS conducted proficiency testing for 7 different APHIS-approved regulatory diagnostic tests for certification of 61 diagnosticians in 21 APHIS-approved laboratories across the United States.

Formal agreements, including cooperative and interagency agreements, material transfer agreements and memoranda of understanding, are used to formalize collaborations with other government scientists, universities, private companies, and other stakeholders. In FY 2018, S&T provided oversight of 277 cooperative and interagency agreements with a total value of over $34 million. The total includes funded with Farm Bill Section 10007 funds and USDA Huanglongbing Multi-Agency Coordination Initiative funds. PPQ also provides leadership and organization for 22 clean plant centers through the National Clean Plant Network in 15 States to support the development and distribution of disease-free stock of fruit trees, grapes, hops, berries, citrus, sweet potato, and roses.

### 2.4.4. Downstream Outcomes

**Publicly accessible online tools for pest identification**

PPQ's Identification Technology Program (ITP) provides technology-based pest identification products including image libraries, taxonomic tools, mobile apps, and pest survey screening aids. As of FY18, 92 of the program's identification products are available via an open-access searchable portal (http://idtools.org). New releases in FY 18 include an Exotic Bee ID tool, and an updated edition of Aquarium and Pond Plants of the World, and an alpha version of seID, a tool designed for identification of toxic seeds for law enforcement. ITP's image ID tool which assists with the identification of pests intercepted at ports, continues to be expanded, and currently has over 130,000 pest images to assist with port operations. 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.

**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 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. The PPQ Mission Laboratory developed the technology to mass produce and release *T. radiata* using a field insectary cage approach for the biological control of ACP in south Texas. Since the project began in 2011, nearly 9 million beneficial insects have been produced by the Mission Lab for field release in Texas, Louisiana, and Mexico border areas. Assessments of area-wide management efforts in south Texas indicate an overall reduction in ACP populations of 92% since initiation of the program in 2011. The biocontrol rearing technology was also transferred to partners in California, which have now developed the capacity to release over 3 million parasitoids per year.

**Biological control of Emerald Ash Borer**

The emerald ash borer is an invasive wood-boring pest of ash trees that was discovered in Michigan in 2002. Emerald ash borer is now widespread in the United States and has killed millions of ash trees. PPQ has worked with federal and state partners to establish a biological control program. Currently the program releases 4 species of parasitoid wasps to help manage EAB populations. S&T continues to conduct research to monitor and improve the effectiveness of the biological control program. Recent research has shown the parasitoids *Tetrastichus planipennisi* and *Spathius galinae* are better adapted to the north and *Spathius agrili* is better adapted to the south, which will allow the program to target biocontrol releases to areas with suitable climates. Research on establishment and impact of EAB in

white ash forests has recently been completed, and has shown that while older ash trees have died, the next generation of ash is being well protected by a combination of parasitism by *T. planipennisi* and woodpecker predation.

**Management Tools for Emergency Program Pests**

In 2018, PPQ conducted emergency response operations for two new pest outbreaks: European cherry fruit fly in New York, and Spotted lanternfly in Pennsylvania. PPQ S&T has led the research to develop new detection and response tools to these pests, in collaboration with state and federal partners. Recent advances for European cherry fruit fly include the development of a systems approach to allow cherry fruit movement from quarantine areas to reduce economic impacts to growers. For Spotted lanternfly, which attacks several tree and fruit crops, PPQ S&T has identified attractant chemicals for traps and survey, and has developed effective insecticide application methods for host trees that are being applied in the eradication program. PPQ S&T is continuing to improve management methods for these pests in order to support response and recovery efforts.

**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 (*C*Las), *C*L. africanus (*C*Laf) and *C*L. americanus (*C*Lam). Only *C*Las, 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

*C*Las introductions to help prevent the spread of the pathogen into commercial groves. S&T has completed development of a new real-time PCR assay that targets the pathogen specific ribonucleotide reductase (RNR) in *C*Las genomes and can be tested on the newer real-time PCR instruments with high throughput capabilities. The RNR assay has been clearly demonstrated to improve specificity and a lower limit of detection over the standard 16S HLB real-time PCR method. Deployment of the assay for use in field and survey testing has been implemented, first by organized collaborative trials in State labs and in 2018 through certification by NPPLAP. This RNR method is expected to enhance the efficiency of our mission to track and prevent the dispersal of *C*Las, thereby limiting the spread of HLB disease.

**Molecular diagnostics workshops for NPDN diagnosticians**

Since 2004, the PPQ 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. In 2018, the Beltsville laboratory held a total of 6 workshops to train 54 NPDN diagnosticians from universities, State Departments of Agriculture, Federal laboratories, commodity groups and commercial diagnostics companies. A new workshop focusing on "Quality Management Systems" (QMS) was presented by PPQ S&T in collaboration with Cornell University and New Mexico State University, and a second QMS workshop that incorporates feedback from the first workshop participants and new QMS developments is planned for November 2018. The focus of the other workshops was on the molecular diagnostics of *Phytophthora ramorum/P. kernoviae*, Potato Cyst Nematode, Phytoplasmas, and bioinformatics of plant pathogens. Each participant was trained to use the current molecular diagnostic

protocols for detection of the pathogens and practicing interpretation of the results to make final determinations. These workshops have not only enhanced the molecular plant diagnostic capability in the Unites 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.

**NPPLAP Planned Deviation Process**

The National Plant Protection Laboratory Accreditation Program (NPPLAP) accredits NPDN, State, Federal and commercial laboratories to perform regulatory diagnostics. In addition to deployment of annual proficiency tests for Certification of diagnosticians to perform regulatory diagnostic testing, NPPLAP also facilitates continual improvement of the programs by incorporating new equipment used for testing into the program.

In November of 2018, the Cepheid SmartCyler real-time PCR instrument is scheduled to be phased out of production. For the last 15 years, the SmartCycler was the primary instrument used by the Beltsville Lab for its molecular diagnostic validation work, as was the main unit used by most NPDN labs for their testing needs. New instrumentation is now produced and available by a variety of vendors, however a certain amount of re-validation work is required to ensure that the test results are acceptable for USDA regulatory purposes. This task is most efficiently accomplished using “Planned Deviations”, a laboratory Quality Management term. A Planned Deviation is a testing process that establishes direct and statistically sound comparability of key test performance measures between the old instrumentation and newly available instruments.

NPPLAP partners with the S&T Beltsville Lab and other NPPLAP accredited labs to develop and execute an experimental design that generates the data needed to establish key testing metrics in the most efficient and effective way possible. In 2018, NPPLAP has approved 8 Planned Deviations on several Applied Biosystem, Inc real-time PCR instruments and on the Bio-Rad CFX 96 instrument. These platforms have proven to be popular replacement by plant diagnosticians, and unlike the SmartCycler, these instruments have high-throughput capacity for testing. Once a Planned Deviation is complete, the process doesn't need to be repeated for that instrument, a simpler assessment or proficiency test will suffice to establish the validity of the test and the diagnostician.

In addition to instrument Planned Deviations, NPPLAP has also developed programs for incorporation of other time and resource saving technologies into regulatory testing. In 2018, NPPLAP has approved the use of 2 liquid handling 'robots' and a new DNA extraction technology for regulatory testing. When these automated technologies are verified to produce consistent high-quality DNA with low chance of cross-contamination, they are found to save time and money when testing large numbers of samples.

**Rapid Immunological Detection by CANARY**

A new serological detection technology, CANARY (Cellular Analysis and Notification of Antigen Risk and Yield), has been evaluated by the Beltsville Lab and offers a simple, fast, and sensitive platform capable of detecting some of PPQ's most high-consequence regulatory pathogens. Implementing such a technology in the quarantine environment would improve the capability of inspectors to find these plant pathogens. In addition, this technology is a useful diagnostic tool for plant clinics of the NPDN and State Departments of Agriculture.

The CANARY technology has been transferred to a partner firm PathSensors, Inc. for further development and manufacture of the system components. Previous studies have demonstrated the ability to use this technology at the USDA Plant Inspection Stations for detection of the US Select Agent *Ralstonia solanacearum* in imported geraniums. In 2018, S&T developed and executed a three-lab comparison test for validation of CANARY to detect *Phytophthora ramorum*. The participating labs included an NPDN testing laboratory, an ARS lab and the PathSensors testing lab. Reagents and samples were generated by PathSensors and the ARS lab and distributed simultaneously to the three labs. Data generated from the study concluded that the technology is acceptable for regulatory uses. Plans are underway to further deploy this technology to other testing labs.

# 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, VS 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. As the Nation's veterinary authority, VS improves the health, productivity, and quality of life for animals and people, and maintains and promotes the safety and availability of animals, animal products, and veterinary biologics. 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 on-farm 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 Program

VS is organized into three strategically focused organizational units. The three units are: Diagnostics and Biologics (D&B), Field Operations (FiOps), and Strategy and Policy (S&P). Organizing by major services allows VS to better align with the changing dynamics of animal health and the needs of our customers. D&B combines and leverages the unique capabilities of two of VS's science centers, focused on veterinary diagnostics and veterinary biologics. FiOps carries out functions ranging from early

awareness and surveillance to the development and field/port implementation of animal health programs. S&P brings together VS' policy and permitting activities, including those in the international, species-specific, one-health, and epidemiology areas. Although scientists and scientific activities are distributed across VS, the 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 TT 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 VS 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 is to explore and analyze animal health and related agricultural issues to facilitate informed decision-making in government and industry. CEAH has a multidisciplinary staff that includes agricultural economists, spatial analysts, geographers, informaticists, veterinary epidemiologists, statisticians and biological scientists. CEAH collaborates with domestic partners on analysis methods and tools. CEAH also partners internationally with a variety of partners including the World Organization for Animal Health (OIE) and its member countries to improve international disease surveillance capabilities and analytic methods. In some cases, academic partners commercialize the products produced.

**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:

- Veterinary Services (VS) developed the Mobile Information Management systems (MIMS) for recording animal health information in field operations. MIMS allows for direct incorporation of data into both VS, state and industry databases. VS, in cooperation with Mexico and Canada, completed MIMS pilot projects on the northern and southern borders allowing VS to receive electronic data of feeder cattle entering the U.S. This technology will advance traceability, reduce time for the inspection process, provide improved worker safety, and reduce stress on animals.
- Biological samples collected through VS' National Animal Health Monitoring System (NAHMS) surveys were used to estimate historical seroprevalence of a specific disease in the U.S., provide data which was used by industry, state/federal animal health, livestock extension, and academia on antimicrobial resistance and production related issues in pre-harvest settings.

- VS transferred animal movement records for use in estimating parameters on swine movement patterns. The records were used by industry, state/federal animal health, and academia to assess epidemiologic and economic impacts of countermeasures and vaccination strategies in disease outbreaks.
- VS participated in the U.S. Department of States' Scientific Exchange Program (SCEP) between the U.S. and China. Discussions included VS' recent work to detect, characterize, and evaluate emerging animal disease risks, potential interconnections with similar activities in China, develop a shared understanding of the top animal diseases of concern to the two countries, identify and evaluate the ecological drivers of disease emergency and transmission, investigate the surveillance and risk analyses for detection and evaluation of emerging diseases, and identify opportunities for collaboration on surveillance and diagnostic tools.
- VS participated in the OIE, Foreign Agricultural Organization, and World Health Organization's Tripartite Joint Risk Assessment meeting which is developing a pilot and operational tool to be used in the assessment and management of zoonotic diseases.
- VS provided foot and mouth disease (FMD) modeling support to state animal health officials and APHIS for their FMD emergency preparedness activities. VS performed model runs and data analysis based on requests from the California Department of Food and Agriculture (CDFA) regarding FMD spread and vaccination options; results were provided to CDFA through a presentation and an interactive Tableau dashboard that allowed CDFA to continue to use the model results to evaluate control strategies.
- VS supported the electronic messaging of test results from NAHLN veterinary diagnostic laboratories – 43 laboratories were capable of electronic messaging as of October 2018.

- VS assisted in the development of assays and the use of new sample types to improve the surveillance and response in the U.S. through negative cohort validation of African swine fever (ASF), FMD, and classical swine fever for swine oral fluids.
- VS established the National Bio and Agro Defense Facility (NBAF) Scientist Training Program with multiple universities, including initial proposal, application process and requirements, monitoring and evaluation procedures, position announcements, and long-term workforce planning, to identify permanent positions for each fellow, part of the NBAF workforce development efforts.
- An MOU with Canada to allow for the exchange and harmonization of whole genome sequencing (WGS) data for tuberculosis (TB) and Brucella was completed by VS. Thousands of sequences have been exchanged and our databases are currently harmonized.
- VS continues to lead the World *M. bovis* WGS Project and, under that project, have sequenced and shared data from isolates from South Africa, Nigeria, Bangladesh, Portugal, Spain, and Mexico. VS has also analyzed and incorporated WGS isolates from France, Uruguay, Brazil, Ireland, and the UK. This allows APHIS to better understand the source of *M. bovis*.
- A bioinformatics pipeline was updated to ensure ease of use in various computing environments was completed by VS personnel. This helped make the pipeline one of the most widely used tools for *M. bovis* WGS analysis. VS has assisted with the installation of this pipeline to Canada, Scotland, Australia, New Zealand, and Portugal in FY 2018.
- An anti-microbial resistance proficiency test was designed, created, and provided to NAHLN and FDA's Veterinary Laboratory Response Network (Vet-LRN) laboratories by VS staff. Standardized procedures with quality control recommendations were also written and provided to the laboratories.

- VS provided guidance to multiple organizations and countries on propagation of Seneca Virus A (SVA) which can be clinically confused with FMD in pigs.
- VS personnel initiated and led bilateral collaborations with colleagues at the Canadian Food Inspection Agency to harmonize diagnostic assays, enhance North American Foot-and-Mouth Disease Vaccine Bank (NAFMDVB) laboratory preparedness, and expand emergency preparedness, identified as a key priority by the North American Animal Health Committee.
- VS recorded the appearance of an exotic tick, *Haemaphysalis longicornis*, and provided confirmatory diagnostic services for states; this discovery could have significant implications for livestock and public health due to the pathogen transmission capacity of the tick.

# 3.0 Agricultural Research Service (ARS)

### 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. Research projects were organized within 1 of 15 national programs (see table). The Office of National

Programs (ONP) in Beltsville, Maryland, plans the scope and objectives of the Agency's research projects, and five area directors implement research projects at the locations in their geographic areas.

**ARS research program management, showing 15 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 | Soil and Air | 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 active research project undergo a thorough, independent external prospective peer review managed by the Office of Scientific Quality Review. 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 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's Office of the General Counsel provides legal guidance to OTT on IP matters 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 Administration Section conducts day-to-day operations, coordinates technology transfer policy development, interacts with ONP 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 Patent Section of OTT 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 a cooperator and an ARS contract law firm. The Licensing Section of OTT 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 assure 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:

- 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 Protection 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 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 higher than the 15 percent required by statute). Thus, policies are 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

- In FY 2018, there were 189 active CRADAs, 51 of which were newly executed. The 51 new CRADAs contributed $3,121,739 directly to ARS research projects, and approximately 61 percent of them are with small businesses. There were 354 active Material Transfer Research Agreements (MTRAs), 118 of which were newly executed. The 118 new MTRAs contributed $2,267,886 directly to ARS research projects. (See Table 1 in Section 3.5 and Figures 1 and 2 in Section 3.9.)
- In FY 2018, 306 new invention disclosures were received; 108 patent applications were filed; and 61 utility patents, 6 plant patents, and 11 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 patents issued over the number of patent applications filed is an indicator of "judicious" patenting. Over the last 3 years, this indicator suggests that approximately 60 percent of the patent applications result in an issued patent. (See Table 2 in Section 3.5 and Figures 4, 5, and 6 in Section 3.9.)

- In FY 2018, 40 new licenses were executed, 33 percent of which were with small businesses and 28 percent were with universities. The total number of active licenses has steadily increased over the last 5 years from 392 to 460. Sixty-eight percent of the income-bearing licenses were granted exclusively. The total income from all active licenses was nearly $3.8 million. Most of the income in FY 2018 came from a few licenses; the median earned royalty income was $3,056. Although the year that a license is signed is not typically the year the patent has issued, over time the ratio of newly signed licenses over the number of newly issued patents is an indicator of "judicious" patenting, considering the commercial viability of the technology and other factors. Over the last 3 years, this indicator suggests that approximately 43 percent of the issued patents have been licensed. (See Tables 3, 4, and 5 in Section 3.5 and Figures 7, 8, 9, and 10 in Section 3.9.)
- OTT reviewed and executed licenses for the Animal and Plant Health Inspection Service (APHIS) and U.S. Forest Service.
- OTT held in-person technology transfer training for more than 200 scientists at 15 locations in 9 States.
- In FY 2018, 57 Innovation Fund applications were received and 30 were funded. The Innovation Fund provides ARS scientists up to $25,000 on a competitive basis for a given project per year. The purpose of the fund is to enhance the commercial potential of an agricultural solution currently under development at ARS. Outcomes would enable the adoption of ARS research outcomes by industry, academia, and other stakeholders.

- OTT 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 after each patent decision and each Innovation Fund round. In

2018, more than 185 strategy sessions were conducted to devise customized technology transfer strategies to ensure adoption of research outcomes of each project. This was featured in the Best Practice Spotlight of *Technology Transfer Tactics*, a monthly newsletter, in March 2018.

- OTT created a LinkedIn group for the ARP Network. Through FY 2018, membership grew from 25 to 250. Each month, a research topic area is highlighted through the posting of an overview of the past and present ARS research program in that area, followed by a posting of technologies available for licensing in that area. In addition, other noteworthy items are posted, such as ARS news, research partnership opportunities, USDA videos on various research projects, and Federal business resources. After a post that aimed to find commercial partners for four different projects, two companies responded, and OTT is negotiating CRADAs with those companies.
- OTT created a quarterly electronic newsletter called "ARP Notes" to update ARP Network members on ARS and members' activities and events and inform members of ARS partnerships and/or licensing opportunities. ARP Notes are distributed by email (150 individuals) and through LinkedIn. In FY 2018, the quarterly ARP Notes advertised 56 patented technologies available for licensing. ARS Tweets an announcement of each new issue of ARP Notes.
- OTT co-hosted with the U.S. Small Business Administration (SBA) and the USDA National Institute of Food and Agriculture (NIFA) a webinar on the 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." Webinar attendance included 49 small businesses. In FY 2018, nine small business CRADA partners applied for SBIR Phase I grants to further commercialize the CRADA research. Seven of these businesses were successful in obtaining SBIR funding leading to a

success rate of approximately 78 percent. The average success rate for USDA-SBIR Phase I funding is approximately 15 percent. In addition, two 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. (See Figure 3 in Section 3.9.)

- OTT created a Strategic Commercialization Exploration Event that has a team of experts review patented technologies that have not been licensed after 4 years and held an event to review four technologies, resulting in the dropping of one patent and a refocus of research on three technologies to collect data for a different market. A CRADA was recently signed for one of the refocused technologies.
- OTT served on the Inter-Agency Working Group on Technology Transfer, led the Return on Investment Group on Private Sector Engagement, and represented USDA on the Lab to Market subcommittee of the National Science and Technology Council's Committee on Technology. It has taken the lead on the Metrics Strategic Group to establish meaningful ways in which to quantify the outcomes of Federal research and development enterprise.
- OTT participated in creating LabTech in Your Life (LTIYL), a virtual environment where visitors can explore the familiar setting of a home and discover successfully commercialized Federal technologies that are now commonly used household items. ARS has nine technologies scattered throughout the house. LTIYL is host on the Federal Laboratory Consortium website at https://www.federallabs.org/successes/labtech-in-your-life.
- OTT led a U.S.-Egypt technology transfer 3-day workshop to help Egypt and the United States use science and apply technology by providing opportunities to exchange ideas, information,

skills, and techniques, and to collaborate on scientific and technological endeavors of mutual interest. The workshop included U.S. speakers from USDA, the United States Patent and Trademark Office (USPTO), the National Institutes of Health, the Department of Energy, the National Institute of Standards and Technology (NIST), the National Aeronautics Space Administration (NASA), the U.S. Department of Commerce, the U.S. Department of Transportation, University of Maryland, Johns Hopkins University, University of Georgia, Kauffman Foundation, and economic development entities.

- OTT employees served as members/moderators/speakers/trainers in broad technology transfer activities and forums, including the FLC national and regional meetings; SBA Roadshow in Delaware; National Summit on Rural Entrepreneurship in West Virginia; National Association for Community College Entrepreneurship annual meeting in Texas; and technology training for delegations from Algeria, Armenia, Japan, Morocco, Pakistan, Sri Lanka, and Tunisia.
- OTT professional staff (M. Bahar and R.J. Griesbach) authored a paper "Can a technology transfer office make a difference in increasing licensing numbers: incorrect assumptions and inadequate context?" that was published in the June 2018 issue of *les Nouvelles*.

## 3.5. Metric Tables

| TABLE 1. Collaborative relationships for research and development | | | | | |
|---|---|---|---|---|---|
| | FY 2014 | FY 2015 | FY 2016 | FY 2017 | FY 2018 |
| **Total number of active CRADAs** | 217 | 223 | 219 | 249 | 189 |
| Active traditional CRADAs | 163 | 163 | 190 | 215 | 159 |
| Active non-traditional CRADAs[1] | 54 | 60 | 29 | 34 | 30 |
| Active CRADAs with small businesses | 96 | 98 | 70 | 62 | 73 |
| **Number of newly executed CRADAs, total** | 38 | 41 | 39 | 57 | 51 |
| Newly executed amendments[2] | 72 | 76 | 64 | 62 | 63 |
| Newly executed traditional CRADAs | 58 | 61 | 52 | 47 | 50 |
| Newly executed non-traditional CRADAs | 14 | 15 | 12 | 10 | 1 |
| Newly executed CRADAs with small businesses | 10 | 31 | 12 | 17 | 31 |
| **Total number of active MTRAs[3]** | 137 | 199 | 288 | 432 | 354 |
| Newly executed MTRAs | 73 | 62 | 89 | 101 | 118 |
| **Total number of active other agreements[4]** | 2,438 | 2,899 | 3,230 | 4,108 | 3,215 |
| Newly executed other agreements | 609 | 687 | 756 | 876 | 621 |
| **Number of newly executed MTAs** | 906 | 743 | 823 | 664 | 645 |
| Newly executed outgoing MTAs | 506 | 513 | 539 | 445 | 476 |
| **Total number of publications[5]** | | | | | |
| Peer-reviewed scientific journal | 4,354 | 4,564 | 4,473 | 4,467 | 4,138 |
| Trade journal | 66 | 57 | 65 | 66 | 68 |
| Meeting abstracts | 1,199 | 1,347 | 1,178 | 1,022 | 855 |

[1] Material Transfer CRADAs.
[2] Amendments extend existing 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 | | | | | |
|---|---|---|---|---|---|
| | FY 2014 | FY 2015 | FY 2016 | FY 2017 | FY 2018 |
| **Total number new invention disclosures[1]** | 101 | 175[4] | 174 | 169 | 306 |
| University co-owned | 37 | 40 | 58 | 27 | 29 |
| Non-university co-owned | ND | 27 | 29 | 21 | 16 |
| Based on scientific discipline | | | | | |
| Biological materials | ND | 32 | 19 | 8 | 141 |
| Life science | 39 | 64 | 73 | 72 | 55 |
| Chemical | 32 | 48 | 48 | 43 | 32 |
| Mechanical & measurement | 9 | 18 | 21 | 28 | 20 |
| Plant patents[3] | 4 | 3 | 5 | 5 | 6 |
| Plant variety protection[3] | 17 | 10 | 8 | 13 | 11 |
| Plant public release | | | | | 41 |
| **Total number patent applications filed[2]** | 110 | 110 | 92 | 109 | 108 |
| University co-owned | 34 | 25 | 10 | 21 | 31 |
| Non-university co-owned | ND | 26 | 9 | 23 | 25 |
| Based on scientific discipline | | | | | |
| Life science | 47 | 47 | 50 | 45 | 53 |
| Chemical | 25 | 38 | 24 | 38 | 30 |
| Mechanical & measurement | 17 | 15 | 10 | 7 | 14 |
| Plant patents | 6 | 4 | 6 | 11 | 3 |
| Plant variety protection | 6 | 6 | 2 | 8 | 8 |
| **Total number patents issued[2]** | 78 | 84 | 53 | 68 | 61 |
| University co-owned | 23 | 12 | 15 | 22 | 19 |
| Non-university co-owned | ND | 20 | 12 | 19 | 11 |
| Based on scientific discipline | | | | | |
| Life science | 36 | 33 | 23 | 37 | 29 |
| Chemical | 21 | 20 | 13 | 13 | 15 |
| Mechanical & measurement | 11 | 10 | 9 | 6 | 12 |
| Plant patents | 10 | 15 | 5 | 6 | 2 |
| Plant variety protection | ND | 6 | 3 | 6 | 3 |

ND, data not available.
[1] Inventions arising at a Federal laboratory. For FY 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 USPTO or variety protection (seed reproduced) through USDA Agricultural Marketing Service.
[4] FY 2015 includes the addition of Biological Material Invention Disclosures for the first time.

| TABLE 3. Profile of active licenses | | | | | |
|---|---|---|---|---|---|
| | FY 2014 | FY 2015 | FY 2016 | FY 2017 | FY 2018 |
| **Total number active licenses** | 392 | 404 | 419 | 426 | 460 |
| Executed to small businesses[1] | 150 | 147 | 150 | 155 | 161 |
| Executed to start-up businesses[2] | 12 | 12 | 6 | 6 | 6 |
| Executed to universities | 168 | 175 | 187 | 186 | 199 |
| Amended in FY | 10 | 5 | 4 | 4 | 8 |
| Invention licenses[3] | 341 | 339 | 348 | 351 | 374 |
| Executed to small businesses | 125 | 112 | 112 | 114 | 113 |
| Executed to start-up businesses | 12 | 12 | 6 | 6 | 6 |
| Executed to universities | 160 | 166 | 178 | 176 | 189 |
| Other IP Licenses[4] | 51 | 65 | 71 | 75 | 86 |
| Executed to small business | 25 | 35 | 38 | 41 | 48 |
| Executed to start-up businesses | 0 | 0 | 0 | 0 | 0 |
| Executed to universities | 8 | 9 | 9 | 10 | 10 |
| **Total number newly executed licenses** | 28 | 35 | 29 | 38 | 40 |
| Executed to small businesses | 15 | 16 | 9 | 19 | 12 |
| Executed to start-up businesses | 1 | 0 | 0 | 0 | 0 |
| Executed to universities | 10 | 9 | 14 | 9 | 12 |
| Invention licenses | 26 | 20 | 23 | 29 | 27 |
| Executed to small businesses | 14 | 5 | 6 | 13 | 3 |
| Executed to start-up businesses | 1 | 0 | 0 | 0 | 0 |
| Executed to universities | 10 | 8 | 14 | 8 | 12 |
| Other IP Licenses | 2 | 15 | 6 | 9 | 13 |
| Executed to small businesses | 1 | 11 | 3 | 6 | 9 |
| Executed to start-up businesses | 0 | 0 | 0 | 0 | 0 |
| Executed to universities | 0 | 1 | 0 | 1 | 0 |

ND, data not available.

[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 IP licenses refer to biological materials licenses.

| TABLE 4. Characteristics of income-bearing licenses | | | | | |
|---|---|---|---|---|---|
| | FY 2014 | FY 2015 | FY 2016 | FY 2017 | FY 2018 |
| **Total number of income-bearing licenses** | 390 | 402 | 418 | 425 | 459 |
| Exclusive | 278 | 274 | 289 | 293 | 312 |
| Partially exclusive | 15 | 11 | 9 | 6 | 7 |
| Non-exclusive | 97 | 117 | 120 | 126 | 140 |
| Invention licenses[1] | 339 | 337 | 347 | 350 | 373 |
| Exclusive | 269 | 266 | 280 | 283 | 302 |
| Partially exclusive | 15 | 11 | 9 | 6 | 7 |
| Non-exclusive | 55 | 60 | 58 | 61 | 64 |
| Other IP licenses[2] | 51 | 65 | 71 | 75 | 86 |
| Exclusive | 9 | 8 | 9 | 10 | 10 |
| Partially exclusive | 0 | 0 | 0 | 0 | 0 |
| Non-exclusive | 42 | 57 | 62 | 65 | 76 |
| **Total number royalty-bearing licenses** | 131 | 139 | 145 | 129 | 134 |
| Invention licenses | 117 | 121 | 123 | 107 | 112 |
| Other IP licenses | 14 | 18 | 22 | 22 | 22 |

[1] Invention licenses refer to patents and plant variety protection certificates.
[2] Other IP licenses refer to biological materials licenses.

| TABLE 5. Income from licensing | | | | | |
|---|---|---|---|---|---|
| | FY 2014 | FY 2015 | FY 2016 | FY 2017 | FY2018 |
| **Total income all active licenses** | $4,927,938 | $5,066,988 | $4,784,466 | $5,713,803 | $3,799,170[5] |
| Invention licenses[2] | $4,733,200 | $4,842,256 | $4,456,054 | $5,377,909 | $3,490,236 |
| Other IP licenses[3] | $194,738 | $224,732 | $328,412 | $325,566 | $308,934 |
| **Total ERI** | $3,610,774 | $3,509,904 | $3,633,239 | $3,503,866 | $2,715,861 |
| Median ERI | $3,232 | $3,525 | $3,966 | $3,698 | $3,056 |
| Minimum ERI | $32 | $13 | $5 | $15 | $21 |
| Maximum ERI | $575,753 | $728,017 | $818,537 | $769,167 | $265,844 |
| ERI from top 1% of licenses[4] | NP | NP | NP | NP | NP |
| ERI from top 5% of licenses | $2,048,317 | $1,756,460 | $1,811,637 | $1,639,557 | $1,218,975 |
| ERI from top 20% of licenses | $3,103,143 | $2,856,924 | $3,043,395 | $2,933,342 | $2,227,058 |
| **ERI distributed** | | | | | |
| Inventors | $1,305,695 | $1,632,130 | $1,188,389 | $2,443,702 | $1,322,224 |
| Funds used for salaries[5] | $2,812,269 | $2,819,906 | $2,051,317 | $1,449,005 | $1,461,164 |
| Innovation Fund[5] | ND | ND | ND | $483,814 | $618,000 |
| Patent filing preparation, fees, & annuity payments paid | $809,974 | $621,701 | $393,533 | $576,120 | $423,948 |

ND, data not available; NP, data not presented; ERI, earned royalty income.
[1] Two of the top revenue-generating licenses expired in FY 2017.
[2] Invention licenses refer to patents and Plant Variety Protection certifications.
[3] Other IP licenses. Refer to biological materials licenses.
[4] Not presented, represents one license.
[5] Funds were from FY 2017 revenue.

| TABLE 6. Licensing management: elapsed execution time and termination | | | | | |
|---|---|---|---|---|---|
| Agricultural Research Service) | FY 2014 | FY 2015 | FY 2016 | FY 2017 | FY 2018 |
| **All licenses** | | | | | |
| Average (months) | 5.9 | 2.8 | 4.9 | 6.1 | 6.3 |
| Median (months) | 5.8 | 2.5 | 3.7 | 5.1 | 5.5 |
| Minimum (months) | 0.9 | 0.5 | 0.9 | 1.3 | 0.9 |
| Maximum (months) | 21.5 | 10.0 | 16.0 | 13.7 | 24.1 |
| **Licenses terminated for cause** | 0 | 0 | 0 | 0 | 0 |

## 3.6. Downstream Outcomes

## NUTRITION, FOOD SAFETY, AND QUALITY

**National Programs:**

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

**Following the Dietary Guidelines for Americans has limited health benefit.**

The Dietary Guidelines for Americans (DGA) are the basis for Federal nutrition policy and are jointly published by USDA and the U.S. Department of Health and Human Services but they had never been tested in a controlled study. DGA recommend more fruits, vegetables, whole grains, and dairy than are usually eaten. A controlled feeding study by ARS scientists in Davis, California, in which all foods were provided over 8 weeks to 52 overweight or obese women who followed the DGA, showed significant improvement in systolic blood pressure but no improvements in levels of insulin, glucose, or lipids in the blood compared with women who ate a typical American diet. This was the first controlled feeding trial of the DGA. The diets were designed to maintain body weight, so a follow-up study will be

conducted to determine whether weight loss from following the DGA is needed to achieve further improvements in health. Project No. 2023-51530-022-00D.

**A gene may be the reason for propensity to gain weight.**

The APOA2 gene, one of the most common proteins that moves fats through the body and plays an important role in the cardiovascular system, may also be associated with increased body mass index. ARS and ARS-funded researchers in Boston, Massachusetts, used a variety of techniques to examine genes at the molecular level and the genetic background of people involved in both the Boston Puerto Rican Health Study and the Framingham Heart Study. By closely examining the characteristics of people who reported eating high levels of red meat, poultry, cheese, and butter, the researchers found that only people with the APOA2 variant gene were likely to gain weight, whereas people without the variant maintained lower body mass index. These results may be important in understanding the variation of response to specific dietary patterns implicated in obesity. Project No. 8050-51000-098-00D.

**A new hormone discovered that controls the desire to eat.**

Several hormones are involved in control of appetite including insulin, glucagon, leptin, and ghrelin, but altering levels of these hormones has not resulted in reduced eating or weight loss. Asprosin is a recently discovered hormone produced by fat cells and induced by fasting. Asprosin circulates in the blood and targets the liver to produce glucose. Scientists in Houston, Texas, found that asprosin enters the brain and activates nerves there through a series of steps that stimulate appetite and add weight and body fat. Obese humans and mice have elevated levels of asprosin in the bloodstream; blocking it in mice reduced appetite and weight. This is a new potential target for the prevention and treatment of obesity and type 2 diabetes. Project No. 3092-51000-059-00D.

**Moderate exercise improves mobility of older adults.**

As people age and become less active they lose mobility, leading to falls, hip fractures, and often, loss of independence. ARS-funded researchers in Boston, Massachusetts, took part in the Lifestyle Interventions and Independence for Elders (LIFE) study, a large multicenter randomized controlled trial designed to compare the effects of moderate-intensity physical activity with an established health education program. The study showed that previously inactive people in their 70s and 80s can improve their ability to move and function by walking at a moderate speed for at least 48 minutes a week. The researchers found participants in the exercise group increased their walking speed and distance and experienced less decline in mobility than study participants enrolled in a health education program that did not include walking. Influencing older adults to walk at least 1 hour a week may reduce healthcare costs and improve the quality of life for millions. Project No. 8050-51000-091-00D.

**An effective method to dry and decontaminate wet whole almonds.**

California produces 80 percent of the world's almonds with a value of more than $5.33 billion. Contamination of almonds with *Salmonella* has caused several large and expensive recalls by the industry and outbreaks of human illness. The occurrence of rain during the harvest season may result in the complete loss of an almond crop due to increased risk of microbial contamination and lack of adequate drying technology. ARS scientists in Albany, California, developed an effective and energy-saving new technology based on sequential infrared heat and hot air to simultaneously dry and decontaminate wet whole almonds. The results were provided to industry and contributed to ARS receiving the 2018 Research and Development Award by the Institute of Food Technologists. Project No. 2030-42000-050-00D.

**Improvements in radio frequency pasteurization of shell eggs.**

Raw shell eggs can be contaminated with *Salmonella*, causing human illnesses and product recalls. ARS developed and patented a radio frequency pasteurization (RFP) process that produced safer eggs with exceptional quality in a small-scale prototype. Now ARS researchers in Wyndmoor, Pennsylvania, in collaboration with a CRADA industry partner, assembled and successfully tested a larger-scale RFP unit, thus paving the way for a commercial-scale RFP unit. In addition, two breakthroughs were achieved that will facilitate commercialization. The first was the modification of the RFP process to operate at 40.68 MHz, which is an international frequency reserved for industrial, scientific, and medical purposes. The second modification of the RFP reduces the cost to use this technology on eggs. This will save between $10,000 to $100,000 per RFP unit. This technology can address a significant, widespread source of foodborne illness and make shell eggs safer. Project No. 8072-41420-021-00D.

**Recognition of emerging food pathogens using the tools of artificial intelligence.**

Pathogen detection and data analysis are often limited to the types of samples present in a database. Problems often occur when new bacteria not present in the database are encountered. ARS in collaboration with the Center for Food Safety Engineering at Purdue University in West Lafayette, Indiana, explored the application of an artificial intelligence (AI) system to phenotypic characteristics of various foodborne pathogens. The aim was to determine the ability of the AI to identify the number of pathogenic classes present, and to recognize new, unknown classes of foodborne pathogens that were not present in the databases. The research developed a functional prototype of an emerging pathogen detection system using AI methodology primarily based on the pattern-recognition neural network created by data scientists at Google initially for the goal of classifying natural images. The technology integrates the cutting-edge machine-learning tools with a unique optical phenotypic biosensing device developed in collaboration with Purdue University. The result demonstrated the tremendous potential of

the AI technology in the areas of biosurveillance, biothreat detection, and agricultural biosafety. Additionally, it emphasized that leveraging the existing state-of-the-art informatics tools employed by the leading U.S. data management companies will lower the cost of adoption of the new AI technologies by food producers and regulatory agencies. Project No. 8072-42000-077-00D.

**Raman sensing technology for chemical hazard detection.**

Detection of chemical contaminants during commercial food processing is a critical issue for rapid authentication of food ingredients and to determine potential adulteration. ARS scientists in Beltsville, Maryland, developed a line-scan high-throughput Raman imaging method and apparatus for rapid, nondestructive detection of chemical contaminants in food materials. The system can directly and rapidly analyze a sample powder in only 10 minutes, compared with conventional instruments that might take hours to perform the same analysis. The system has imaged a variety of food powders mixed with chemical additives, and results indicate that the system can provide quantitative measurement of chemical adulterants. This technology (patent No. 9,927,364) provides a practical industrial screening tool to address chemical contamination and adulteration of food products. Project No. 8072-42000-077-00D.

**Development of sensitive detection assays for abrin toxin.**

Abrin is a natural toxin found in the seeds of the jequirity pea. The toxin is similar to ricin, a poison found in the seeds of the castor oil plant. Abrin, like ricin, is considered a select agent toxin and a potential bioterror weapon. Researchers in Albany, California, developed new monoclonal antibodies against abrin and assembled a sandwich enzyme-linked immunosorbent assay (ELISA) (similar to a pregnancy test) capable of detecting a mixture of abrin isoforms. The ELISA can detect as little as 1 ng/ml of abrin in phosphate-buffered saline, nonfat milk, and whole milk, an amount that is significantly

below concentrations that would pose a health concern for consumers. Fortuitously, some of these antibodies can also neutralize abrin toxicity in cell-based assays, so they may have vaccine potential. Easy, cost-effective, and more rapid methods of detection for abrin toxins are critically necessary during incidences of deliberate or suspected food contamination. Project No. 2030-42000-049-00D.

**A box liner with a slow-release sulfur dioxide pad enhances the killing of foodborne pathogens.**

California produces 99 percent of the commercial table grapes in the United States. Ensuring that they arrive safely and not contaminated at food stores for consumer purchase is a critical issue for the California Table Grape Commission and California agriculture. ARS researchers in Albany, California, at the request of the Commission, examined the survival of three common but important foodborne pathogens: *Listeria monocytogenes*, *Escherichia coli* O157:H7, and *Salmonella enterica* Thompson, inoculated on commercially packed table grapes under simulated refrigerated transit conditions. Results showed that a box liner in the shipping container enhances the bactericidal effect of a sulfur dioxide ($SO_2$) pad in a pathogen-dependent manner. The use of slow release $SO_2$-generating pad combined with the box liner was found to be effective in killing *L. monocytogenes* and *S. enterica* Thompson, whereas the use of a $SO_2$-generating pad alone was more effective in killing *E. coli* O157:H7. Project No. 2030-42000-050-00D.

**Effect of raising beef cattle without antibiotics on the occurrences of antimicrobial resistance.**

There is a significant societal concern that traditional antimicrobial use patterns for food-animal production have contributed to the occurrence of antimicrobial resistance (AMR) in human infections. In response to this concern, ARS researchers in Clay Center, Nebraska, compared fecal AMR levels between U.S. beef cattle produced conventionally, with no restrictions on antibiotic use other than regulatory compliance, and U.S. beef cattle raised without antibiotics. Fifty of 67 individual microbial

AMR levels were not different between production systems, whereas 17 of 67 levels exhibited significant increases in conventional animals. However, although these increases in AMR were statistically significant, they were so small they are not likely biologically significant. More importantly, cattle raised without antibiotics typically grow more slowly, so they must be fed 50 days longer and thus produce about 2,500 pounds more manure. Therefore, the 31 percent increase in amount of manure from cattle raised without antibiotics more than offsets the small reduction in a few resistances and may actually increase the total AMR in the environment. Thus, beef cattle production without any antibiotics would not be expected to reduce the amount of AMR contributed to the environment compared with conventional production. Project No. 3040-42000-018-00D.

**A treatment for peanut allergy.**

ARS researchers in New Orleans, Louisiana, collaborated in the characterization and development of the first peanut-based therapeutic oral immunotherapy (OIT) drug for the treatment of peanut allergy. The peanut OIT drug has been demonstrated to desensitize allergic individuals. The drug has passed Phase 3 clinical trials. Once it becomes available for public use it will be the first treatment available in the world for individuals with peanut allergy. Project No. 6054-43440-046-00D.

**A new USDA standard protocol for determination of wheat quality.**

"Falling number" (FN) is a procedure used by the USDA Agricultural Marketing Service (AMS) and industry to gauge the level of naturally occurring alpha-amylase in wheat, an enzyme responsible for grain-starch break down. High levels of alpha-amylase activity lowers wheat starch concentration, giving low FN readings and resulting in lower quality, marketability, and price. This procedure is directly affected by barometric pressure and by elevation of the testing laboratory. Lower barometric pressure at elevations above 1,000 feet can lead to misleading FN values that when retested at sea level

for marketable price determination can find previously high-FN-graded wheat to have a critically low FN reading that results in a dramatic reduction in price. ARS scientists in Beltsville, Maryland, working at simulated elevations between 0 and 5,000 feet developed a correction-equation model that allows all FN values, regardless of the barometric pressure, to be reported on a sea-level basis. Initially requested by USDA's Federal Grain Inspection Service, this correction-equation was turned over to AMS for incorporation into a directive that guides Federal, State, and private laboratories on the FN procedure. This issue is important because overseas customers of U.S. wheat often have strict wheat FN requirements, thus making the procedure's accuracy a monetary concern to U.S. exporters, especially in the Pacific Northwest. Project No. 8042-44000-001-00D.

**Fast and cheap detection of Zika virus in mosquitos.**

The accelerating global spread of arboviruses such as the Zika virus highlights the need for more proactive mosquito surveillance. However, a major barrier to anticipating Zika virus outbreaks has been the lack of rapid and affordable tests for detection in mosquitoes. ARS researchers in Manhattan, Kansas, collaborated on research that showed for the first time that near-infrared spectroscopy (NIRS)—a reagent-free, instantaneous, low-cost, and effective method—can be used to non-invasively detect Zika virus in whole, intact *Aedes aegypti* mosquitoes with a prediction accuracy of 99.3 percent. This relatively simple NIRS technology compares favorably with the current highly technological quantitative reverse transcription quantitative polymerase chain reaction (RT-qPCR) procedure. NIRS involves simply shining a beam of light on a whole mosquito for less than 3 seconds to collect a diagnostic spectrum. Given that NIRS is 18 times faster and 110 times cheaper than RT-qPCR, the use of NIRS is anticipated to expand for identifying potential arbovirus hotspots and guiding the spatial prioritization of vector control of the Zika virus. A proposal based on these findings has been submitted to the United States Department of Defense by cooperators in Australia, Brazil, Kenya, Thailand, and

the United States to develop a portable, handheld, cell phone-based technique for rapid surveillance of Zika, dengue, and malaria control programs. Project No. 3020-43440-008-00D.

**Overcoming antibiotic resistance using a novel antibiotic.**

Beta-lactam antibiotics are a class of broad-spectrum (i.e., effective against a large variety of organisms) antimicrobials that include penicillin derivatives and cephalosporins. The use of these important drugs has been limited over the years with the development of antibiotic-resistant bacterial strains. Tunicamycin is a powerful antibiotic that can be combined with beta-lactam antibiotics to overcome this resistance. Scientists have known about this antibiotic for decades, but toxicity in human and animal cells prevented it from being used for therapeutic application. Recently, ARS researchers in Peoria, Illinois, have chemically modified tunicamycin into less harmful derivatives. The modified tunicamycins did not show any toxicity to human and hamster cells but were still capable of increasing the efficacy of clinical penicillin-based drugs by 32 to 64 times. This significant discovery now allows older-type antibiotics to once again be effective and is an important step toward combating drug resistance. It is currently being evaluated by a U.S. drug company. Project No. 5010-41000-172-00D.

**Repelling biting flies.**

Biting or blood-sucking insects (flies, mosquitos, ticks, and bed bugs) can transmit various diseases that cause major health concerns and economic losses for both animals and humans worldwide. Currently, there are no effective pesticides available for use against either biting stable flies or biting face flies. ARS scientists in Peoria, Illinois, and Lincoln, Nebraska, identified and developed a new biobased insect repellent formulation designed to meet the challenges posed by these insects. The researchers discovered that naturally derived fatty acids from coconut oil function as a very effective repellent with long-lasting effectiveness against multiple blood-sucking insects. The all-natural aqueous formulation was effective

in field trials conducted on cattle in North Platte, Nebraska. Biting fly pests in the United States cost the cattle industry more than $2.4 billion annually. This new product is being tested by U.S. cattle farmers and ranchers as a sustainable natural technology to address their biting insect issues. Project No. 5010-41000-171-00D.

# 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**

**Lifetime merit indices for dairy cattle now include health traits.**

Genetic economic indices for dairy cattle are used to improve the efficiency of the U.S. dairy population by ranking animals based on their combined genetic merit for economically important traits, but health traits had not been included because they were not available. ARS researchers in Beltsville, Maryland, collaborated with the Council on Dairy Cattle Breeding to develop genetic evaluations for disease resistance to the six most common and costly health events for U.S. dairy cattle and then added these traits to the lifetime merit indexes. The economic impacts of direct expenses associated with health traits, such as clinical mastitis treatment, were given greater emphasis, and traits previously correlated with health, such as somatic cell score, were given reduced emphasis. In August 2018, the Council on Dairy Cattle Breeding adopted and officially released the revised indices to the dairy industry. Breeders can use the new indices to select for genetic traits to use in breeding new cow lines that are healthier and

more profitable than cows with health conditions that require extra farm labor, veterinary treatment, and medicine. Breeders using the original index increased the profitability of dairy by $250 million annually, while breeding dairy cows using the new index will increase profitability by an additional $1.4 million annually. Project No. 8042-31000-002-00D.

**Rumen microbiome community profiles are associated with feed efficiency.**

Feed costs are estimated to be 60 percent of the total cost of raising cattle. Improving feed efficiency and reducing subsequent levels of wastes such as manure will reduce feed inputs and their environmental impacts. In cattle, microbes in the rumen degrade forages into metabolites that can be used for growth, but more information is needed about how the rumen microbial composition affects feed efficiency. ARS researchers in Clay Center, Nebraska, and the University of Nebraska collaborators characterized the rumen microbial communities (microbiomes) of each individual in two large-animal cohorts (125 heifers and 122 steers) to identify specific bacterial members associated with feed efficiency traits in beef cattle. This innovative study showed that the species and abundance of the microbes present in the rumen account for 20 percent of the variation in feed efficiency. These data demonstrate that rumen microbial communities have a significant effect on feed efficiency and will inform future strategies for altering these communities to improve feed efficiency in cattle. Project No. 3040-31000-097-00D.

**Demonstrating the impact of eliminating animal agriculture.**

Farmed animals provide essential nutrients in human diets, but they also produce greenhouse gases and use food resources that could potentially be used by people. ARS scientists in Madison, Wisconsin, collaborated with Virginia Tech University scientists to evaluate the hypothetical impact of converting U.S. agriculture to a plant-only system by completely eliminating livestock production. They found that removing livestock production resulted in the production of substantially more food; however, people

consuming a plants-only diet without supplementation would need to consume more calories than needed to meet dietary requirements for other nutrients. Even with this extra caloric intake, people consuming a plant-only diet will have more nutrient deficiencies. Whereas greenhouse gas emissions associated with U.S. agriculture were projected to decline 28 percent, agriculture contributes only 9 percent of national-level greenhouse gas production, so total U.S. net greenhouse gas production would be reduced only 2.6 percent. The need to produce synthetic fertilizer to replace animal manures and other systemic changes also reduced the benefits of removing livestock from U.S. agricultural production. These findings show that changing a complex system may have some cost-effective results but may also generate unexpected effects that reduce these benefits. Recommendations for changes in the U.S. agricultural system requires integrating studies from multiple disciplines to adequately evaluate potential impacts. Project No. 5090-31000-026-00D.

**Genetic resources for responsible lamb production.**

The efficiency of sheep production is significantly influenced by the number of lambs born per ewe. But sufficient feed resources, which may not always be available on western rangelands, are required to support lamb production. ARS researchers in Clay Center, Nebraska, evaluated reciprocal crosses between Romanov and Rambouillet breeds to identify genetic traits that could be used to increase lamb production and found that half-blood Romanov crossbred ewes were equivalent in lamb production (two per year) regardless of whether they were descended from Romanov or Rambouillet males. However, ARS researchers in Dubois, Idaho, collaborated with Virginia Tech University scientists to test the limits of lamb production per ewe in the harsh conditions of the U.S. mountains. They determined that production levels of 2.2 lambs per ewe each year are optimal, because ewes rearing triplets had higher lamb loss rates. These findings indicate that Romanov/Rambouillet crossbred ewes will be useful in

increasing the number of lambs produced per ewe in the harsh U.S. production environments of the western mountains. Projects No. 2056-31610-006-00D and 3040-31000-100-00D.

**A subunit vaccine against *Streptococcus suis* in swine.**

The bacterium *Streptococcus suis* is an important and common cause of disease in pigs and costs the swine industry millions in losses annually. The World Organization for Animal Health ranks it as a high priority disease because improved vaccines could significantly reduce the need for antibiotic administration. ARS researchers in Ames, Iowa, and University of Cambridge collaborators identified five candidate proteins of *S. suis* that were formulated into a vaccine with different adjuvants to help stimulate an immune response. The vaccine effectively prevented disease caused by *S. suis,* and antiserum from the vaccinated pigs was reactive against whole *S. suis* bacteria of differing serotypes, indicating a potential for cross-protection. An animal health company is now developing these proteins into a vaccine that can be used by swine producers to protect against this devastating and costly swine disease. This technology may markedly improve the health and welfare of pigs, reduce pork production costs, and reduce the use of antibiotics in pigs by reducing the occurrence of diseases caused by an important bacterial pathogen. Project No. 5030-32000-119-00D.

**Susceptibility of white-tailed deer to Rift Valley fever virus.**

Rift Valley fever virus (RVFV) is a zoonotic disease spread by mosquitos that will pose major health threats to livestock and humans if introduced into the United States. Domestic cattle, sheep, and goats are susceptible to RVFV, and infected animals can serve to amplify the disease in their bodies and enable disease spread by mosquitoes during epidemics. The potential role of wildlife species such as white-tailed deer in epidemics is unknown, but because white-tailed deer are abundant throughout the United States, there is concern they could also serve to amplify RVFV and become a reservoir and

source of infection for livestock and humans. ARS scientists in Manhattan, Kansas, and Kansas State University scientists confirmed these deer are susceptible to RVFV and found infected deer developed hemorrhagic enteritis and bloody diarrhea that resulted in RVFV transmission to control animals. The results of this investigation provide evidence that white-tailed deer could potentially play a major epidemiologic role in disease transmission if a RVFV outbreak occurs in the United States. Project No. 3020-32000-009-00D.

**Using gene editing as a tool to engineer an African swine fever vaccine.**

African swine fever (ASF) is a deadly disease that causes near 100 percent mortality in swine, and ASF outbreaks result in trade restrictions and significant economic losses globally. Since the introduction of ASF into the Republic of Georgia in 2007, 16 countries have reported new ASF outbreaks, including Belgium and China in 2018, and the risk for the introduction of ASF to the United States has never been higher. No commercial vaccine is currently available to prevent this devastating disease, and despite more than 50 years of research, no efficient molecular tools are available to help develop a safe and effective live recombinant ASF vaccine. Gene editing is a new type of genetic engineering in which DNA can be directly inserted, deleted, modified, or replaced in the genome of a living organism. Unlike early genetic engineering techniques that randomly inserts genetic material into a host genome, genome editing directs the modification to site-specific locations. ARS scientists in Orient Point, New York, investigated the use of the “CRISPR-Cas9” gene-editing system as a potentially more robust and efficient system to produce live recombinant ASF viruses. Compared with traditional genetic engineering techniques, the CRISPR-Cas9 system resulted in the successful development of a recombinant ASF virus in record time. These results demonstrate the potential advantage of using CRISPR/Cas9 over traditional methods and should significantly improve the ability to develop a first-generation modified live ASF vaccine. Project No. 8064-32000-056-00D.

**Identifying and breeding goats resistant to scrapie.**

Scrapie is a fatal and untreatable brain disease of goats and sheep that is caused by the progressive accumulation of an abnormal form of the prion protein and loss of brain cells. Historically, a single diagnosis of scrapie resulted in permanent quarantine or euthanasia of all goats and sheep on a farm. Sheep have acquired genetic resistance to scrapie through ARS breeding efforts and this has supported scrapie eradication efforts by the sheep industry, but goats do not exhibit the same genetic resistance. This recently changed with the discovery of two naturally occurring prion gene alleles in goats that have shown exceptional promise for conferring resistance. ARS scientists in Pullman, Washington, and scientists in other laboratories around the world have shown that even one copy of either of these genes confers strong resistance to classical scrapie in goats. Although the USDA National Scrapie Eradication Program has not yet formally recognized these alleles, USDA is planning pilot genetic-based cleanup plans for goats that are similar to programs used in sheep. Scrapie resistance should significantly enhance goat breeding programs and goat health; in addition, breeding scrapie-resistant goats will benefit all small ruminant producers by reducing scrapie in the United States and supporting efforts to designate the import-export status of the United States as a scrapie-free country. Project No. 2090-32000-035-00D.

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

An important complication to controlling and eradicating foot-and-mouth disease (FMD) is the existence of a persistent, subclinical phase of FMD infection in ruminants. Animals with this status are referred to as carriers. Although the epidemiological significance of these FMD virus (FMDV) carriers is uncertain, 50 percent of cattle infected with FMDV become carriers, and fears that these carriers could transmit FMDV has a substantial impact on the international trade of animal products. ARS scientists in Orient

Point, New York, investigated whether oral fluids from these carrier animals could transmit FMDV to cattle and pigs and found that naïve cattle inoculated orally with fluids harvested from carrier cattle developed clinical FMD. In contrast, pigs exposed by inoculation to the same infectious agents did not develop FMD. These findings indicate FMDV carrier cattle can infect other cattle with FMDV and provide new information that should improve response plans for FMD control and eradication. Project No. 8064-32000-061-00D.

**Red imported fire ant detection device.**

Fire ant introductions at United States ports and at quarantine boundaries are a constant problem, and the ants must be rapidly identified to minimize shipping delays. ARS researchers in Gainesville, Florida, and APHIS researchers in Biloxi, Mississippi, developed a rapid, field-portable kit that untrained personnel can use to identify fire ants. The kit is based on the lateral flow immunoassay technology used in home pregnancy tests and can confirm the presence of fire ants within 10 minutes without any prior training or knowledge. Agdia, Inc. (https://orders.agdia.com/invictdetect-isk-49700-0010) has acquired the Biological Material License for the monoclonal antibodies in the test from USDA and is commercially manufacturing the kits under the trade name INVICTDETECT. Project No. 6036-32000-048-00D.

**Sequencing the longhorned tick genome.**

The longhorned tick (*Haemaphysalis longicornis)*, originally from Asia, is a serious pest of livestock; it is an aggressive biter with a diverse host range, can reproduce asexually, and is a vector of several debilitating agents of livestock and human diseases. This tick has recently established populations in at least nine U.S. states. As part of an emergency response to assist APHIS, ARS scientists in Kerrville, Texas, collaborated with researchers at Texas A&M University AgriLife in College Station, Texas, to

sequence the genome of the tick. The completed genome opens new avenues of research on tick control methodology, including vaccine development and detection of pesticide resistance-associated genes. Project No. 3094-32000-036-00D.

**Models to improve integrated pest management of mosquitoes and determine risk of emerging disease threats to the United States.**

ARS scientists in Manhattan, Kansas, collaborated with Kansas State University researchers to develop models quantifying the risk from introduction of Japanese encephalitis and Rift Valley fever viruses to the United States. The analysis suggests that airplanes and cargo ships currently present a minimal risk of introducing Japanese encephalitis. However, the results also indicate the behaviors of mosquitoes responsible for disease transmission play a more significant role than originally realized. Another model used disease outbreak data from South Africa to better understand host and vector roles in the spread of Japanese encephalitis and Rift Valley fever viruses between farms in the Midwest, Texas, and the eastern seaboard. The results are useful to epidemiologists, State and Federal mosquito management districts, and healthcare specialists for improving the surveillance and population management of disease vectors to prevent disease outbreaks in humans and livestock, and to Federal emergency planners who may need to quickly develop plans for protecting food supplies from the introduction of exotic pathogens. Project No. 3020-32000-007-00D.

**Widespread pyrethroid resistance in Florida mosquitoes that transmit Zika and dengue viruses.**

Recent outbreaks of locally transmitted Zika and dengue viruses in Florida have highlighted the importance of integrated vector management plans for the yellow fever mosquito (*Aedes aegypti)*. ARS researchers in Gainesville, Florida, worked with collaborators to conduct a statewide examination of pyrethroid resistance in Florida populations of *Ae. aegypti* and demonstrated that permethrin resistance

and the genetic markers for resistance are widely present, although the strength of the resistance varied. This information will be useful for managers who need to select the most effective pesticides to use in programs for controlling mosquitoes that transmit diseases to humans. Project No. 6036-32000-050-00D.

**Genomic selection for growth and carcass yield in the Delta Select strain of channel catfish.**

Determining the relative value of an individual fish for breeding has depended on traditional methods that use parentage information and trait measurements. ARS scientists in Stoneville, Mississippi, collaborated with University of Georgia scientists to develop a technology that uses genome information to improve the accuracy of breeding value estimates. This approach led to 30 percent improvement in breeding value accuracy for growth and carcass yield in 2,000 Delta Select strain catfish. The improved breeding value accuracy will result in more rapid genetic gain for growth and carcass yield in the Delta Selects, which will be released to U.S. catfish farmers to improve their production efficiency. Project No. 6066-31000-012-00D.

**Gene editing in rainbow trout.**

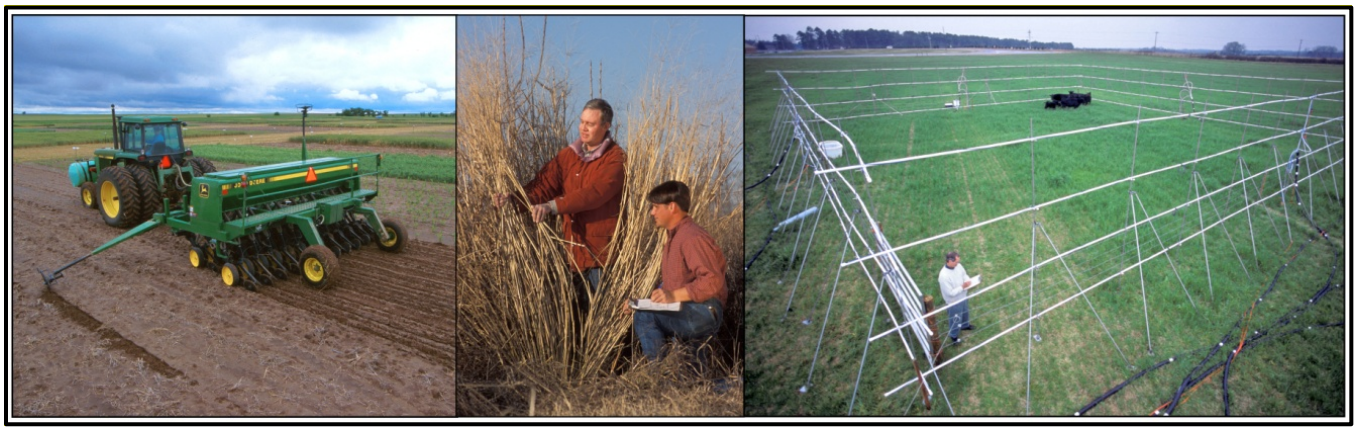
Advancements in gene editing technologies have enabled the induction of targeted mutations in genes of interest, allowing for precise manipulation of the genome. ARS researchers in Leetown, West Virginia, have provided the first proof-of-concept for rainbow trout by demonstrating that this technology can produce fish that exhibit a desired trait and that these genetic modifications are transmitted to the next generation via typical reproduction. Gene editing provides a new opportunity to understand gene function and an alternative strategy that can complement other approaches to genetic improvement. Project No. 8082-31000-012-00D.

**Use of woodchip bioreactors to improve water quality in fish farm effluents.**

As with all intensive agricultural systems, fish farms produce waste that has the potential to affect the surrounding environment. ARS extramural researchers in Shepherdstown, West Virginia, determined that woodchip bioreactors can capture nitrate nitrogen and suspended solids from aquaculture effluent streams to minimize nutrient discharge into surrounding waterways. A cost and engineering assessment demonstrated that the woodchip bioreactor is an affordable, low-maintenance technology to treat aquaculture effluent, and reduce environmental impacts and wastewater treatment costs. Project No. 8082-31320-002-00D.

**Incubation temperature affects rainbow trout embryo survival.**

Incubation temperature is commonly manipulated to control and predict hatch date in salmonids so that suppliers can consistently provide their customers with eyed eggs across the spawning season. However, little information exists on how temperature changes affect embryo survival. ARS scientists in Leetown, West Virginia, found that incubation at 5°C within the first day of fertilization reduced embryo survival around 5 percent compared with incubation at 10°C, and that rapidly transferring embryos between 10°C and 5°C after 100-degree days of incubation did not affect survival. This information suggests that stakeholders should end the practice of initially incubating fertilized eggs at 5° C. Project No. 8082-31000-012-00D.



# 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**

**Windows Dam Analysis Modules (WinDAM) C adopted by worldwide leaders in dam safety.**

WinDAM C, a CCE-certified software, is a computational tool released in 2016 by ARS in cooperation with the USDA Natural Resources Conservation Service (NRCS) and Kansas State University. This decision support software is used by dam safety engineers in predicting potential dam breaches. The software incorporates algorithms developed by ARS scientists for predicting embankment dam failures from overtopping or internal erosion and includes breach outflow and breach timing estimates. Since its release, the software has been adopted by consulting engineers, academic researchers, and Federal agencies, including the U.S. Corps of Engineers, the U.S. Bureau of Reclamation, NRCS, and the Tennessee Valley Authority. In FY 2018, 10 countries requested the software and the majority have incorporated WinDAM C into their educational and design analysis toolboxes. This technology is helping dam safety engineers prioritize the rehabilitation schedules for the aging U.S. embankment dams

and levees. Dams built, evaluated (using WinDAM C), and maintained by NRCS provide an estimated $2.5 billion in annual benefits to producers, shippers, communities, and others. ARS scientists and their collaborators are currently exploring options to use WinDAM C in developing early flood warning systems that can be used by emergency managers, city planners, and policymakers in establishing zoning regulations, developing flood inundation maps, and improving emergency action plans. Project No: 3072-13000-010-00D.

**Managed deficit irrigation can save 6 inches of irrigation water per acre and boost yields.**

Development of sustainable and efficient irrigation strategies is a priority for agricultural producers faced with water shortages. Managed deficit irrigation is a promising management strategy for reducing water use; the crop is not fully irrigated, but greater irrigation is applied during grain set and early fill. However, experimental results are lacking for this strategy. ARS scientists in Bushland, Texas, collaborated with Texas A&M AgriLife Research and Extension Service to study managed deficit irrigation with grain sorghum. Yields from crops produced with managed deficit irrigation averaged 25 bushels per acre more than crops produced with deficit-irrigated sorghum and used only 1.5 inches of additional irrigation compared with nearly 8 inches with fully irrigated sorghum. If irrigation water availability is limited, managed deficit irrigation has significant advantages over deficit irrigation. Project No. 3090-13000-015-00D.

**Efficient nitrate recycling and re-use.**

Nitrate contamination of surface and ground waters is a serious problem in many agricultural regions. It is a human health risk and contributes to eutrophication of fresh water and the Gulf of Mexico. Most mitigation efforts focus on denitrification through a process of encouraging microbes to convert nitrate to nitrogen gas. This is inherently wasteful because much energy is required for the initial manufacture

of nitrogen fertilizer. A more efficient solution would be to develop methods to recycle nitrate for re-use. ARS scientists in St. Paul, Minnesota, have developed a system that can remove nitrate from contaminated water and concentrate it for re-use as fertilizer. The system runs on electricity from solar panels, so it is suitable for remote locations. A feasibility test was successfully conducted on a contaminated trout stream that has a nitrate concentration of more than 20 ppm (twice the United States Environmental Protection Agency safety standard of 10 ppm). The system was able to remove an average of 42 percent of the nitrate from water passing through it, concentrating it in a tank that ultimately reached a concentration exceeding 500 ppm, which was subsequently used elsewhere as fertilizer. This approach could be used to recover nitrate from streams and contaminated wells, ponds, and lakes. Project No. 5062-12130-007-00D.

**Subsurface drainage pipes can be mapped using unstaffed aerial vehicles.**

Effective and efficient methods are needed for locating pre-existing drainage pipes to modify or repair subsurface drainage systems, and to assess environmental effects of drainage practices. ARS researchers in Columbus, Ohio, and the University of Tennessee collaborators used an unstaffed aerial vehicle (UAV) mounted with visible, near-infrared, and thermal infrared cameras to conduct a preliminary drainage pipe mapping case study at an Ohio farm field. The thermal infrared imagery successfully mapped 60 percent of the drainage pipes present within the field. Although more investigation is needed, thermal infrared imagery obtained by a UAV exhibits promise for drainage pipe mapping, which in turn, will provide benefits for farmers and land improvement contractors involved with repairing/modifying subsurface drainage systems while also helping research scientists and regulatory personnel assess the environmental risks of drainage practices within agricultural landscapes. Project No. 5080-13210-002-00.

**Rice water use can be reduced 22 percent by good management coupled with irrigation innovations.**

Rice is an important crop in the Lower Mississippi River Valley (LMRV); however, it currently requires up to three times the amount of irrigation as soybean, cotton, and corn. The Mississippi River Valley alluvial aquifer is the primary source of irrigation in the LMRV and the water level is dropping. Efforts are ongoing to devise management practices that reduce irrigation use. Multiple-inlet rice irrigation uses plastic tubing to simultaneously deliver irrigation to all paddies of a rice field. This practice can reduce irrigation use by up to 25 percent compared with the standard practice of cascade flooding. ARS researchers in Jonesboro, Arkansas, have demonstrated that the irrigation savings achieved when using multiple-inlet rice irrigation depend heavily on a farmer's management style. Even without rainfall, multiple-inlet rice irrigation was found to reduce irrigation use by 22 percent relative to cascade flooding when irrigation was halted as soon as runoff occurred from a rice field. These results show that multiple-inlet rice irrigation saves water through a combination of improved application efficiency and rainfall capture. Project No. 6024-13000-003-00.

**Nitrogen Index helps farmers better manage fertilizer, save money, and protect the environment.**

A problem faced by agricultural producers around the country and world is the proper use of nitrogen fertilizers. Agricultural system managers (e.g., farmers, landowners, Government agencies) need data, information, and tools to help them easily assess how their management decisions can increase the nitrogen use efficiency of crops, or conversely, how they result in the loss of necessary nitrogen from the soil. Version 4.5.1 of the Nitrogen Index was developed by ARS scientists in Fort Collins, Colorado, to enable users to conduct quick assessments of the effects of their management practices on nitrogen use efficiencies and to better manage their use of this important fertilizer. The index is now being used in California, Kentucky, South Dakota, Bolivia, Brazil, several Caribbean nations, Ecuador, Mexico, and

other locations. Surveys conducted in 2016, 2017, and 2018 demonstrate that the index is in widespread use by farmers in many of these locations and has been downloaded or distributed more than 2,000 times by users in 65 countries and used by at least 4,500 farmers who manage more than 240,000 acres. The index is also used in academic settings, where to date it has served as a teaching tool for 1,516 undergraduate students and 432 graduate students; in these settings, it has been downloaded by at least 566 professors, crop consultants, or other professionals. The Nitrogen Index is available free and can be downloaded through the ARS home web page. Project No. 3012-11120-001-00D.

**Poultry litter significantly lowers production costs for biofuel production.**

Under the Energy Independence and Security Act of 2007 and the Renewable Fuel Standard program, 36 billion gallons of biofuels must be produced annually by 2022, more than twice the level currently being produced. Temporal patterns of biofuel crop growth, composition, and nutrient removal affect the development of models for predicting optimal harvest times and nutrient inputs for large-scale, sustainable bioenergy production. ARS researchers in Fayetteville, Arkansas, completed a series of experiments that evaluated environmental aspects and economic feasibility relative to the cost of specific fertilizers needed to grow biofuel crop switchgrass in the mid-South. They found that poultry litter was less expensive than synthetic fertilizer for production, which lowered the break-even price for a user by nearly 50 percent per acre. The research team further developed models that would enable a user to predict both within-season changes in production and nutrient cycling. These models give users the ability to simulate productivity trade-offs, and the resulting information can be used for both economic and environmental analyses that lead to more sustainable bioenergy production. Project No. 6022-63000-005-00D.

**Novel gas-permeable membranes greatly reduce gaseous ammonia in poultry barns.**

Conservation and recovery of nitrogen from livestock and urban wastes is important for both economic and environmental reasons. ARS researchers in Florence, South Carolina, developed new systems using gas-permeable membranes to collect and reuse ammonia that is harvested from waste in poultry barns and thus removing ammonia from the air. The membrane manifolds are suspended inside the barns, and the gaseous ammonia closest to the litter is removed. The technology has been demonstrated at University of Maryland Eastern Shore chicken houses through a NIFA grant. In rooms fitted with the ammonia recovery system, the ammonia level decreased 46 percent in the air and 45 percent in the litter, and bird mortality was reduced 47 percent. The new system offers poultry producers a better way to manage ammonia and bird health in their poultry barns. Project No. 6082-12630-001-00D.

**Microbial inoculants can reduce nitrous oxide emissions from nitrogen fertilizer application.**

The loss of nitrous oxide ($N_2O$) is of concern not only because the loss of nitrogen from the soil means that plants cannot use it, but also because it is a potential contributor to global warming. Over the past few decades, $N_2O$ emissions have increased worldwide due to several factors, including increases in cultivated crop area, excessive application of nitrogen fertilizers, and livestock production. But loss of $N_2O$ from fertilizer is considered to be the largest contributor from agriculture as a whole. ARS researchers in Auburn, Alabama, have identified microbial inoculants that can improve plant production and plant nutrient efficiency. Development of these microbial inoculants was conducted to reduce $N_2O$ losses that may arise from fertilizer nitrogen use. ARS research led to the discovery that specific combinations of soil microorganisms applied with fertilizer can reduce $N_2O$ emissions, which became the basis of a new U.S. patent. The newly patented microbial inoculant will help reduce $N_2O$ emissions from production agriculture and could lead to an income stream in the carbon trading market while reducing the effects of greenhouse gas emissions. Project No. 6010-11120-008-00D.

**Improving restoration practices to reduce wildfire threats.**

The accidental introduction and subsequent invasion of cheatgrass to Great Basin rangelands has increased the frequency of wildfires, and millions of dollars are spent annually fighting them. ARS scientists in Reno, Nevada, have been testing pre-emergent herbicides to control cheatgrass, diminish the levels of cheatgrass-associated fuels for fires, and improve rangeland restoration efforts. This research has resulted in more than a ninefold increase in the growth of perennial grasses, shrubs, and forbs that successfully suppress cheatgrass. A reduction in cheatgrass-associated fuels significantly reduces the chance, rate, spread, and season of wildfires. Converting cheatgrass-dominated habitats back to perennial grasses, forbs, and shrubs has also substantially improved sustainable grazing resources and improved plant and wildlife diversity in the Great Basin. Using pre-emergent herbicides to control cheatgrass improves the overall health of the habitat, lowers the threat of wildfire, preserves wildlife, increases rangeland livestock production, and reduces the costs of fire control. Project No. 2060-13610-001-00D.

**Identification of more competitive nitrogen-fixing bacteria for use in alfalfa production.**

Most alfalfa seed is treated with symbiotic bacteria before planting to ensure the formation of nitrogen-fixing nodules on roots. Improving nitrogen fixation reduces the need for synthetic fertilizers, but establishment of the necessary bacterial strains is hampered by competition from indigenous, less effective bacteria. ARS scientists in Saint Paul, Minnesota, and University of Minnesota colleagues developed methods for identifying the origin of bacteria in root nodules in two field sites that had not been in alfalfa cultivation for more than 30 years. All bacteria in nodules originated from soil rather than from seed inoculation and were genetically diverse. However, approximately one-third of the bacterial strains in nodules had a gene involved in transfer of bacterial proteins to plant cells, which appears to

accelerate nodulation, potentially making these strains more competitive in forming root nodules. This gene gives researchers a marker to rapidly identify additional strains that would be more effective as seed inoculants. Increasing nitrogen fixation and the amount of nitrogen available to alfalfa plants will increase crop yields without raising costs for crop production. Project No. 5062-12210-002-00D.

**Increasing big sagebrush densities for sagebrush obligate species.**

Recurring wildfires have significantly reduced the density of big sagebrush and have resulted in the loss of critical habitats for sagebrush obligate species such as sage grouse and mule deer. ARS scientists in Reno, Nevada, tested how big sagebrush could be transplanted to increase its density in crested wheatgrass stands. Their efforts resulted in a sixfold increase in big sagebrush density. Fall transplanting versus spring transplanting resulted in larger density increases of big sagebrush. The increase in shrub density improves wildlife habitat and ecosystem function while reducing livestock-wildlife conflicts. Project No. 2060-13610-001-00D.

**Elevated $CO_2$ effects on forage quality in mixed grass prairie.**

Two of the most important aspects of the global climate are increases in the concentration of carbon dioxide ($CO_2$) in the atmosphere and increases in global temperature. ARS scientists in Fort Collins, Colorado, and Cheyenne, Wyoming, in collaboration with ARS scientists in Woodward, Oklahoma, conducted a field experiment from 2007 to 2013 to examine how increasing atmospheric $CO_2$ (from the current 400 ppm to a simulated future level of 600 ppm) and increasing temperature (by 1.5°C during the day and 3°C at night), both alone and in combination, affected the productivity and quality of forage for livestock in the northern mixed-grass prairie. Total forage production increased by an average of 38 percent over the 7-year study period, but forage quality decreased with increased atmospheric $CO_2$ combined with warming. Dry matter digestibility of the primary cool-season forage grass (western

wheatgrass) dropped from 63.3 percent to 61.1 percent, and crude protein content also decreased from 7.8 percent to 6.5 percent with combined elevated $CO_2$ and warming. These changes could significantly influence management decisions by ranchers because rates at which individual cattle gain weight during the growing season are expected to decrease. Adaptation strategies to reverse this loss in weight gain could include increasing stocking rates, patch burning, fertilization at low rates, and legume interseeding. Project No. 3012-21610-001-00D.

**Increasing crop diversity increases economic returns and reduces risk.**

Increasing crop diversity by growing a larger variety of crops in rotation has been proposed to increase sustainability; however, for producers to adopt these rotations as standard practice, they need to be profitable. In a long-term crop rotation study, ARS researchers in Mandan, North Dakota, showed that crop productivity and economic returns increased with increasing crop diversity, whereas economic risk decreased. In most cases, increasing crop diversity also resulted in higher soil organic carbon levels, which allows producers in the region to simultaneously realize economic benefits of $25 to $83 per acre while maintaining or building soil organic carbon. Project No. 3064-21660-003-00D.

**Optimizing yield, profit, and environmental protection.**

ARS researchers in Tifton, Georgia, found that strip tillage (ST) in conjunction with winter cover crop planting and poultry litter application improved plant nitrogen availability by more than 24 lb/acre/yr in sandy landscapes of the southeastern Coastal Plain via microbial cycling of organic nitrogen and reduction of nitrate leaching. Total soil nitrogen content increased 27 percent over 5 years with ST compared with 22 percent with conventional tillage (CT). Cumulative nitrate-nitrogen leached from soils during the 5-year study was 126 lb/acre (CT) versus 109 lb/acre (ST). Both of these values were higher than the 5-year average tile flow losses of nitrogen but suggest that leaching from the top 6 inches

of soil is an important pathway for dissolved nitrogen loss from the rooting zone in this landscape. Regardless of tillage, soil microbial biomass nitrogen was equal to or higher than soil inorganic nitrogen, suggesting that soil microbial biomass is a key factor for retaining nitrogen in the rooting zone and thus mitigating soil nitrate loss and delivery to ground and surface waters. Project No. 6048-11130-004-00D.

**Decision support tools that help growers select biochars to improve soil health and economic return.**

Despite the known agronomic benefits of biochar, few farmers have adopted biochar-based strategies to improve soil health or increase plant productivity primarily because standards and agronomic recommendations regarding application rates and techniques are lacking. ARS researchers in Corvallis, Oregon, in collaboration with researchers from Oregon State University, published the Pacific Northwest (PNW) Biochar Atlas, a suite of decision-support tools designed to alleviate uncertainty regarding the use of biochar on farms. The atlas includes a soils property explorer that allows users to identify soil deficiencies in soils across the PNW. A biochar selection tool pairs these deficiencies with biochar types best suited to their soil needs and crop type and calculates the carbon sequestration, fertilizer, and liming value of amending at different rates. A cost-benefit calculator determines the cost savings from offsetting fertilizer, lime, and irrigation water, and potential income from increased crop yield. The website is useful for both growers and researchers and has had nearly 20,000 page visits in the first 6 months, with visitors from 75 countries. Project No. 2072-21410-004-00D.

**Incorporating soil health management practices into potato cropping systems lowers disease incidence and increases productivity.**

Use of longer rotations, disease-suppressive green manures, cover crops, and organic amendments have all been shown to increase tuber yield, reduce disease, and improve soil health in previous potato cropping studies. However, such practices need to be implemented in integrated cropping systems that maintain economic viability for growers. ARS researchers in Orono, Maine, examined ways to incorporate effective soil health management practices into practical potato cropping systems through the establishment of enhanced 3-year rotations with management goals of soil conservation, soil improvement, and disease suppression, in relation to a standard (2-year) rotation and no rotation. Previously established systems were modified to better fit into grower production systems, and evaluated for their effects on soil properties, tuber yield, soilborne diseases, and economic viability. Overall, the soil improvement system (including compost amendment, reduced tillage, and cover crops) resulted in greater potato yield, higher organic matter and other nutrient contents, and higher microbial activity relative to the standard rotation. The disease suppressive system also increased yield and microbial activity and reduced soilborne diseases. Enhanced cropping systems also provided comparable or increased net income relative to other 3-year rotations. These results demonstrate that soil health management practices can be incorporated into economically viable cropping systems that can enhance sustainability, productivity, and ecosystem function, and lead to improved agricultural viability and vitality for potato production systems. Project No. 8030-62660-003-00D.

# 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**

**Deciphering the genetics of fast-cooking dry beans.**

Cooking time is an important consumer trait in dry bean, and long cooking times discourage greater consumption of beans. ARS scientists in East Lansing, Michigan, previously discovered bean germplasm that significantly reduces cooking time, but the genetic control of the trait was unknown. The scientists developed a population from a cross between a slow-cooking bean and a fast-cooking bean. The cooking times for individuals in that population ranged from 21 to 135 minutes. The beans were grown in Tanzania under temperate and hot, humid tropical climate conditions for two field seasons and scientists observed that beans grown in the hot-humid zone took 15 minutes longer to cook than those grown in the temperate zone. They determined that cooking time was strongly influenced by genetic factors that were controlled by interactions of four different regions of the genome. After tagging those four regions with DNA markers, the researchers identified several bean lines containing genes from all

four regions, which made them cook 16 minutes faster. This work demonstrated the potential value of integrating cooking time into breeding programs and the value of using molecular markers to help select for fast-cooking beans. Breeders are now using these lines and markers to develop fast-cooking beans. Project No: 5050-21430-010-00D.

**A high-throughput automatic platform for root growth phenotyping.**

Drought threatens crop production in the United States and around the world. Drought tolerance is influenced by genetic, physiological, and environmental factors, including root traits, but more information is needed about the relationship between roots and drought tolerance in agronomic crops. ARS researchers in Columbia, Missouri, have developed a low-cost robotic system to directly observe roots in soil and measure the growth rate response under both optimal and water-deficit conditions. The robot, referred to as "RootBot," was designed for use in a controlled environment and enables roots to develop normally in the dark and in soil. This technology has broad applications for use in multiple crops and with varying soil treatments, including water deficit stress. The platform facilitates the rapid assessment of root traits, which will support breeding efforts to improve drought tolerance in all major crops. Project No. 5070-21000-041-00D.

**Novel hard-white waxy winter wheat.**

Waxy wheats can be used for novel whole grain products and are a promising substrate for ethanol production. Hard-red winter wheat and hard-white winter wheat are both waxy wheats grown in the Great Plains region. White wheats do not contain the condensed tannins that confer the red grain color and have some potential advantages over red wheats, including wider application in non-pasta noodles and steamed wheat products, and the production of higher extraction flours. The lack of condensed tannins imparts a slightly sweeter, less bitter taste to whole grain products; in addition, white wheat

products can be significantly brighter in color and have greater appeal to consumers than products made with red wheats. To fill potential demand for a hard-white waxy wheat adapted to Great Plains production, ARS scientists in Lincoln, Nebraska, in cooperation with the University of Nebraska, developed and released 'Matterhorn', the first U.S. hard-white waxy high-yielding winter wheat. Project No. 3042-21000-031-00D.

**New system for engineering novel traits into crop genomes.**

The genetic improvement of crops is one of the most effective ways to increase their productivity in agriculture. Until now, it has been difficult to genetically engineer improvements in complex traits like yield or disease resistance that require the action of multiple genes. An ARS scientist in Albany, California, developed a novel technology called Gene Assembly in Agrobacterium by Nucleic Acid Transfer using Recombinase technology (GAANTRY), that enables the efficient assembly and introduction of multiple genes into plants. The system can interlink multiple genes in a simple, reliable and highly effective process, and then generate transformed plants that frequently produce all the introduced traits as desired. This technological breakthrough enables the use of crop biotechnology to effectively improve complex traits in a wide array of crop plants. Project No. 2030-21000-020-00D.

**Reducing tree fruit production costs through architectural design.**

The major cost of fruit tree production for growers is managing the shape and size of trees through grafting, training, and/or pruning. The ability to breed trees with simpler and more easily managed shapes would lead to substantial savings to growers and consumers, but more information is needed about how tree branches adopt specific growth orientations. ARS researchers in Kearneysville, West Virginia, discovered a gene responsible for branch orientation in peach. A mutation in a gene they dubbed WEEP changed the way the peach branches respond to gravity and resulted in branches growing

down instead of up. The researchers also determined that a set of previously discovered related genes controlling branch growth direction is influenced by gravity, light, and photosynthesis. Collectively, this information and the associated technologies (U.S. Patent 9,371,536) offer new strategies for developing plants and trees with shapes that are easier to manage; the advances have the potential to ultimately boost crop yields and reduce labor costs and chemical spray use. Project No. 8080-21000-023-00D.

**Analyzing genome sequence architecture by machine learning.**

There are more than two billion base pairs in a genome; they are a complex mixture of "readily accessible" regions that can interact with a wide range of proteins and regions that are not highly "accessible" for protein interactions. The interactions between these regions control how and when genes are turned on and regulated. ARS researchers in Ithaca, New York, and their collaborators constructed machine learning models for understanding natural written language and applied them to understand the language of DNA. These language-based models can accurately predict DNA structure between 95 and 99 percent of the time. This general approach can be applied to learning how aspects of the genome function and help identify single DNA changes that contribute to crop yield losses. Project No. 8062-21000-039-00D.

**Characterization and selection of a new highly effective oat crown rust resistance gene from wild oat, *Avena strigosa*, into cultivated oat.**

Oat crown rust (*Puccinia coronata* f. sp. *avenae*) is a major disease that can result in a significant reduction in global oat production. ARS scientists in St. Paul, Minnesota, identified a new, highly effective resistance gene to oat crown rust from wild oat, *Avena strigosa*, and introduced it into cultivated oat through a technique called marker-assisted selection. The gene confers broad resistance to

this devastating disease of oat, making it highly valuable to scientists around the globe. Project No. 5062-21220-023-00D.

**Release of disease-resistant germplasm from wild sunflowers.**

Sclerotinia basal stalk rot (BSR) and downy mildew are two fungal diseases that are major yield-limiting factors in global sunflower production. The use of resistant hybrids, where available, is the most efficient and environmentally friendly means of managing these diseases. ARS scientists in Fargo, North Dakota, transferred resistance to BSR from three species of wild annual sunflowers into cultivated sunflower, resulting in the release of seven sunflower germplasm lines. All lines except one also contain resistance to downy mildew derived from one of the parents. These lines represent the first oilseed sunflowers with resistance to Sclerotinia BSR and downy mildew together and are being used across the United States and internationally to breed sunflower for resistance to multiple diseases that reduce seed quality and severely affect yield. Project No: 3060-21000-039-00D.

**PhylloLux technology for crop protection.**

New approaches are needed for controlling strawberry diseases. Current strategies that rely mainly on the use of fungicides have significant limitations because they have become less effective in their ability to control plant pathogens. In addition, restrictions on the use of fungicides and public demand for produce free of pesticide residues are both increasing. ARS researchers in Kearneysville, West Virginia, developed PhylloLux technology, a plant disease-management system that combines Ultraviolet C (UV-C) irradiation followed by a specific dark period with the application of biocontrol agents. The PhylloLux system can also be used to control mites—the major arthropod pest in strawberry production. Microbiome analysis revealed no major shift in the composition of the microflora of fruits and leaves that would indicate an increase in foodborne pathogens after antagonist treatment. The potential of this

technology goes well beyond its application to strawberries to include other fruit and vegetable crops as well as ornamental plants and nursery stocks. Project No. 8080-22000-010-00D.

**Mating disruption of glassy-winged sharpshooter by playback of vibrational signals through vineyard trellis.**

Glassy-winged sharpshooter (GWSS) is an important vector of the bacterium *Xylella fastidiosa*, the causal agent of Pierce's disease of grapevine. GWSS insects communicate by exchanging mating calls that are transmitted through host plants as vibrational signals. ARS scientists in Parlier, California, showed that interference with GWSS communication by playback of disruptive, vibrational signals through vineyard trellis systems resulted in a significant reduction in GWSS mating on grapevines. Although further studies are needed before commercial adoption, data from this study support application of vibrational mating disruption as a novel method to control GWSS populations. Project No. 2034-22000-012-00D.

**Completion of the synthetic pathway of a bioherbicide.**

No new herbicides with new modes of action have been discovered since the 1980s, and this has exacerbated the herbicide-resistance problem. ARS scientists in Oxford, Mississippi, previously discovered a compound called sorgoleone that gives sorghum its natural weed-fighting properties. This compound holds potential to be an effective new bioherbicide with a new mode of action. These ARS scientists have now identified the complete biosynthetic process for how the plant makes sorgoleone, including all the genes involved. In addition, they discovered the gene responsible for sorgoleone is produced only in the roots of the sorghum. With this information, scientists now have the tools in hand to develop the production of sorgoleone in other crop species, which could lead to new crop varieties with enhanced resistance to weeds. Weed-resistant crops could significantly reduce the need for

chemical herbicide applications and increase options for crop rotations. Project No: 6060-21410-011-00D.

**Discovery of a new class of safer insecticides.**

Methyl benzoate exists naturally as a floral fragrance in many plants. ARS scientists in Beltsville, Maryland, found that methyl benzoate also has insecticidal properties and is more toxic to gypsy moth larvae and brown marmorated stink bug nymphs than commercial insecticides. It was found to be 5 to 20 times more toxic to larvae of a fruit fly called the spotted wing *Drosophila* than it is to these other two insects and is also environmentally friendly. ARS has patented it as a safe, new insecticide for use on this fruit fly. Furthermore, studies of methyl benzoate analogs may help explain how a related compound, DEET, works so well as an insect repellant. Further chemical analyses will help improve the efficacy of this new class of insecticide. Project No. 8042-22000-291-00D.

**Impact of sublethal and long-term concentrations of insecticides on honey bee survival.**

Understanding the impact of pesticides through both direct and residue contact is important in developing strategies that mitigate their impact on honey bees. ARS scientists in Stoneville, Mississippi, fed honey bees with several different formulations of the insecticide clothianidin at concentrations typical for field residues. The scientists did not observe any effects on adult bee survivorship but did observe reductions in body weight. They also found that long-term spray treatments with imidacloprid at low rates did not adversely affect bee survival, but higher concentrations (>80 mg/L) did significantly reduce survival. Results from these studies are being used to determine effects of different insecticide concentrations on honey bee health. Project No. 6066-22000-084-00D.

**Glyphosate not found to affect disease rates or mineral uptake in GMO corn and soybeans.**

Glyphosate (the active ingredient in the herbicide Roundup) and genetically modified (GMO) corn with glyphosate resistance have dominated agronomic cropping systems throughout the United States for nearly 20 years. Concerns have arisen that genetically engineered corn may be more susceptible to a disease called Goss's wilt following glyphosate application. A report was also made that significant mineral deficiencies might develop in GMO corn and soybeans following glyphosate use. ARS scientists in Illinois, Maryland, and Mississippi conducted a very large experiment across several years and several regions to quantify these effects. They found that GMO crops were no more likely to develop Goss's wilt than non-GMO corn and found that glyphosate applications were not associated with mineral deficiencies in these crops. In conclusion, these unintended effects do not occur in association with GMO crops or glyphosate applications. Project No. 5012-12220-009-00D.

**Successful cryopreservation of a honey bee embryo.**

ARS scientists in Fargo, North Dakota, collaborated with ARS bee breeders in Baton Rouge, Louisiana, to create the world's first cryopreserved honey bee embryo. Honey bee sperm is currently stored by the ARS National Animal Germplasm Program in Fort Collins, Colorado, and sperm preservation provides biodiversity, but embryo preservation enables breeders to access genetically identical lines of bees. This is a major advancement in the ability to improve the biosecurity of honey bee germplasm and the accessibility of the nascent National Honey Bee Germplasm Repository. Project No. 3060-21000-041-00D.

**Native pollinators support consistent high sunflower yields.**

Low or inconsistent yields are challenging for individual sunflower growers and the overall sunflower market. Pollinators are needed to ensure high yields, especially when sunflower hybrids do not

effectively self-pollinate because of crop genetics or environmental conditions during flowering. ARS scientists in Fargo, North Dakota, grew 15 confection sunflower hybrids over 2 years and documented contributions of bee pollination to crop yields. On average, bees accounted for 26 percent of yield and lines that attracted more bees obtained higher benefits from pollinators. Although honey bee colonies were located adjacent to the research plots, almost all bee visits to confection sunflowers were by solitary wild bees. These results document the contribution of wild bees to sunflower yield increases and their clear preference for certain hybrids. Growers are now using bee conservation as part of crop management, and breeders are now using pollinator attraction as a component of inbred and hybrid development. Project No. 3060-21000-039-00D.

**A noninvasive method to quantify starch reserves at micrometer resolution.**

Starch is the primary energy storage molecule used by plants to fuel respiration and growth during periods of limited photosynthesis. Until now, starch could only be measured using destructive techniques, which limited studies on carbohydrate metabolism in living plants. Prior methods also lacked adequate spatial resolution to study starch metabolism in different cell types. ARS researchers in Davis, California, with Yale University researchers and scientists at the University of California, Davis, used X-ray microcomputed tomography and a novel machine-learning algorithm to quantify plant starch content over time within the woody stems of living grapevines. After validating the machine-learning algorithm, the spatial distribution of starch was characterized in woody stems at micrometer resolution as the plants were exposed to experimental conditions that halted photosynthesis and starch production. This new study tool has applications to many horticultural crops and will support producers who are under increasing pressure to minimize water use without limiting crop longevity or yields. Project No. 2032-21220-006-00D.

**Brown marmorated stink bug (BMSB) commercial pheromone lure development.**

BMSB is a highly invasive pest of agricultural and nursery crops and is a nuisance when it invades homes to overwinter. Based on the identification of the BMSB pheromone and pheromone synergist, ARS researchers in Kearneysville, West Virginia, and university collaborators around the country developed lures that are now commercially available from three commercial companies, AgBio, Trece, and AlphaScents. The lures can be used with crop-compatible trap designs to measure BMSB presence, relative abundance, and seasonal activity. Project No. 8080-21000-024-00D.

**Hot water and steam can be used to sanitize plastic nursery pots and trays for weed seed.**

Seeds of many weeds, particularly bittercress and creeping woodsorrel, stick to plastic nursery containers and trays and are reintroduced into production systems when that plastic is reused. ARS scientists in Wooster, Ohio, determined the specific temperatures and exposure times necessary when using either hot water or steam to kill weed seeds on plastic containers and propagation trays. Temperatures of 194°F provided nearly complete control of seeds for both species. The results of this work can be used by greenhouse and nursery producers to control weed seeds between crops and drastically reduce weed populations in propagation and other phases of production where herbicides are limited. Project No. 5082-21000-017-00D.

**Release of new plant germplasm and cultivars.**

In FY 2018, ARS scientists released 57 enhanced germplasms and cultivars. Of these, 41 were publicly released and 16 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 2018, 269,204 samples were distributed to foreign genebank/resources units; international agricultural research centers; U.S. and foreign commercial companies; and U.S. and foreign agencies and universities.

| Site | Samples | Accessions | Requests | Countries |
|---|---|---|---|---|
| National Arid Land Plant Genetic Resources Unit (PARL) | 519 | 331 | 44 | 10 |
| National Laboratory for Genetic Resources Preservation (NSSL) | 889 | 886 | 46 | 1 |
| National Small Grains Collection (NSGC) | 29,070 | 22,198 | 657 | 42 |
| Natl. Germplasm Repository - Corvallis (COR) | 7,021 | 3,434 | 703 | 15 |
| Natl. Germplasm Repository - Davis (DAV) | 2,898 | 1,318 | 311 | 10 |
| Natl. Germplasm Repository - Geneva (GEN) | 8,084 | 2,317 | 541 | 9 |
| Natl. Germplasm Repository - Hilo (HILO) | 170 | 94 | 36 | 4 |
| Natl. Germplasm Repository - Mayaguez (MAY) | 171 | 112 | 77 | 3 |
| Natl. Germplasm Repository - Miami (MIA) | 682 | 440 | 122 | 9 |
| Natl. Germplasm Repository - Riverside (RIV) | 10 | 10 | 1 | 1 |
| North Central Regional PI Station (NC7) | 62,158 | 23,123 | 1,424 | 55 |
| Northeast Regional PI Station (NE9) | 13,618 | 7,060 | 240 | 25 |
| Ornamental Plant Germplasm Center (OPGC) | 651 | 399 | 98 | 6 |
| Plant Genetic Resources Conservation Unit, Griffin, GA (S9) | 49,084 | 27,759 | 885 | 48 |
| Plant Variety Protection Voucher Collection (PVPO) | 4 | 4 | 1 | 1 |
| Potato Germplasm Introduction Station (NR6) | 6,846 | 1,789 | 203 | 15 |
| Rice Genetic Stock Center (GSOR) | 20,910 | 13,570 | 176 | 15 |
| Soybean Collection (SOY) | 21,254 | 9,582 | 516 | 29 |
| U.S. National Arboretum | 289 | 236 | 85 | 3 |
| U.S. Nicotiana Germplasm Collection (TOB) | 218 | 144 | 69 | 10 |
| Western Regional PI Station (W6) | 44,658 | 28,812 | 1,106 | 44 |
| **Total** | **269,204** | **143,618** | **7,341** | **355** |

# NATIONAL AGRICULTURAL LIBARY

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. NAL's vision is "advancing access to global information for agriculture."

**Ag Data Commons.**

In FY 2018, NAL continued development of the Ag Data Commons catalog for agricultural research datasets. Development focused on transferring most custom-developed code to the professionally maintained DKAN Science product. Our Research, Education, and Economics one-stop-shop campaign brought growth of 562 percent in the number of catalogued datasets, resulting in significant growth in the ARS contribution to data.gov. Strategic partnerships with ARS and NIFA senior program leadership ensure consistent data management guidance to researchers. ARS and NIFA project proposals now require data management plans (DMPs), and the Ag Data Commons team launched a service to consult on DMP drafts before submission. NAL gathered customer perspectives on best practices in dairy agroecosystem research and agricultural economics via a NIFA-funded workshop and a monthly data management webinar series. Ag Data Commons can be found at https://data.nal.usda.gov.

**PubAg.**

During FY 2018, NAL continued technical development of PubAg and continued building up service content, and by the end of FY 2018, PubAg contained 2,140,000 citations to peer-reviewed, agriculture-

related scientific articles. Each article citation in PubAg includes NAL Thesaurus subject terms and a link to the full-text article if it is available from an internal NAL repository, PubMed Central, and/or the publisher. PubAg's Advanced Search function was improved in response to requests from the library community and in support of the effort to enrich the overall user experience. NAL nearly doubled the full-text corpus in PubAg, adding 39,000 full-text articles, which better fulfills the Department's and U.S. Government's mandate for open access to Federally-funded research. Finally, NAL entered into an agreement with the CHORUS organization (https://www.chorusaccess.org/) to provide access to even more full-text content from cooperating publishers. PubAg can be found at https://pubag.nal.usda.gov/.

**I5K Workspace.**

In FY 2018, NAL implemented new tools, added new data, and performed updates to the i5K Workspace@NAL, a web resource for arthropod genome access and curation. The i5k Workspace issued two major releases of its genomics-workspace software, a web interface for BLAST, and other search tools that can be accessed by users of other genome databases. Several new user interface updates were developed and are awaiting release, including increased Section 508 compliance and a new mechanism to import FAIR metadata. New tools include the remap-gff3 software package for remapping gff3 files to updated genome assemblies. The tool has been used to update three genome assemblies. NAL also drafted a 5-year plan for future program guidance. Twelve new species, and at least 51 new datasets, including 3 Official Gene Sets, were added to the Workspace. The i5k Workspace has been cited 45 times in peer-reviewed scientific papers since its inception 5 years ago, including a 50 percent increase in citations in FY 2018 over FY 2017 totals.

**Long-Term Agroecosystem Research (LTAR) Data Portal.**

In FY 2018, more than 400 metadata records describing LTAR-related data were added to GeoData/Ag Data Commons in a significant effort to inventory LTAR and other datasets. More than 550 datasets can currently be located through GeoData, the NAL geospatial data catalog. In related work, nearly 40 users were trained and given access to create records for their data. In FY 2018, the GeoData system became available to the public, although it was not formally launched. System developments made it more user-friendly, enhanced performance, and included implementation of ISO 19115-3, the latest version of the Federally required geospatial standard. As a result, NAL and USDA are ahead of National Oceanic Atmospheric Administration, NASA, U.S. Geological Survey, and EPA in upgrading to 19115-3 as the primary standard.

**Life Cycle Assessment (LCA) Commons.**

In FY 2018, NAL implemented and documented repository management and data stewardship best management practices based on Open Archival Information System (OAIS) reference model. NAL completed development and deployed the open LCA Collaboration Server data collection, publication, and search application. Consequently, NAL has reduced LCA Commons product operating costs by 60 percent and reduced the time required for publishing a complex data set from months to days. NAL also led the development of the Global LCA Data Access (GLAD) application, which provides distributed access to national-level data sets around the world. The GLAD prototype launched at a European Commission event in April 2018. NAL continued to lead the Federal LCA Commons interagency coordination activity, which has expanded to include the U.S. Forest Service and Federal Highway Administration, in addition to DOE, EPA, DoD, and NIST. In FY 2019, NAL will develop a continuous integration and deployment environment for the LCA Commons product. With an automated testing and deployment environment, the LCA Commons application will be ready for cloud migration per

departmental requirements. The www.lcacommons.gov website will also be redesigned to be more agency-neutral to reflect that the LCA Commons is an interagency collaboration.

**NAL Mass Digitization.**

In FY 2018, NAL digitized and created citation information for 14,954 items (713,548 pages), bringing the total number of digitized items to 147,875 (6,761,642 pages). NAL continues a large-scale digitization project to digitize agricultural literature and provide public online access. During FY 2018, NAL digitization continued to focus on historic USDA-issued publications, nursery and seed trade catalogs, and topic-specific content to support NAL online exhibits and information. In addition, NAL continued 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.

**NAL Digital Collections.**

In FY 2018, the National Agricultural Library's Digital Collections (NALDC) consisted of more than 30,000 historical documents and reports across 10 major collections. Building on upgrades developed for PubAg, NAL modified database, search, and user-interface technology to support an upgrade that was deployed in FY 2018. NAL migrated the upgraded metadata records for items in three collections (Organic Roots, Historical Dietary Guidance, and the Animal Welfare Act History) to the new NALDC location named NALDC Beta. Work also began on migrating the other remaining digital sub-collections to the new interface infrastructure. The National Agricultural Library's Digital Collections can be found at https://naldc.nal.usda.gov/.

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

| Location | Laboratory | Description |
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| AL | Soil Dynamics Research | Presented at the Wiregrass Crop's Field Day in Headland, AL, on ongoing research focused on comparisons between single species and cover crop mixtures. Participants (~50) included growers, industry representatives, and professionals from universities and other government agencies. |
| AL | Soil Dynamics Research | Presentation on screening for drought and charcoal rot resistance at the Milan Field Day attended by approximately 2,000–3,000 growers, industry representatives, and professionals. |
| AL | Soil Dynamics Research | Co-hosted with Auburn University 35 board members from the Southern Cover Crop Council. Activities included a 1-day meeting and a half day to allow board members to tour current cover crop research plots being conducted by ARS and Auburn University. |
| AL | Soil Dynamics Research | Presented at the Central Alabama Cover Crop Tour on ongoing research designed to identify best management practices for late-planted cover crops and current research for cover crop mixtures and discussed weed suppression benefits from cover crops. Participants (~50) included growers, industry representatives, and professionals from universities and other government agencies. |

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| AL | Soil Dynamics Research | Presented at the Southeast Alabama Cover Crop Field Day on ongoing research designed to identify best management practices for late-planted cover crops. Participants (~65) included growers, industry representatives, and professionals from universities and other government agencies. |
| AL | Soil Dynamics Research | Present at the 2017 Alabama Row Crops Short Course on "Management and Economic Considerations for Cover Crops in Alabama." Participants included growers, industry representatives, students, and professionals from universities and other government agencies. |
| AL | Soil Dynamics Research | Presented at the Alabama Soil Health Team Meeting on an update on current cover crop research being conducted by the research team. Participants (~20) represented various State and Federal agencies focused on improving soil health. |
| AL | Soil Dynamics Research | Presented at the Louisiana Soil Health and Cover Crop Conference on "Cover Crop Management and Equipment Considerations." Participants (~75) included growers, industry representatives, and professionals from universities and other government agencies. |
| AL | Soil Dynamics Research | Presented at the Cover Crop Symposium on "Weed Management in Conservation Systems." Participants included growers, industry representatives, and professionals from universities and other government agencies. |
| AL | Soil Dynamics Research | Presented at the Central Alabama Crops Tour in Shorter on ongoing cover crop mixtures and weed suppression benefits from cove–r crops. Participants (~50) included growers, industry representatives, and professionals from universities and other government agencies. |
| AL | Soil Dynamics Research | Provided an overview of conservation system research and a tour of the soil bin facility to 12 Texas A&M AgriLife Extension agents visiting Alabama as part of a professional development tour. |
| AL | Soil Dynamics Research | Presented on-screening for drought and charcoal rot resistance at the Milan Field Day attended by approximately 2,000–3,000 growers, industry representatives, and professionals. |
| AR | Dale Bumpers Small Farms Research Center | Held stakeholder event to connect local agriculture members (Conservation Association, Farm Bureau, Beef Council, NRCS, Grazinglands Coalition, Extension Service, and local beef, sheep, and goat farmers). |
| AR | Dale Bumpers Small Farms Research Center | Presented at the Arkansas Forage and Grassland Council Fall Forage Conference. |

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| AR | Dale Bumpers Small Farms Research Center and Poultry Production and Product Safety Research | Co-hosted with University of Arkansas Tractor Assisted Guidance Field Day that demonstrated the potential usefulness and economic analysis of tractor-guided assistance. Extension agents, professors, USDA scientists/employees, industry personnel, and producers were in attendance. |
| AR | Harry K. Dupree Stuttgart National Aquaculture Research Center | Initiated and engaged in stakeholder meetings at four farms in North Carolina to listen to producer concerns; determine areas of research where ARS scientists could offer positive, effective assistance to the stakeholders and the domestic hybrid striped bass industry (the fourth largest food-fish grown industry in the U.S.), and gain a better understanding of production methods used by the farms to better assist their needs. |
| AR | Harry K. Dupree Stuttgart National Aquaculture Research Center | Engaged in a stakeholder meeting with a hybrid striped bass and red drum producer in Texas to discuss producer concerns; determine areas of research where ARS scientists could offer positive, effective assistance to the stakeholder to overcome areas of concern in the production of both fish species; and to deliver high-quality customer service and assistance. |
| AR | Harry K. Dupree Stuttgart National Aquaculture Research Center | Engaged in a stakeholder meeting with a fish producer in North Carolina who uses a bio-floc production system to grow fish for market. The Center conducts cutting-edge research on the system. The stakeholder visit was designed to listen to producer concerns and to determine areas of research where SNARC expertise could offer assistance to the customer. |
| AR | Poultry Production and Product Safety Research | Participated in a field day held at the University of Arkansas. Presented on how landscape attributes influence nutrient and water movement spatially. Approximately 75 extension agents, professors, USDA scientists, and industry personnel were in attendance. |
| AR | Poultry Production and Product Safety Research | Presented at the Arkansas Forage and Grassland Council Fall Forage Conference on carbon and nutrient dynamics of a bioenergy agroforestry system to 55 producers/industry personnel/stakeholders. |
| AR | Poultry Production and Product Safety Research | Hosted the 2018 stakeholder's meeting at the University of Arkansas Extension Office. The aim was to engage agricultural community stakeholders and to gain their input on developing, implementing, and evaluating our research programs. |
| AZ | Honey Bee Research | Held an open house for beekeepers and other stakeholders to familiarize stakeholders with research projects at the laboratory. |

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| AZ | Plant Physiology and Genetics Research | Held a focus group meeting to discuss current, ongoing, and future research. The meeting will enhance economic growth in rural communities and develop solutions to agricultural problems facing the Nation. The meeting provides a venue for stakeholders to offer ideas and suggestions on research direction and help maintain a strong relationship among scientists and stakeholders at the local, regional, and national levels. |
| AZ | Southwest Watershed Research | Presented to the U.S. Fish and Wildlife Buenos Aires Wildlife Refuge staff on the geomorphic legacy of water and erosion control structures in a semiarid rangeland watershed. |
| AZ | Southwest Watershed Research | Presented at NRCS Arizona Region 2 area wide winter operational meeting on "Structural Practices for Water and Sediment Control (Conservation Planning Considerations)." |
| AZ | Water Management and Conservation Research | Held a focus group meeting to discuss current, ongoing, and future research. The meeting will enhance economic growth in rural communities and develop solutions to agricultural problems facing the Nation. The meeting provides a venue for stakeholders to offer ideas and suggestions on research direction and help maintain a strong relationship among scientists and stakeholders at the local, regional, and national levels. |
| AZ | Water Management and Conservation Research | Advised growers on agronomic practice for the oil seed crop camelina. |
| AZ | Water Management and Conservation Research | Presented at the 2018 Yuma Southwest Ag Summit on "Working toward a Better Understanding of Crop Water Use in Desert Crop Production Systems" and "Innovations in Water and Nitrogen Management for Drip Irrigated Cotton." |
| CA | Commodity Protection and Quality Research | Presented at the Southern San Joaquin Valley Table Grape Seminar series. |
| CA | Contaminant Fate and Transport Research | Presented at the University of California "Desert Agriculture and Natural Resources Symposium" on informing local agricultural and natural resources professionals about salinity and water management research being conducted by ARS. |
| CA | Crops Pathology and Genetics Research | Presented at workshop on innovating global fruit and vegetable food systems to help bring sustainable nutrition security on environmental challenges and opportunities in fruit production. The workshop was organized by the Aspen Global Change Institute and was hosted at the Keystone Policy Center. The purpose of the workshop was to create a future vision for more sustainable and |

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| | | resilient fruit and vegetable food systems in a changing climate. |
| CA | Crops Pathology and Genetics Research | Presented to growers and private extension on effects of cover crops on wine grape production and soil health to stakeholders. The event was sponsored by Gallo, with approximately 40 people in attendance. |
| CA | Crops Pathology and Genetics Research | Presented at the "Peter Christensen 2-Day Short Course" (an education and outreach program sponsored by the Department of Viticulture and Enology at University of California, Davis) on the effects of vineyard floor management on wine grape production and wastewater management for irrigation to industry members, farmers, cooperative extension agents and research scientists. More than 300 were in attendance. |
| CA | Healthy Processed Foods Research | Presented a paper on "Stop! Food Waste" at the 31st Southern California Food Industry Conference. |
| CA | Invasive Species and Pollinator Health | Hosted field tour for University of California, Davis Cooperative Extension's Weed Day. Activities included short talks, demonstration displays for aquatic weed identification, and introduction to outdoor experiments on display and in progress. The tour included busloads of weed managers and other interested members of the public. |
| CA | Invasive Species and Pollinator Health | Presented field training, demonstrated and transferred technical information to State Park managers, State Park pesticide applicator/contractor field crew, and field biologist contractors and assistants on management techniques and procedures for active weed control and avoidance measures for conservation of threatened and endangered plant populations in wetland preserves. |
| CA | Invasive Species and Pollinator Health | Provided outreach expertise for University of California Picnic Day's weed science booth. Aquatic weeds such as water hyacinth and Brazilian egeria were on display. Experts answered general questions on weed identification, weed biology, and management of specific pest species. |

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| CA | Invasive Species and Pollinator Health | Co-chaired the Aquatic Weed School at University of California, Davis, an outreach workshop on the biology, ecology, and management of aquatic weeds targeted at resource managers and aquatic herbicide applicators. The workshop was filled to capacity with 80 registered attendees. |
| CA | Invasive Species and Pollinator Health | Presented to about 125 pesticide applicators and professional crop advisors at a Professional Applicators Professional Association training on basic concepts of biological control of invasive weeds of non-crop areas, past success stories, and current projects involving biological control agents of invasive weeds in California. |
| CA | Invasive Species and Pollinator Health | Presentation on the biological control of water hyacinth, followed by a release of the water hyacinth weevil and planthopper. The audience (25 people) consisted of scientists, managers, and senior administrators in State and local water management agencies, legislative staffers, and boat industry representatives. |
| CA | Invasive Species and Pollinator Health | Site visit/tour, presentation and transfer of technical information to Department of Water Resources Suisun Marsh and Native Fish Restoration program managers and scientists on identification of native and exotic *Phragmites* genotypes, management options for management of invasive *Phragmites australi,* and recovery of native emergent vegetation in the Blacklock Restoration Project and mitigation site. The invasion is compromising restoration goals for Delta smelt habitat and recovery. |
| CA | Invasive Species and Pollinator Health | Field tour, presentation and transfer of technical information to U.S. Fish & Wildlife Service and Regional Water Quality Control Board project managers on management options for controlling new invasion of *Ludwigia hexapetala* in the Clear Creek Restoration Project Area for restoration of historic stream channel alignment and salmonid habitat. |
| CA | Invasive Species and Pollinator Health | Keynote presentation to predominately resource, natural and agricultural land manager attendees at Oregon Department of Agriculture Noxious Weed Forum 2018: Water Primrose and Floating Yellowheart. Purpose was to provide education, discussion, and networking opportunities for groups and individuals working on control of these aquatic weed species. |

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| CA | Invasive Species and Pollinator Health | Presented information to State Park managers and weed management contractors on results of experimental trials, GPS-based mapping and assessment of weed management results at winter meeting of State Park Adaptive Management Team for comprehensive weed management for endangered species and tidal wetland recovery in the San Francisco Estuary. |
| CA | Water Reuse and Remediation Research | Presentation on recent research on salt tolerance in almonds at the almond conference. The conference was attended by almond growers, almond industry representatives, students, scientists, and other invited guests. |
| CA | Water Reuse and Remediation Research | Presented current research and provided tour of labs, greenhouses, and field experiments to Materra Farms. |
| DC | U.S. National Arboretum, Gardens Unit | Hosted a 1-day workshop to discuss strategies to control the invasive emerald ash borer. Attendees included scientists, landscapers, nursery professionals, extension agents, and staff from other public gardens. |
| DC | U.S. National Arboretum, Gardens Unit | Presented to the Northern Virginia Daylily Society and the Four Seasons Garden Club on "Modern daylily hybrids." |
| DC | U.S. National Arboretum, Gardens Unit | Presented to members of the North Carolina Herb Society on "Herbal Trees." |
| DC | U.S. National Arboretum, Gardens Unit | Presentation on "National Arboretum Azaleas—2007–2017" to members of two local chapters of the American Rhododendron Society. |
| DC | U.S. National Arboretum, Gardens Unit | Presentation on azalea cultivars, culture, and the collection to members of the Northern Virginia chapter of the Azalea Society. |
| DC | U.S. National Arboretum, Gardens Unit | Hosted an Aki Matsuri Festival, featuring tours of plant collections and demonstrations of Bonsai techniques. |
| FL | Invasive Plant Research Laboratory | Presentation and site tour to mixed group of professionals in the environmental field as part of the University of Florida training "Florida Lake Management Society Workshop." |
| FL | Invasive Plant Research Laboratory | Presentation and site tour for Big Cypress National Preserve park rangers. This information will assist rangers to further understand invasive plant issues that affect their areas and allow them to educate the public on these issues during tours of the park. |

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| FL | Subtropical Horticultural Research | Participated in a workshop on "Hurricane Preparedness and Recovery of Living Collections" at the University of Miami. Workshop resulted in a set of protocols and establishment of a network that will be useful to all participants. It brought together individuals from various institutions who have expertise in the management and value of tropical living plant collections both locally and nationally. |
| FL | Sugarcane Field Station | Co-hosted with the University of Florida a field day that toured field plots of the ARS cultivar development programs for the organic and sandy soils, and a discussion of yield improvement and disease resistance data collected from multiple years and locations. |
| GA | Bacterial Epidemiology and Antimicrobial Resistance Research | Participated, collaborated, and gave a presentation at the 2017 U.S.-Japan Natural Resources Panel working group on food safety |
| GA | Bacterial Epidemiology and Antimicrobial Resistance Research | Presented ARS food safety/environmental antimicrobial resistance research to industry/university/Federal agencies at the National Antimicrobial Resistance Monitoring System stakeholder meeting |
| GA | Bacterial Epidemiology and Antimicrobial Resistance Research | Presented food safety research to university/industry representatives at the ARS stakeholder meeting. The goal was to seek feedback from industry stakeholders on current issues and potential areas where further research is needed. |
| GA | Crop Genetics and Breeding Research | Presented research on Winter Crop Production Tour that included 3 stops (alfalfa and other crops used for forage; lupin and rye as covers within a cotton/peanut rotation; and *Brassica carinata* as a winter biofuel crop). Approximately 70 scientists, extension agents, and growers participated. |
| GA | Peanut Research | Hosted a small group from Severn Peanut Company from North Carolina. Discussed and highlighted ongoing research and demonstrated ongoing technology transfer related to the deployment of automation systems for the pneumatic sampler used to retrieve representative samples from farmers' stock peanuts. |
| GA | Peanut Research | Presented to the American Peanut Shellers Association during their facilitated brainstorming session on evaluating the shelling industry's research needs. |

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| GA | Peanut Research | Stakeholders interested in natural resource conservation toured the National Peanut Research Lab's research facility at the Hook's Hanner Environmental Resource Center to view conservation practices related to irrigation, land preparation, crop production, and ongoing research to reduce the environmental impact of producing peanuts, cotton, and corn in the humid southeastern United States. |
| IA | Agroecosystems Management Research | Presentation on "Using Cover Crops to Reduce Leaching Losses of Nitrate" at the National Conference on Cover Crops and Soil Health in Indianapolis, Indiana. Talk was attended by approximately 50 people. |
| IA | Agroecosystems Management Research | Presentation at the 17th Annual Iowa Organic Farming Conference on "Securing Tomorrow Today: Organic Leads the Way." |
| IA | Agroecosystems Management Research | Presentation for the Practical Farmers of Iowa 2018 Soils Short Course on "Alternative strategies for building soil health and enhancing ecosystems." More than 100 people participated in the short course, including farmers, representatives of nonprofit organizations, agriculture industry, and scientists. |
| IA | Agroecosystems Management Research | Presentation on the Agricultural Conservation Planning Framework ArcGIS toolbox to the Iowa Floodplain and Stormwater Management Association at their annual meeting. Most attendees were water resources consulting engineers and city/county planning staff. |
| IA | Agroecosystems Management Research | Presented information on cover crops at an NRCS, Iowa State University Extension, and Iowa Learning Farms Field Day. |
| IA | Agroecosystems Management Research | Held a stakeholder meeting and presented research to approximately 40 stakeholders. Research summaries for both units were presented, and selected presentations on watershed management tools and enhanced diets for swine and poultry were presented. |
| IA | Corn Insects and Crop Genetics Research | Presented at the first conference on Biotechnology at Universidad de Valle, Guatemala City, Guatemala, and met with corn breeders and producers. |
| IA | National Laboratory for Agriculture and the Environment | Participated in a field day sponsored by the Southfork Watershed Alliance in collaboration with the Iowa Soybean Association, Iowa Corn Growers Association, and Soil-Tek with exhibits, demonstrations, and presentations including installation of a saturated buffer, a blind inlet, and filter socks designed to reduce nutrient transport via tile drains and tile line surface inlets. |

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| IA | SOIL, WATER & AIR RESOURCES RESEARCH | Presented on-field evaluations of humic products at a conference organized by Central Iowa Agronomics. About 100 farmers and industry representatives were present. |
| IA | SOIL, WATER & AIR RESOURCES RESEARCH | Presented on-field evaluations of humic products at a conference organized by the Fertilizer Institute. About 250 industry representatives, crop consultants, university researchers, and State and Federal government employees were present. |
| IA | Soil, Water, and Air Resources Research | Presentation outlining 15 years of pesticide volatilization measurements was made at the Workshop on Protocols for Measurements of Emission of Pesticides into the Air in Agriculture in Montpellier, France. The technology is a micrometeorological approach to measuring pesticide volatilization losses to the atmosphere. The workshop was attended by 18 international experts on environmental and agricultural monitoring. |
| ID | Northwest Irrigation and Soils Research | Held a field day for the Idaho Dairymens Association on current long-term manure study. |
| ID | Northwest Irrigation and Soils Research | Discussed research studies about nutrient management and soil erosion with 12 members of the Twin Falls County Soil and Water Conservation District. |
| ID | Northwest Irrigation and Soils Research | Discussed research that has improved nutrient and disease management for sugar beet production and released breeding lines with excellent disease resistance and production traits with the Ukraine Company UKRPROMINVEST-AGRO. |
| ID | Northwest Irrigation and Soils Research | Presented on new static nitrogen management for sugar beet, and effects of manure on sugar beet production to Amalgamated Sugar Company. Attended by approximately 100 sugar beet growers present across all locations. |
| ID | Range Sheep Production Efficiency Research | Presented on "Leveraging Ewe Lambs to Increase Flock Productivity" at the West Central States Wool Growers Convention, which was attended by sheep/wool growers associations from Idaho, Nevada, Utah, and Wyoming. Approximately 280 producers and sheep industry representatives attended. The overall goal of the presentation was to demonstrate the production superiority of ewes that can lamb at 1 year of age. |

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| ID | Range Sheep Production Efficiency Research | Presentation on "Land-Use Research in the West" was given to the Montana Wool Growers Association Executive Board. The goal of the presentation was to describe current and potential research endeavors regarding land use and management strategies that involved sheep grazing. |
| ID | Range Sheep Production Efficiency Research | Presentation on "Leveraging Ewe Lambs to Increase Flock Productivity" was given at the American Sheep Industry Convention. Approximately 80 producers and sheep industry representatives attended. The overall goal of the presentation was to demonstrate the production superiority of ewes than can lamb at 1 year of age. |
| ID | Range Sheep Production Efficiency Research | Hosted a field day on using herbicides to control toxic lupine, demonstrated model application to predict post-fire recovery of shrubs, and provided an update on the sage grouse population at the ARS location and current rangeland research. Attendees were supervisory and field specialist personnel responsible for management of Bureau of Land Management lands in eastern Idaho. |
| IL | Global Change and Photosynthesis Research | Hosted a grape workshop and presented research on improving photosynthesis to grape growers and producers in the industry. |
| IL | Global Change and Photosynthesis Research | Presented to Illinois grain farmers at the University of Minnesota Extension in Minneapolis on preventing evolution of herbicide resistance. |
| IL | Soybean/Maize Germplasm, Pathology, and Genetics Research | On the Technical Advisory Board for Integrated Pest Management Innovation Lab. The meeting was held in Cambodia. |
| IL | Soybean/Maize Germplasm, Pathology, and Genetics Research | Participated in a planning meeting for a USAID project on soybeans. |
| KS | Hard Winter Wheat Genetics Research | Participated in the 2017 U.S. National Wheat Improvement Committee meeting. |
| KY | Food Animal Environmental Systems Research | Provided cover crop demonstration and information on the benefits of using cover crops at the Kentucky State University's Soil Health Assessment Use of Manure and Cover Crop in Small-Scale Farm Field Day. |
| KY | Forage-Animal Production Research | Provided information on research carried out at the Forage-Animal Production Research Unit at the University of Kentucky Beef Bash Field Day. |

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| KY | Forage-Animal Production Research | Presented at the Eastern Mississippi Sustainable Grazing Lands Initiative (SGLI) meeting on the benefits of legume isoflavones for grazing livestock. The SGLI meeting provides education to new farmers and focuses on veterans and small farms. Approximately 80 farmers were in attendance, the majority of whom were African American and other underrepresented minorities. |
| KY | Forage-Animal Production Research | Presented at the annual meeting of the American Forage & Grasslands Council on mitigation strategies for fescue toxicosis. The attendees include small and large ranchers, hay producers, cooperative extension professionals, scientists, educators, and their students. Approximately 100 people were in attendance. |
| KY | Forage-Animal Production Research | Presented at the annual meeting of the Fayette County Cattlemen's Association on the benefits of legume isoflavones for grazing livestock. Approximately 30 small farmers were in attendance. |
| LA | Honey Bee Breeding, Genetics, and Physiology Research | Presentation on research about the utility and field performance of honey bees with Varroa-sensitive hygienic behavior to approximately 100 members of the South Dakota Beekeepers Association. |
| LA | Sugarcane Research | Visited with a group of from Mitr Phol, a sugarcane research and processing group from Thailand. The group included the manager of sugar research and crop production, the manager of sugar technology, the senior expert of innovation and global sourcing, and the deputy manager of bio-based chemicals. The scientists discussed potential areas of collaboration and variety exchange. |
| LA | Sugarcane Research | Presented at the Louisiana Agricultural Technology and Management meeting on "A review of topramezone in sugarcane and potential carryover of post emergence soybean herbicides on plant cane." |
| LA | Sugarcane Research | Discussed with BASF on evaluating USDA planned and conducted field trials with Armezon for control of bermudagrass and other problematic weed species as well as sugarcane tolerance to Armezon. |
| MD | Crop Production and Protection | Presented at the North American Alfalfa Improvement Conference on the ARS National Plant Germplasm System to approximately 125 forage, pasture, and range plant seed company researchers, and university researchers. |
| MD | Food Components and Health Laboratory | Facility tour and research discussion with TTI/Vanguard, a professional society for technology and business leaders. |

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| MD | Food Components and Health Laboratory | Provided description of research activities and a tour of research facilities to stakeholders from The Beer Institute. |
| MD | Foreign Disease-Weed Science Research | Held a stakeholder and research community meeting with APHIS, Forest Service, National Ornamentals Research Site at Dominican, California Department of Food and Agriculture, AmericanHort, Oregon State and Washington State Universities to present research reports and outreach activities. |
| MD | Foreign Disease-Weed Science Research | Presented at the boxwood management meeting hosted by the American Boxwood Society to communicate results of ARS research on boxwood blight disease in the United States. |
| MD | Genetic Improvement for Fruit and Vegetables Laboratory | Presentation to growers at the annual North American Strawberry Growers Association to approximately 120 farmers. |
| MD | Genetic Improvement for Fruit and Vegetables Laboratory | Presentation to owners of farms and small farms at Virginia Beach Strawberry Field Walk, New Growers Workshop and Strawberry School and Trade Show. Around 80 farmers were present. |
| MD | Genetic Improvement for Fruit and Vegetables Laboratory | Presented at the Chesapeake Foodshed meeting of the Chesapeake Alliance for Sustainable Agriculture. Around 50 farmers attended. |
| MD | Genetic Improvement for Fruit and Vegetables Laboratory | Presented owners of small farms at the Bob Rouse Agriculturalist's Grower Client Meeting on research results on microenvironmental effects on strawberry yield in the low-tunnel production system. |
| MD | National Agricultural Library | Exhibited at the USDA Agriculture Outlook Forum. An opportunity for outreach to all USDA agencies represented and participants from academia and industry. |
| MD | National Agricultural Library | Hosted Wikipedia Edit-a-Thon to introduce ARS pages, resources, and information to the Wikipedia community. |
| MD | U.S. National Arboretum, Floral and Nursery Plants Research | Presented at a boxwood management seminar hosted by the American Boxwood Society. Attendees included U.S. and international nursery growers, landscape architects, industry professionals, university and ARS scientists, and leaders from AmericanHort, ARS, and APHIS. |
| MD | U.S. National Arboretum, Floral and Nursery Plants Research | Presentation on native trees and shrubs for the landscape to a group of 75 members of the Halifax County (VA) Cooperative Extension Program. |
| MD | U.S. National Arboretum, Floral and Nursery Plants Research | Hosted a booth at the Mid-Atlantic Trade Show (MANTS) in Baltimore, Maryland, where more than 11,565 attendees from the nursery and allied industries gathered to view products from 963 vendors. The |

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| | | outcome was meeting new and reconnecting with existing stakeholders and hearing about problems, challenges, and pressing needs of the industry. |
| MI | Sugarbeet and Bean Research | Participation in development and presentation of hands-on activities and informational displays for Fascination of Plants Day, which was 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 200 people (doubled attendance of previous year) attended this activity. |
| MI | Sugarbeet and Bean Research | Participated in the annual Michigan State University Autumnfest. |
| MN | Soil Management Research | Presented results from interseeding camelina and pennycress in corn and soybean at North Dakota State University's Utilizing Cover Crops in Farming Systems Field Day. |
| MN | Soil Management Research | Presented on the benefits of cover crops and alternative oilseeds to pollinators at an NRCS field day. |
| MN | Soil Management Research | Presented at Camelina Field Day on Winter camelina as a cash cover crop. |
| MN | Soil Management Research | Presented Carrington Research Extension Center's field day on ancient grains for modern times. |
| MN | Soil Management Research | Conducted a field tour and demonstrations on soil health at the Sustainable Farming Association of Minnesota's Soil Health Field Day. |
| MN | Soil Management Research | Demonstrated soil health and aggregate stability at Grant County Soil and Water Conservation District's No-Till Cover Crop Demonstration Field Day. |
| MN | Soil Management Research | Hosted a regional stakeholder workshop "Promoting a more resilient agricultural industry in the Upper Midwest." |
| MN | Soil Management Research | Presentation on understanding, recognizing, and improving soil health for erosion control and water quality at the Minnesota Erosion Control Association annual conference. |
| MN | Soil Management Research | Presentation on "Dual purpose cover crops and onsite retention water and nutrients" at the Minnesota Environmental Health Association Winter Conference. Approximately 150 people from government, academia and industry attended. |

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| MS | Crop Genetics Research | Presented to the Mid-South Soybean Promotion Board on ongoing soybean research focused on reducing mature soybean seed damage. |
| MS | Crop Genetics Research | Highlighted the development of ARS soybean germplasm with new source of nematode resistance at the University of Tennessee's No-till Field Day to more than 160 soybean growers. |
| MS | Crop Genetics Research | Participated in discussions regarding research progress and future research needs with representatives from the Mississippi Soybean Promotion Board. |
| MS | Southern Horticultural Research | Hosted Muscadine Field Day and presented research results on muscadine grapes. |
| MS | Southern Horticultural Research | Hosted Blueberry Field Day with educational talks for growers and potential growers with a tour of new blueberry cultivars. |
| MS | Southern Horticultural Research | Presentations on current research at the Mississippi State Ornamental Field Day. |
| MS | Southern Horticultural Research | Presented on current and future genetic research to Blueberry Grower Council meeting. |
| MS | Water Quality and Ecology Research | Gave a laboratory tour and presentation of ongoing research involving measurement of nitrogen fluxes and planned field-scale applications of novel methods to maximize denitrification to Cotton Incorporated. |
| MS | Crop Genetics Research | Presented screening for drought and charcoal rot resistance at the Milan Field Day attended by approximately 2,000–3,000 growers, industry representatives, and professionals. |
| MT | Range and Livestock Research | Participated in the annual meeting of the Northern Great Plains Society of Rangeland Management. |
| MT | Range and Livestock Research | Presented to producers about drought during the Prairie County tour. |
| MT | Range and Livestock Research | Participated in the annual meeting of the Montana Audubon Association. |
| MT | Range and Livestock Research | Presented at the Joint Thunder Basin Research Initiative-U.S. Forest Service meeting on "Use of *Pseudomonus* bacteria for downy brome/cheatgrass control." |
| MT | Range and Livestock Research | Attendance of the National Cattleman's Beef Association annual meeting. |
| MT | Range and Livestock Research | Hosted an annual customer focus group to discuss current research and what research would be useful in the future. |
| ND | Natural Resource Management Research | Co-hosted with North Dakota State University, Bismarck State College, and NRCS "Farming & Ranching for the Bottom Line Family Farmer and Rancher" workshop that highlighted drought mitigation strategies. |

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| ND | Natural Resource Management Research | Taught courses for the Bureau of Land Management courses at their National Training Center in Reno, NV. |
| ND | Natural Resource Management Research | Hosted a customer focus group to provide input to help ask better questions to meet the needs of family farmers and ranchers. |
| NY | Emerging Pests and Pathogens Research | Presented research results at the New York State Farm Show. |
| OH | Application Technology Research | Presentation at the Ohio Grape and Wine Conference on "New Intelligent Spray Technology in Vineyard." |
| OH | Corn, Soybean, and Wheat Quality Research | Held Annual Research Review and Soft Wheat Quality Council Meeting and presented on "High Molecular Weight Glutenin Subunit and Rye Translocation Profiles of Eastern Soft Wheat Varieties, and their Influences on Protein Characteristics," "Pre-Harvest Sprouting Resistance of Soft Winter Wheats," and "The Historic Diversity Soft Wheat Population has a Wide Range in Pre-Harvest Sprouting Resistance under Natural or Artificial Conditions." The meeting also included a tour of the soft wheat quality laboratory and workshop. |
| OH | Soil Drainage Research | Presentation at the Ohio Pork Congress on reducing nutrient movement: data from edge of field studies. |
| OH | Soil Drainage Research | Presentation on "Unmanned Aerial Vehicle (UAV) Surveys for Drainage Applications" at the Overholt Drainage School. Attended by 15 drainage contractors. |
| OH | Soil Drainage Research | Presentation on "Mapping Agricultural Subsurface Drainage with Remote Sensing" at the Ohio Land Improvement Contractors of America Annual Convention. Attended by 40 drainage contractors. |
| OH | Soil Drainage Research | Presentation on "Mapping Drainage Pipes with UAV Thermal Infrared Imagery: A Case Study" at the Agricultural Drainage Management Systems Task Force meeting. |
| OH | Soil Drainage Research | Presentation on "Findings from the Edge-of-Field Research Network" at an Ohio Farm Bureau meeting. |
| OH | Soil Drainage Research | Presentation on the influence of planting grass filter strips on headwater fish populations in channelized agricultural headwater streams at the Upper Midwest Stream Restoration Symposium. |
| OH | Soil Drainage Research | Presentation on "Headwater Fish Population Responses to Planting Grass filter Strips Adjacent to Channelized Agricultural Headwater Streams" at the annual meeting of the Society for Ecological Restoration's Midwest-Great Lakes Chapter. |

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| OH | Soil Drainage Research | Presentation on evaluating the Recycle, Reduce, Reuse, and Recreate (4R) nutrient stewardship concept and certification program in the Western Lake Erie Basin to approximately 75 fertilizer industry, certified crop consultants, researchers, and extension specialists. |
| OH | Soil Drainage Research | Provided webinar on using edge-of-field research to assess agricultural management practices to 25 certified crop advisors. |
| OH | Soil Drainage Research | Presentation on using edge-of-field research to assess conservation management and water quality to 50 producers, commodity staff, and ag industry professionals at Ohio Corn, Wheat, and Soybean Annual Growers Meeting. |
| OH | Soil Drainage Research | Presentation on "Evaluating Best Management Practices for Nutrient Management in the Lake Erie Catchment" to 50 researchers, policymakers, and stakeholders at Northern Ireland's Agri-Food and Biosciences Institute phosphorus workshop. |
| OH | Soil Drainage Research | Presentation on "Instrumentation, Measurement and Findings from the USDA-ARS Edge-of-Field Research Network" to 20 phosphorus researchers, modelers, and stakeholders at Phosphorus Alliance Workshop. |
| OK | Great Plains Agroclimate and Natural Resources Research | Provided research results to stakeholders at the Ag Amarillo Farm and Ranch Show. |
| OK | Great Plains Agroclimate and Natural Resources Research | Co-hosted a technical workshop on Drought and Seasonal Forecasting Tools. Participants represented multiple Federal and State agencies, land-grant universities, water management districts, and other interests. |
| OK | Great Plains Agroclimate and Natural Resources Research | Assisted the South-Central Climate Science Center in developing a hands-on vulnerability assessment workshop for the Delaware Nation and the Shawnee Tribes of Oklahoma. The workshop assessed ways the tribes can better prepare the farming and ranching operations of the tribes and their tribal members to the extreme weather events being exacerbated by our changing climate. |
| OK | Great Plains Agroclimate and Natural Resources Research | Co-hosted with the University of Oklahoma the Southern Plains Wildfire Forum. More than 110 attendees representing producers, fire chiefs, local and State officials, and USDA agencies learned about strategies to lessen the danger of wildfire on their agriculture operations and resources to assist with wildfire recovery. |

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| OK | Great Plains Agroclimate and Natural Resources Research | Participated in the Texas Association of Soil & Water Conservation Districts Conservation Board meeting. Participants included Texas Natural Resource and Conservation Service employees and board members of the Texas Soil and Water Conservation Board. |
| OK | Great Plains Agroclimate and Natural Resources Research | Participated in Soil Health Field Day and discussed benefits of soil health as a tool for helping producers deal with extreme weather events. |
| OK | Great Plains Agroclimate and Natural Resources Research | Co-hosted the Ogallala Collaborative Agricultural Project and National Integrated Drought Information System a Oklahoma panhandle stakeholder listening session. Attendee were from USDA, extension programs, groundwater and conservation districts, and others in a four-State area engaged in semi-structured discussions around issues of drought, wildfire, and water availability. |
| OK | Great Plains Agroclimate and Natural Resources Research | Hosted a meeting of the Society for Range Management's Native American Rangeland Training Initiative. Attendees representing NRCS, State and local conservation district associations, Cheyenne and Arapaho Tribes, Noble Research Institute, and academia participated in a half-day set of discussions aimed at implementing the initiative in Oklahoma through upcoming Tribal workshops and online education material development. |
| OK | Hydraulic Engineering Research | Participated in the Oklahoma Association of Conservation Districts Annual State Meeting. Interacted with stakeholders and provide information on current research. |
| OK | Rangeland and Pasture Research | Held annual stakeholder meeting. The 21 stakeholders in attendance heard presentations from ARS scientists on their current research and what they would like to research in the future. The stakeholders then expressed what they would like to see accomplished at our location. |
| OR | Forage Seed and Cereal Research | Presentation on epidemiology of powdery mildew to the Oregon Hop Commissions. |
| OR | Horticultural Crops Research | Hosted a workshop on fungicide resistance and fruit rot to blueberry growers and packers. |
| OR | Horticultural Crops Research | Presented information on the plant pathogen *Botrytis cinerea* and its resistance to fungicides at the Oregon Blueberry Conference. |
| OR | Horticultural Crops Research | Presented and discussed information on the plant diseases gray mold *(Botrytis),* crown gall *(Agrobacterium* spp.), and silver leaf *(Chondrostereum purpurea)* and their management at the AgriCare blueberry agronomy meeting. |

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| OR | Horticultural Crops Research | Presentation on the plant pathogen *Botrytis cinerea*, disease management, and fungicide resistance during the Oregon Berry Packing Growers annual meeting. |
| OR | Horticultural Crops Research | Presentation at "Strawberry Field Day" event about the plant pathogen *Botrytis cinerea* and its resistance to fungicides. |
| OR | Horticultural Crops Research | Presentation at "Blueberry Field Day" event about crown gall outbreak on blueberry. |
| OR | Horticultural Crops Research | Presentation on assessing and managing nitrogen in vineyards during Virginia Vineyards Association annual meeting |
| OR | Horticultural Crops Research | Presentation on the phosphorus and potassium requirements of grapevines during Virginia Vineyards Association annual meeting. |
| OR | Horticultural Crops Research | Presentation on managing nutrition in wine grape vineyards to Rogue Valley Winegrowers Association. |
| OR | Horticultural Crops Research | Presented on methods for monitoring, managing, and mitigating fungicide resistance to the Napa wine grape growers. |
| OR | Horticultural Crops Research | Presented on methods for monitoring, managing, and mitigating fungicide resistance to Sonoma wine grape growers. |
| OR | Horticultural Crops Research | Presented the conceptual framework of building a cyber-physical system for risk management that strategic planning session between the grape industry and ARS during National Grape Wine Initiative. |
| OR | Horticultural Crops Research | Presented research results on monitoring for fungicide resistant grape powdery mildew, fungicide mobility, and phenological timing to Walla Walla small fruit producers. |
| OR | Horticultural Crops Research | Presented to growers on the presence and distribution of fungicide-resistant grape powdery mildew and methods for mitigation at the Long Grower meeting. |
| OR | Horticultural Crops Research | Presentation on causes and management of fungicide resistance and methods for mitigation at OVS, Inc. small fruit grower meeting. |
| OR | Horticultural Crops Research | Updated growers on the presence and distribution of fungicide resistant grape powdery mildew and methods for mitigation at OVS, Inc. grape grower meeting |
| OR | Horticultural Crops Research | Presented research results related to berry breeding and discussed ongoing research at the Lower Mainland Horticultural Improvement Association annual meeting |
| OR | Horticultural Crops Research | Participated in a strategic planning meeting on how to respond to Quinone Outside Inhibitor (QoI) and Demethylation Inhibitors (DMI) resistant grape powdery mildew at University of California Cooperative Extension. |

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| OR | Horticultural Crops Research | Educational program on berry breeding to Sant Orsola growers. |
| OR | Horticultural Crops Research | Presented a workshop to nursery growers at OktoberPest series on pest management at the North Willamette Research and Education Center. |
| OR | Horticultural Crops Research | Presented results on funded research in raspberry breeding and new blossom disease and cane diseases of red raspberry at the Washington Red Raspberry Commission. |
| OR | Horticultural Crops Research | Presented results on funded research in strawberry breeding at the Washington Strawberry Commission meeting. |
| OR | Horticultural Crops Research | Presented results on funded research in blueberry breeding at the Washington Blueberry Commission meeting. |
| OR | Horticultural Crops Research | Presented on strawberry breeding during Northwest Berry Foundation meeting. |
| OR | Horticultural Crops Research | Presented results of ongoing berry breeding research to commercial berry industry at the Lynden Small Fruit Conference. |
| OR | Horticultural Crops Research | Presentation on use of natural enemies and bankers in nursery production at the Oregon Association of Nurseries. |
| OR | Horticultural Crops Research | Presented results of ongoing berry breeding research to commercial berry industry at the Oregon Raspberry and Blackberry Commission. |
| OR | Horticultural Crops Research | Presented research results related to blueberry breeding and discussed ongoing research at Oregon Blueberry Commission. |
| OR | Horticultural Crops Research | Provided updates on fungicide resistance monitoring and best practices for management and mitigation to the LIVE, Inc. Technical Committee. |
| OR | Horticultural Crops Research | Presentations on managing nitrogen inputs in the vineyard and winery and impacts of mycorrhizal fungi on grapevine growth and nutrient uptake and on monitoring for fungicide resistance and timing of mobile fungicides during Grape Day at Oregon State University. |
| OR | National Clonal Germplasm Repository | Presented to the North American Raspberry & Blackberry Association on the contributions of the *Rubus* germplasm to international research. |
| OR | National Clonal Germplasm Repository | Hosted a tour to approximately 30 visitors from Azerbaijan (hazelnut growers, nurserymen, equipment vendors to USAID). |
| OR | National Clonal Germplasm Repository | Presented results of an industry-funded pear rootstock project at the Pear Research Review. |

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| OR | National Clonal Germplasm Repository | Presented on germplasm activities to plant pathology and quarantine stakeholders in Washington, D.C. |
| OR | National Clonal Germplasm Repository | Hosted a stakeholder meeting with about 23 attendees. |
| PA | Pasture Systems & Watershed Management Research | Presented Pennsylvania Ag Progress Days research on a behavioral recorder, forward-looking infrared camera, drone, field portable ion chromatography instrument, and tangible landscape geospatial modeling technologies. Attended by approximately 45,000 producers and the general public. |
| PR | Tropical Crops and Germplasm Research | Presented information on research in tropical and subtropical fruits and ornamental crops, and the control and eradication of exotic plant insects at Community Day. |
| TN | Floral and Nursery Plants Research | Participated in the annual Tennessee State University Nursery Research Field Day. |
| TX | Grassland Soil and Water Research Laboratory | Hosted a field day with tours of grassland and cropping systems research encompassing 10 presentations. Attended by approximately 85 local farmers, crop consultants, and researchers from universities and State and Federal agencies throughout central Texas. |
| TX | Livestock Arthropod Pest Research | Presented research results in support of the Cattle Fever Tick Eradication Program to APHIS and Texas Animal Health Commission program leaders. |
| UT | Pollinating Insect-Biology, Management, and Systematics Research | Presented "Landscaping for native bees: floral options that work" at the annual Utah Green Conference and Trade Show. |
| UT | Pollinating Insect-Biology, Management, and Systematics Research | Presented "Two honey bee visits satisfies red raspberry pollination, and how to measure bee stocking densities" at the North American Raspberry & Blackberry Conference. |
| WA | Northwest Sustainable Agroecosytems Research | Presentation on management practices and technologies associated with soil health testing and interpretation of the tests for enhancing soil health to 500 customers representing agricultural producers, agribusiness, NRCS, other agencies, and Washington State University personnel. |
| WA | Northwest Sustainable Agroecosytems Research | Hosted a soil health workshop on wind erosion control technologies. About 75 farmers and agribusinesses attended. |
| WA | Northwest Sustainable Agroecosytems Research | Presented at the quarterly meetings of the Washington State Food and Agriculture Council and NRCS Technical Advisory Committee on research activities regarding wind erosion and soil health. |

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| WA | Physiology and Pathology of Tree Fruits Research | Presented at the Washington State Fruit Association annual meeting on recent research results in the areas of soil management, fruit tree genomics, fruit physiology and molecular biology, and apple fruit storage technology. |
| WA | Physiology and Pathology of Tree Fruits Research | Presented at the Washington Tree Fruit Research Commission Technology Research Review on current research in apple and pear fruit postharvest biology. |
| WA | Physiology and Pathology of Tree Fruits Research | Presented at the Pacific Northwest Pear Committee Research Review on current research in pear fruit postharvest biology. |
| WA | Physiology and Pathology of Tree Fruits Research | Presented at the Washington Tree Fruit Research Commission Apple Horticulture and Crop Protection Research Review on current research in the areas of plant pathology and postharvest biology of apple. |
| WA | Physiology and Pathology of Tree Fruits Research | Presented at the Pace International Postharvest Academy on current research regarding postharvest biology of apple fruit. |
| WA | Physiology and Pathology of Tree Fruits Research | Presentation on 'Honeycrisp' apple storage management to employees of a fruit warehouse. |
| WA | Physiology and Pathology of Tree Fruits Research | Presentation on apple and pear fruit storage management to a group of fruit growers from Spain. |
| WA | Temperate Tree Fruit and Vegetable Research | Presented research results to pear growers at the North Central Washington Pear Day. |
| WA | Temperate Tree Fruit and Vegetable Research | Presented research results to potato growers at the Washington/Oregon Potato Conference. |
| WA | Wheat Health, Genetics, and Quality Research | Presented to the Wine Research Advisory Committee on the characterization of indigenous yeasts associated with wine grapes and early stage fermentations. |
| WA | Wheat Health, Genetics, and Quality Research | Presented 3-minute radio broadcasts and podcasts for the Washington State Ag Network website. |
| WI | Vegetable Crops Research | Presented an interactive booth to educate the general public about distinct pollinators and how pollinators influence the food the general public consumes at the Wisconsin Science Festival in Madison. |
| WI | Vegetable Crops Research | Presented an interactive booth for the general public to learn to distinguish bees from wasps and other insects, learn about differences in life histories between bumble bees and honey bees and between social and solitary bees and demonstrate methods to help preserve these distinct bees at the Science Expeditions in Madison. |

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| WV | Cool and Cold Water Aquaculture Research | Hosted approximately 60 members of the U.S. Trout Farmers Association as part of their annual fall conference. Each scientist provided a brief overview presentation of their research followed by walking tours of the broodstock building, main hatchery, fish health lab, and research laboratories. |
| WV | Cool and Cold Water Aquaculture Research | Discussed with two West Virginia Department of Natural Resources employees on recommendations on how to fix their sedimentation and water quality problems in their brook trout raceways. |
| WV | Innovative Fruit Production, Improvement and Protection | Presented at the Ag Innovation Showcase on USDA involvement in the Patriot Gardens joint project with the National Guard and on plant breeding research for improved varieties and disease resistance. |

## 3.8. FY 2018 Technology Transfer Award Winners

## Federal Laboratory Consortium for Technology Transfer (FLC) Awards

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

***Title:*** Purification and Recycling Wastewater in Space and Decentralized Wastewater Systems

***Award:*** National Excellence in Technology Transfer Award

***Lab:*** Southwest Watershed Research Center, Tucson, Arizona, with EPA, National Interagency Fire Center, Bureau of Land Management, National Weather Service, and University of Arizona

***Title:*** Automated Geospatial Watershed Assessment Tool Streamlines Burn Area Emergency Response Efforts

***Award:*** National Interagency Partnership Award

***Office:*** Office of Technology Transfer, Beltsville, Maryland

***Name***: Mojdeh Bahar

***Award:*** National Harold Metcalf Award

***Lab:*** U.S. Dairy Forage Research Center, Madison, Wisconsin

***Title:*** Starch Analysis and Application for Animal Feeds and Pet Foods

***Award:*** FLC Midwest Region, Excellence in Technology Transfer Award

***Lab:*** Inouye Pacific Basin Agricultural Research Center, Hilo, Hawaii, with the U.S. Forest Service and University of Hawaii

***Title:*** Discovery, Diagnosis, and Distribution of Educational Material on Rapid Ohi`a Death

***Award:*** FLC Far West Region, Outstanding Partnership Award

***Lab:*** Forage Seed and Cereal Research Unit, Corvallis, Oregon

***Title:*** Pacific Northwest Biochar Atlas

***Award:*** FLC Far West Region, Outstanding Partnership Award

***Lab:*** Appalachian Fruit Research Station, Kearneysville, West Virginia, and Beneficial Insects Introduction Research Laboratory, Beltsville, Maryland, with Cornell University, North Carolina State University, Oregon State University, Pennsylvania State University, Rutgers University, University of Delaware, University of Maryland, Virginia Polytechnic Institute and State University, and Washington State University

***Title:*** Specialty Crop Initiative Coordinated Agriculture Project—the Brown Marmorated Stink Bug

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

***Lab:*** Genetics, Breeding, and Animal Health Research, Clay Center, Nebraska

***Title:*** Combining Technologies to Transfer a Reference Genome Assembly in Cattle

***Award:*** Mid-Continent Region, Regional Partnership Award

***Lab:*** Meat Safety & Quality Research: Clay Center, Nebraska

***Title:*** Novel Sampling Methods for Beef Trim Pathogen Testing

***Award:*** Mid-Continent Region, Excellence in Technology Transfer Award

### 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 lower number of CRADAs is because some collaborative research that was previous carried out under a CRADA is now carried out an MTRA.

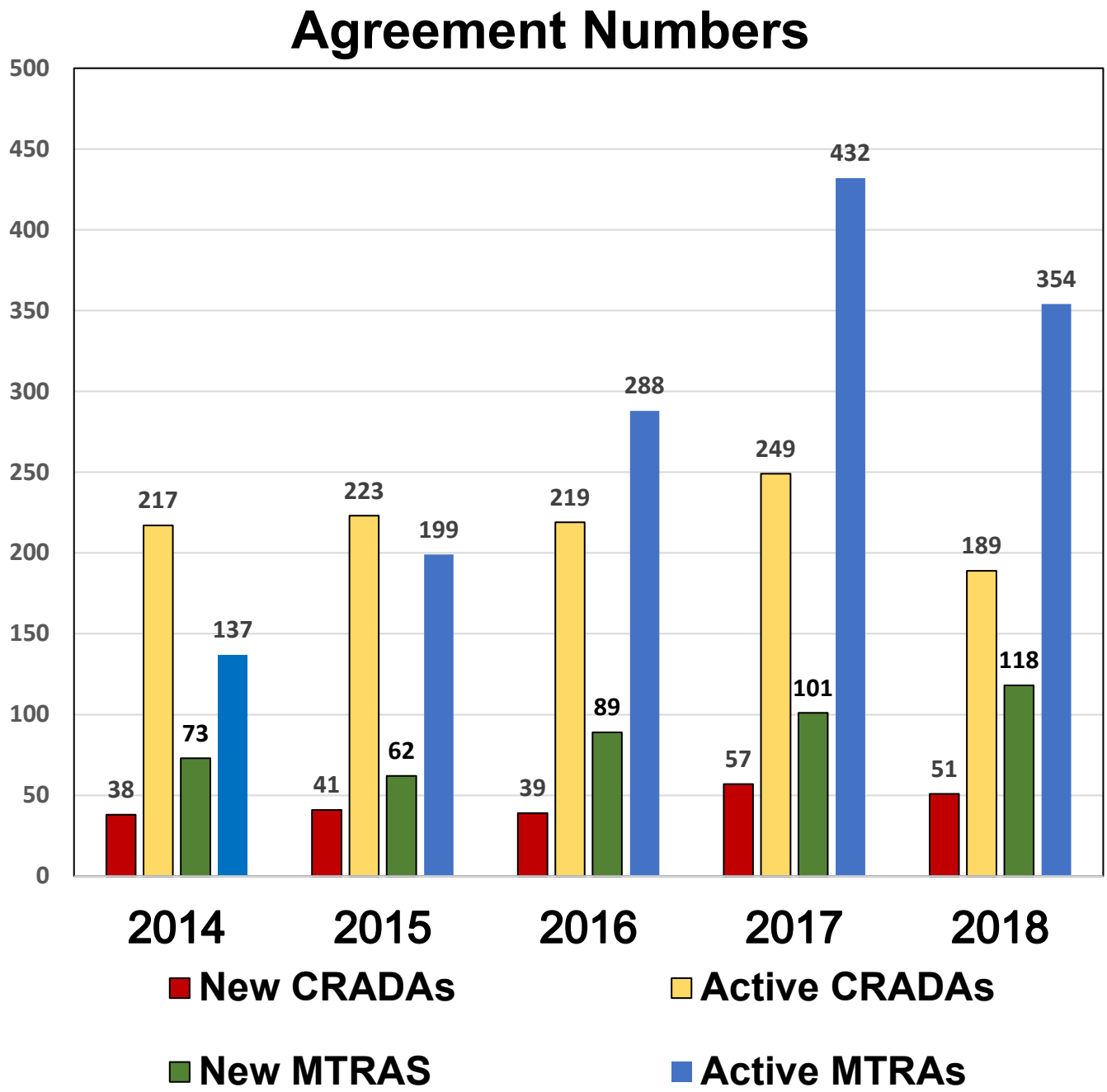


**Figure 2.** Number of collaborative research agreements (Cooperative Research and Development Agreements [CRADAs], Material Transfer Research Agreements [MTRAs], Material Transfer Agreements [MTAs], and others) executed by type in FY 2018.

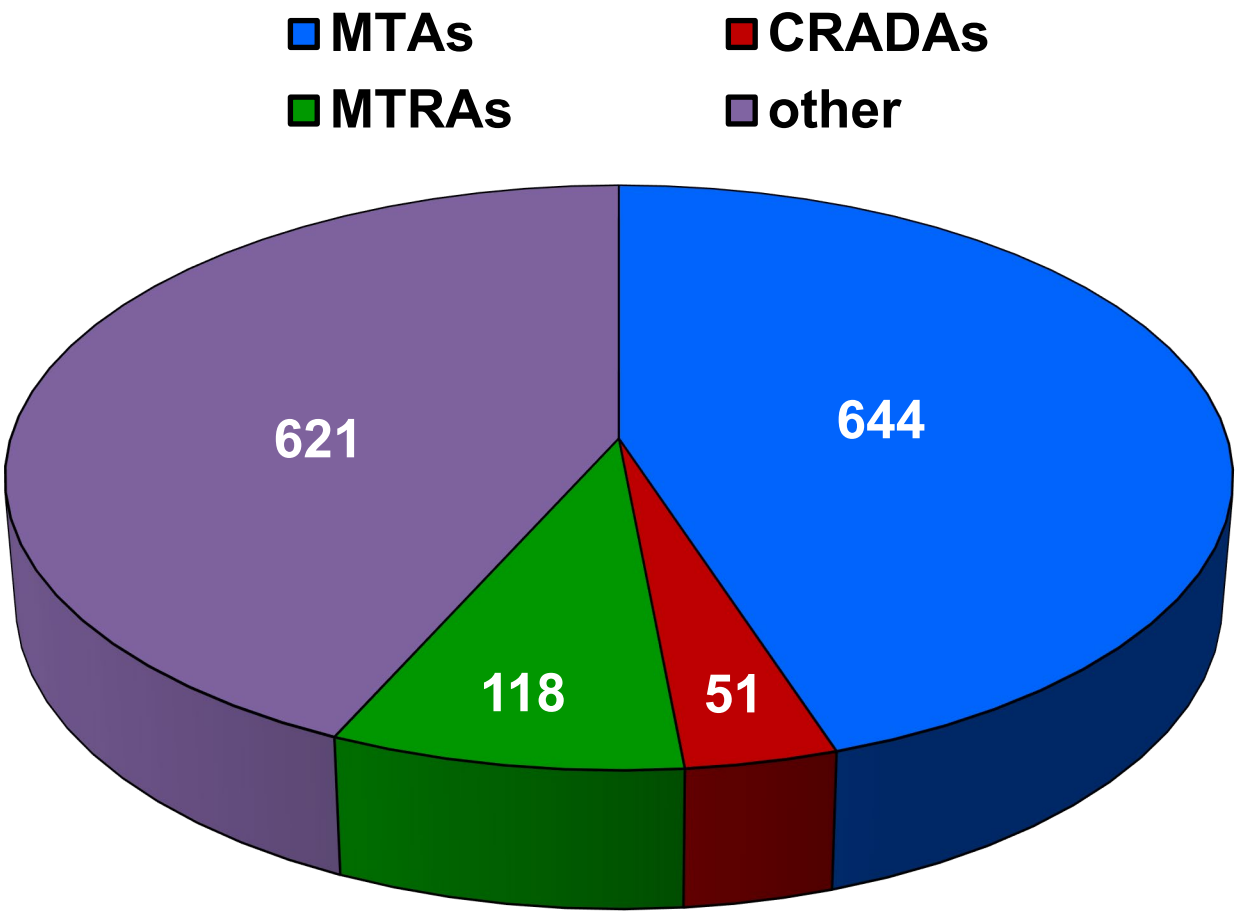


**Figure 3.** Number of NIFA-SBIR Phase I proposals submitted and funded per year for ARS CRADA partners. NIFA-SBIR receives a total of ~500 proposal and funds ~80.

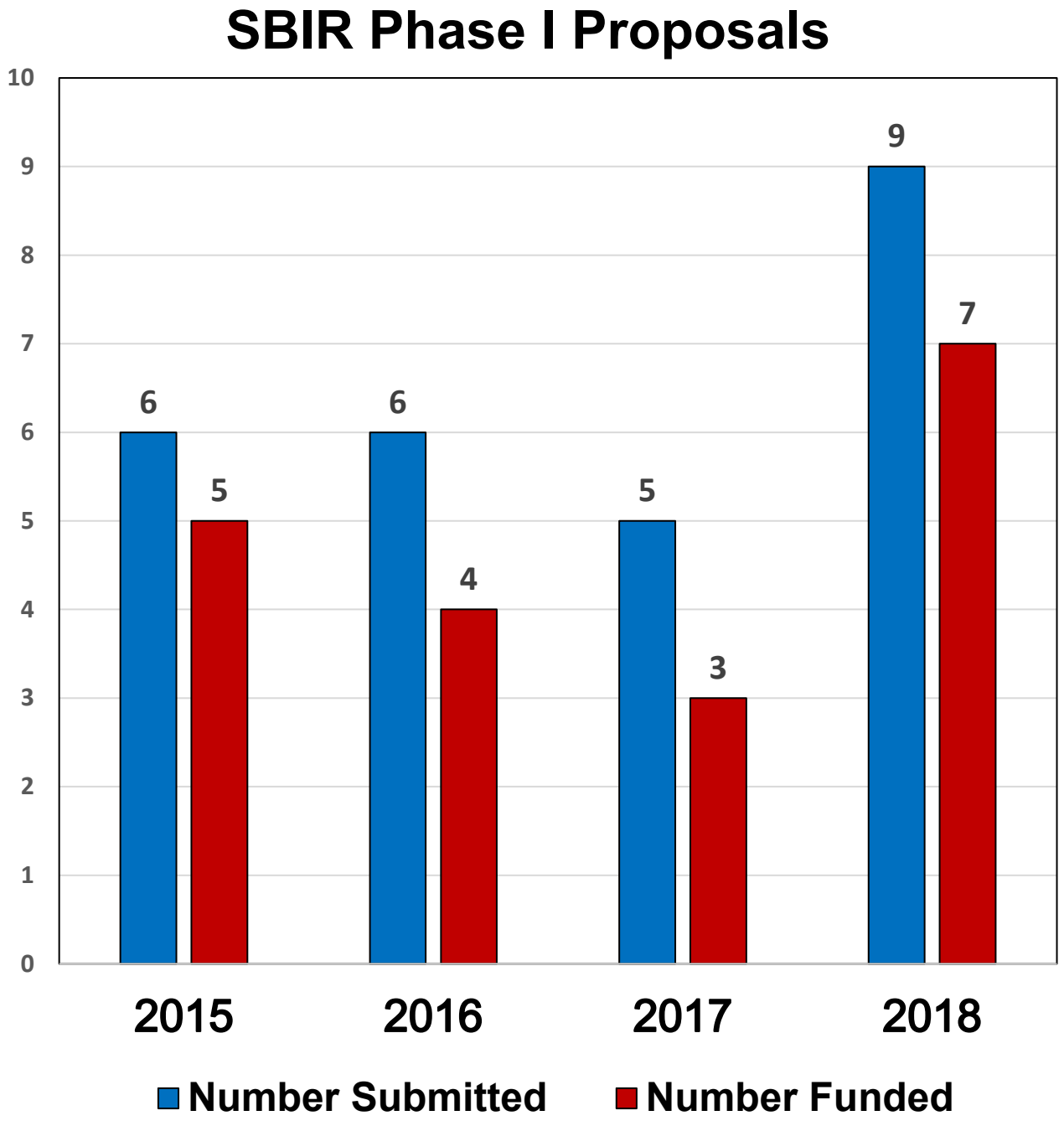



**Figure 4.** Number of invention disclosures, patent applications filed, and patents issued. The year in which a patent issues is not the year in which the patent is filed. The increase

in the number of invention disclosures in FY 2018 was the result of a significant increase in biological materials disclosures.

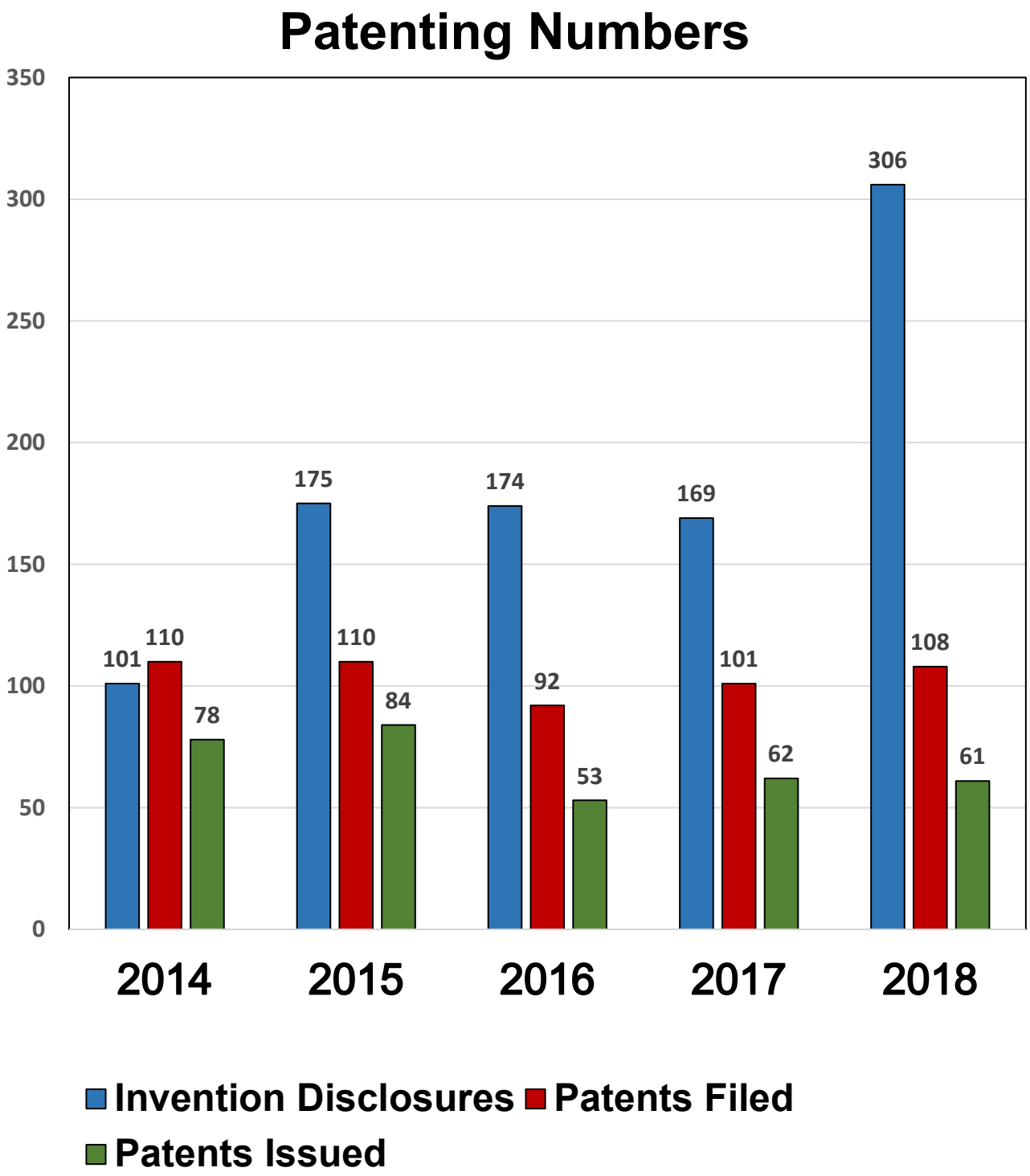


**Figure 5.** Percentage of patents issued in FY 2018 by scientific discipline.

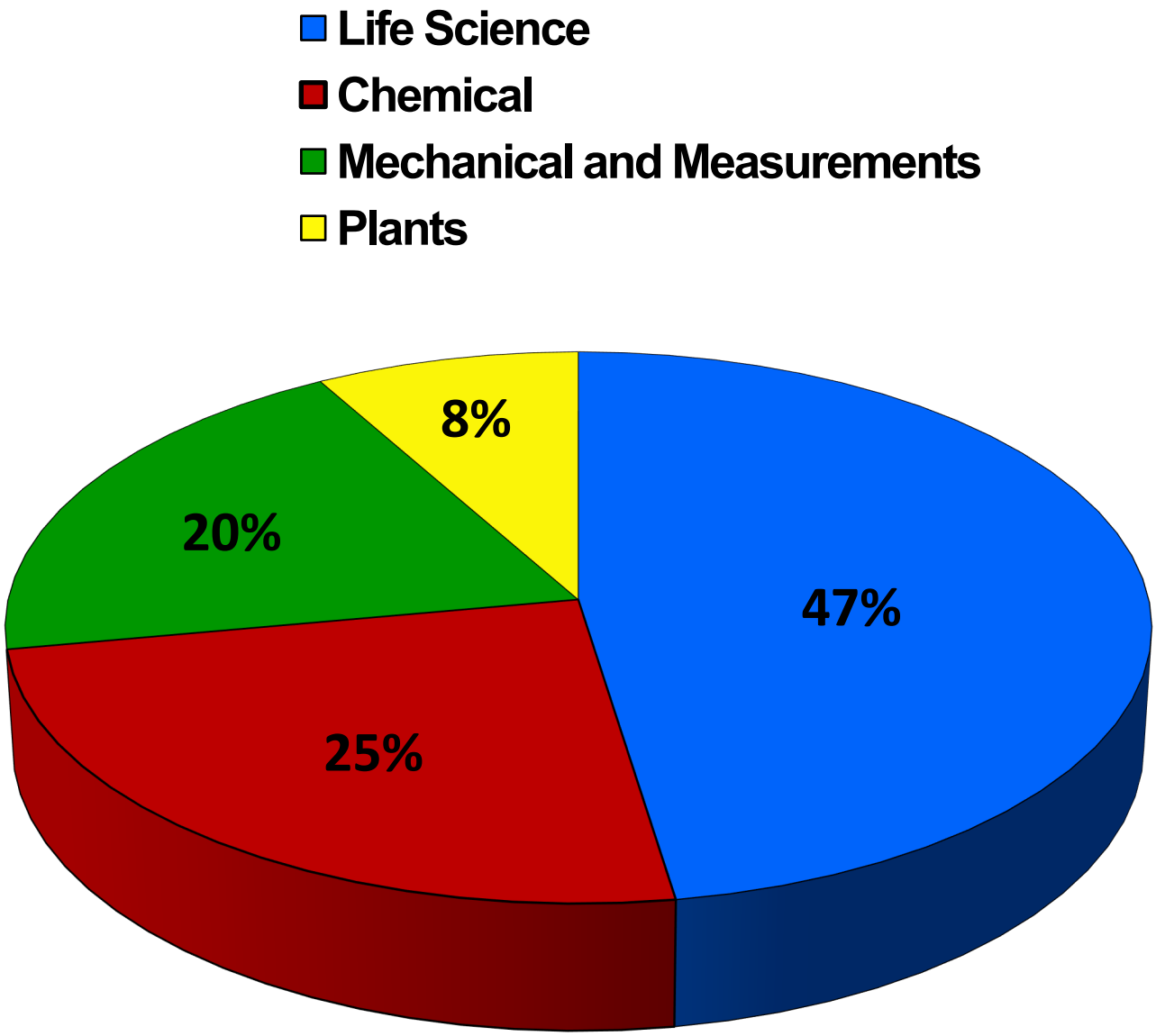


**Figure 6.** The ratio of patents issued over patent applications filed per year. Although the year in which a patent is issued is not typically the year in which the patent application is filed, over time the ratio of patents issued over the number of patent applications filed is an indicator of "judicious" patenting. Over the last 3 years, this indicator suggests that ~60 percent of the patent applications result in an issued patent.

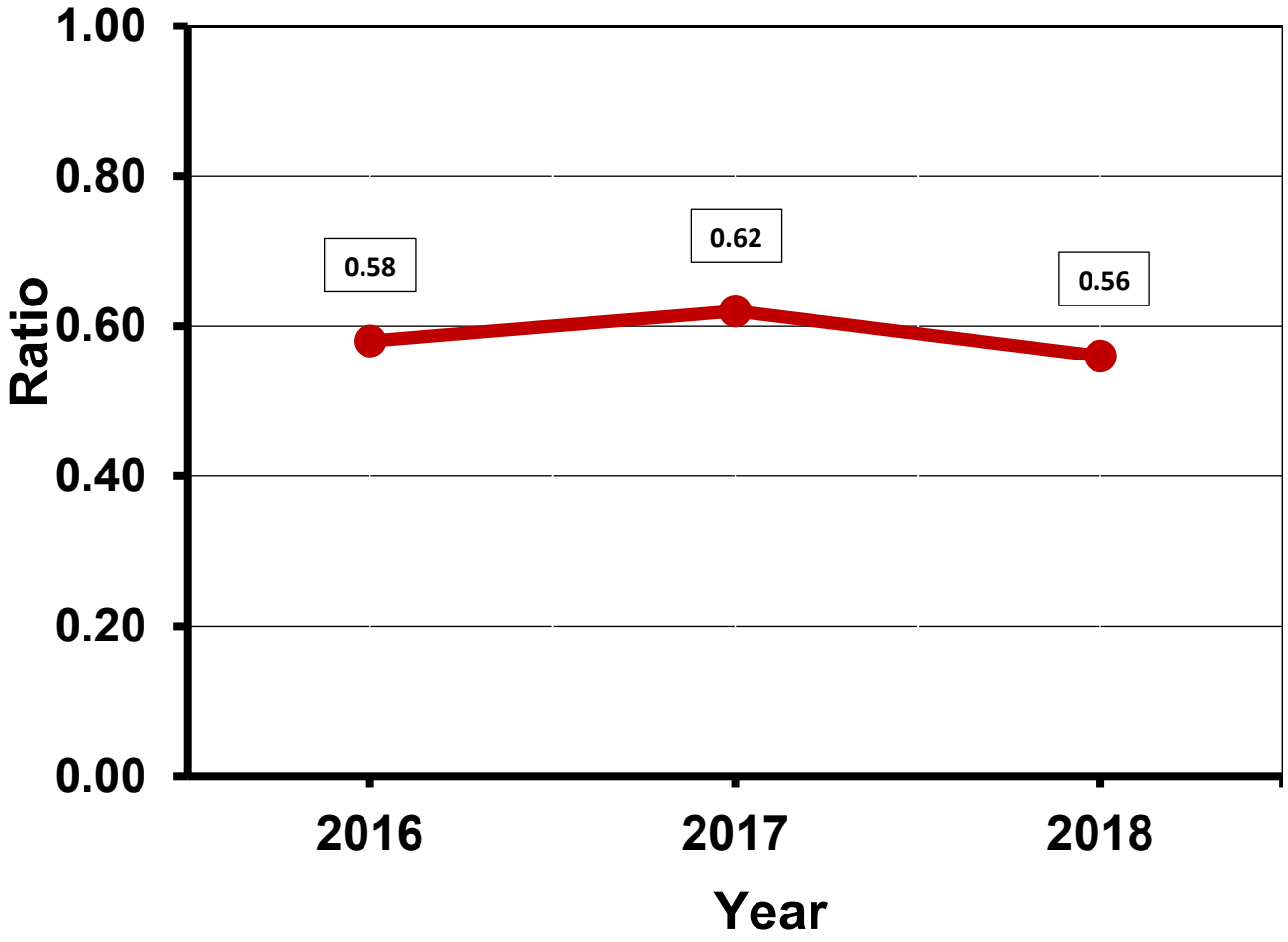


**Figure 7.** Number of license types per year.

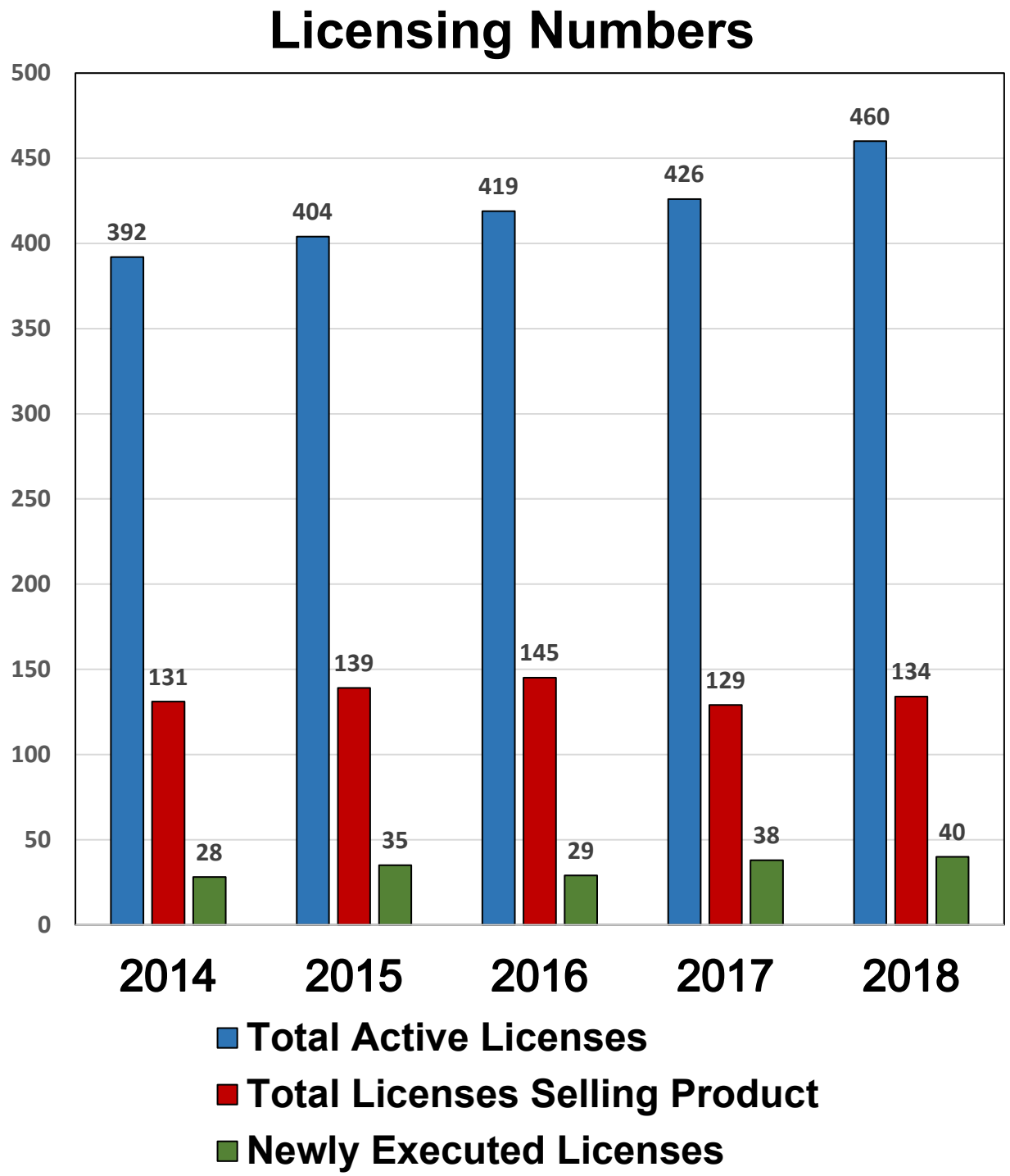


**Figure 8.** Earned license royalty income (ERI) over time. The lower income in FY 2018 was due to two of the top revenue generating licenses expiring in FY 2017.

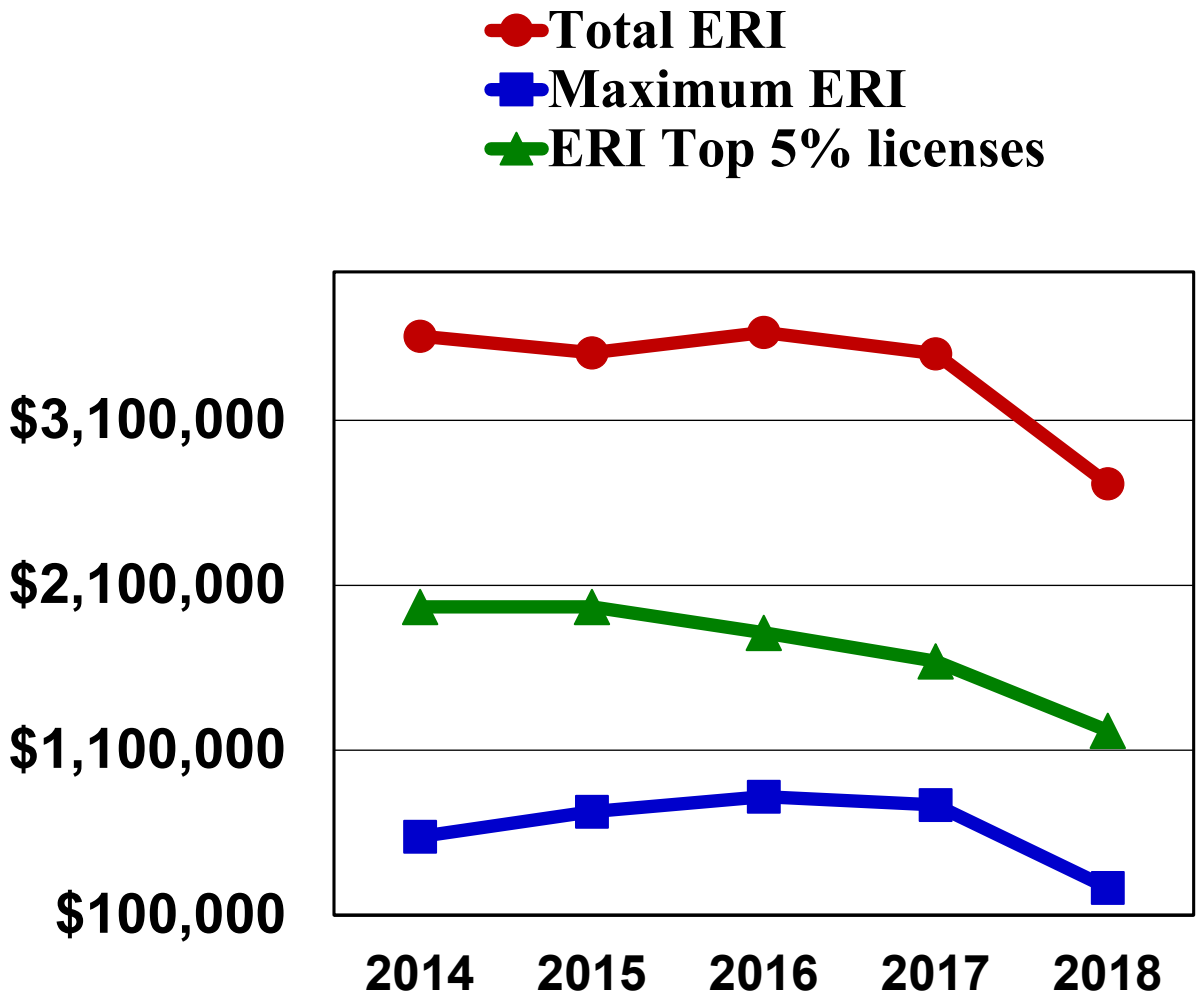


**Figure 9.** The number of new licenses executed in FY 2018 by business type.

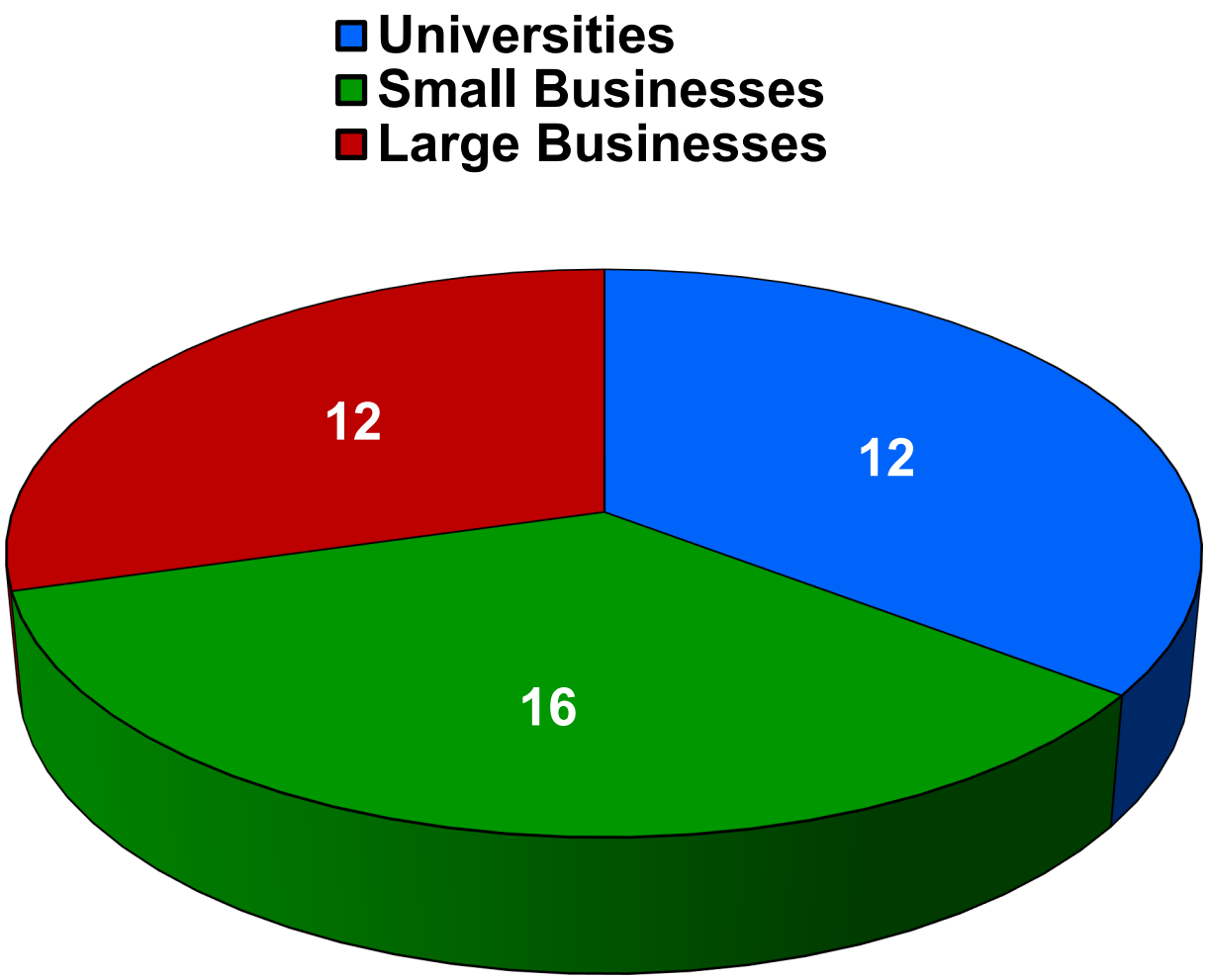


**Figure 10.** The ratio of newly signed invention licenses over newly issued patents per year. Although the year in which a license is signed is not typically the year in which the patent has issued, over time the ratio of newly signed licenses over the number of newly issued patents is an indicator of "judicious" patenting contemplating among other things commercial viability of the technology. Over the last 3 years, this indicator suggests that ~43 percent of the issued patents are licensed.

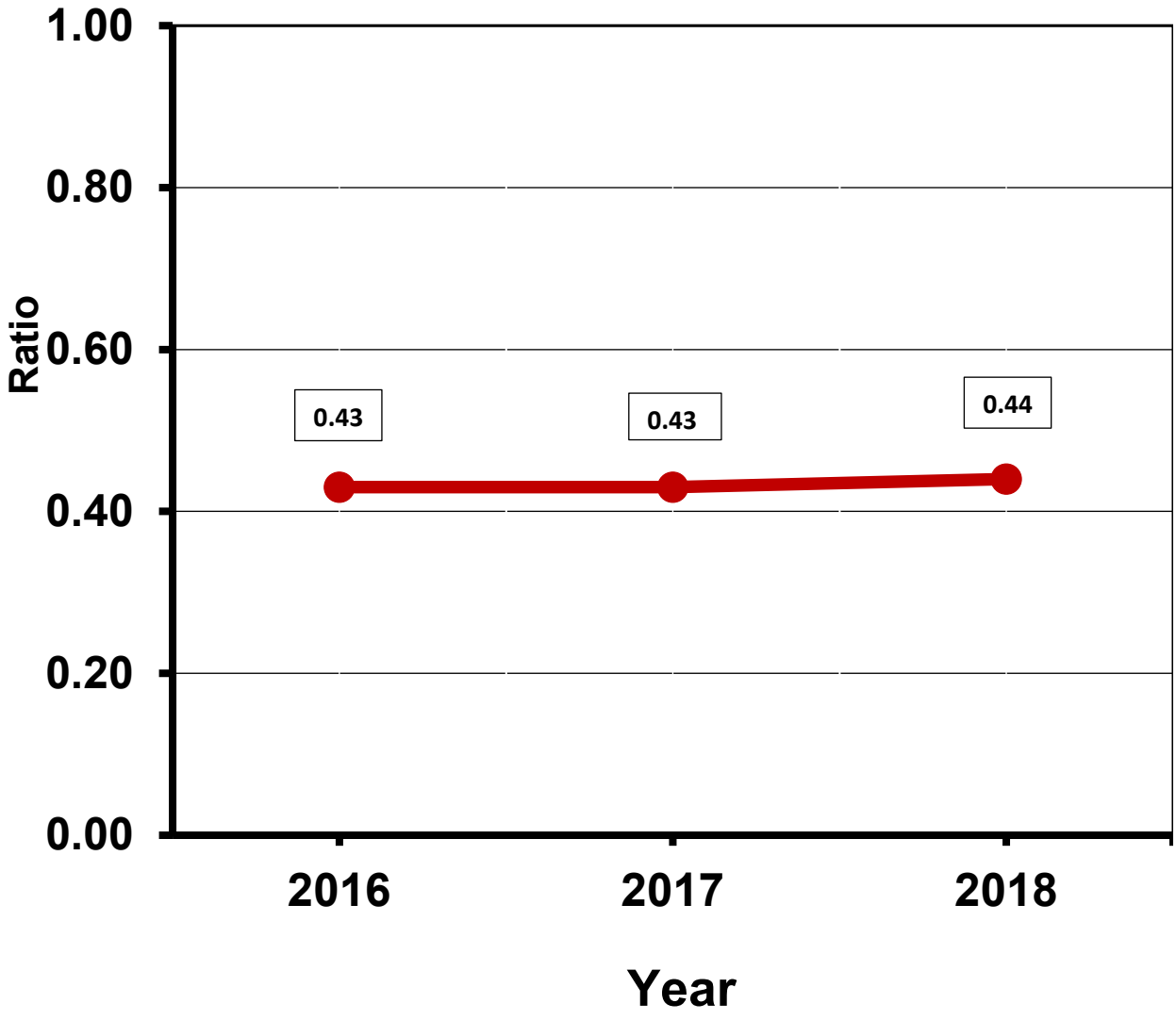
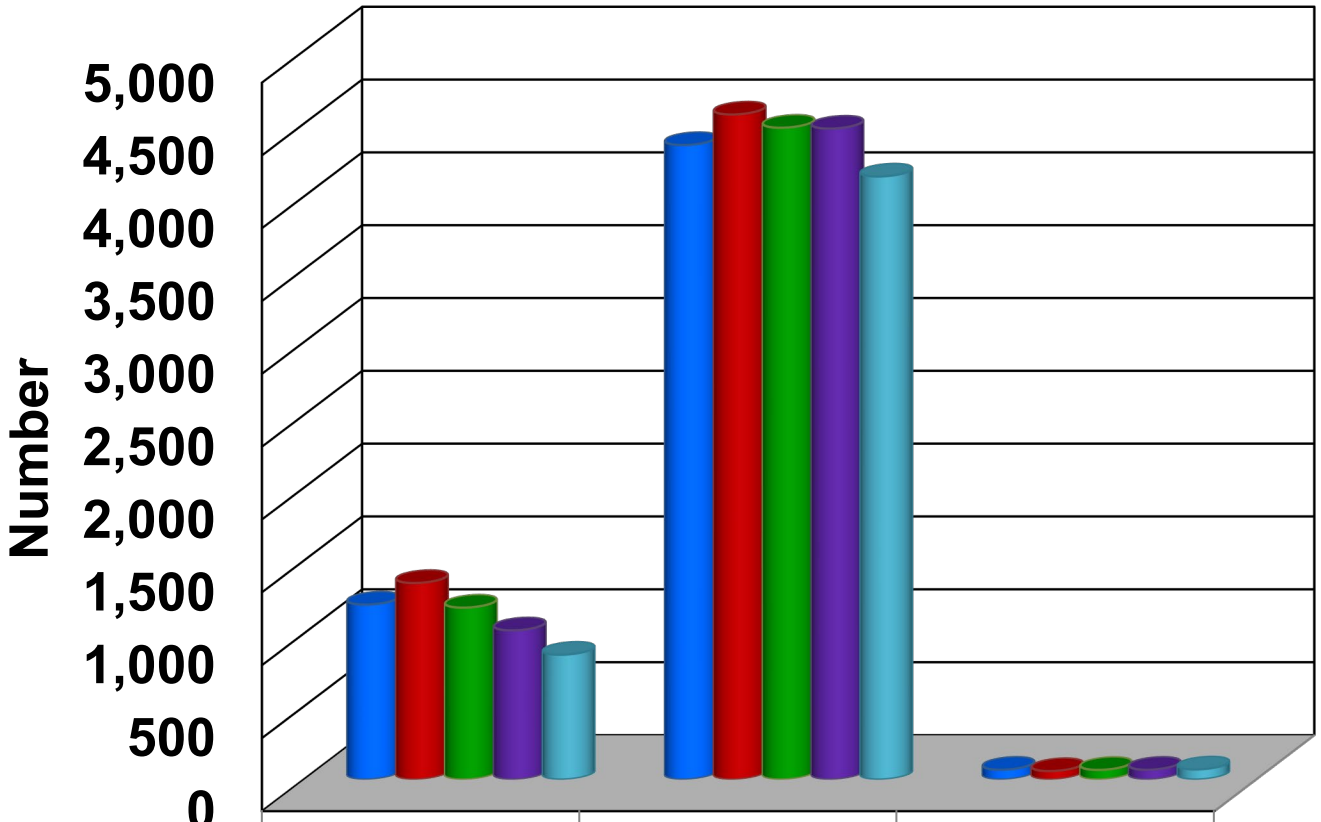


**Figure 11.** Number of publications per year.




| | Meeting Abstract | Scientific Journal | Trade Journal |
|---|---|---|---|
| 2014 | 1,199 | 4,354 | 66 |
| 2015 | 1,347 | 4,564 | 57 |
| 2016 | 1,178 | 4,473 | 65 |
| 2017 | 1,022 | 4,467 | 66 |
| 2018 | 855 | 4,138 | 68 |

# 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 200 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's major FY18 IT accomplishment was successfully migrating its entire IT infrastructure to the Cloud—a first in USDA. This includes all of the data holdings previously housed in file systems and databases, as well as the ERS Website and Web publication processes. Among the benefits of this move include robust

backup and failover capabilities, thus reducing operational risk.

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 2018 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-responsive/device-agnostic 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 2018, ERS used several 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 29,000 followers in fiscal 2018—up from 27,000 followers in 2017 and 24,000 in 2016. See https://twitter.com/usda_ers

- **Responsive, Device-Agnostic Design:** ERS continued to optimize its website for mobile users, providing fast, easily navigable, mobile-friendly pages that automatically adapt to the user's computer, tablet, and smartphone —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 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 2018, the Atlas was updated with the most recent information on veterans, education, migration, and income from the American Community Survey.

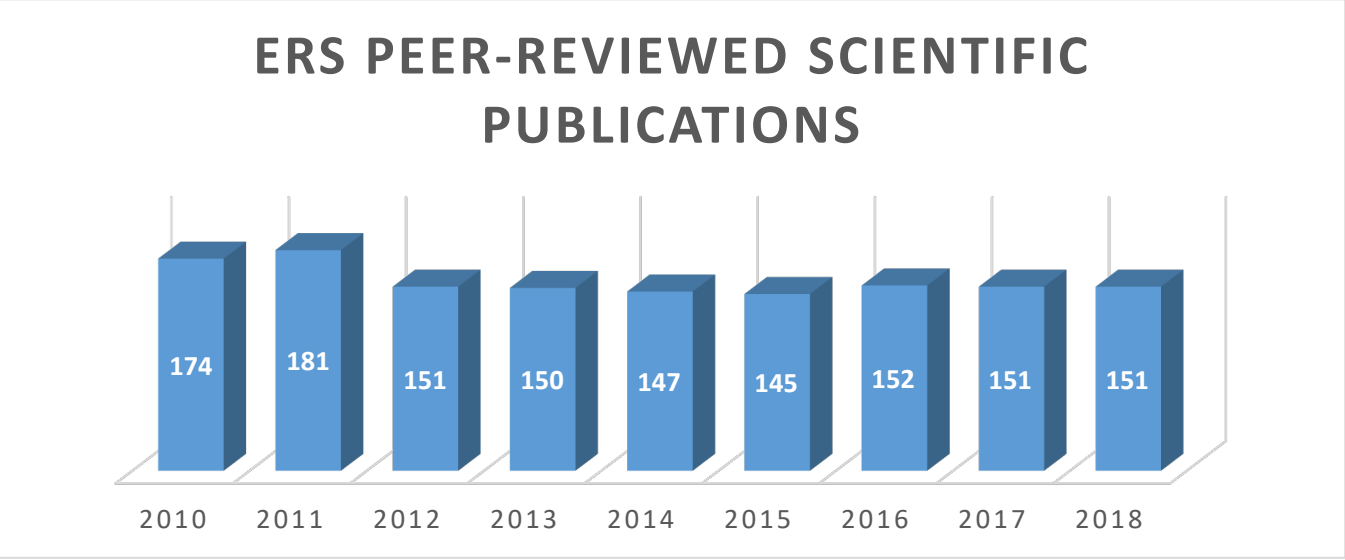
- Local officials throughout the country can easily gauge the characteristics of their food environment and target actions that alleviate problems with the availability of healthy food options for the people in their counties or State using the ERS Food Environment Atlas (http://www.ers.usda.gov/data-products/food-environment-atlas.aspx). 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 7webinars in FY 2018 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 2018, 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)

## 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, the Office of the U.S. Trade Representative, and other Federal agencies, 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.

**Borlaug International Agricultural Science and Technology Fellowship Program**

In FY 2018, the Borlaug International Agricultural Science and Technology Fellowship Program (Borlaug) supported 31 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 850 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.

Mongolia

A Mongolian Fellow received training on using near infrared (NIR) technology for food and feed safety and quality inspections. Specifically, the Fellow was trained on spectral instruments ranging from ultraviolet, visible, NIR and mid-infrared spectrophotometers to those with built-in microscopes and Raman imaging capabilities. The training also addressed other analytical equipment and processes in a food analysis service lab and a food microbiology service lab to test for pathogens. This allowed the Fellow to prepare samples for NIR scanning and analysis, evaluate NIR spectral data, develop qualitative and quantitative multivariate models to screen and estimate chemical attributes or quality of animal feed and beef products, validate testing models and articulate their capabilities and limitations,

and report results of food and feed safety research in peer-reviewed journal articles. The adoption of such scientific and internationally recognized import approval systems by Mongolia's regulatory agencies will ultimately support market access for U.S. agricultural exports to Mongolia.

Southern Africa

Five Fellows from South Africa and Zambia conducted research on Fall Army Worm (FAW), studying integrated pest management, molecular techniques for identification of FAW species, and risk assessments and efficacy of bio-pesticides and other biological methods for FAW control. Their training and research contributed urgently needed expertise to help combat FAW in southern Africa, where FAW was recently detected and has since become a significant threat to crop production. The Fellows' training and research will also enable them to provide expertise that will be valuable combatting other insect pests, now and in the future.

Malaysia

A Fellow from Malaysia's Agro-Biotechnology Institute (ABI) received training and conducted research at Tennessee State University to apply genetic-markers assisted selection for developing fragrant rice varieties. Specifically, the Fellow benefitted from hands-on experiences with spectrophotometric and fluorescence resonance energy transfer (FRET) based technologies for evaluating single nucleotide polymorphism (SNP) markers as well as genotyping by sequencing (GBS), which is a relatively new technology to detect genetic polymorphisms around a gene of interest. After returning to ABI, the Fellow used these techniques to initially screen 26 rice varieties with the fragrant grain trait and, of these, ultimately identify a variety with superior agronomic traits, grain size, and yield potential. Her

work to further develop that variety for cultivation in Malaysia and other areas with similar conditions is ongoing.

Ukraine

A Ukrainian Fellow from the National Scientific Center's Institute of Experimental and Clinical Veterinary Medicine studied approaches and methods used in tick molecular biology, genomics and bioinformatics at three research institutions in Texas: Baylor College of Medicine, Texas A&M University, and the USDA-ARS Knipling-Bushland U.S. Livestock Insects Research Laboratory and Veterinary Pest Genomics Center. The research focused on soft ticks as potential vectors for African swine fever virus in Eastern Europe. The Fellow learned about applications of multiple genetic sequencing platforms including Illumina, PacBio, and Oxford Nanopore, as well as DNA quality requirements, and the benefits and disadvantages of each approach. The Fellow also gained practical experiences in sequence data handling (quality control and trimming, obtaining consensus sequences from forward and reverse Sanger reads), and analysis (BLAST, Multiple sequences alignment, phylogenetic analysis) and integration of such genetic sequence data with "big data" sets. Overall, this fellowship generated new data and analyses that will be a significant contribution to soft tick biology and plans are underway to publish his research results in a peer-reviewed scientific journal. Together with his collaborators at the Texas A&M Genomics and Bioinformatics Center, the Fellow is helping to launch a Global Soft Tick Genomics Consortium to further advance genomics studies of soft ticks and better combat these disease vectors.

**Cochran Fellowship Program**

Since 1984, the Cochran Fellowship Program (Cochran Program) has helped to spread American agricultural technologies and innovations across the world, providing U.S.-based training opportunities for more than 18,500 agricultural professionals from 126 countries. Livestock genetics is among the top training topics addressed by the Cochran Program and recent results from Nicaragua illustrate how the Program mutually benefits the United States and our partner countries. In 2016, the Cochran Program and U.S. Livestock Genetics Export, Inc. provided training in Texas and Wisconsin to the owner of a Nicaraguan distributor of livestock genetics. As a result, the Fellow formalized an ongoing partnership with Sexing Technologies, a Texas-based commercial livestock genetics company that utilizes USDA-licensed technology, with an initial $21,000 order of bovine semen that was successfully exported to Nicaragua. In 2017, the Cochran Program collaborated with the U.S. Livestock Genetics Association and the Montana Department of Agriculture to organize a Nicaraguan trade mission to Montana. The mission included representatives of Nicaraguan cattle companies, owners of feedlots and slaughterhouses, and Executive Directors of Nicaragua's two largest cattle associations. As a result, the Fellows made an initial $100,000 investment in Montana cattle genetics for use in a national artificial insemination initiative to improve Nicaragua's herds. This ongoing initiative has potential to dramatically increase U.S. exports of livestock genetics to Nicaragua in coming years.

**Food for Progress Program**

Recent developments from USDA Food for Progress Program (FFPr) activities in Ghana (FY 2015) and El Salvador (FY 2014) 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 post-harvest technologies training on determining maturity indicators and timeliness of harvesting, reducing danger of mycotoxins, determining moisture content of grains using the GrainMate moisture meter, and proper storing of harvested crops and produce storage using the Purdue Improved Crop Storage (PICS) and Zerofly hermetic bags. In addition, farmers in the Northern region were sensitized on the Fall Army Worm menace and the need to use of Aflasafe to reduce aflatoxin contamination in maize in the field. In September 2018, Sesi Technologies delivered 120 GrainMate moisture meters to the Adventist Development and Relief Agency, which the AMPLIFIES Project ordered for its post-harvest loss (PHL) activities. Sesi Technologies is a start-up company trained by USAID's PHL Innovation Laboratory to locally assemble USDA's open patent moisture meter at the KNUST Biotech Laboratory. The moisture meters will be distributed to Crop Aggregation Center Management Committees, Ministry of Food and Agriculture extension agents, poultry farmers, aggregators, and others.

El Salvador

In collaboration with the National Cooperative Business Association's (NCBA) 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. Ninety-seven percent of project beneficiaries have applied or tested some or all of the techniques and technologies promoted by the project. The application of these new technologies and sustainable techniques have reduced production costs by up to 60 percent, increasing net incomes and resilience climatic and disease shocks. Additionally, NCBA is promoting these technologies as replicable and scalable not only in the Salvadoran coffee sector but at the regional level.

**IR4 Project, the Global Residue 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 countries. Therefore, many tropical crops grown in developing countries lack MRLs, and accordingly, exporters of those products face international trade barriers and unnecessary destruction of safe food 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. In 2018, the Project continued work with stakeholders in 14 partner countries in Africa, Asia, and the Western Hemisphere, where national research teams collaborated on joint residue trials that are based on study protocols and technology models developed by the USDA-funded IR4 Project. By transferring these policy concepts and technical skills to foreign partners, the Global Residue Project has continued coordinating with and 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 2018, the

Codex Alimentarius established four new MRLs that were based on data generated through the Global Residue Project and its Global Partnership for Pesticide Standards. 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. In 2017, the Global Partnership's third quadrennial Global Minor Use Summit was hosted by FAS and IR-4 Project to review progress, identify additional joint projects and opportunities to expand partnerships, and continue disseminating knowledge and information about safe crop protection, which ultimately expands trade.

## Aflatoxin-Reducing Technologies

### Africa

FAS continued to facilitate vital links between the U.S. developers of an aflatoxin-reducing technology and foreign beneficiaries. This technology, trademarked 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 2018, Aflasafe products were formally approved for registration in Tanzania, joining Burkina Faso, The Gambia, Kenya, Nigeria, and Senegal as countries having a country-specific Aflasafe product available. In addition, the Permanent Interstate Committee on Drought Control in the Sahel (Comité Permanent Inter-État de Lutte Contre la Sécheresse au Sahel;

CILSS) in 2016 granted a CILSS-wide registration of the Senegalese product (including Benin, Burkina Faso, Cape Verde, Chad, Côte D'Ivoire, Gambia, Guinea Bissau, Mali, Mauritania, Niger, Senegal, and Togo). However, launch of the product in individual CILSS countries in which the product is not already available is awaiting confirmation that the product will be appropriate in the particular markets, as well as development of private sector interest in production and commercialization in those countries. Similar products are nearing approvals for registrations 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.

Pakistan

In October 2018, researchers, government agencies, and private businesses from the United States and Pakistan participated in a well-publicized launch of the program, *Safer Food through Aflatoxin Control,* in Islamabad, Pakistan. It is estimated that aflatoxin currently contaminates up to 25 percent of crops produced by Pakistan. Through a public-private partnership, led by U.S. company Ingredion and its Pakistan subsidiary Rafhan Maize, this program is paving way for Pakistani firms to register and use a cutting-edge biological control technology, originally developed by USDA/ARS, to help eliminate aflatoxin contamination of key crops (e.g., grain, nuts, chilies) in Pakistan. This joint effort is already increasing Pakistan's leadership in regional and global efforts to utilize biological control technologies to grow safer crops. In addition, this effort is helping Pakistan realize benefits to its livestock producers by offering technology that can reduce aflatoxin contamination of locally produced animal feeds. This ongoing effort is leading towards the first documented registration and uses of the Aflasafe technology,

known locally in South Asia as AflaPak, where it is expected to improve food and feed safety and further strengthen food security for over 200 million Pakistanis over the coming years.

# 6.0. Forest Service (FS)

The USDA Forest Service Research and Development (FS R&D) is the world's largest forestry research organization combining both basic and applied research, and aimed at discovering solutions to problems or creating new goods and knowledge. FS R&D supports the entire forest and natural resources management sector by providing the best available science to the FS, other Federal agencies, State agencies, private landowners, and others for the sustainable management of natural resources nationwide. R&D furnishes the foundational science for improving forest and grassland conditions for the benefit of both rural and urban communities so they remain socially, economically, and ecologically viable.

## 6.1. Understanding:

Defining the new Technology "tech" Transfer and Science Delivery at the USDA FS R&D with the goal of science delivery to enhance the usefulness of scientific information. "Pulling together and synthesizing information from a range of disciplines and deliver it in clear and accessible formats to fit user needs." USDA FS science is complex, but the need for the research is simple. Land managers, forest managers, city planners, and policy-makers 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.

The culture of focusing on "science delivery" (and "tech transfer" as a subset of science delivery) is a bit dated. R&D has evolved as a science organization to pursue co-development of knowledge together with practitioners and decision-makers. Science delivery and tech transfer describe a linear process

where science is conducted, knowledge gained by scientists, and then provided to the end-users as a final step. In contrast, our scientists are bringing knowledge users, stakeholders, and decision-makers into the science process from the very beginning; there are feedback loops. This it is now more mainstream in the FS, a more contemporary method and thus one that is much more relevant. There is real value of this form of "science delivery" and the FS is a pioneer, and it is what sets FS R&D apart from universities and other academic institutes. R&D works hand in hand with managers to build knowledge together and design solutions.

**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 FS, summed up the mission of the FS —"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.

FS 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 FS 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 FS 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 FS leadership and the Department, other agencies and Congressional staff; fostering cross-station communication and collaboration among scientists; and developing working relationships with national-level non-profit 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 tradeshows and with universities; patents; webinars; workshops; partnerships; field visits; coordination and participation in

working groups and discussions; demonstration of decision support tools systems; 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 five 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 all needed paper work for the US Patent Office. The Patent Program also oversees contract law firms that draft utility patent applications (provisional applications are filed by USDA 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 FS 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 FS 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 Forest Products Laboratory (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 2018

- **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.

- **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.

- **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.

- **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:**

**Fire-Retardant-Treated Structural Glued Laminated Timber (Glulam) and Laminated Veneer Lumber (LVL)**

Interest in using engineered wood products in Type III construction in the United States has been rising in recent years. The wood industry has been heavily engaged in the promotion of multifamily and light

commercial construction in which wood-frame Type III construction predominates. Type III construction, based on the definition of the International Building Code (IBC) is "that type of construction in which the exterior walls are of noncombustible materials and the interior building elements are of any material permitted by this code," except that fire-retardant-treated (FRT) wood framing complying with the IBC is permitted within exterior wall assemblies of a 2-hour rating or less.

**Background**

As part of the Type III construction, the exterior bearing walls of wood-frame construction must be FRT wood with a 2-hour fire rating, and the floor framing is required to be 1-hour fire rated. At the intersection of the 2-hour wall and 1-hour floor, where the floor framing is attached to the wall with joist hangers, a popular solution is to use solid structural rimboard or header to provide the needed load transfer mechanism. Due to the requirement for continuity on the 2-hour fire rating, the rimboard or wall header is a good fit for structural glued laminated timber (glulam) and structural composite lumber (SCL) products. Unfortunately, this market demand has faced a strong technical challenge due to the lack of consensus-based evaluation standards or product specifications for FRT glulam and SCL. ASTM and AWPA have published FRT test standards and FRT product specification for lumber and plywood, but not glulam and SCL. For SCL, due to the different treatment requirements and the market size, this study will focus on laminated veneer lumber (LVL).

**Objective**

The objective of this research is to develop ASTM standards for the evaluation of FRT glulam and LVL in support of wood-frame construction, especially Type III construction. This study is intended to cover

the evaluation of FRT glulam and LVL in various sizes and will not be limited to the relatively small dimension glulam and LVL rim boards, even though it will be one of the targeted areas. ASTM D5516 and D6305 for plywood and ASTM D5664 and D6841 for lumber will be used as guides. It is also expected that the existing FRT chemicals for lumber and plywood could be used for glulam and LVL with limited modifications. Collaboration with the FRT industry is expected. The glulam volume effect and the SCL depth effect will be considered in this study.

**Approach**

In this study, the fire-retardant treatment will be performed by a treater using the AWPA P49 standard, which was used in previous FPL studies. In addition, limited study will be conducted with treatment provided by another treater using the AWPA P50 standard for glulam.

*Glulam*—Matched samples for 302-24 end joints will be prepared for evaluation of treatment effects by full-scale tension tests under as-received moisture conditions. Additional matched samples for 302-24 end joints will be prepared for evaluation of treatment and hygrothermal effects by full-scale tension tests after hygrothermal conditioning on treated and control specimens. The hygrothermal effect is targeted at 150 + 4 °F and 50% or higher RH for 108 ± 3 days in accordance with ASTM D5664. Similarly, matched samples for 302-24 tension laminations will be prepared for evaluation of treatment and hygrothermal effects by full-scale tension tests. In addition, full-size glulam beams of four different sizes, ranging from 5-1/2 in. by 6 in. by 10 ft to 5-1/2 in. by 24 in. by 37 ft, will be prepared and tested in bending after FRT treatment to confirm the glulam volume effect. The glulam gluebond performance will also be evaluated after the FRT treatment.

*LVL*—Matched samples for 2.0E/DF LVL will be prepared for evaluation of treatment and hygrothermal effects by full-scale tension and edgewise bending tests. In addition, full-size LVL specimens of four different sizes, ranging from 1-3/4 in. by 3-1/2 in. by 6 ft to 1-3/4 in. by 9-1/4 in. by 14 ft, will be prepared and tested in edgewise bending after FRT treatment to confirm the LVL volume effect.

**Expected Outcomes**

It is expected that the results from this study will provide test data to support the development of ASTM standards for FRT glulam and LVL.

**Timeline**

The study plan was developed in July 2016, and materials were procured in August 2016. Fire retardant treatment and re-dry were completed in December 2016, hygrothermal conditioning was completed by June 2017, mechanical and gluebond testing were completed in October 2017. ASTM standard development is targeted for October 2018, with a final report prepared by December 2018.

**Cooperators**

USDA Forest Service, Forest Products Laboratory

APA–The Engineered Wood Association

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Photo caption: Measuring the bending strength of a glulam beam.

**Statistical Investigation of Modulus of Elasticity and Modulus of Rupture Distributions in Mill Run Southern Pine Lumber**

The Southeastern region of the United States produces the nation's largest volume of structural lumber. The several tree species that make up the Southern Pine lumber species group grow on hundreds of

millions of acres across approximately 10 states. Annually, the value of lumber production from this resource is in the billions of dollars.

To maintain its competitive position, structural lumber properties must accurately reflect the strength and stiffness of the resource. In this manner, consumers receive a reliable and safe product with high economic and engineering value. Of key interest is the nature of lumber properties among the weaker specimens, which comprise the lower tail of the statistical strength distribution. As lumber comes from both younger plantation thinnings and older mature saw logs, investigating mixed populations is of interest.

The current best practice is to base strength design values on the nonparametric fifth percentile so that the design strength of lumber is independent of its statistical distribution. If strength distributions could be more accurately characterized, estimated lower tail strength values might increase, and higher economic value could be assigned to lumber while maintaining safety and conservatism.

**Background**

The wood reliability engineering community commonly models modulus of elasticity (MOE) as a normal distribution and strength as a normal, lognormal, or two-parameter Weibull distribution; or it sets these aside and uses a nonparametric fifth percentile. Preliminary research has shown that lumber populations may be composed of statistically mixed distributions. This is particularly true for mill run populations. Mill run populations are essentially all the lumber mills produce before the lumber gets meted out into various assigned grades. If the lower tail of strength populations (i.e., the weaker pieces) can be better modeled statistically, then it may be possible to improve reliability models, which in turn

will lead to greater engineering efficiency and associated forest stewardship and conservation. Small changes in value, applied to tens of billions of board feet, equate to billions of dollars in economic activity spread across nearly 200 million acres of timberland.

**Objectives**

The primary objective of this study is to investigate and statistically analyze the stiffness and strength distributions of mill run Southern Pine lumber in an effort to generate an improved means of assessing left tail percentiles. The secondary objective is to investigate the use of a wide range of nondestructive evaluation technologies, including slope of grain detection via permittivity, as a means of improving the predictability of stiffness and strength of structural pine lumber as well as improving the automation of these properties.

**Approach**

For this project we will (1) procure 1,400 kiln-dried, rough, mill run southern yellow pine (*Pinus* spp.) lumber specimens from four sawmills, (2) transport the specimens to Mississippi State University, (3) dress the lumber to 1.5- by 3.5-in. dimensions, (4) perform several nondestructive tests on each specimen, including automated assessment of slope of grain via permittivity, (5) destructively test each specimen to establish its stiffness and strength, and (6) perform statistical analyses of the resulting data with particular interest in describing the lower tail from mixed populations.

**Expected Outcomes**

This project is expected to establish novel information that can be used in developing improved parametric assessments of the left tail percentiles of lumber strength distributions. Thus, it should be possible to better estimate appropriate and conservative structural design values for pine lumber, which will lead to more jobs and higher economic value and returns for lumber manufacturers and timberland owners.

**Timeline**

The experimental phase of the project will run from July 2017 through August 2018. Statistical analyses will follow through June 2019. Final reporting and dissemination will conclude by June 2020.

**Cooperators**

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Photo caption: Softwood lumber used in engineered glulam construction. With improved understanding of strength distributions, additional volumes of raw material will be available for these and other high-value markets.

**Development of Seismic Performance Factors for Cross-Laminated Timber Shear Walls**

Since its initial introduction in Europe more than two decades ago, cross-laminated timber (CLT) has been established as a new-generation product (UNFAO 2016). Recent construction projects in both Canada and the United States (Pei et al. 2016) and research efforts in Europe, North America, and Japan on CLT-based lateral force resisting systems (Pei et al. 2014) have demonstrated that CLT can be a viable alternative to steel and concrete in mid-rise construction, particularly in seismic regions. However, CLT-based seismic force resisting systems are not included in current design codes and standards, meaning that any CLT seismic design can be conducted only through alternative methods.

This approach is both costly and complicated, making CLT less competitive than other conventional structural systems such as light-frame wood and heavier materials such as steel and concrete.
The purpose of this Forest Products Laboratory partnership with Colorado State University is to determine seismic performance factors for CLT, thereby enabling CLT to be used efficiently and competitively throughout the United States.

**Background**

CLT panels are constructed of several layers of lumber boards stacked orthogonally and glued together. They are usually constructed in odd number of layers that varies from three to seven, sometimes even more.

This innovative product offers a number of advantages, such as the potential for mass production, prefabrication, rapid construction, and sustainability as an environmentally friendly renewable construction product. Very good thermal insulation, acoustic performance, and fire ratings are some additional benefits of this system (CLT Handbook 2013; Ceccotti 2008).

**Objective**

The main objective of this project is to develop an understanding of the cyclic and seismic behavior of the proposed CLT shear wall systems. This includes (1) testing at the component and assembly level (Fig. 1), (2) developing the design methodology and calibrating it based on test data, (3) developing and calibrating the numerical model, (4) designing a suite of archetypes that are representative of the design space, and (5) performing extensive analysis to identify the seismic performance factors. In addition, the

project team will work with the American Forest & Paper Association (AF&PA) to propose these factors for inclusion in current design standards.

**Approach**

The study utilizes the FEMA P695 methodology (FEMA 2009), which provides a systematic approach consisting of nonlinear static and dynamic analyses. The procedure also takes into account uncertainties inherent in test data and modelling methods. The methodology is applied to a number of archetypes extracted from index buildings that are representative of the CLT design space. Figure 2 shows one such index building from which several archetypes will be extracted and analyzed.

**Expected Outcomes**

At the completion of this research project, the proposal for seismic performance factors will be submitted to the peer review panel. This research will result in the following:

- Evaluation of seismic performance factors, including response modification factor (R-factor), system over strength factor, and deflection amplification factor for seismic design in the United States

- Design methodology based on the 2015 *National Design Specification for Wood Construction*, including appendix E, ASCE/SEI 7-10, *Minimum Design Loads for Buildings and Other Structures*, and applicable building code that can be used by engineers nationwide

- Component tests data that are reported in accordance with the standards and are widely available to the engineering community, allowing application of P795 methodology to facilitate potential use for alternative fasteners and connectors by manufacturers

**Timeline**

The last phase of the project began in early 2017. The project is expected to be completed by the end of 2017, with reporting in early 2018.

**Cooperators**

Colorado State University

USDA Forest Service, Forest Products Laboratory

American Wood Council

Colorado School of Mines

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*References cited available upon request.*

Figure 1. CLT shear wall testing with horizontal actuator in displacement control applying shear load and vertical actuator in load control applying gravity.

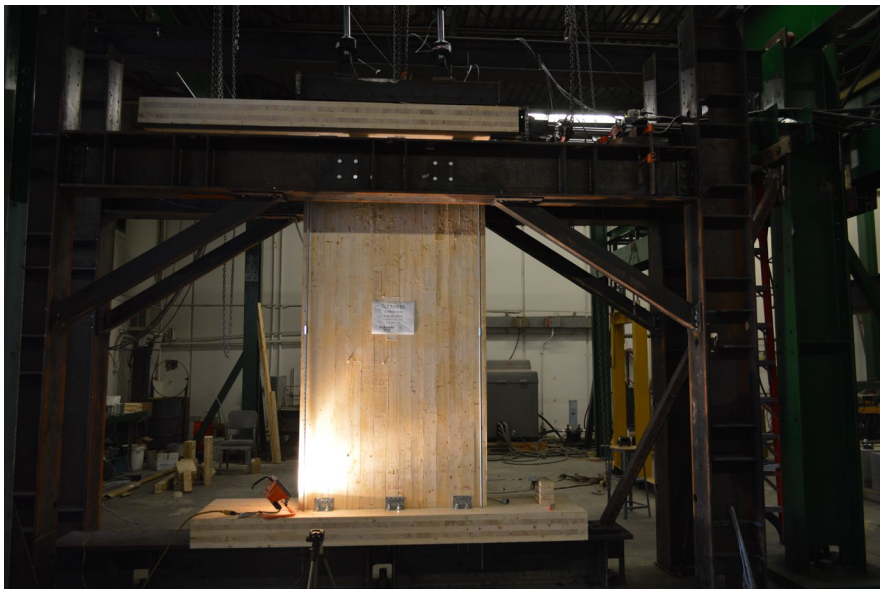
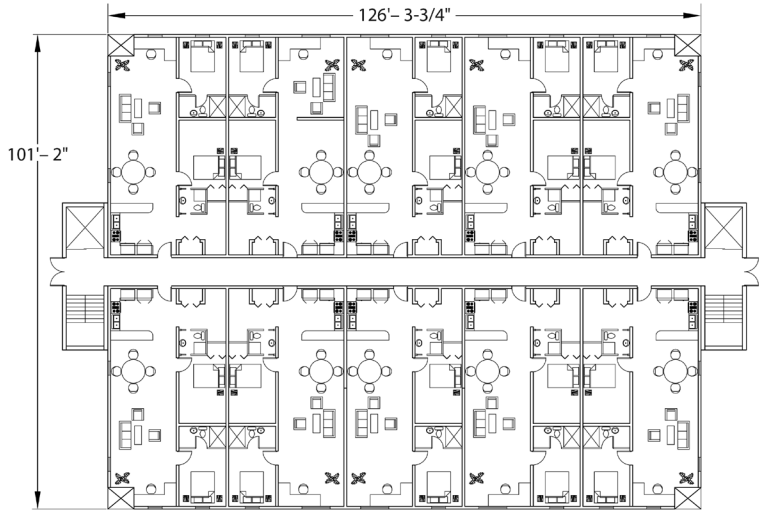


Figure 2. CLT index building.



**Engineering Performance Characteristics of Hardwood Cross-Laminated Timber**

The hardwood industry in the Great Lakes region faces tremendous economic and competitive pressures that demand companies to focus on developing innovative and value-added products from undervalued hardwood materials (Fig. 1). Particularly in Michigan, there is an abundant supply of hardwood resource and there have not been many new applications for the low grades of hardwood materials (Ross and Erickson 2005). This project addresses the issues that are important to local sawmills and wood products manufacturers in reducing material waste and increasing profitability. It is also important to the economic growth and development in the region. The use of low-grade and undervalued hardwood materials in engineered wood products such as cross-laminated timber (CLT) will create new opportunities for many hardwood companies in the region. The technical information gained through this project will facilitate the development of new hardwood CLT products using local hardwood species.

**Background**

The eastern forests of the United States hold 90% (357 billion cubic feet) of all hardwood resource of the nation, and most of the hardwood timber species are undervalued. The volume of hardwood sawn timber has increased significantly in the eastern forests because of decades of positive growth-to-removals ratios and diminished demand in the traditional markets for these hardwood species. There is a critical need to expand the use of these hardwoods, especially undervalued hardwoods, for value-added products. Current advances in the development of CLT have resulted in an increased interest in furthering the use of wood in engineering applications and more significantly, in construction of large, multi-story wood structures around the globe.

Traditionally, CLT panels are produced from softwood lumber. There has been an increasing interest in using CLT in commercial and residential construction in the United States and to fully develop a CLT manufacturing industry countrywide. This will require use of a variety of regional species, including hardwood. At this time, the product standard for CLT in the United States does not apply to CLT manufactured from hardwood lumber (APA 2018). Given this situation, further research is necessary to justify the inclusion of hardwood species into the standard.

**Objective**

The goal of this project is to examine whether CLT panels made from low-grade hardwood lumber can provide sufficient engineering performance needed for structural applications. Our specific objectives are to evaluate the baseline structural properties (mechanical strength and stiffness) of CLT panels manufactured from low-grade northern hardwoods and develop mathematic models for predicating hardwood CLT engineering properties and optimizing the layup of CLT panels for maximum performance.

**Approach**

Figure 2 shows the overall approach of this project with the following tasks: (1) obtain low-grade northern hardwood lumber and sort lumber on species and visual grades; (2) nondestructively E-rate the lumber to obtain basic wood properties; (3) characterize knot and slope of grain properties; (4) fabricate CLT panel specimens; (5) conduct qualification test on all the CLT specimens and determine the mechanical properties; and (6) analyze the results and write final report.

**Expected Outcomes**

Two major outcomes are expected. First is the establishment of a technical basis for developing allowable bending strength and stiffness of hardwood CLT panels. Second is the development of models for predicting the mechanical properties of CLT products made of log-grade hardwood lumber. The results will be shared with hardwood sawmills, adhesive suppliers, CLT manufacturers, hardwood loggers, and colleagues within the forest products community.

**Timeline**

The project will be conducted from September 2017 through April 2019. Material evaluation and fabrication of CLT panels will be completed by September 2018. Qualification tests of CLT panels are scheduled to be completed by December 2018. Data will be consolidated and analyzed, and a final report will be submitted by April 2019.

**Cooperators**

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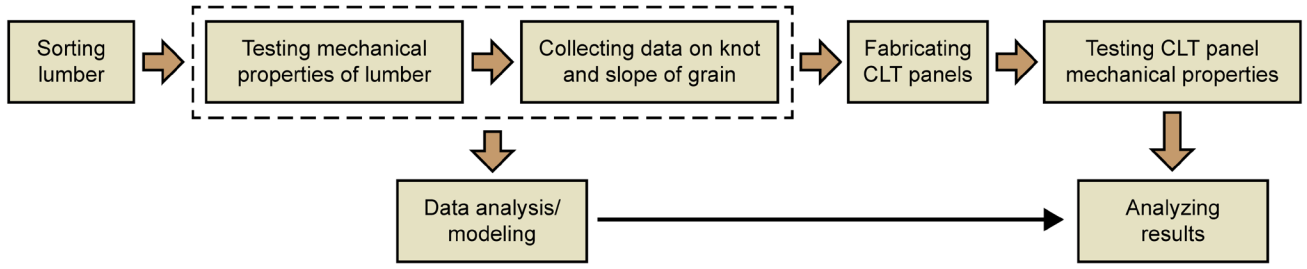
APA–The Engineered Wood Association. 2018. ANSI/APA PRG 320-2018: Standard for performance-rated cross-laminated timber. Approved February 2018.

Ross, R.; Erickson, J. 2005. Undervalued hardwoods for engineered materials and components. Madison, WI: Forest Products Society. 134 pp.

Figure 1. Low-grade northern hardwood lumber obtained from a local company.

Figure 2. Schematic of the overall approach of the project.




**Biomass Pre-Processing by Torrefaction Improves Biofuel Consistency (FPL)**

Custom-made equipment fabricated for the torrefaction of wood chips now provides the sample quantities needed for application testing and quality control assessments.

Biofuel properties can be improved through torrefaction, a thermal process whereby biomass is treated with moderately elevated temperatures (200 to 300 °C) under conditions that are essentially anaerobic and at atmospheric pressure. A custom-made crucible furnace retort was fabricated to produce intermediate quantities of torrefied material and accommodate large particles that would be encountered in real-world operations. Varying the torrefaction conditions of temperature, and treatment duration, generated products having varying degrees of thermal degradation. For pulp-grade pine wood chips, yields ranged from 51% to 96%, and were impacted to a greater extent by varying the treatment temperature as opposed to the treatment time. Spectroscopy-based models were developed as a rapid assessment technique for use in a production environment to measure yields and facilitate adjustments to process parameters. Regarding the use of torrefied wood as a feedstock for thermochemical operations, higher treatment temperatures, which gave the lowest yields of torrefied wood, demonstrated the highest recalcitrance during liquefactions targeted to generate liquid chemical products from wood.

**International Research Institute Formed to Address Utilization of Plantation Grown Biomaterials (FPL)**

Leading wood scientists and engineers from around the globe formed an international group to address conservation issues surrounding historic trees and structures. An international research group was formed to develop nondestructive evaluation technologies to address a range of conservation related issues, including evaluation of historic wood structures and trees, and uses for plantation grown biomaterials. Leading wood scientists from Asia, Australia, Europe, North America, and South America gathered in Beijing, China, combining resources and technical expertise, to address the need for technologies to assess the condition, performance, and utilization potential for forest biomaterials.

**Updating a Building Design Standard with Improved Criteria for Preventing Mold Growth (FPL)**

Building designers often address many different expectations. Designers commonly run analysis for various performance criteria, such as life safety (e.g., structural, fire), comfort, lighting, acoustics, energy use, and environmental impact. An important consideration for human health and building serviceability is avoiding potential moisture problems such as mold growth. Although moisture problems are often a result of improper construction, building operation, or maintenance, some moisture problems stem from poor design, and fixing moisture problems is much less expensive during the design process than after construction is underway. A consensus standard developed by an international expert committee, known as ASHRAE Standard 160, Criteria for Moisture-Control Design Analysis in Buildings, has included criteria to prevent mold growth since it was published in 2009. Since then researchers and practitioners have pointed out that the criteria were unrealistic both scientifically and practically. This collaborative project investigated a state-of-the-art empirical model that describes mold

growth and decline over time and takes into account the sensitivity of the material and the surface temperature and humidity conditions. The results showed that this model did a much better job of predicting mold growth in buildings than the old criteria in the standard.

### 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 demands 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 and often subject to resource constraints and decision problems. The Community of Practice of Forest Management Decision Support Systems provides a large repository on knowledge about the construction and use of forest Decision Support Systems.– (Community of Practice Forest Management Decision Support Systems, http://www.forestdss.org/)

The U.S. FS currently reports 98 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 U.S. 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).

The Hot-Dry-Windy Index improves fire weather forecasting (PNW) - A new tool helps fire managers anticipate when wildfires could become erratic or dangerous. Predicting the weather is notoriously complicated, which can be a challenge for fire managers. Weather plays a major role in how a wildfire behaves and whether it might become erratic or endanger firefighters. For thirty years, fire weather forecasters used the "Haines Index" to assess how weather might intensify wildfire and drive its spread. Forecasters knew that the index had shortcomings. But very few studies had ever evaluated its performance, and no peer-reviewed studies had ever quantitatively examined the performance of the index for multiple days of multiple, individual fires. Brian Potter, a research meteorologist with the USDA FS, sought to address this gap, leading a study that evaluated the accuracy of the Haines Index for 47 fires that burned in the United States from 2004 to 2017.

The study revealed fundamental flaws in the Haines Index. But Potter and his colleagues also came up with a new fire weather index, called the Hot-Dry-Windy Index. It is based on physics (rather than statistics) and appears to have predictive skill at identifying days when weather processes could contribute to especially dangerous fire behavior.

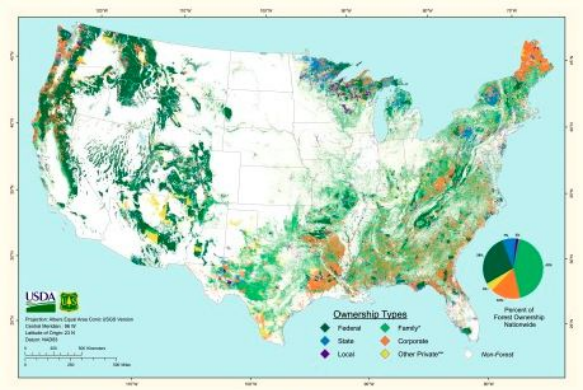
**Data - Research Data Archives**

This archive publishes and preserves short and long-term research data collected from studies funded by:

FS 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 FS 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 FY2017; customers accessing data publications rose 20% to 4,498. (Session traffic is more impressive: 17,615 customers came into the store; 26% more than in FY2016.)

**6.8. Who Owns the Forest?**



U.S. forest ownership map. Jake Hewes, USDA Forest Service

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 FS 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 FY2017.

**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 government partner with non-profits, fire departments, and other stakeholders to reduce wildfire risk locally through the use of mitigation best practices. The FSs 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 nation-wide.

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

Wildland Urban Interface Research: The community wildfire risk reduction work the FS 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 FS Research Stations, and FS fire researchers like Dr. Sarah McCaffrey and Dr. Jack Cohen (retired) form the foundation of best practices. As an example, the FS, 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 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-asssement-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 FS, 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 to help communities reduce risk, their successes, and work 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. FS, 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, FEMA, U.S. Fire Administration, Dept. 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 FY2017 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 all 50 states across the US and represents almost 500 million acres of forest pest survey.

**Urban &Community Forestry:**

The FS has a long history-well over three decades of delivering urban forestry research, technology, and information to our partners, stakeholders, and customers. In FY2018, the Urban & Community Forestry

Program provided technical or financial assistance to more than 7,951 communities across the United States, 35% of which were small, rural communities sharing FS knowledge and tools is essential to improving the management and long-term sustainability of urban ecosystems. Our partners and customers, including state forestry agencies, non-profit organizations, private industry, academic institutions, and municipalities, are asking the FS to continue to provide our much-needed science and technology delivery services. This demand is increasing as our audience and customer base expands 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 FS 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 FS 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 FS, major North American wood associations, and other organizations, WoodWorks promotes the construction of wood buildings. The $2 million contributed by USFS 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 FS 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:**

FS 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. FS 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 STEAM education; targeting 5th - 8th grade students. Hardcopy and digital publications are available to students and educators. These publications educate students about research generated by the FS, engage youth in STEM education, and inspire youth to pursue science driven careers. Scientist Cards present information on specific FS 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 FS 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 1000 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

FS is the Nation's largest water company.

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 U.S.

- 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 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.

FS 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 FS, 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.

**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.

## 6.11. 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)**

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 that is delivered through five station 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 assure 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 sustain ability 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 FS 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 range-lands and changing weather patterns (temperature and precipitation), atmospheric deposition, air quality, and soil health.

- Researches sustainable production of forest and range-land 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 FS 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 conduct innovative and seminal research that provides sound science, innovative technologies, and practical applications to improve the health and productivity of our Nation's forests and grasslands, inform natural resources policy and land management decisions, and anticipate emerging natural resource issues.

**Key Elements**

The Landscape Restoration & Ecosystem Services Research (LR&ESR) Staff has leadership responsibility in the R&D mission area for five broad lines of inquiry:

- Providing renewable natural resource managers and policy makers with management and policy options that promote healthy, resilient, watershed conditions, and wildlife and fish habitats;

- Designing new approaches to "green" investment and development that have lower impacts on the environment and that create sustainable economic development, increased employment, and healthy communities.

- Exploring how settings with trees all along the urban-to-wildland gradient create values for people—whether neighborhood residents or the recreation visitor—and how to practice more effective stewardship to enhance and sustain these values.

- Creating deeper understanding of how emerging technologies, products, and markets, along with changing economic and societal values, impact forests and the goods and ecological services they provide;

- Inventing wood-based materials that create new markets or expand existing markets, including inventing advanced manufacturing and conversion processes for utilizing woody biomass and recycled materials.

The prime objective for LR&ESR staff members across these five lines of inquiry is to build through syntheses and advocacy of field scientists' findings a solid scientific foundation for natural resource management and policy-making at multiple spatial scales in boreal, temperate, and tropical forest ecosystems.

**Recent Achievements**

**eDNAtlas:** Launched the eDNAtlas, an open-access online database, to provide precise spatial information on the occurrence locations of aquatic species in the U.S., as determined by eDNA sampling. The eDNA samples constituting the database are collected using a standardized field

sampling protocol by numerous natural resource agencies and non-governmental organizations partnered with the USDA FS National Genomics Center for Wildlife and Fish Conservation. The eDNAtlas database currently contains results from thousands of sites and dozens of species and will be annually updated with additional results for a growing list of species.

**Bat Genomics Database**: The USFS RMRS National Genomics Center (NGC) is developing a Bat Genomics Database. The goals of this database are to create a national genomics repository for North American bat species for accurate species identification, and to develop more sensitive Pd detection methods to trace origins of the fungal pathogen across the United States whether by natural dispersal or due to human assistance. NGC is also interested in developing the tools to collect bat and Pd eDNA from fresh watershed samples

**Economic Valuation Protocol for Recreation:** Developed a scientifically valid protocol and data tables for calculating economic value of recreation on national forests, including a webinar and guidance document for training planners, managers, and specialists in the use of the method. The method is being rolled out this year.

**Timber Appraisal Methodology:** Developed a new method for timber appraisal to account for contemporary market conditions and prices so that fair market prices can be implemented to ensure positive bids and contract awards that generate timber revenue while improving forest health conditions. The method is under testing with positive results thus far.

**Urban Forest Connections:** Hosted nine webinars that showcased the state of the art in research and best practices on topics ranging from integrating trees into stormwater management design to studying

the impact of trees and green space on cardiovascular health. These webinars had an average of 214 attendees per session during the live webinars, and are available for download after the fact, reaching countless more practitioners. https://www.fs.fed.us/research/urban-webinars/

**Illegal marijuana site detection:** R&D scientists built a remote sensing model that can identify illegal marijuana grow sites from satellite imagery. They combined standard and novel technologies to 'find the needle in the haystack.' Advanced image classification algorithms can sort a few hundred acres of illegal trespass grow operations from millions of acres. The system enables us to identify specific location coordinates of trespass grows and the detection of grow sites when it is not the growing season, making it useful to both law enforcement and ecological conservation priorities.

**Monarch habitat management:** Developed the technical transfer of materials concerning milkweed (Asclepias spp.) propagation and monarch butterfly waystation establishment, as well as field trials to determine feasibility of outplanting rhizomes of milkweed to inform the propagation and outplanting of milkweeds to support monarch butterfly populations. (Monarchs cannot survive without milkweed; their caterpillars only eat milkweed plants, and monarch butterflies need milkweed to lay their eggs. Milkweed has been in decline in recent decades.)

**e-Nose:** The electronic-nose (e-nose) is a relatively new diagnostic tool that has been used successfully for early detection of disease-associated biomarkers in certain human diseases. SRS researchers are working to adapt e-nose for early detection of animal disease pathogens such as *Pseudogymnoascus destructans* (Pd), the causative agent of white-nose syndrome (WNS) and the prions which cause chronic wasting disease (CWD). The e-nose is a non-invasive tool that conducts highly-specialized

chemical analysis of infected animals before they show clinical signs of disease which could reduce the incidence of disease transmission.

**Bat-AMP and NABat:** PSW and SRS scientists have developed the Bat Acoustic Monitoring Portal (Bat AMP) and the North American Bat Monitoring Program (NABat Program), respectively, for monitoring the status of bat populations on the landscape over time. Both databases are collaborative efforts to share bat population data across multiple federal and state agencies.

**Improved efficiency of blister rust screening technique:** White Pine Blister Rust is an invasive pathogen that kills white pines, including the revered and high value Sugar pine. Years ago, PSW research discovered there is a major gene for resistance. A process was developed to screen seedlings to determine if the parent has the gene, and the technique has been used ever since to identify seed sources for reforestation, however, the process takes over a year, with only a 1-10% success rate. Recent genome sequencing research discovered 5 locations (markers) on the genome were potentially associated with the gene for resistance. Our research scientist realized the potential of these markers, and, then developed the markers, tested them, and demonstrated that 70-90% of the time the markers correctly identified resistant and non-resistant trees, allowing for candidate trees to be identified within one day and resistant seed sources to be identified with 100-fold efficiency.

**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, policy-makers, 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 account-ability, science applications, science education, data quality, peer review, tech transfer and licensing activities and information management for FS 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 FS 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 Secretary of Agriculture from Federal, State, university, industry, and nongovernmental organizations, the FRAC meets annually and presents recommendations to the Secretary on the FS 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 FS 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**

- **R&D WO Newsletter:** Produced 12 monthly newsletter issues on time. Recruited 1,660 new subscribers in 2018, including leaders in the FS and partner organizations and Congressional staffers. Currently have about 11,000 subscribers. Infographics featured in newsletter are multi-purposed and are among OC's most popular social media features.

- **Rollouts of Reports:** Wrote communication plan for agroforestry report and helped execute plan, which helped agroforestry report score in top 5 percent of all research outputs rated by Altmetric. Wrote first draft of communication plan for Non-Forest Timber Products. Helped coordinate rollout of PNW Forest Plan Science Synthesis.

- **Research Highlights:** 252 highlights were reviewed and edited and will be uploaded imminently.

- **Blogs:** About 15 blogs written for R&D, FS and USDA blog sites and Inside the FS. This included a Leadership Corner bylined by Carlos Rodriguez-Franco and a graphene blog, which OC says was among USDA's all-time favorites. Suggested seven R&D employees for profiles in "Faces of the FS"—including Sharon Parker's Faces, which received more than 1,000 hits. (Faces usually receive about 50 hits.)

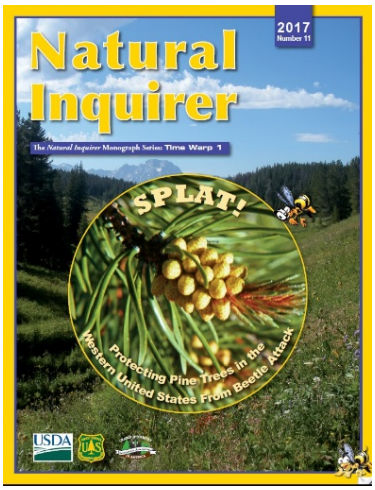
- **Other High Impact Products:** Produced three new glossy handouts: 1) R&D research for NFS; 2) illegal marijuana grows and 3) fire research. Also produced "A Sample of Recent Research Accomplishments: Science and Innovation for a New Century of Conservation." Informally called "Greatest Hits," this document--a summary of R&D research achievements--in the formal approval process. Large sections of this document were incorporated into a Charles Riley Memorial Foundation document that describes the importance of R&D. In addition, the communication team is preparing "self-serve" BOX containing commonly used documents for distribution to entire R&D WO staff.

- **Altmetrics:** Promoted the use of Altmetrics by station Public Affairs Officers.

- **Facebook and Inside the Forest Service:** Provide postings for these outlets on a weekly basis.

- **Web Modernization:** Streamlined the R&D home page and improved carousel, and working with Climate Change Resource Center on web modernization of R&D site.

- **Conferences:** Staffed booth at Ag Outlook Conference in Washington DC, supported Carl Lucero's Ag Outlook session and staffed booth at 2018 Stem Expo in Washington, DC. (Prepared to staff booth at National Council of Science and Environment Conference in Crystal City, VA but was snowed out.) Completed redesign of R&D conference booth and purchased PSW banner.




The *Natural Inquirer* program creates and distributes re-usable science journals and materials written for K-12 students. In FY 2018, approximately 150,000 of these products (excluding cards) were distributed to classrooms and homeschools across the country. All work is done with our non-profit 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 FY2018 Program Accomplishments**

The following products were distributed in FY18:

- 109,597 scientist & engineering cards
- 1,121 "America's First Forest" DVDs
- 173 Social Scientists Packs (Four journals and thirteen cards)
- 162 *Natural Inquirer* Reader Packs (Seven readers and seven cards)
- 6,386 *Natural Inquirer* Readers

- *Nature Science Investigator(NSI)*- 11,890
- *"Bee A Scientist*" Coloring Books – 27,148
- *Natural Inquirer* and *Investi-gator* journals – 104,153
- Spanish *Natural Inquirer* editions – 1,629
- *Natural Inquirer* social media: 4.5 percent increase in followers on Facebook, and 3.8 percent increase on Twitter

**New products**: Spanish "Bee" A Scientist coloring book, "Where There's Smoke There's Fire" monograph, "Standing on the Shoulders of Giants" monograph, Smokey Bear card completed for Smokey's 75th birthday in the 2019, 36 new scientist and engineer cards, "Meet Dr. Roman" Reader

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

- National Girl Scout Conference
- Wayne (OH) Police Department
- Georgia STEM Forum
- Red Butte Gardens (U of U) Botany Bins
- Society for American Foresters Conference
- National Conference for Science and the Environment
- AgOutlook Forum
- Gum Springs Elementary School (Jackson Co.) Career Day
- USFS Civil Rights Northeastern Service Center
- National Science Teachers Association National Conference

- College of Menominee Nation Career Day
- USA Science & Engineering Festival
- Cradle of Forestry in America (CFAIA) visitor sites & campgrounds
- WNEG Quality of Life Show
- CFAIA Pisgah Explorers Club
- FS Southern Research Station
- Troy, New York High School Earth Day
- Rocky Mountain Research Station/ Philadelphia Field Station - Science Carnival
- SciStarter
- Gum Springs Elementary School (Jackson Co.) - Girl Scouts Entomology Program
- Philadelphia Field Station - Federal Fair event
- PLT Conference (Cody WY)
- CFAIA – BioBlitz
- North Georgia Children's Forest Network
- Schenck You Event
- Hemlock Festival
- New England State Fair "The Big E"
- Play at the Park and In our Fair bags for Families, Forsyth Ga County Extension
- Experience UGA (University of Georgia outreach event for K-1 students)

- **Partnerships:**

    - United Nations Food and Agriculture Organization (World's Forest 3 edition)

- FS Conservation Education
- FS Southern Research Station (Hidden Figures partnership)
- FS Northern Research Station (Production of Time Warp monograph series)

## National Agroforestry Center

Established in the 1990 Farm Bill, 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. Located in Lincoln. Nebraska, the Center works with a national network of more than 4,000 natural resource and agriculture professionals who, in turn, provide technical assistance to land owners.

Work at the Center includes research and/or outreach on the five agroforestry systems most utilized in the United States:

- **Windbreaks and shelterbelts,** to shelter crops, people, animals, buildings, and soil from wind, snow, dust, and odors;

- **Riparian forest buffers** that filter farm runoff, reduce soil erosion, and diversify income sources;

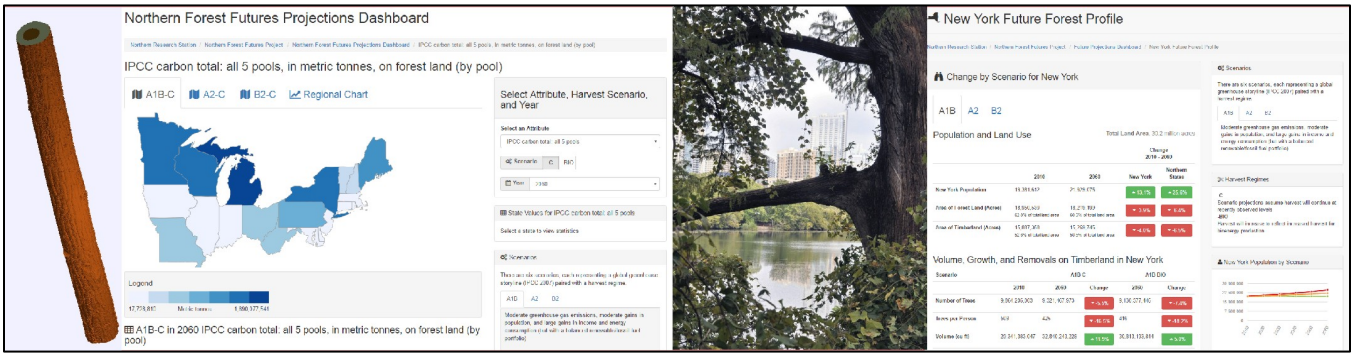
- **Silvopasture,** to increase the efficiency of land use and diversify incomes;

- **Alley cropping** to augment landowner income before trees are mature enough to harvest and/or produce fruit, berries, or nuts: and/or
- **Forest farming, or multi-story cropping,** to produce food, herbal, botanical, or decorative crops under the protection of a managed forest canopy**.**

Accomplishments in FY2018 focused on enhancing economic opportunity for rural communities to practice and benefit from agroforestry and improving customer access to existing USDA programs that advance agroforestry research and technology transfer. Activities included convening members of the public and private sectors to identify opportunities for enhancing economic access, as well as leading the eight-member USDA Interagency Agroforestry Team to produce the 2019-2024 USDA Agroforestry Strategic Framework. Additional accomplishments included creating new publications and tools to help USDA stakeholders learn how USDA programs can be used to support agroforestry research.

In addition, the Center published a new scientific assessment entitled “Agroforestry: Enhancing Resiliency in U.S. Agricultural Landscapes Under Changing Conditions” with input from more than 50 authors across the United States, Canada and Mexico; provided training in agroforestry in several US regions; advanced on-going work that facilitates the use of agroforestry in pollinator production; and continued to work with Great Plains States to map and inventory trees outside of forests. The Center also continued to enhance regionally-specific information transfer through support for regional agroforestry networks, including initiating the establishment of a new Southwest working group.

## Northern Research Station (NRS)




The Northern Research Station provides the science land managers, city planners and policy makers need to improve the condition of the Nations forests and grasslands. 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 FS 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 FS 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 FS 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**

**Fire Weather Prediction Tool Modernizes Science Behind Forecasts**

Fire weather forecasters need accurate and proven tools to help them anticipate when weather conditions can make wildfires dangerous for fire managers. USDA FS scientists are expanding the options with the development of the Hot-Dry-Windy Index (HDW), a new fire-weather prediction tool based on the key atmospheric variables that affect wildland fire: temperature, moisture, and wind.

For 30 years, the Haines Index has been the standard measure used by fire weather forecasters to assess how weather conditions above the ground might contribute to large growth days for wildfire. While some forecasters knew it had shortcomings, they had no research to support their concerns, and use of the Haines Index became further entrenched every year. Northern Research Station scientists and colleagues in the Southern Research Station and the Pacific Northwest Research Station developed the Hot-Dry-Windy Index (HDW), a physically based and easily understood new fire weather index named after the key atmospheric variables that affect wildland fire. When tested against several past wildfires, HDW appears to correspond with conditions recorded in those large fire events. National Weather Service meteorologists across the United States have access to an HDW forecast website for use in their work, and they are providing scientists with feedback on its performance that will be considered as evaluation of HDW continues. In Washington, Oregon, and Idaho, forecasters are citing it in their daily fire weather briefings. The research team demonstrated that the Haines Index is fundamentally flawed and performs poorly; the National Wildfire Coordinating Group's Fire Weather Subcommittee has formally recommended that the Haines Index be dropped from training curricula and from use.

**Vacuum Steam Heat: A New Method to Kill Oak Wilt Fungus in Logs**

International export of oak logs from the United States requires fumigation of the logs with methyl bromide. However, methyl bromide causes severe damage to the Earth's ozone layer. Scientists recently discovered that using vacuum steam heat to treat oak logs kills the oak wilt fungus and is environmentally friendly.

The oak wilt fungus (Bretziella fagacearum), which is only known to exist in the eastern United States, is a significant cause of oak death in the region. To contain the fungus, officials established quarantines to regulate movement of oak logs to other regions and countries. Over 30 years ago, fumigation of oak logs with methyl bromide became the standard practice to kill the fungus and prevent its spread. When methyl bromide was found to be a serious threat to the Earth's ozone layer, scientists began looking for alternative treatments that would kill the fungus while not causing damage to the environment. In recent studies, a Northern Research Station scientist working in collaboration with USDA Animal and Plant Health Inspection Service, Plant Protection and Quarantine, and university colleagues tested the feasibility of using vacuum steam to treat oak logs.

Prior to treatment, the fungus was consistently isolated from an average of 18 percent of log samples taken from naturally-infected red oaks and 38 percent of those taken from artificially-inoculated trees. Treatments involved raising the temperature of the wood to a 2-inch depth to 133 or 140 degrees Fahrenheit for 30 or 60 minutes, respectively. In no case was the fungus isolated from the study logs after treatment. Future work on this promising alternative to methyl bromide will focus on questions related to use for commercial-size log loads.

**Agencies Collaborate on Tools to Manage the Asian Longhorned Beetle**

Working across natural resource agencies, Northern Research Station scientists have collaborated to build new tools that benefit state and federal agencies in efforts to eradicate the invasive Asian longhorned beetle (ALB), *Anoplophora glabripennis Motschulsky*.

The ALB is an invasive insect that threatens the sustainability of maples, willows, poplars, and at least 12 other genera of trees native to North America. State and federal natural resource agencies have mobilized to eradicate infestations, and they have had some success, but it has been at a cost of approximately $750 million.

Eradicating the beetle depends on destroying infested trees, but first the infested trees must be found. Currently, the best way to find infested trees is with visual surveys, searching each tree for the chew marks or exit holes left by adults. These marks are very small and occur across large landscapes with millions of trees, thus finding the infested trees becomes a “needle in the haystack” challenge.

Researchers with the USDA FS Northern Research Station and the Animal and Plant Health Inspection Service Center for Plant Health Science and Technology worked together to develop a suite of tools to help identify where in the haystack to search. These tools reconstruct the patterns of beetle movement which are unique to each infestation, and then apply the patterns to the surrounding landscape to identify potential areas of high and low risk. Combined with local expertise, the tools can help identify where to search, when to search, and how often to search, which greatly increases the efficiency and efficacy of eradication programs.

**Farms and Forests: Quantifying the Tree Resource in the Great Plains**

Between 1935 and 1942, the Prairie States Forestry Project orchestrated the planting of more than 220 million trees in 33,000 windbreaks totaling more than 18,000 miles in a swath stretching from North Dakota to Texas. Today, scientists with the Northern Research Station's Forest Inventory and Analysis (FIA) Program are helping establish the extent and location of windbreaks in the Great Plains.

Forests in the Great Plains are not like traditional forests. Their placement is often intended to provide an ecological service, such as conserving soil, protecting crops, livestock and humans, or enhancing water quality. They occur in patterns that range from scattered trees in a pasture to neat rows along a field boundary or around a farmstead. While these tree features often fail to meet the definition of "forest" employed by national inventory programs, they are viewed as such by the region's land managers. Windbreaks are a prime example; they are critically important yet little information describing their extent and location is available in formats (e.g., maps) that are useful for resource professionals and decision-makers. Researchers with the Northern Research Station's Forest Inventory and Analysis unit collaborated with the USDA National Agroforestry Center to develop an operational land cover mapping process that uses 1-meter aerial photography. The availability of such fine-scale information over large geographic areas, such as a state, delivers detailed spatial information about trees in agroecosystems to land managers and decision-makers. The data are being used by foresters and natural resource professionals in the Great Plains to target areas where windbreak renovation or installation would help farmers conserve topsoil. This endeavor is the first of its kind in the region and provides information at a new scale that is appropriate for inventory, monitoring, and decision-making related to nontraditional forests.

**A New Tool for Tracking Deer Browse Risk across 24 States**

The scourge of white-tailed deer and their impacts on young tree seedlings have made regeneration of native forest almost impossible for landowners as devastating browse impacts often co-occur with other stressors such as invasive plants and climate variability. Scientists at the Northern Research Station cooperated with partners to develop a region-wide browse-impact "risk" map to identify and track forest land under stress.

The maturation of midwestern and northeastern forests has led to a dangerous imbalance in age-class structure as young forest habitat has become very rare. This means values the public has come to expect from healthy young forest are largely missing and there are few if any young trees to take the place of older trees when they die. Increased concern about regeneration challenges in native forests led the Northern Research Station Forest Inventory and Analysis group (NRS-FIA) to conduct browse evaluations as part of a new suite of field measurements, called the regeneration indicator that includes assessing all established seedlings that are at least 2-inches tall. An interdisciplinary team used the browse evaluations to develop a map depicting the probability of occurrence for moderate and high browse impacts. The reason for modeling moderate and high impact areas is that they signal the need to consider site-specific conditions prior to making stand-initiation prescriptions.

The map fills a critical information gap for policy makers and managers tasked with understanding where overbrowsing has obliterated habitat for young forest species and tree seedlings needed to restore high-canopy native species. The regeneration indicator data are available along with all of the NRS-FIA variables in a public database that is updated each year. These data provide a platform for conducting geospatial analyses using related geodatabases (e.g., fragmentation, population, or land use) to answer larger, more complex policy questions.

**Mapping Local Stewardship to Support Resilience and Preparedness**

As our cities and towns face challenges ranging from overstressed infrastructure to extreme weather, community-based civic groups are often on the frontlines of responding to these challenges. The Stewardship Mapping and Assessment Project (STEW-MAP) is a framework for identifying, assessing, and mapping community groups that take care of the local environment to help communities better prepare for and respond to natural disasters.

Community stewardship can help revitalize communities, restore nature, and prepare for, respond to, and recover from disturbances. Yet there can be challenges associated with identifying and organizing the capacity of stewardship groups. Researchers at the Northern Research Station developed a way to quantify, assess, and map community environmental stewardship groups. The Stewardship Mapping & Assessment Project (STEW-MAP) is a methodology for more effectively engaging with these sometimes “unseen” groups by understanding their organizational capacities, physical turf, and social networks.

STEW-MAP began in the Northeast, but it has been adapted to smaller communities, rural areas, and international settings, including Denver, Colo., and San Juan, Puerto Rico. The STEW-MAP survey identifies stewardship groups that may include block associations, tree-planting groups, nonprofit educational institutions, and other groups that care for natural resources. As a longitudinal study, new data have now been collected in the New York City region in 2017, which will show how groups respond to disturbances, such as Hurricane Sandy. In addition, case studies demonstrate the role of stewardship in the context of disturbance across different landscape types. By using these data, researchers, policymakers and managers can encourage public engagement, build partnerships between

stakeholders, and promote efforts related to community resiliency creating a civil society that is stronger, healthier, greener, and more resilient.

**Mapping U.S. Drought Projections Helps Foresters Plan for Sustainability**

Droughts are natural disturbances that can cause negative effects on natural ecosystems and also have important social and economic consequences. Researchers are helping land managers prepare for changing climate conditions by developing projections of how drought may change in the future. Scientists with the USDA FS Northern Research Station and their partners are investigating how regional temperatures, precipitation, and drought may change across the United States in coming decades. Mapped projections of multiple climate scenarios throughout this century provide important information useful for natural resource managers working to sustain natural ecosystems and the benefits that they provide. Although relatively small changes in drought are expected during the next few decades, these changes are expected to accelerate during latter half of the century. These changes will likely impact plant and animal growth and survival and lead to changes in forest composition and structure.

These projections of drought, when considered in light of the uncertainties present within climate models, can help managers and individual landowners prioritize strategies to help the ecosystems they oversee adapt to the upcoming conditions. Efforts to make this information more accessible to landowners and managers is vital; current management and silvicultural activities will shape the next forest over the course of this century. Understanding these potential patterns, as well as advancing understanding of how species respond to global change pressures, will be essential in planning for forest resilience and adaptation, other aspects of biological conservation, and society as a whole.

**WaterViz: A Multimedia Tool for Experiencing the Water Cycle**

WaterViz takes complex water and weather data and translates it into live-streaming art and music, inviting viewers and listeners from around the world to experience complex forest data online. Poised at the nexus between the hydrological sciences, neurosciences, visual arts, music, and education, WaterViz is an online water cycle visualization and sonification tool that makes large multidimensional forest data sets more intuitive and easier to comprehend. WaterViz captures water and weather data from environmental sensors located in two USDA FS Experimental Forests: the Hubbard Brook Experimental Forest, a northern hardwood forest in New Hampshire, and the HJ Andrews Experimental Forest, an old-growth Douglas fir forest in Oregon. The tool then uses the data to drive artistic visualizations and musical sonifications of the water cycle at these two contrasting forest sites. WaterViz can be set to display real-time data or historical trends in long-term data and extreme weather events.

**Hardwood Sawmills Abuzz about Lumber from Small Logs**

Standard operating procedures for merchandizing hardwood from timber harvests is to ship small-diameter material to a wood chipping/stranding operation for conversion into pulp, engineered wood/panel products, or wood pellets. These markets rarely yield a profit to forest landowners. Profits come when logs are sawn into lumber for high-end markets. Instead of assuming that sawmills cannot produce profit sawing small-diameter logs, scientists put this long-held assumption to the test.

The Northern Research Station continues to lead efforts to find new markets and processing efficiencies to add value to low-value hardwoods. At the request of the primary processing industry and landowners,

the most recent effort focused on value-added utilization of logs with small-end diameters less than 10 inches. Study results showed these small diameter logs can produce lumber volume recoveries that are comparable to or greater than those of somewhat larger logs (10-13 inches diameter) that are established as profitable sawmill inputs. However, lumber grades from these small diameter logs can be highly variable with drying processes especially critical to maintaining higher-value lumber grades.

**In Appalachia, Consortium Delivers Fire Science and Fosters Communicati**on

Prescribed fire is an important tool to restore Appalachian forests, but land managers responsible for achieving restoration goals and ensuring human health and safety need access to relevant fire science. The Consortium of Appalachian Fire Managers and Scientists (CAFMS) is improving fire science delivery to managers and fostering communication between researchers and managers through a variety of activities and products.

After nearly a century of effective fire suppression, many forests of the Appalachian region are exhibiting undesirable changes, including poor oak and pine regeneration, increased fuel loading of evergreen shrubs, and declines of plant and animal species that are adapted to habitats created and sustained by periodic fire. These changes have led managers to see prescribed fire as an increasingly important tool in restoring woodlands and forests to a more desired condition. However, while there has been a rapid expansion of fire science in recent years, it has been difficult for fire managers and practitioners to access fire science information that is relevant to the region. The CAFMS is one of 15 regional Fire Science Exchanges that are funded by the Joint Fire Science Program. With more than 1,000 members, CAFMS is improving fire science delivery to managers and fostering communication between researchers and managers through a website, social media, webinars, newsletters, recorded

presentations, research briefs and syntheses, and field tours. Land managers now have better access to science that informs their work, and ongoing communication with scientists about on-the-ground observations, restoration challenges, and research needs is helping shape new research.

**For 50 Years, SILVAH Collaboration Shapes Pennsylvania Forestry**

The 50-year journey from a small forestry meeting to a regional community of practice has lessons for anyone interested in how the private and public sectors can work together to solve common problems. In September 2017, the Northern Research Station and the Allegheny Section of the Society of American Foresters jointly held a meeting marking the 50th anniversary of the management-research partnership that has shaped the practice of forestry in northwestern Pennsylvania and beyond. In the late 1960s, serious forest regeneration issues plagued the area; 50 percent of all timber sales failed to replace harvested trees with new trees. To address this crisis, USDA FS scientists joined forces with foresters from local industry and state land management agencies. These scientists sought the advice of the foresters in identifying possible causes of the forest regeneration problems and implementing studies to test those causes. They quickly identified excessive browsing by whitetail deer and dense understory shade as the primary causes of forest regeneration difficulties. In time, the scientists developed forest management guidelines called SILVAH and began offering training courses. Local foresters took the training and, because they had been involved with their development from the beginning, applied the guidelines with tremendous success. Since then, SILVAH has evolved into a community of practice consisting of foresters and scientists working together to solve forestry problems throughout Pennsylvania and neighboring states.

## Pacific Northwest Research Station (PNW)

The Pacific Northwest (PNW) Research Station is one of seven research centers that are part of the USDA FS. 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 assure future generations enjoy the same benefits from forests that we do today. As part of the USDA FS, 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 managing forests, wildlife and fish habitat, recreation, climate change, human health and well-being, and more. We have the honor of bringing science to the table as people make often difficult choices about managing land.

The PNW 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**

**Synthesis of Science to Inform Land Management Within the Northwest Forest Plan Area**

- The synthesis was designed as a go-to source of scientific information to inform national forest land management decisions in the Plan area. Its regional focus reduces the need for individual national forests to produce their own science report and provides a consistent base of science information to inform planning efforts.

The 1994 Northwest Forest Plan was developed as a solution to a regional stalemate over logging and habitat protection for the threatened northern spotted owl. Unprecedented in scope, the Plan prioritized biodiversity conservation but stipulated that a sustainable level of timber harvest continue from federal forests. The Plan also addressed anadromous fish, marbled murrelets—a threatened bird that nests in large coastal trees but forages in the ocean—and other species associated with older forests.

In the past two decades much has been learned about specific species, ecosystem processes, and particularly the intertwined nature of human communities, natural resource management, and forest health. The 2012 FS Planning Rule specifically states that the best available science shall be used in planning. So, in 2015, regional foresters in the Pacific Northwest Region and Pacific Southwest Region asked the Pacific Northwest and Pacific Southwest Research Stations to synthesize the accumulated knowledge.

The resulting synthesis, published by the PNW Research Station in June 2018, will inform the assessment stage of the land management planning process across the Northwest Forest Plan area. Using the synthesis as its scientific foundation, assessments will evaluate existing and possible future conditions and trends in social, economic, and ecological systems. Individual national forests can also use the information to support design and implementation of land management projects. The science information considered all land ownerships, so managers can use it to identify issues where coordination with other agencies and landowners may be needed.

**The Hot-Dry-Windy Index improves fire weather forecasting**

A new tool helps fire managers anticipate when wildfires could become erratic or dangerous
Predicting the weather is notoriously complicated, which can be a challenge for fire managers. Weather plays a major role in how a wildfire behaves and whether it might become erratic or endanger firefighters. For 30 years, fire weather forecasters used the “Haines Index” to assess how weather might intensify wildfire and drive its spread.

Forecasters knew that the index had shortcomings. But very few studies had ever evaluated its performance, and no peer-reviewed studies had ever quantitatively examined the performance of the index for multiple days of multiple, individual fires. To address this, the PNW Research Station took the lead and conducted a study that revealed fundamental flaws in the Haines Index. They also developed a new fire weather index, called the Hot-Dry-Windy Index. It is based on physics, rather than statistics, and appears to have predictive skill at identifying days when weather processes could contribute to especially dangerous fire behavior.

This new fire-weather prediction tool is based on the key atmospheric variables that affect wildland fire: temperature, moisture, and wind. It works with the same weather models that are used every day in fire weather forecasts and can be applied anywhere in the world.

The National Weather Service has recommended that fire weather forecasters begin evaluating the Hot-Dry-Windy Index as a potential fire weather tool.

**The new normal: empirical estimates of future fire environments in the Pacific Northwest**

A set of time series maps provides empirical estimates of how climate change might affect the geographic distribution of large wildfires and fire rotations in the Pacific Northwest. This information can help forest resource managers and policymakers plan strategically for changing conditions.

Large wildfires in the Pacific Northwest are increasingly frequent compared to the last three decades of the 20$^{th}$ century. These wildfires are products of their environment. As droughts become more common in much of the western United States and temperatures warm, forest environments appear to be coming more suitable for large wildfires.

Scientists with the PNW Research Station and collaborators extrapolated and contrasted what is consider today's ‘‘normal” fire environment to what might be considered normal by the end of this century as a result of forecasted changes in climate. Their findings indicate more forest area in all ecoregions of the Pacific Northwest will be suitable for the occurrence of wildfire larger than 100 acres over the next century. The largest increases are projected to occur on federal lands, while private and state lands showed less. By the end of the century, the models predict shorter fire-rotation periods; cooler, moister forests are projected to experience larger magnitudes of change than warmer, drier forests.

This project yielded a set of time series maps that provide forest resource managers, fire protection agencies, and policymakers with empirical estimates of how much and where climate change might affect the geographic distribution of large wildfires and effect fire rotations. Areas where the fire environment is not likely to change much might serve as focal areas for fire refugia and reserves designed to maintain or restore older, denser, closed canopy forests. Forest that are currently classified as moderately suitable for large wildfires or are predicted to transition into it may be places to focus active management to improve resilience to future wildfires. Management to ameliorate fire risk may be needed where forests have or are predicted to transition into higher wildfire suitability classes and, due to their location, also pose threats to infrastructure or valued forest resources, and where fire has not been as common.

**Gaining carbon benefits with afforestation and reforestation**

Afforestation and reforestation policies could provide a marginal increase of $21.4 to $147.1 billion in carbon benefits, well in excess of likely policy costs.

The Council on Food, Agricultural and Resource Economics convened a team of researchers, including a scientist with the PNW Research Station, to estimate the benefits of forest carbon sequestration in the United States (excluding Alaska and Hawaii) for a baseline and three policy scenarios: (1) land use policy to reduce forest development; (2) afforestation policy targeting rural landowners in the eastern United States and a reforestation policy targeting federal forest lands in the Western United States; and (3) policy reducing stand-replacing wildfires by 10 percent. Carbon sequestration projections were expressed in terms of dollar value of benefits, based on the social value of carbon estimates.

Their results suggest that under the baseline scenario, the present value of sequestration in U.S. forests through 2050 would be $125.5 to $806.7 billion, depending on the discount rate. Afforestation and reforestation policies would provide the greatest marginal increase in carbon benefits ($21.4 to $147.1 billion), well in excess of policy costs.

Afforestation and reforestation have long been featured in conservation efforts by the U.S Department of Agriculture. This analysis demonstrates that such approaches would be viable for mitigating climate change. Strategies for encouraging greater carbon sequestration in the United States include creating financial incentives to induce private landowners to plant trees and emphasizing reforestation of public forest lands.

**New model predicts Douglas-fir flowering to 5 days, on average, of observed flowering date**

Seed orchard managers in Oregon and Washington used the model in winter 2017 to plan time-sensitive management decisions for spring 2018.

To successfully reproduce, trees must open their reproductive buds at the right time to coincide with others, minimize exposure to damaging frosts, and synchronize development with soil resources. Understanding the environmental cues that influence the timing of tree flowering is important for predicting how reproduction and survival of trees will change in the future.

Using over 4,500 flowering observations from 12 sites across western Oregon and Washington, PNW Research Station scientists created a model to predict reproductive budburst for Douglas-fir. Managers of seed orchards across the two states helped validate the model, which is now accurate to within an average of 5 days of observed flowering dates.

Temperature during the dormant season was the strongest predictor of flowering time, with fewer hours of forcing (warm) temperatures required for flowering on sites and during years that had many hours of chilling (cold) temperatures. In addition, genotypes from warmer, drier locations flowered earlier in common gardens than genotypes from colder, wetter locations. Warmer temperatures in the future will likely result in earlier flowering on sites that are currently colder during winter. Sites that are already generally warmer in winter may display no change, or possibly even experience a delay in flowering. These findings can also be used to predict optimal locations for future seed orchards.

To enhance the model's usability, a Microsoft Excel workbook has been developed that draws on the model's projections. Users supply hourly temperature data over the dormant season to predict the timing of Douglas-fir budburst in the spring.

**Postfire logging produces minimal persistent impacts on understory vegetation in northeastern Oregon**

Postfire logging in dry forests can serve as an effective, long-term fuel-reduction treatment. It reduces future woody fuel loads and broadens the range of conditions under which prescribed fire can be used as a restoration tool in regenerating forests.

A PNW Research Station scientist and colleagues investigated the long-term effects of postfire logging on woody fuels in 255 coniferous forest stands that burned with high fire severity in 68 wildfires between 1970 and 2007 in eastern Washington and Oregon. They found that postfire logging significantly reduced future surface woody fuel levels. Without postfire logging, surface woody fuels peaked 10 to 20 years after fire, on average, as most snags fell or developed broken tops during this time.

The researchers also investigated the long-term response of understory vegetation to two postfire logging treatments—commercial salvage logging with and without additional fuel reduction logging—on a long-term postfire logging experiment in northeastern Oregon. They found that postfire logging produced minimal or no persistent impacts on understory plant cover, species diversity, or exotic species abundance. This suggests that understory vegetation can be resilient to postfire logging, particularly when best management practices, like logging over snow, are used to limit damage to soils and understory vegetation. More study is needed, however, to confirm the generality of this finding for other ecosystem components.

## 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 eight 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 forestry of the Pacific Islands. For more information, visit fs.fed.us/psw.

### PSW SCIENCE DELIVERY

#### Supporting owls compatible with managing forests for fire, drought

In what is believed to be the largest spotted owl study in terms of area analyzed, remote sensing technology is providing a more precise look at habitat preferences for the sensitive species with implications for greater flexibility in forest management.

"For the last 25 years, forests in the western United States have been managed to protect habitat for spotted owls based on ground surveys that were limited by plots with a small sample area and what could be seen from the forest floor," said Malcolm North, a research ecologist with the U.S. FS's Pacific Southwest Research Station and lead author of the study. "We're employing relatively new technology to get a new vantage point into the forest canopy – across an unprecedented amount of terrain – to better understand what that means for spotted owls."

Using Light Detection and Ranging imaging, or LiDAR, North and colleagues from partnering organizations studied forest attributes across 1.2 million acres, encompassing 316 documented owl territories, along California's Sierra Nevada. LiDAR uses laser pulses shot from an instrument mounted in an airplane that can measure a forest's canopy, including tree height, distribution of tree foliage and any forest gaps.

Whereas previous research led to the assumption that spotted owls needed dense canopy cover (generally estimated at 70 percent or greater) across a broad landscape, LiDAR data revealed it's more the height of the canopy, as opposed to the expanse of it, that matters most to owls.

"Cover of tall trees best predicts California spotted owl habitat," recently published online by the journal of "Forest Ecology and Management," reports spotted owls typically were found in forests with

high concentrations of tall trees measuring at least 105 feet in height, but preferably taller than 157 feet. Meanwhile, dense stands of trees measuring 52 feet or shorter were generally avoided by the owls.

"We rarely found owls in high canopy cover without tall trees. We also found owls in areas with tall trees but low surrounding density," North said. "It's really the big trees that the owls are selecting for."

The study's findings could have implications for land management strategies to improve forest resilience to wildfires, drought, insects and diseases. Forests with tree densities greater than historical ranges – especially with high densities of smaller trees – are more susceptible to extreme wildfire behavior or vulnerable to the effects of drought, insect infestations and disease.

"While land managers may have felt compelled to maintain these abnormally high densities to adhere to the 70 percent canopy cover threshold, it might also have placed forests and owls at risk," North said. "The large trees favored by spotted owls can typically withstand low to moderate wildfires and other disturbances. But when exposed to extreme wildfires from high fuel loads or when their vigor is compromised by too many trees competing on the landscape, these tall trees can become vulnerable."

Researchers also studied how large openings in the canopy or gaps in the forested landscape, ranging from 0.03 to greater than 2.5 acres, impacted owl use or nest site selection.

"Land managers may have been leery of creating gaps in the landscape because of the reduction in canopy over," North said. "But other than avoiding placing their nests directly adjacent to a gap, owls showed no difference in the areas they used compared to the surrounding landscape with regard to gaps."

North and his colleagues' study comes on the heels of a newly available report synthesizing the last two decades of research pertaining to spotted owls. "The California Spotted Owl: Current State of

Knowledge" was made available online by the FS's Pacific Southwest Research Station. The report represents a comprehensive review by scientists of the ecology, habitat use, population dynamics and current threats to the viability of the California spotted owl.

**Forecasts predict reduced likelihood of tree mortality in 2018**

Between 3 to 26 million trees are projected to die by the end of summer 2018 in California. This is down from an estimated 27 million in 2017 and a peak of 62 million in 2016.

Background:

Five consecutive years of drought and warmer than normal temperatures created prime conditions for bark beetle and wood borer outbreaks in parts of California. The result: an estimated 129 million trees died from 2010–2017. This standing fuel is a fire risk that could threaten human lives, property, water supplies, wildlife habitat and other forest resources.

In recent years, aerial surveys have been used to collect data and map the extent and severity of tree mortality; these maps are compiled and finalized during the summer. However, having tree mortality forecasts prior to fire season would allow more time for land management agencies to take action and strategically reduce fire hazard in high-risk areas. Recognizing this need, Forest Health Protection collaborated with scientists from the Pacific Southwest Research Station and the Western Wildland Environmental Threat Assessment Center to develop just such a tool.

Model forecasts summer tree mortality 10 months earlier with high accuracy

The forecast for following-year locations and expected level of tree mortality is based on data available in autumn prior to the following growing season. These data include:

- FS Aerial Detection Survey data collected from 1993 to year prior to forecast for observed tree mortality and attributed cause in California and western Nevada.

- Forest Inventory and Analysis data used as a basis to develop forest composition (tree hosts).

- Precipitation and temperature data from PRISM (parameter elevation regression on independent slopes model).

- Fire data from California's Department of Forestry and Fire Protection (CalFire).

Given the high levels of beetle induced tree mortalities in the last three years, projected high-risk locations in 2018 are mostly driven by high levels of beetle pressure, regardless of precipitation levels in the last four years.

**Rapid Ohia Death (ROD)**

The statewide Rapid Ohia Death (ROD) partnership in Hawaii has advanced our understanding of ROD in Hawaii in 2018. Monitoring indicates the pathogen is still moving within Hawaii Island. PSW has developed airborne observatory processes to differentiate Ohia death attributed to ROD as well as canine scent training protocols. Preliminary results show that the canines were >90% accurate in detecting the fungal pathogen Ceratocsytis spp in Metrosideros spp. ('Ohia). PSW is also working with partners to look for Ohia resistance to ROD. We have identified ten locations with high ROD mortality but several

survivor ohia and will utilize these areas to determine if there are varieties of Ohia that are resistant to ROD.

More detail on the airborne observations work: Rapid Ohia Death (ROD) is a disease aggressively killing large numbers of Metrosideros polymorpha (ohia), a native keystone tree species on Hawaii Island. This loss threatens to profoundly alter the biological make-up of this unique island ecosystem. Spatially explicit information about the present and past advancement of the disease is essential for its containment; yet, currently such data are severely lacking. To this end, we used the Carnegie Airborne Observatory to collect Laser-Guided Imaging Spectroscopy data and high-resolution digital imagery across >500,000 ha of Hawaii Island in June–July 2017. We then developed a method to map individual tree crowns matching the symptoms of both active (brown; desiccated ohia crowns) and past (leafless tree crowns) ROD infection using an ensemble of two distinct machine learning approaches. Across the island of Hawaii, we found 43,134 individual crowns suspected of exhibiting the active (browning) stage of ROD infection. In comparison, leafless crown detections were much more numerous (547,666 detected leafless crowns in total) and more dispersed across the island. Mapped hotspots of likely ROD incidence across the island will enable scientists, administrators, and land managers to better understand both where and how ROD spreads and how to apply limited resources to limiting this spread.

**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 FS as well as other federal and state agencies, international organizations, Tribes, academia, non-profit groups and the public.

Research has been part of the FS 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. FS 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), Forest Products Laboratory, and International Institute of Tropical Forestry.

RMRS maintains 14 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 FS 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 long-term. Fort Valley Experimental Forest, established by Gifford Pinchot in 1908, was the first of the nationwide system of experimental forests and ranges. 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 ACTIVITIES

### A unique set of challenges and restoration guidelines for uniquely structured forests: RMRS GTR-373 and Practitioner Field Workshops

In response to the need to for locally-based science to guide Colorado Front Range forest restoration, a diverse author group of scientists, land managers, and non-profit organizations including RMRS, USDA FS, The Nature Conservancy, The Wilderness Society, CFRI, U.S. Geological Survey, Rocky Mountain Tree-Ring Research, and the Natural Resource Conservation Service convened to better understand Colorado Front Range forests. This is a true example of knowledge co-production.

The Colorado Front Range is unique in its topography, growing conditions and resulting forest structure. Through the Collaborative Forest Landscape Restoration Program and the need for local science for Colorado Front Range, the authors published multiple studies to guide restoration. After years of thought and a lot of effort and collaboration from the author group, RMRS published GTR-373: Principles and practices for the restoration of ponderosa pine and dry mixed-conifer forests of the Colorado Front Range in January 2018.

This forest restoration framework needed a thoughtful, targeted roll-out strategy. This included, in addition to presenting to forest management, leadership groups, and silviculturists in traditional meeting settings, getting people that implement forest restoration projects on the Colorado Front Range together to look at projects and talk through the process of moving from principles into practice.

The Rocky Mountain Research Station (RMRS) Science Application and Communication staff, along with the Colorado Forest Restoration Institute (CFRI), hosted two field workshops in September highlighting the science and practical application of forest restoration from the recently published General Technical Report, The goals and objectives of the workshop were to engage forest managers along the Colorado Front Range in a way that would translate science-based principles and practices for restoration in this area to real-life, on-the ground projects.

Since the gradients/conditions vary along the Colorado Front Range, conducting two workshops made the most sense: one in the northern Front Range near Red Feather Lakes, and one in the southern Front Range on the Pikes Peak Ranger District. Each workshop had 65-80 participants plus 20 presenters, representing an impressive number of organizations that manage Colorado Front Range forests.

After careful review and analysis of the post-workshop evaluations for both workshops, the next steps in promoting the science from the GTR-373 will be smaller, more targeted workshops designed to address specific needs along the Colorado Front Range.

**Building durable scientist-manager relationships in the Intermountain Region**

The Region 4 Science Partner Program was initiated in 2016 is to establish and foster collaboration opportunities between RMRS researchers and Intermountain National Forests and Grasslands at multiple scales. For example, as forests and grasslands revise Forest and Grassland Plans, RMRS researchers will provide technical support to create better strategies and practices for land managers. These partnerships help land managers by improving science based-NEPA decisions, establishing support and consultation networks, and engaging management professionals in recent and relevant science findings and co-production of knowledge. Currently there are eight formalized groups ranging in size from 2 people to 10 or more. The program is led by regional office and RMRS co-leads, “match-up” interested pairings from R4 and the Station, check in with partner groups on a 2-3-month basis and administer travel funds intended to encourage face-to-face interactions. All participants from the partner program met in October 2018 to evaluate how well this partner model works and identify how to expand the program. A meeting of this kind is planned for Fall 2019. As a piece of the Science Partner Program, the competitive BeSMART microgrant program awards small scale grants are used to encourage research-management

partnerships. The 2019 funding cycle focus is on Shared Stewardship. We are currently evaluating proposals which we expect to be announced in February.

Science Partner Videos: RMRS recently released a series of short videos highlighting the RMRS-R4 Science Partner Program efforts. The 6-part YouTube Playlist is featured here: https://www.youtube.com/watch?v=tH8wbPnoVIY&list=PLNsZX2SBTlVmJUigal3RovCyjV-iZl-Cp and each video is 2-3 minutes long. The R4-RMRS Science Partner Program pairs RMRS Scientists with Intermountain Region (R4) managers in small work groups to co-create solutions to land management challenges. In the videos, these scientist and manager partners describe projects ranging from mesocarnivore monitoring, development of climate change maps for Forest Planning and socio-economic support to Forest Plan Revision efforts. These partner groups are integrating with National Forest Systems challenges and efforts to find ways to best integrate science into planning and management at all levels and phases of project development. The Science Partners reflect on what has been learned by pairing science and management together in a programmatic fashion. In addition to being broadcast on the FS YouTube Channel, we have also embedded these videos in the Science Partner webpages which provide more details on individual projects.

**Other Activities:**

Partnering for climate change adaptation: Northern Region Adaptation Partnership **(NRAP) and** Intermountain Adaptation Partnership **(IAP) (Analysis):** Long term partnerships centered on climate change vulnerability and adaptation between RMRS research and R1 and R4 managers have recently culminated in two GTR publications and a workshop. These resources and relationships will be invaluable for use in Forest Plan Revision and other project-level planning. A three-day workshop was

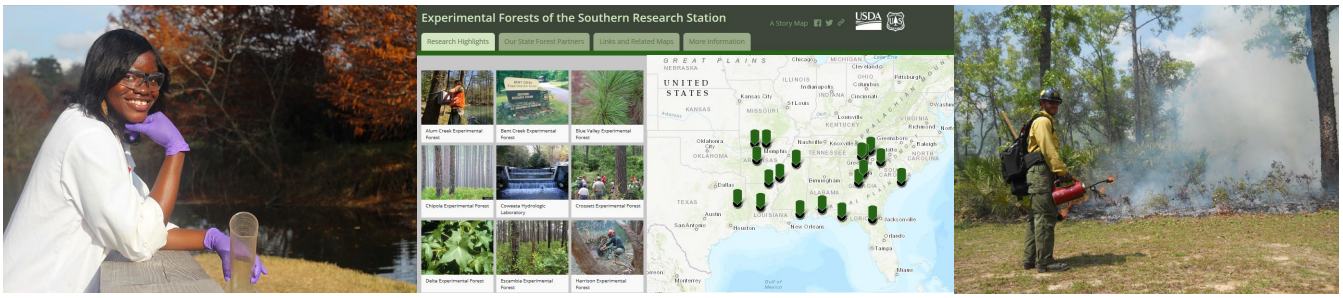
recently hosted by R4 in Ogden with attendance by managers and authors (including many RMRS scientists) to deploy results and climate adaptation strategies to field units.

**Northern Colorado Fireshed Network:** RMRS Scientists are partnering with the Arapaho-Roosevelt NF and many local, state and university collaborators in pursuit of increasing the use of prescribed fire in the Northern Colorado landscape. Examples of station engagement include: our social scientist working directly with the Network communication team to develop messages likely to resonate with the local community; co-development of potential fire operational delineations (PODS) with forest managers and our Wildfire Risk Management Science Team to be used for pre-wildfire response planning and prioritization of prescribed burning locations; and ecological support from research foresters and biogeochemist in development of prescribed fire plans based on best available science.

**Groundwater Dependent Ecosystems** (Analysis, Pre-planning): RMRS Research Ecologist has partnered with the WO NFS Groundwater Program and R1 to host the 'Wetland Rendezvous' in June on the Helena-Lewis and Clark National Forest. In Region 4, RMRS is partnering with R4 managers, Colorado Natural Heritage Program and the WO to characterize and conserve groundwater dependent ecosystems. This works builds on the USFS Level 1 GDE Inventory Field Guide and station scientists has conducted trainings on the Ashley and Bridger-Teton National Forests. Improved assessments of GDE resources foster conservation through stronger forest plans, contribute to management strategies, and potentially locate new populations of rare biota (rare plants and spring snails) and other resources. RMRS is conducting a series of riparian and wetland assessments across Region 4 forests undergoing forest plan revision to provide information on the current conditions of riparian and wetland ecosystems in reference to their natural range of variability during forest plan revision. We use peer-reviewed literature, data from the forest and other partners, and site visits to evaluate the status of four key

ecosystem characteristics: (1) distribution of riparian ecosystems, (2) groundwater and surface water fluctuations, (3) channel and bank stability, and (4) floodplain condition. We determined that riparian and wetland ecosystems of each national forest have experienced many stressors that have influenced their current conditions, including livestock and wild ungulate grazing, altered flow and fire regimes, road construction, timber harvest, invasive and encroaching species, vegetation mortality due to insects and disease, and altered temperature and precipitation regimes. Our results have been incorporated in forest plan revision processes and will continue to be useful to resource managers and planners during efforts to restore and/or maintain riparian and wetland ecosystems on intermountain national forests.

## Southern Research Station (SRS)




The Southern Research Station (SRS) is part of the FS Research and Development program, with research work units across 13 southern states. The SRS mission is to engage in high-quality research leading to the scientific and technological advances needed to sustain and enhance forest ecosystems and the full range of benefits they provide.

SRS employs more than 300 people, including 100 research scientists. SRS partners with the Southern Region of the National Forest System to conduct research on 19 experimental forests. The Experimental Forest Network, a regional network of sites, experiments, and expertise is a strategic asset to address broad-scale monitoring and emerging management questions.

SRS research advances many areas of forestry science: the use of prescribed fire; hardwood and softwood silviculture, harvesting, and utilization; protection of drinking water supplies and water quality; sustainable management of wildlife habitat; and the control of insects, diseases, and pests.

SRS excels in generating and advancing knowledge, transferring technology and applications, and forming partnerships to research emerging issues. Our commitment to forest health and ecosystem productivity and sustainability is demonstrated by:

- Identifying factors impacting forest ecosystems and the human communities that depend on them and understanding the potential responses to these factors;

- Developing science-based management and forest operations options designed to maintain productive and sustainable forests;

- Evaluating policy options that potentially improve forest-based ecosystems and their associated human communities.

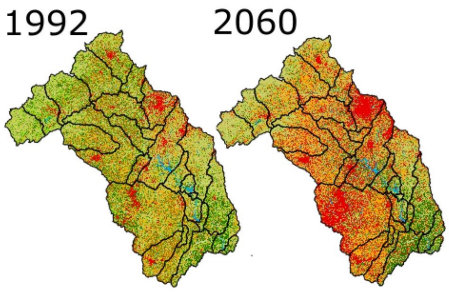
**SRS Science Delivery**

**Connecting future residential construction and lumber demand in the United States**

Future forest conditions in the U.S. depend in part on timber harvest rates, which are a function of overall demand for wood in construction. For the 2020 RPA Assessment, we developed a simple yet highly accurate model of housing starts as a function of aggregate inflation-adjusted (real) economic growth, recent start activity, and mortgage delinquency rates, along with similarly simple models of softwood lumber demand models as a function of current starts and economic growth. Given alternative assumptions about future economic growth in the U.S., we can better understand how a range of possible economic growth rates will lead to a range of construction rates and softwood lumber consumption rates. At recently observed real economic growth rates of 2.4 percent per year, starts would average about 1.2 million per year, while growth of 3 percent would lead to starts averaging 1.3 million and growth of 0 percent would have starts at 0.9 million. Softwood

lumber consumption would grow at about 0.5 percent per year if economic growth were at recently observed rates, increase at 1.3 percent per year if real economic growth were 3 percent, and would decline by 2.5 percent per year if real economic growth were zero. Given that sustained long-run economic growth is unlikely to exceed 3.5 percent and more likely to average less than 2 percent over the coming decades, softwood lumber consumption growth will average less than 0.5 percent per year. For more information: https://www.fs.usda.gov/treesearch/pubs/55659

**Understanding how complex landscapes will respond to more extreme precipitation events: the role of forests in mitigating responses**




In many regions of the U.S., forests are a component of complex landscapes that also include developed and agricultural land uses. Watersheds where a high proportion of forested land will be converted to other land uses are most vulnerable to future climatic regimes, especially high stream flows. Recognizing that urban development and population growth will continue, FS research can help prioritize forest areas to conserve within a watershed and serve as an important first step for informing land use planners and policy makers.

The increased risk of floods due to both heavier precipitation events and increased urbanization underscores the importance of forests as hydrologic regulators. While it is clear that climate change mitigation will require substantial international cooperation, conservation of forested areas could play a large role in climate adaptation strategies at the watershed scale. In the Yadkin Pee Dee River basin in North Carolina, watersheds with a high proportion of forest area converted to developed uses will be the most vulnerable to future climatic regimes, especially high flows. More specifically, models suggest that

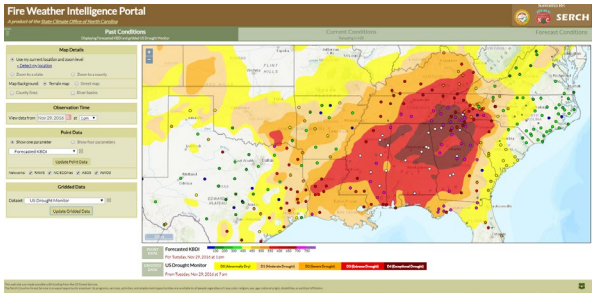
a hotter and wetter future climate will overwhelm the ability of the forest land areas to protect against flooding during wet periods or to sustain baseflow during dry periods. For more information: https://www.fs.usda.gov/treesearch/pubs/56780

**Do roads drive forest plant invasions?**

While there is little doubt that roads are linked to forest plant invasions at local scales, effective resource conservation at regional scales requires an understanding of other factors linked to both roads and invasions across the larger landscape. It turns out that the presence of a road may be less important than the presence of farms and other human activities nearby. SRS researchers and partners developed a series of models that allowed them to see the incremental influences of land use – including agriculture and development, forest fragmentation, local site conditions, and regional ecosystem characteristics in comparison to road proximity effects in eastern U.S. forest plant invasions.

Regional ecosystem characteristics best explained the odds of invasion. The next best predictors of invasion were land use, site productivity, forest fragmentation, and distance from a road, respectively. Because roads and human activities surrounding them are so pervasive in the East, land managers should think of 'human impact zones' instead of 'road effect zones' when evaluating the risk of forest plant invasions. These research findings were awarded an editors' choice award from the journal Diversity and Distributions in March 2018. For more information: https://www.fs.usda.gov/treesearch/pubs/55558

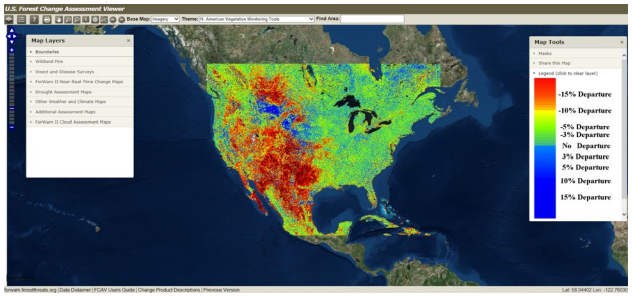
**Fire Weather Intelligence Portal expanded to entire southern region**




Fire managers need information – weather for the past hour, week, and year, as well as forecasted fire risk and more. The Fire Weather Intelligence Portal is designed to meet their needs. It is a single source for fire weather and fire danger information. Through a cooperative agreement between the USDA Southeast Climate Hub and North Carolina State University, the portal was updated to cover the entire 13-state USDA FS Southern Region. The original version of the Fire Weather Intelligence Portal was developed in 2011 by the State Climate Office of North Carolina and the North Carolina Forest Service. It only provided information for fire and weather conditions in North Carolina.

In addition to covering the southeastern U.S., the expanded portal features faster loading times, a mobile-friendly design, and updated information packages, critical to assessing daily burning and smoke dispersion conditions. Southern fire managers can use this real-time and forecasted weather and fire risk information to make informed on-the-ground decisions that best use resources and protect life and property. For more information: https://climate.ncsu.edu/fwip/

**New Views of Vegetation: ForWarn Updates Popular Monitoring and Assessment Tool**




For seven years, users have relied on ForWarn tools to monitor vegetation disturbances in near-real-time across the conterminous U.S. In 2018, the SRS development team completed a major ForWarn upgrade, known as ForWarn II, which expanded coverage to lands across boreal Canada, Mexico, and most of the Caribbean.

ForWarn II includes the original suite of data and map products and can also map vegetation green-up and brown-down relative to an 18-year history of satellite records. This Seasonal Progression Departure product highlights areas that are experiencing an early or late growing season due to variability between years—important information for distinguishing year-to-year vegetation changes from true disturbances or long-term shifts in forest conditions.

All ForWarn II products are available through the Forest Change Assessment Viewer. Products are accessible through tablets, phones, and any web browser. Users can click on a map location to see its 18-year history of seasonal vegetation changes and gain management insights into its past ecological history. The ForWarn development team continues to generate data and map products in the computing cloud every eight days to minimize production costs and issues alerts to managers working in or near areas observed to have potential vegetation disturbances. They plan to further expand the coverage of ForWarn II to include lands across Alaska, Hawaii, and all of Central America. For more information: https://forwarn.forestthreats.org

**A new approach to estimate impacts of extreme rainfall events upon water quantity and quality for local watersheds**

Future climate scenario datasets, created by general circulation models, have been used in conjunction with watershed models to project future hydrologic processes and water quality impacts. These datasets are often difficult to downscale spatially and disaggregate temporarily and may not be accurate for watersheds at the state level or finer scales. In this study, we applied the U.S. Environmental Protection Agency's Climate Assessment Tool to create future climate variability scenarios based on historic measured data for local watersheds.

For demonstration, the Climate Assessment Tool was used in conjunction with the Hydrological Simulation Program model to assess the potential impacts of extreme rainfall on nitrate-nitrogen ($NO_3$-N) and orthophosphate ($PO_4$) loads in the Lower Yazoo River Watershed, Mississippi. An extreme summer rainfall scenario was defined as a 10 percent or greater increase in rainfall. If this event occurred, it could increase the monthly loads of $NO_3$-N and $PO_4$ by 31 and 41 percent, respectively, during that period. Extreme rainfall events have tremendous impacts on nutrient loads. Our approach and findings are useful to state and local water resource managers, as well as stakeholders, who manage forest and crop lands in Mississippi and around the nation. For more information: https://www.fs.usda.gov/treesearch/pubs/56355

**Best weather conditions for measuring smoke plumes: FASMEE & comprehensive field campaigns**

Comprehensive field fire and smoke campaigns such as the Fire and Smoke Model Evaluation Experiment (FASMEE) need to carefully design and implement prescribed fires to generate the desired smoke plumes to be measured. Weather is one of the most important factors to be considered while designing a prescribed fire. This research is important because prescribed fire generates smoke, which can harm human health – particularly pertinent in areas where forest lands and human populations interface. The Southeast is one of the sites planned for the FASMEE field campaign. SRS conducted a research project supported by the Joint Fire Science Program to identify the preferred weather systems for generating the desired smoke plumes for FASMEE measurements. The scientists modeled smoke plumes by day and fog at night. They also measured smoke drainage at night. In all simulations, the setting was hypothetical prescribed fire at the Stewart Army Base in southeastern Georgia. Field-measured plume heights were used to evaluate model performance.

Weather conditions on the FASMEE experimental burn days could vary remarkably on a daily basis, the simulations suggest. To generate the desired plumes for FASMEE measurement, the prescribed burns would likely need to be conducted between two low-pressure systems. Meanwhile, as the fire smolders into the night, the burns would likely lead to fog formation when the burn site is located in the warm and moist section of a low-pressure system or a cold front. The results are intended to help in planning smoke measurements of FASMEE as well as similar field campaigns. For more information: https://www.fs.usda.gov/treesearch/pubs/56847

**Technology and development Centers**

**Missoula & San Dimas**

**History**

The Missoula Technology and Development Center (MTDC) began as the support facility for FS fire management in the late 1940's, when a small group started developing techniques for parachuting men and cargo. In the early 1960's, the center's role was expanded to a Service-wide technical center with a nationwide program that now encompasses all FS 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 FS 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 FS 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 FS signs
- Improved aerial ignition equipment
- Disk chain for range improvement
- Fire shelter training facilitator's guide
- Sign maintenance guide for FS 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 FS 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 FS 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 FS Engineering staff in Washington, DC, and serves emerging technological requirements of the FS 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 a Research and Development and State and Private Forestry missions. It is a unit of the FS since 1939 and it specializes in tropical forestry, a specialty for which is globally known given the 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 practices in the region. Today, the programs of the Institute support the FS mission in the only tropical forest in the National Forest System, the El Yunque National Forest. That forest is also an experimental forest in its entirety (unique in the agency) and is the most studied tropical forest in the hemisphere. The results of the research program of the Institute are broadly

transferred to a diverse network of collaborators including non-governmental organization, 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, new eco-tourism enterprises; all are programs that provide jobs and economic development to people.

The Institute also has a conservation education program that reaches underrepresented populations from kindergarten to post-doctoral levels.

## 6.12. Metric Tables.

**TABLE 1. Collaborative Relationships for Research and Development.**
*ND-no data available.

| Forest Service (FS) | FY2014 | FY2015 | FY2016 | FY2017 | FY2018 |
|---|---|---|---|---|---|
| **Total number active CRADAs** | 44 | 79 | 73 | 74 | 22 |
| **Number newly executed CRADAs** | 16 | 20 | 33 | 34 | 9 |
| Newly executed amendments[1] | N/A | 13 | 12 | 3 | |
| Newly executed traditional CRADAs | 9 | 7 | 9 | 30 | 6 |
| Newly executed non-traditional CRADAs | 7 | 13 | 24 | 4 | 3 |
| Newly executed CRADAs with small businesses | 0 | ND | ND | ND | ND |
| **Total number active MTRAs[2]** | 0 | 4 | 7 | 1 | 9 |
| Newly executed MTRAs | 0 | 4 | 5 | 1 | 8 |
| **Total number of active other agreements[3]** | 2,550 | 1,083 | 1,274 | 1261 | ND |
| Newly executed other agreements | 701 | 261 | 322 | 642 | ND |
| **Number newly executed MTAs** | 7 | 3 | 5 | 3 | 10 |
| Newly executed outgoing MTAs | 7 | 3 | 5 | 3 | 5 |
| **Total number of analysis publications** | 2,083 | 2,013 | 2,022 | | ND |
| Peer-Reviewed Scientific Publications[4] | 1,285 | 1,151 | 1,169 | 1,214 | ND |
| Trade Journal Publications[5] | 798 | 798 | 862 | 853 | 824 |
| Abstracts[6] | N/A | N/A | N/A | N/A | N/A |
| **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 five 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**
*ND-no data available.

| Forest Service (FS) | FY 2014 | FY2015 | FY2016 | FY2017 | FY2018 |
|---|---|---|---|---|---|
| **Total number new invention disclosures[1]** | 24 | 13 | 24 | 20 | 10 |
| University co-owned | 7 | 4 | 2 | 7 | 1 |
| **Total number patent applications filed[2]** | 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**
*ND-no data available.

| Forest Service (FS) | FY 2014 | FY2015 | FY2016 | FY2017 | FY2018 |
|---|---|---|---|---|---|
| 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 licenses[3]** | 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[4]** | 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 IP licenses included biological materials licenses and plant variety protection licenses.

**TABLE 4. Characteristics of Income Bearing Licenses**

| Forest Service (FS) | FY 2014 | FY2015 | FY2016 | FY2017 | FY2018 |
|---|---|---|---|---|---|
| **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 licenses[1]** | 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 Licenses[2]** | 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 |

1. Invention licenses refer to licenses resulting from a patent.
2. Other IP licenses included biological materials licenses and plant variety protection licenses.

**TABLE 5. Income from Licensing**

*ND-no data available.

| Forest Service (FS) | FY 2014 | FY2015 | FY2016 | FY2017 | FY2018 |
|---|---|---|---|---|---|
| **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 | N/A |
| Minimum ERI | $256 | $230 | $256 | $11 | N/A |
| Maximum ERI | $827 | $230 | $623 | $623 | N/A |

| | | | | | |
|---|---|---|---|---|---|
| ERI from top 1% of licenses | $827 | $230 | $623 | $623 | N/A |
| ERI from top 5% of licenses | $827 | $230 | $623 | $623 | N/A |
| ERI from top 20% of licenses | $827 | $230 | $623 | $623 | N/A |
| **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 | N/A |
| Patent filing preparation, fees, & annuity payments | $15,144 | $15,600 | $13,500 | $63,053[4] | N/A |
| Other technology transfer expenses (plaques) | $665 | $910 | $1,158 | $320 | N/A |

FSIS applies the latest technologies to assure the safety of meat, poultry 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 Service

## 7.1. Mission Statement

The Food Safety and Inspection Service (FSIS) is the public health agency in the U.S. Department of Agriculture (USDA) responsible for protecting the public's health by ensuring the safety of the Nation's commercial supply of meat, poultry, and processed egg products. FSIS ensures food safety through the authorities of the Federal Meat Inspection Act, the Poultry Products Inspection Act, and the Egg Products Inspection Act, as well as humane animal handling through the Humane Methods of Slaughter Act.

## 7.2. Nature and Structure of the Program

FSIS applies the latest advances in food safety technologies to monitor chemical, microbial and physical hazards in meat (including Siluriformes fish (catfish)), poultry, and egg products. FSIS also facilitates the application of new food safety technologies to food production by the 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 slaughter and processing establishments); and
- 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 2018, the FSIS Research Priorities and Food Safety Research Studies pages on the FSIS website were each accessed on more than 5,000 occasions. During FY 2018, FSIS added one new Research Priority (Assess the Occurrence of Potential Emerging Pathogens That May Present a Public Health Risk to US Consumers in FSIS-Regulated Products) and eight new suggested Food Safety Research Studies

(associated with existing priorities). These new suggested Research Studies address issues such as emerging pathogens and improved food processing techniques for a variety of FSIS regulated products.

### 7.3. Activities in FY 2018

**Facilitating the Application of New Food Safety Technologies to Food Production**

- FSIS encourages continued improvement and innovation in food safety technologies. During FY 2018, 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[1]. In FY 2018, FSIS evaluated 95 new technology submissions. Of these submissions, FSIS issued 29 "no objection" letters.

**Facilitating the Application of Food Safety Research Findings to Produce Safe Food**

- In FY 2018, FSIS published seven guidance documents to assist industry to comply with regulatory requirements and with identifying and applying relevant scientific information with the goal of producing safe meat, poultry, and egg products, including:

[1] https://www.fsis.usda.gov/wps/portal/fsis/topics/regulatory-compliance/new-technologies/new-technology-information-table

- **FSIS Compliance Guideline for the Prevention and Control of *Trichinella* and Other Parasitic Hazards in Pork Products**. This guideline is designed to help establishments understand options available for the prevention and control of *Trichinella spiralis* and other parasitic hazards in ready-to-eat and not-ready-to-eat pork products.

- **FSIS Compliance Guideline for Small and Very Small Plants that Produce Ready-to-Eat Egg Products**. This guideline is designed to help small and very small plants producing ready-to-eat egg products to meet the new regulatory requirements under the Egg Products Inspection Regulations proposed rule.

- **FSIS Guideline for Determining Whether a Livestock Slaughter or Processing Firm is Exempt from the Inspection Requirements of the Federal Meat Inspection Act.** This guideline is designed to help establishments that slaughter livestock or process meat and meat products determine whether they are exempt from required Federal inspection under the Federal Meat Inspection Act.

- **Meat and Poultry Hazards and Controls Guide**. This guide is designed to help FSIS personnel to evaluate all aspects of an establishment's system for producing processed meat and poultry products.

- **Minimizing the Risk of *Campylobacter* and *Salmonella* Illnesses Associated with Chicken Liver.** This guideline is to assist FSIS-regulated establishments, retail food outlets, and foodservice entities mitigate the public health risks associated with undercooked chicken liver. This guideline will also be referenced in the 2020 FDA Food Code under Annex 2.

- **FSIS Compliance Guideline: Modernization of Swine Slaughter Inspection System.** This guideline is designed to help all swine slaughter establishments meet the sampling and analysis requirements under the proposed rule to modernize swine slaughter inspection.

- **Data Samples and Guidelines for Using the Partner Government Agency (PGA) Message Set for Electronic Completion of the U.S. Department of Agriculture, Food Safety Inspection Service Application for Import Inspection.** This document is a guide to understanding the FSIS data requirements when an Automated Broker Interface filer is using the Automated Commercial Environment System of Customs and Border Protection to provide PGA Message Set data.

- **FSIS published 104 new and revised Notices and Directives that Principally Provide Instructions to FSIS Inspection Program Personnel and Administrative Instructions for all Agency Personnel.**

**FSIS Uses Science-Based Food Safety Information to Educate Consumers and Other Stakeholders**

- In FY2018, FSIS supported effective policy implementation by the Agency through the askFSIS system. The askFSIS database provides online answers to technical, policy, and inspection-related questions. In FY2018, askFSIS customers visited the site 637,231 times, conducted 225,674 searches, and viewed 739,123 published answers. The askFSIS customers also

submitted 24,704 questions for individual answers. Approximately, 45 percent of the 24,704 questions submitted to askFSIS came from FSIS employees.

- During FY2018, FSIS answered chemical residue related questions received from producers with violations, inspection personnel, industry, pharmaceutical industry technical service veterinarians, consumers, and other government agencies. One hundred sixty nine of 9389 (1.8 percent) incidents in askFSIS were chemical residue related. The low number of chemical residue related questions received in FY 2018 indicate that major residue policies are understood and implemented correctly.

- FSIS presented information on Shiga toxin-producing *Escherichia coli* (STEC) adulteration and detection policies to internal and external stakeholders (State Meat and Poultry Inspection programs, field personnel, and several Food Safety Summits). These presentations clarified policies to strengthen compliance with FSIS requirements and to decrease illnesses associated with STEC.

- FSIS resumed posting individual establishment specific *Salmonella* performance standard categories for poultry carcasses, poultry parts and comminuted poultry on January 23, 2018. Posting individual establishment *Salmonella* performance standard categories provides the public with information relating to how well establishments are controlling *Salmonella* and has led to establishments more effectively addressing this pathogen.

- FSIS organized a public meeting on Whole Genome Sequencing (WGS), in Washington, D.C. on October 26 and 27, 2017. The Agency heard major themes from public health partners and

stakeholders (industry and consumer groups). FSIS is collaborating with partners to harmonize procedures and policies and develop standards for WGS.

- In FY2018, FSIS developed and published the Import Library. The Import Library is a public site providing more transparency to stakeholders regarding countries that are eligible to export meat, poultry and egg products to the U.S. The Import Library also identifies countries that FSIS had determined to have an equivalent food safety inspection system, but that have stopped exporting to the U.S. for an extended period. Therefore, these countries would have to request reinstatement of equivalence to be eligible to once again export to the U.S.

**FSIS Uses Science-Based Food Safety Information to Educate Consumers and Other Stakeholders**

- ***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. The "Ask Karen" database received 5,077 email questions and more than 3.5 million answers were viewed in FY 2018. This is a 20% increase over last fiscal year. The "Ask Karen" live chat feature is available during specified weekday hours and allows consumers to chat online with a hotline food safety specialist. "Ask Karen" received 3,292 chat requests in FY2018.

- ***FoodKeeper Application:*** The FoodKeeper application remains a relevant, useful and effective way to educate consumers about proper food storage and its relationship to safe food handling behaviors. The application provides consumers with information about safe handling and storage times for hundreds of food items. The data the FoodKeeper app uses to serve its storage timelines to users was updated FY2018. The total number of foods and beverages the app

includes expanded in FY2018 to more than 650 items. More than 35,000 downloads of the application this fiscal year brought cumulative download totals of the application to nearly 200,000.

- ***Social Media:*** During FY2018, FSIS used a variety of social media networks to enhance our ability to educate the public on recalls, foodborne illness, and safe food handling practices. FSIS used Twitter (including Twitter in Spanish), Facebook (including one Spanish post monthly). 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 1,427,346 followers. The FoodSafety.gov Facebook account ended the year with a total of 215,515 fans. In an effort to educate the Hispanic community about safe food handling, FSIS continued posting messages in Spanish on Facebook once a month achieving a total of 78,759 impressions and 1,322 engagements. In FY2018, the FSIS Spanish language Twitter account achieved a total of 436.5K impressions, 9,839 engagements and 635 new followers. This represents a follower's growth of 13.8 percent. FSIS used pop culture topics like International Women's Day, Earth Day, Major League Baseball All-Star weekend, and Elephant Day to promote food safety messages to audiences engaged in discussion about those trending topics. Across all social media platforms, in FY2018 FSIS generated 426,000 total engagement (up 18 percent compared to last fiscal year's total of 360,000) and 22,147,153 total impressions (up 10 percent compared to last fiscal year's total of about 20 million).

**Transferring Analytical Methods Development Research and New Technologies to FSIS Laboratories for Monitoring Hazards and Regulatory Compliance in Meat, Poultry, and Processed Egg Products**

FSIS laboratories deploy new technologies to better monitor hazards in meat, poultry, and egg products and to minimize human exposure to foodborne hazards. FSIS laboratories also conduct food chemistry analyses to monitor compliance with regulations including labeling and standards of identity. In FY 2018, FSIS validated and adopted ten new or revised laboratory chemistry methods, varying from minor changes in quality control criteria to adding new matrices. These methods improve the Agency's ability to monitor for 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 for Pesticides by LC/MS/MS and GC/MS/MS.** Multi-residue methods to detect pesticides (and veterinary drugs) are used by the Agency to ensure that FSIS regulated products do not contain unsafe levels of chemicals. Pesticides are extracted from muscle tissue with high speed dispersion in ethyl acetate followed by solvent exchange to acetonitrile and clean-up using ultra-low temperature freezing, centrifugation, and solid phase extraction. Detection of pesticide residues is performed by gas chromatography with tandem mass spectrometry (GC/MS/MS) and liquid chromatography with tandem mass spectrometry (LC/MS/MS). This analytical method was developed by the USDA, Agricultural Research Service (ARS) and was subsequently validated and implemented in FSIS laboratories. This method can be used to screen for a variety of pesticides in bovine, caprine, equine, ovine, porcine, poultry, fish of the order Siluriformes (catfish) muscle, and as of FY2018 can be used to screen for a variety of pesticides in liquid and

powdered egg products. Results from this method may be used both for regulatory enforcement purposes and for FSIS, U.S. Food and Drug Administration (FDA), and U.S. Environmental Protection Agency (EPA) consumer chemical exposure and risk assessments.

- **Screening and Confirmation of Animal Drug Residues by UHPLC-HRMS-MS.** Multi-residue methods to detect veterinary drugs and pesticides are used by the Agency to ensure that FSIS regulated products do not contain unsafe levels of these chemicals. An ultra-high-performance liquid chromatography–tandem high-resolution mass spectrometry (UHPLC-HRMS-MS) method was developed by the USDA, ARS. The method was subsequently validated and implemented in FSIS laboratories. This method is used to screen for a variety of animal drugs in bovine and porcine muscle and kidney. In FY2018, the quality control screening criteria in the method were updated. Results from this method may be used both for regulatory enforcement purposes and for FSIS, FDA, and EPA consumer chemical exposure and risk assessments.

- **Food Chemistry Methods**

  FSIS runs four food chemistry methods to analyze for protein, moisture, fat, and salt in meat and poultry products. In FY2018, the Moisture Determination methodology was updated to clarify the Quality Control (QC) acceptability criteria, and Protein Determination methodology by Combustion was updated to clarify the QC acceptability criteria as well as to specify the instrument used to analyze for protein content.

- **Preliminary and Confirmatory Testing of FSIS Regulated Products for Staphylococcal Enterotoxin**

These tests are for the identification of Staphylococcal enterotoxins A, B, C, D, and E in FSIS-regulated products. The Microbiology Laboratory Guidebook method was updated in FY2018 to use the VIDAS® Staphylococcal enterotoxins 2 Food Pathogen Detection System to screen FSIS-regulated products for Staphylococcal enterotoxins. The RIDASCREEN® Staphylococcal enterotoxins Total immunoassay was validated by FSIS laboratories and will be used for the confirmation of Staphylococcal enterotoxins in screen-positive samples.

**Interagency Collaboration to Reduce Foodborne Illness**

- **Interagency Food Safety Analytics Collaboration (IFSAC)**

  In FY2018, FSIS continued to participate in the Interagency (Centers for Disease Control and Prevention (CDC), FDA, and USDA-FSIS) Food Safety Analytics Collaboration (IFSAC). This collaboration improves coordination of Federal food safety analytic efforts and addresses cross-cutting priorities for food safety data collection, analysis, and use. IFSAC's main focus is foodborne illness source attribution: identifying which foods are the most important sources of selected major foodborne illnesses.

  FSIS uses IFSAC outputs in a wide variety of mission critical activities. In FY2018, FSIS used IFSAC harmonized attribution estimates to estimate foodborne illnesses attributed to FSIS-regulated products. IFSAC attribution estimates were used in the development of FSIS risk assessments for comminuted poultry, ground beef and beef trim. FSIS also used IFSAC illness estimates to help evaluate and refine its microbiological sampling programs.

# 8.0 National Agricultural Statistics Service (NASS)

## 8.1 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.

## 8.2 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.

**8.3 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 have been developed to improve the county-level estimates of acreage, yield, and production and are being reviewed by field staff with the goal of implementation for the 2019 crop year. The small area model for county-level cash rental rates is being modified to reflect data collection biannually instead of annually. A new small area model was developed for the agricultural labor program.

Forecasts of corn yield for the 16 largest production States and of soybean yields for the 11 largest production States are also provided to the Agricultural Statistics Board for their consideration in producing reports. After the season's full conclusion, county-level yield estimates for corn and soybeans were generated by integrating MODIS Land Surface Temperature (LST) products through modeling.

A decision-support application, which should eventually lead to crop phenology being more explicitly accounted for in the yield models has been developed for the states in one or more crop speculative regions and is being extended to all states.

An approach that combines a state-space model with a biologic model with the ability to capture a disruption in the system, such as a disease outbreak, is being finalized for modeling hogs and pigs. This approach will be the focus of a National Academy of Science workshop in March 2019. 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, Nebraska, and Texas have been 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 working with the Multi Agency Collaboration Environment (MACE), a cross-agency effort to create data sharing partnerships across the federal government, to harvest open source information to develop web-scraped lists of agricultural operations that are not well covered by the NASS list frame, 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 FY18, NASS continued 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. A pilot study in the State of Washington begun in FY17 to assess the feasibility of using a web-scraped list to account for undercoverage of hard-to-survey groups in the Census of Agriculture. The Census Mailing List (CML) is the NASS list frame frozen as of September 1st, 2017. The CML is incomplete; not all farms are on the list. To account for farming operations not on the CML, NASS uses the June Area Survey (JAS). As part of the 2017 Census of Agriculture, the CML was overlapped against both the JAS sample and the WA web-scrapped list. The records that did

not overlap the CML represented the Not-on-Mail-List (NML) domain. The WA NML web-scraped records were mailed a census questionnaire in April 2018 and followed the same processing timeline as the JAS NML domain. The CML and both NML domains were mailed different colored census questionnaires. All data collection activities were completed for the WA MACE NML records. During FY19, the data will be analyzed to assess the viability of using the web-scraped list to provide a measure of undercoverage for the hard-to-survey groups. In FY18, NASS assembled a June Area Research Project (JARP) team to explore the feasibility of utilizing a web-scraped list instead of the NASS area frame in the conduct of the June Area Survey (JAS). JARP was designed to (1) assess the effectiveness of using a web-scraped list to account for undercoverage of list-based NASS surveys; (2) assess the efficacy of collecting JAS data by mail, telephone and the web; and (3) determine whether estimates from this web-scraping approach have comparable precision to the traditional (area-frame-based) JAS estimates. The web scraping was completed in FY18 for four test states (Kansas, Nebraska, New York, and Pennsylvania). In FY19, the web-scraped results will be used to derive list frames for each test state, collect data and produce JAS estimates from the test states, assess undercoverage for at least one major NASS survey for the test states, and compare the results to the JAS.

- **Geospatial Products:** NASS completed its 48-state Cropland Data Layer (CDL) in 2018 for the 2017 crop year, making 10 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 2018 for the 2017 crop season. The Crop Frequency Layers identify crop specific planting frequency and are based on land cover information derived from the 2008 through 2017 CDL. Currently, these are produced for corn, soybeans, wheat, and cotton.

Geospatial decision support products were derived and provided for rapid response to assess flooded areas and identify potential crop losses caused by Hurricane Florence. The geospatial data products were derived from remotely-sensed satellite and meteorological information obtained from NASA, European Space Agency (ESA), and National Oceanic Atmospheric Administration (NOAA). This was the second year that this technology was available for Agency use. The products included flood assessment reports with crop and pasture land inundated areas and percentages of impacted crops, CDL crop area maps, and wind swaths or surface winds overlaid onto crop areas identified from the CDL product. The estimates of crop and pasture hay inundation were provided to the NASS Agricultural Statistics Board for decision support. Crop inundation raster layers were shared with the USDA Operations Center Emergency Programs Division to be included in their mapping efforts. The disaster assessment reports, maps, crop inundation raster layers, metadata and a methodology report were posted on the NASS website for public dissemination at https://www.nass.usda.gov/Research_and_Science/Disaster-Analysis/index.php. Final reports, excluding in-season crop and pasture hay estimates, were posted on the NASS web site for public use.

- **Improved Rounding and Calibration Processes:** After the capture-recapture weights are associated with each Census of Agriculture record, the weights are calibrated to known commodity targets and rounded to whole numbers. During the 2012 Census of Agriculture, it

became evident that both the rounding and the calibration processes could be improved. Improved methods for rounding (so that only whole numbers of farms are reported) and calibration have been developed, and better measures of uncertainty have been derived. These new methods are being used in the production of the 2017 Census of Agriculture.

- **Data-Collection Enhancement for Census of Agriculture and NASS Surveys:** 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 system for producing this responsive instrument and is moving all NASS surveys to the new system with completion targeted for 2019. The goal is to provide an enhanced experience for the respondent that reduces burden while also improving data quality.

- **Propensity Model for Census of Agriculture:** NASS developed a propensity model for estimating the probability of response to the Census of Agriculture. This machine-learning algorithm was used to increase initial response rates and overall response rates for the 2017 Census of Agriculture.

- **Removing Out-of-Scope Records from the NASS List Frame:** A machine-learning algorithm was developed that estimates the probability of a record being out-of-business (termed deadwood) on the NASS list frame. Removing the deadwood records from the list frame can lead to increased response rates, reduced bias, and more accurate estimates. In addition to using the algorithm to identify potential deadwood on the NASS list frame, a deadwood variable was

created during the 2017 Census of Agriculture. This new variable was used in the modeling and other analyses conducted for the census.

### 8.4 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 Chicago, Illinois, on April 24, 2018. 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.

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# 9.0. The Natural Resources Conservation Service (NRCS)

## 9.1. 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.

## 9.2. 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.

### 9.3. Soils Research and Technology Transfer

The NRCS Soil and Plant Science Division (SPSD) 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.

#### 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. SPSD 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. All soils information collected in the field has been reviewed for quality assurance. Quantitative soil data forms the basis for wetland assessment throughout the United States. This data will be available for public use on the EPA National Wetland

Condition Assessment website.

**Alternative Crops in Colombia – Cacao for Peace**

The SPSD is collaborating with the U.S. Agency for International Development (USAID) through the U.S. Department of Agriculture's Foreign Agricultural Service (USDA-FAS) and Penn State University International Center for Tropical Agriculture (CIAT) to develop a pilot project to building capacity through public-private partnerships to increase quality cacao production in the Sierra Nevada de Santa Marta region in Colombia. NRCS's role is to build capacity by providing technical assistance in digital soil mapping at resolutions suitable for management at the farm level. Higher resolution soil maps will better delineate areas suitable for cacao production and will be used to promote natural resources conservation and land use sustainability to meet established soil and food security goals. NRCS staff will apply established digital soil mapping practices and standards, in collaboration with CIAT and local Colombian scientists and growers, to develop higher resolution soil maps for project focus areas and refine the cacao suitability assessments. NRCS-SPSD staff in collaboration with Penn State faculty will also provide training to build the necessary local capacity to support the continuation and expansion of cacao cultivation efforts in the future. Through these efforts, NRCS will help build local capacity in digital and traditional soil mapping technologies. Field observations as well as laboratory data will be used to create high resolution maps and a soils information system with interpretations that meet the needs of individual farmers, land owners, policy makers and other interested parties.

**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. In 2018, a pilot project was implemented to include all common land uses (crop, range, pasture, and forest) in Ecological Site Descriptions and organizing interpretations to allow users to compare changes in ecosystem services as land use changes and to provide a common basis for selecting appropriate conservation practices and evaluating effects of management. 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. In FY 2018, EDIT was opened to public access. Connections to other NRCS planning tools and decision support systems are planned in the next few years. 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. EDIT is a collaborative project with USDA, Agricultural Research Service (ARS).

**NRCS National Soil Survey Center**

The SPSD, 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

600,000 people annually who are preparing customized soil reports, over 3 million interested viewers per year, and over 700,000 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. During FY 2018, the KSSL staff analyzed 22,895 soil samples from 8 countries (including the United States); with a total of 465,788 chemical, physical, and biological analyses conducted on these samples. During FY 2018, the KSSL staff gathered mid-infrared spectra from 13,283 soil samples for predictive soil property analysis of 10+ soil chemical and physical properties. These were added to a spectral library of mid-infrared scans for over 69,545 soil samples. All laboratory data are freely distributed via the web.

**NRCS Investments in University Research**

The SSD has invested $2 million in research agreements with 13 universities in 2018 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 2018 included change responses to dynamic soil properties from human management, development of soil raster property maps and data, understanding surface hydrology in desert landscapes, and soil research in Alaska focusing on Tribal conservation areas.

**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 SPSD developed and supports the NCCPI and continues to refine the index as new knowledge is gained and new crops are identified. 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**

Devastating hurricanes are an annual threat resulting 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 continues 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.

**Soil Health Interpretations on the Web Soil Survey**

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 fragile soils. 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. Information was also developed for siting farm and garden composting facilities.

**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.

### 9.4. 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 2,800 technical documents downloaded more than 1.5 million times per year. Plant Materials studies resulted in the addition of 125

new technical documents to the Plant Materials website in 2018.

- Plant Materials staff conducted 51 technical training sessions for over 840 field staff and conservation partners in 2018. 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. Technical knowledge of the NRCS field staff is improved by holding many of these PMC trainings in conjunction with Conservation Planner Certification training sessions. The PMCs also conducted 44 field days and tours to inform and educate field staff, farmers, ranchers, and the public on current plant materials activities and new technology.

- Over the last 4 years, PMCs have prepared over 580 written documents, including fact sheets, planting guides, technical notes, study reports, newsletters, and conservation practice documents, have been prepared to support NRCS vegetative conservation practices and provide awareness of new plant information from the program. Plant materials employees have delivered technical training on plant materials topics to approximately 4,200 participants involved in conservation, to improve awareness and planner knowledge of new PMC information, tools, and technology. Plant materials employees made 360 presentations, hosted 150 tours, and held 45 field days to a total of 4,400 NRCS participants and 11,600 partner agency, farmer, rancher, and other landowner participants.

- 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 575 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 2018, PMCs released one new conservation plant to the public and commercial growers. PMC conservation 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 activities.

Santiago Germplasm silver bluestem (*Bothriochloa laguroides ssp. torreyana*), was released by the Knox City, TX, and the Kingsville, TX PMCs in cooperation with Texas A&M University-Kingsville and Sul Ross State University, Alpine, TX, to commercial growers to produce material for the public. Santiago Germplasm is a native perennial bunch grass for use in upland wildlife plantings and range plantings. The forage value is fair to good for livestock and big game. Santiago Germplasm adds diversity to plantings in the western part of the Edwards Plateau (Major Land Resource Area (MLRA 81A); the Southern High Plains (MLRA) 77C); and the Central Rolling Red Prairies (MLRA 78B) of Texas and the Southern Desertic Basins, Plains, and Mountains (MLRA 42) in western Texas and southern New Mexico.

## 9.5. Conservation Engineering

### Using Regional Architect-Engineering (A&E) Contracts

NRCS awarded twenty A&E, Indefinite Delivery, Indefinite Quantity (IDIQ) contracts to provide engineering services nationwide. These contracts are available for use by NRCS offices in all 50 states and U.S. territories for engineering work under all NRCS programs. The services provided through these contracts helps NRCS accomplish our complex engineering workload and ensure successful implementation of the NRCS watershed and Farm Bill programs. The contracts are also available for use by other USDA agencies.

### Contribution to Development of new American Society for Testing and Material (ASTM) Standard

NRCS contributed to the development of the first ever ASTM standard—*ASTM D8167, Standard Test Method for In-Place Bulk Density of Soil and Soil-Aggregate by a Low-Activity Nuclear Method [Shallow Depth]*. NRCS engineers from North Carolina participated in the ASTM Interlaboratory Study (ILS 1339) at Troxler Electronic Labs. The results from the study were used to provide the necessary independent repeatability and reproducibility data for the low-activity device, which is described in detail in ASTM research report RR:D18-1024 and illustrates the precision of measurements made by the gauge. The laboratory study data was included in the new standard, D8167, released in June 2018. NRCS engineers were nominated for an ASTM Committee D18 Laboratory Participation Award. Furthermore, the density gauge covered by this new standard uses a very small radioactive source with an activity level so low that it does not require a license from the US Nuclear Regulatory Commission

(NRC). Ratification of this new standard enables NRCS to use these gauges for construction quality assurance testing. The new license-free gauges have a higher initial cost, but the annual cost savings from not having to maintain the NRC license is substantial. Factoring in both the higher initial cost and elimination of the annual license fee, NRCS is saving approximately $60,000 per year due to having switched to the new license-free gauges.

**Achieving Agricultural Energy Efficiency**

Improving the energy efficiency of agricultural operations is an important objective for NRCS. In 2018, NRCS awarded an agreement through the Cooperative Ecosystem Studies Units Network (CESU) to the University of Clemson, in conjunction with the University of Missouri. The objective of the agreement is to develop a series of tools and publications related to the design and evaluation of energy efficient systems used in agricultural production facilities. Items completed include a prototype of a tool for General Lighting, development of the process for using weather data to evaluate energy use in buildings, and a draft publication for Energy Efficient Greenhouse and Nursery Production Facilities. Upon completion of the agreement, the tools and publications will be used by NRCS planners and engineers to assist clients with energy efficiency evaluations and improvements on their farms.

**National Design, Construction, and Soil Mechanics Center–Soil Mechanics Laboratories**

The Soil Mechanics Laboratories consists of two laboratories that performs state-of-the-art soil mechanics testing, analyses, and recommendations adapted to the needs of customers to design and implement conservation practices and systems that conserve, improve, and sustain our natural resources and the environment.

The laboratories provide support to the agricultural waste lagoon projects, the Emergency Watershed Protection Program, Watershed Rehabilitation Program, Watershed Operations Program, and Environmental Quality Incentives Program, wetland restoration, and rehabilitation of aging watershed structures. A few examples include:

- The laboratories performed geotechnical analysis and soil mechanics testing and prepared full reports for the repair and rehabilitation of 25 dams with notable dam safety concerns.

- The laboratories performed geotechnical design analysis, geotechnical testing, and prepared reports for 184 conservation related engineering structures funded under the mandatory farm bill programs.

- The laboratories updated and compiled all soil and rock testing data into a data base used to develop engineering material and varying geologic formation site correlations for research, development of NRCS National Conservation Practices, and geotechnical analysis for individual site conditions.

- The laboratories provided testing for the development of ASTM-American Society for Testing and Materials (ASTM) standards which include Crumb Dispersion, Double Hydrometer and Pin Hole Dispersion testing. In addition, the data from this testing was used in the update of the National Engineering Handbook 633 Chapter 26 - Gradation Design of filters and Drains.

- The laboratories provided lime treatment and specify testing which included developing a new procedure and performing triaxial shear strength testing on varying lime/soil mixes for a large problem dam site for the US Army Corps of Engineers.

**National Design, Construction, and Soil Mechanics Center–Design and Construction**

The center provides NRCS with interdisciplinary technical support for design, construction, operation, and rehabilitation of complex engineering projects essential to resource conservation, environmental enhancement, and agricultural productivity.

The center provides support to the Emergency Watershed Protection Program, Watershed Rehabilitation Program, Watershed Operations Program, and Environmental Quality Incentives Program and rehabilitation of aging watershed structures. A few examples include:

- Assisted the NRCS National Employee Development Center (NEDC) in providing quality technical instruction for NRCS personnel through formal training courses.

- Performed over 20 independent design reviews of high hazard engineering structures for States.

- Assisted States in site-specific engineering issues by performing numerous field reviews, making recommendations, and proposing alternatives in addressing difficult natural resource concerns.

- Represented NRCS on committees responsible for establishing industry engineering standards, such as the American Society for Testing and Materials (ASTM), American Concrete Institute (ACI), American Water Works Association (AWWA), and Association of Agricultural and Biological Engineers (ASABE).

**9.6. 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.

### 9.7. 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.

**9.8. Soil Health**

NRCS launched its Soil Health Initiative in 2012 to refocus agency efforts on improving the physical, chemical, and biological functioning of soil on private-lands and, shortly after that, established a national Soil Health Division. NRCS's soil health activities have expanded greatly, and interest in soil health has spread rapidly to partners and stakeholder groups, including the corporate agricultural sector and large land owners making decisions on millions of acres of land. The NRCS Cover Crop conservation practice standard has risen to the number one EQIP-cost-shared practice in the last year. 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.

Since division inception in late 2014, the division performed soil-health-related outreach and tech transfer reaching over 150,000 people through presentations, workshops, technical assistance, staff and partner trainings, and demonstrations. The division has redesigned the 3-day Soil Health and Sustainability for Field Staff course, now required for conservation planners, to include interactive Soil Health scenario-based problem-solving activities that will produce locally applicable Soil Health Management Systems templates for use conservation planners. Also, there are 77 soil health-related webinar posted on the NRCS Science and Technology Training Library that are available to the public and have over 40,000 views. NRCS's Science of Soil Health videos, available on YouTube, have been viewed over 132,000 times, and a National Public Radio interview reached 2 million people.

The science of soil health efforts are collaborative across the Science and Technology, Soil Science and

Resource Assessment, and Programs Deputy Areas within NRCS, as well as 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 such 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.

### 9.9. 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 10,000 individuals participated in over 260 training sessions in 2018. Many NTSC employees also supported development of new mixed-method curricula for Planner Certification training required for NRCS field staff. This support was in cooperation with University of Wisconsin Cooperative Extension and NRCS-National Employee Development Center.

NTSCs also provide critical support to the models and tools used by NRCS for conservation plantings. A few examples include:

- The NTSCs provided leadership for development, testing and training for three new web-based applications that make maintaining conservation practice standards and the Field Office Technical Guide (FOTG) more efficient at the national and state levels. Those new applications are Conservation Practice Document-Document Management System (CPD-DMS), Conservation Practice Date Entry System (CPDES), and FOTG ver. 5.0.

- The National Animal Manure and Nutrient Management Team (NAMNMT), one of the NTSC national technology acquisition and development teams, provides assistance to states and national headquarters with animal manure and livestock related issues. The team developed a national Comprehensive Nutrient Management Plan (CNMP) course available for NRCS and Technical Service Providers (TSP) to provide guidance in developing quality CNMPs. This training serves as part of the requirements for receiving a CNMP Planner designation. A CNMP addresses soil erosion, water quality and air quality resource concerns. Some of the other assistance provided by the team include evaluation of innovative technologies, animal manure and livestock related trainings, nutrient management, biosecurity, feed management, and review

of animal waste system designs.

- NTSC personnel provide training, development, analysis of site data, and coordination for completion of rangeland health reference worksheets. Rangeland health matrices and reference worksheets within an ecological site description are ecological site products used extensively for conservation planning on rangeland. The Rangeland Health Assessment protocol, which evaluates 17 indicators related to assessing biotic integrity, hydrologic function, and soil and site stability, is an integral part of the inventory and assessment process in conservation planning.

- 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.

**9.10. 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 2018, these webinars were viewed by over 17,400 individuals, including both NRCS and non-NRCS participants. More than 7,500 continuing education unit (CEUs) were issued to maintain professional certifications for NRCS employees, partners, and other participants. More than 3,700 conservation-planner CEU certificates were awarded.

### 9.11. Phytoremediation Data

The NRCS Plant Data Team continued its cooperation with Brooklyn College to update NRCS's database of over 1,130 plant species used to remediate contaminants, based on research published in the past decade (the original database was developed in the 2000s). The database is being finalized and will be made available online with a user interface allowing users to search by plant species and contaminant. Scientific references used for documentation are searchable as well on the database. The Brooklyn College researchers are also working on developing a set of standards to reflect degrees of success a plant species has with respect to contaminant removal. 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.

### 9.12. The National Resources Inventory

The National Resources Inventory (NRI) has an ongoing agreement with Iowa State University (ISU) to

improve ways of providing information on the status and trends of national land use characteristics and soil erosion. A web-based data analysis and visualization tool known as the Land Use and Cover Inventory Database (LUCID) is being prototyped within the NRCS with a goal of making it widely available for analysis of publicly-released NRI data. ISU is also conducting research on model-assisted county-level and other sub-state estimates to further the application of NRI data in environmental analyses.

### 9.13. 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. 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.

# 10.0. National Institute of Food and Agriculture (NIFA)

## 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 that 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 their 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 116-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 2018, 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 of 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 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 has been conducted in 2018. Responses are still being collected. The survey is collecting information 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 FY2018 and is now being reported (see Table 1).

**Table 1.** Patents Issued in FY2017 based upon Competitive NIFA Funding.

| Institution Name | Award Number | Patent Number | Issue Date | Invention Description |
|---|---|---|---|---|
| University of Wisconsin, Madison | 05-CRHF-0-6055 | 9,856,531 | 1/2/2018 | METHODS AND COMPOSITIONS FOR GENETICALLY DETECTING IMPROVED MILK PRODUCTION TRAITS IN CATTLE |
| University of Wisconsin, Madison | 2001-35204-10184 | 9,814,770 | 11/14/2017 | H3 INFLUENZA A VIRUS |
| University of Wisconsin, Madison | 2001-35204-10184 | 10,034,932 | 7/31/2018 | H3 INFLUENZA A VIRUS |
| University of Wisconsin, Madison | 04-CRHF-0-6055 | 9,855,323 | 1/2/2018 | VACCINE CANDIDATES AGAINST JOHNE'S DISEASE |
| University of Wisconsin, Madison | 05-CRHF-0-6055 | 9,926,608 | 3/27/2018 | DETECTION OF LETHALITY GENE |

| | | | | |
|---|---|---|---|---|
| | | | | FOR IMPROVED FERTILITY IN MAMMALS |
| University of Wisconsin, Madison | 05-CRHF-0-6055 | 10,017,771 | 7/10/2018 | CONSTRUCTION OF A QUADRUPLE ENTEROTOXIN-DEFICIENT MUTANT OF BACILLUS THURINGIENSIS |
| University of Wisconsin, Madison | 09-CRHF-0-6055 | 9,976,182 | 5/22/2018 | METHODS AND COMPOSITIONS FOR IMPROVED FERTILIZATION AND EMBRYONIC SURVIVAL |
| University of Wisconsin, Madison | 12-CRHF-0-6055 | 9,777,331 | 10/3/2017 | SINGLE NUCLEOTIDE POLYMORPHISMS ASSOCIATED WITH BULL FERTILITY |
| University of Wisconsin, Madison | 00-CRHF-0-6055 | 9,879,271 | 1/30/2018 | IRES ELEMENTS FOR EXPRESSION OF POLYPEPTIDES AND METHODS OF USING THE SAME |
| University of Wisconsin, Madison | 96-35203-3268 | 9,955,673 | 5/1/2018 | MILK UREA-N EXCRETION (MUNY) AS A NUTRITIONAL AND ENVIRONMENTAL MANAGEMENT TOOL FOR THE DAIRY INDUSTRY |
| University of Wisconsin, Madison | 2012-33610-19517 | 10,054,586 | 8/21/2018 | BIOMARKERS FOR EARLY DIAGNOSIS AND DIFFERENTIATION OF MYCOBACTERIAL INFECTION |
| University of Wisconsin, Madison | 18-CRHF-0-6055 | 9,943,480 | 4/17/2018 | COMPOSITIONS CONTAINING PREEN OIL AND METHODS OF USE THEREOF |
| University of Massachusetts, Amherst | 2011-65210-20032 | 9,781,949 | 10/10/2017 | Fabrication of Antimicrobial Delivery Systems Based on Electrostatic Complexes of Cationic E-Polylysine and Anionic Biopolymers |

| | | | | |
|---|---|---|---|---|
| Green Heron Tools, LLC | 2010-33610-21862 | 9,877,421 | 1/30/2018 | Systems and Methods for Tilling Ground Materials |
| Oklahoma State University | 2009-34447-19951 | 10,053,711 | 8/21/2018 | Method Improving Producer Gas Fermentation |
| University of Kansas, Lawrence | 2011-10006-30362 | 9,994,601 | 6/12/2018 | DEPOLYMERIZATIO N OF LIGNIN USING ZIRCONIUM INCORPORATED MESOPOROUS SILICATE CATALYSTS |
| University of Connecticut School of Medicine | 2015-31200-06009 | PP 29575 | 8/7/2018 | Prunus x cistena |
| Penn State University | Capacity Program | 9,835,532 | 12/5/2017 | Laser-based Tomography |
| Penn State University | Capacity Program | 9,976,939 | 5/22/2018 | Laser-based Tomography |
| Penn State University | Capacity Program | 9,790,110 | 10/17/2017 | Animal Manure Treatment System |
| University of South Carolina | 2001-35319-09848 | 9,822,376 | 10/21/2017 | Manipulation of Gene Expression Via the Micro-RNA Pathway |
| University of Hawaii | 2005-31100-06015 | PP 28567 | 10/24/2017 | Colocasia Plant Named |
| Iowa State University | 2008-35302-18824 | 9,896,698 | 2/20/2018 | miRNA396 and Growth Regulating Factors for Cyst Nematode Tolerance in Plants |
| Iowa State University | 2012-67009-19713 | 9,804,097 | 10/31/2017 | Crop Stand Analyzer Using Reflective Laser Proximity Sensors |
| Iowa State University | 2011-51181-30735 | 9,988,318 | 6/5/2018 | Biodegradable Fertilizer |
| Kansas State University | 2010-38624-21709 | PV 201500335 | 7/13/2018 | Griffin |
| Michigan State University | 2005-35504-16195 | 10,006,039 | 6/26/2018 | PRODUCTION OF OIL IN VEGETATIVE TISSUES |
| Mississippi State University | Capacity Program | 9,924,706 | 3/27/2018 | System and Methods for Pest Reduction |
| Mississippi State University | Capacity Program | PV 201600309 | 3/21/2018 | Thad Than Rice |
| Ohio State University | 2008-55112-18760 | 9,808,758 | 11/7/2017 | Spray Acid Wet Scrubbers to Recover Ammonia Emission from Poultry Houses and Manure Composting Facilities to produce Nitrogen Fertilizer |

| | | | | |
|---|---|---|---|---|
| Ohio State University | 2013-67018-21240 | 9,896,450 | 2/20/2018 | Modulators of Clavibacter Michiganensis and Methods of Making and Using Thereof |
| Washington State University | 00-CRHF-0-6055 | 9,790,115 | 10/17/2017 | Processing biomass using thermochemical processing and anerobic digestion in combination |

**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. Plans for FY 2018 are under development

(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. Plans for FY 2018 are under development.

### 10.6. Downstream Outcomes

**ePaint Company** is located in East Falmouth, MA and has received support from the SBIR program. Biofouling in the marine environment is where marine organisms attach to hard surfaces and this is a major problem for marine aquaculture. The most common approach to this problem is to use paint that contains copper since the copper will inhibit attachment to hard surfaces. The problem is that copper

can accumulate in sediments and the water column and this poses environmental problems. This company has developed a soy-based resin that contains a photosensitizer that in the presence of blue light causes the formation of peroxides. The peroxides are short lived but they are effective in deterring attachment by marine tunicates, sponges and other organisms to hard surfaces. They are working with shellfish farmers in New England and salmon farmers in Canada, Norway and Chile and are in the process of commercializing their anti-fouling paint.

**Ridge Quest** is a Michigan Company located in Kent City Michigan in an area of the state where apples and other fruits are grown. There are a number of insect pests that present serious problems for fruit orchards with codling moth and obliquebanded leafroller being the most serious. Traditionally these insects have been controlled with chemical pesticides but in recent years the level of resistance to the pesticides has increased and the toxicity of the pesticides for beneficial insects is becoming a serious problem. Because of these problems there is greater interest in using biocontrol methods that utilize natural insect pheromones that are released by females as a way to attract male insects. When large amounts of the pheromone are released in the orchard the males cannot find the female against a high background level of the pheromone. Use of this approach has been hampered by the cost of releasing within the orchard the devices that release the pheromone. This company has developed a device for quickly distributing the pheromone-releasing devices and thereby has substantially reduced the cost of utilizing this biocontrol approach. Last year they produced 500,000 of these devices and sold every one of them. Next year they plan to produce over one million devices. They also plan to expand their distribution to other apple and fruit growing regions in the country.

**Operational Technologies Corporation** was funded through USDA's SBIR Food Science and Nutrition portfolio and has developed a highly sensitive and specific test strip for major foodborne

pathogens, Campylobacter jejuni, Escherichia coli O157:H7, Salmonella enterica and Salmonella typhimurium. This research was published in 10 peer reviewed journal articles and a US Patent, No. 9,562,900 has been issued. The Food Safety aptamers, the technology behind the test strips, have been acquired by CibusDx and they will begin marketing the test strips in conjunction with its portable biosensor in 2018. This combined technology significantly reduces the time required to test pathogens in foods from 24-72 hours to approximately 30 minutes which allows foods to be tested more often and less expensively, thereby reducing the spread of pathogens and minimizing food waste. The video for this technology sold through CibusDx is online at **https://vimeo.com/225509374.**

**Experiential Training in Use of Unmanned Aerial Systems (UAS) Technology for Agriculture Applications.** The primary purpose of this four-year interdisciplinary multi-institution project is to increase the number of south Texas students graduating from 2-yr Associate-granting institutions transitioning to 4-yr Bachelor of Science and Master's degrees (TAMUCC, TAMUK, UTRGV) in fields related to the agricultural, plant and biological sciences. Faculty and staff at partner institutions will provide undergraduate and graduate training and education in the use of Unmanned Aerial System (UAS) technology for precision farming in agriculture. Targeted coursework will be created to include two permanent on-line introductory courses in UA Vehicles technology and ethics and one blended (on-line/hands-on) course in UAS applications. Training will include internships and assistance in research projects aligned with UAS as a tool for crop/soil management, plant and natural resource sciences. Products will produce 28 Bachelor of Science and 11 Master's of Science graduates working in food, agriculture, and natural resources-related fields. This project will also affect 48 students from two-year academic institutions. Educational needs areas addressed by this project include: (1) curricula design in terms of development of new courses of study and (5) student experiential learning. The major project outcome will be production of approximately 40 Hispanic Americans with additional experience and

education in food, agricultural, and natural sciences better prepared to engage in careers with the USDA or other federal agencies as well as the private sector.

The **Louisiana State University Agricultural Center** used several exotic donor germplasm to develop pre-breeding lines with improved drought and salinity tolerance in the background of multiple US rice cultivars. The advanced breeding lines can be released as varieties for cultivation in salt affected areas as well as for use in breeding programs to improve abiotic stress tolerance. The genomic and germplasm resources will accelerate large scale discovery of genes involved in abiotic stress tolerance mechanisms in the future.

**Iowa State University** studied how to deploy a small unmanned aircraft system to quantify the biological signals present in the field throughout the growing season. This research facilitated the general transition of high throughput phenotyping from fixed data collection to designed crop monitoring and pattern recognition. Findings from this study are contributing to designing the precision agriculture that integrates technologies in phenotyping, genomics, and analytics to accelerate plant breeding.

**North Dakota State University** has performed studies to enrich and understand the wheat genome for wheat improvement using a novel chromosome engineering technology. This research diversified the genetic basis of wheat and strengthened the defense of US wheats against various biological and environmental threats. This research developed new genetic resources and tools useful in wheat breeding and genome studies.

**Chris Callahan**, **University of Vermont (UVM)** Extension agricultural engineer, predicts his invention could save artisanal cheese and meat producers $10,000 a year. Produce growers would save too: an annual average of $6,500. The invention, "DewRight," measures temperature and humidity in high-humidity environments, like those required by food storage and processing facilities. Existing sensors give readings that may be off by as much as 6 percent and have a high failure rate in high-humidity environments. DewRight improves that accuracy by 67 percent and uses a design more suitable to that environment. This can result in reduced spoilage and increased yield and quality. Vermont Energy Control Systems took Callahan's patent to the next level by working with UVM Innovations to license and develop it commercially. DewRight is currently in use at 10 facilities.

David Stern and his team at the **Boyce Thompson Institute (BTI) and Cornell University** was awarded an Agriculture and Food Research Initiative (AFRI) Foundational and Applied Sciences Physiology of Agricultural Plants program grant in 2015 to study the regulation of photosynthesis and plant biomass. Dr. Stern's team found that by boosting the central carbon-craving enzyme in photosynthesis, Ribulose-1,5-bisphosphate carboxylase/oxygenase (RuBisCO), it can lead to improvements in agricultural efficiency and yield. The Stern team over-expressed the RUBisCO Assembly Factor 1 (RAF1) to make more RUBisCO in greenhouse-grown corn plants. This project resulted in corn plants that flower sooner, grow taller and produce more biomass. Detail description of their project can be found here: https://news.cornell.edu/stories/2018/10/turbocharging-photosynthesis-increases-plant-biomass and their published work can be found in the journal Nature Plants: https://www.nature.com/articles/s41477-018-0268-9. Stern and his team have filed the following patents:

Application Number: 15/371,185; Filing Date: 12/06/2016; Title: Compositions and Methods useful for the Regulation of Abiotic Stress

Application Number: 2,951,48012; Filing Date: 12/06/2016; Title: Compositions and Methods useful for the Regulation of Abiotic Stress Responses in Higher Plants

The Northeastern Integrated Pest Management Center awarded a small enhancement grant to **Pennsylvania State University** to complete the project, "Towards Implementation of a Novel Fungal Biopesticide for IPM of Bed Bugs" in 2013. Bed bug infestations have grown virtually exponentially in both North America and Europe. Insecticide resistance, together with concerns over extensive use of chemicals in domestic home environments has created a need for alternative methods of bed bug control. The approach of this project was the formulation of a fungal entomopathogen as a novel biopesticide. The goal of the project was to fully develop a bed bug control package using this novel biopesticide that could be used by professional pest controllers and made available as an IPM kit for individual domestic use. The project successfully identified an active fungal endopathogen and developed a comprehensive delivery system design prototype spore delivery technology. The patent-pending product has now received EPA registration and the product is being marketed as the product, Aprehend, a nontoxic biopesticide, for the professional pest management industry. The Northeastern Integrated Pest Management Center is funded by the National Institute of Food and Agriculture's Crop Protection and Pest Management Program.

The canola breeding program at **Kansas State University (KSU)** has a successful track record of technology transfer from the university to the general public, through new canola oilseed varieties. Nine winter canola varieties have been released and licensed to regional and national seed companies over a

10-year period (2008-2017). These varieties are bred to fit the cropping systems of producers all across the southern Great Plains region, including Kansas and Oklahoma, and adjacent regions of Nebraska, Colorado, and other states. For instance, Griffin is a dual-purpose variety that can be used for both forage and oilseed grain from a single planting. It shows better biomass recovery and grain yield following forage removal than other varieties commonly used as forage for livestock. Torrington winter canola has demonstrated superb winter survivability and is the first winter oilseed canola variety that can be planted confidently across the entire state of Kansas. The KSU canola variety development program is supported through publicly-funded research including both capacity funding and competitive grants through USDA NIFA, and industry partnerships. Variety sales are also a source, generating royalty revenue that is returned to the university, and a percentage is reinvested in the breeding program for future variety development.

Potato production and consumption in the Eastern U.S. is as diverse as the variety of culinary choices that Easterners enjoy. While the West is famous for baked potatoes, consumers in the Eastern U.S. look for locally-grown potatoes for salads, soups, and other recipes. In response, states up and down the coast collaborate to understand agricultural conditions in those states, as well as local tastes, and then develop both potato varieties, and production and marketing methods, that different consumers use and enjoy, while also generating farm and market income and helping sustain local farmland. New potato varieties bred by eastern research programs include as multi-purpose round white potatoes Lamoka and Waneta, which are giving rise to a new local potato chip processing business, and the more recent potato varieties Red Maria, Adirondack Red and Adirondack Blue, proven popular with consumers due to their novel red and purple pigmented flesh (all bred at Cornell Univ. in New York state). Colleagues at **the University of Maine** have recently released “Pinto”, a high-yielding, yellow-fleshed specialty variety with excellent roasting and eating quality. The oblong tubers have a red and yellow “pinto type” skin

pattern, which makes them appealing to smaller specialty markets. The Pinto Gold variety name highlights a unique pinto-pattern skin color against the tubers' yellow flesh. They are excellent roasted, and can also be used for boiling, pan frying, baking and in salads. Public potato breeding and production research, including research on resistance to plant pests and diseases in the region, is funded by national programs such as capacity funds and competitive grants through USDA's NIFA, in combination with other state and private sector sources, each funding the aspects of the program for which it is best suited – such as long-term development of well-adapted parents; hybridization and early testing; field testing and extension; and using new genomic and robotic techniques to develop the exciting potato breeding of the future. The potato breeding programs use Plant Variety Protection (PVP) as a well-suited intellectual property protection system for new varieties; an important reason is that PVP allows other programs to use the new varieties as parents in recombined new populations for developing completely new varieties. Lamoka, for example (a PVP'd variety), is being used by public breeding in other regions, to combine its qualities with other traits needed by farmers and consumers of those regions

**4-H National Headquarters staff within Division Youth and 4-H**, USDA NIFA, in partnership with NASA GLOBE Observer (NGO) and Rutgers University 4-H, developed a 4-H citizen science activity guide to be used with the NGO citizen science Cloud project to contribute observations to NASA earth science data collections using a mobile app. **National and state 4-H program staff** representatives coordinated the National 4-H GIS/GPS Leadership team composed of teens and adult mentors from five states. This past year, the team developed maps showing the possible factors involved with drug overdose deaths. They presented their work in 2018 at the National Youth Healthy Living Summit and the Esri International GIS conference. **West Virginia University, 4-H National Headquarters and National 4-H Council** in partnership with Google, collaborated on the 2018 4-H National Youth Science Day project "Code Your World." In events across the country, youth learned about coding

through a four-part challenge that teaches youth to get involved in computer science and gain computational skills through hands-on activities. **An IY4-H NPL** helped design a youth education activity utilizing a texting platform to engage small groups of teens in discussions around Reviving Civility when communicating with others about difficult issues or topics. Two hundred fifty youth participated in the texting driven activity at the 2018 National 4-H Conference. In addition, approximately eight LGU's utilized the activity with 4-Hers in their state. In FY18, an **IY4-H NPL** helped develop and facilitate the first National 4-H Volunteer E-forum. Over thirty states hosted a combined total of over 200 local sites where 4-H volunteers came to a local extension office to participate in three monthly educational sessions. The sessions were a combination of national live presentations via webinar and locally facilitated face to face educational training activities that were related to the national presentations.

Investigators at **Prairie View A&M University (PVAMU)** have developed VetLink, an innovative technology that integrates education and veterinary advice with modern technology to increase access to vital information to improve animal care and reduce costs. The App VetLink is now available in the Apple store, and the Android version will be released in spring of 2019. The App primarily focuses on goats, an animal that is primarily raised by small farms or individuals and is growing in popularity in the meat sector. The fact that there is little information available regarding goats made this the ideal strategic species to lead this effort. The management and development of "VetLink was integral for providing producers with the ability to upload pictures of their goats, and in exchange, can receive guidance on animal care. The concept of telemedicine is not new; however, the idea of veterinary telemedicine is still in its infancy. Initial feedback from the presentations of VetLink to the community motivated the project team to fulfill this need through the VetLink app. VetLink initially started as a website and evolved into

the app due to a growing demand for it. This work was supported by USDA's National Institute of Food and Agriculture through the **1890 Capacity Building Grants Program** (award 2017-38821-26423). The objectives of this project were: (1) to develop apps that will allow producers to share livestock information, (2) create a searchable web database about livestock diseases, and (3) create a portal for livestock producers to share management concerns with other producers and livestock healthcare professionals.

The **University of Nebraska** is leading a CAP project is 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% of the cases in the U.S. attributable to beef. There are a number of tech transfer activities, Here are a few examples:

- An integrated analysis of economics, environmental footprint, and antimicrobial efficacy of 40 antimicrobial systems (a sequence of three interventions) was performed. The antimicrobial effectiveness (in log CFU/cm2), environmental (mPt environmental score /1000 kg Hot standard carcass weight [HSCW]), and economic impacts ($/1000 kg HSCW), by meta-analysis, life cycle assessment, and operational cost analysis, respectively, was evaluated. This integrated analysis will allow the industry to select appropriate intervention system. Results from this study can be impactful for the U.S. beef processing industry to advance the sustainability of antimicrobial systems while ensuring satisfactory effectiveness.

- An innovative framework to estimate and compare foodborne disease burden associated with

U.S. beef consumption and U.S. beef slaughtering/processing (i.e., environmental and occupational risks) on a common metric, disability-adjusted life year (DALY) was developed. Although uncertainties and underestimation might exist in this study, results showed that environmental and occupational risks at beef slaughtering/processing are on the same magnitude with foodborne risks of beef consumption. By disclosing the relative magnitude of the three risks associated with U.S. beef consumption and slaughtering/processing, this work can help decision makers target efforts on minimizing the overall human health impacts of the U.S. beef industry and has broad implications for other food processing industry.

- The wastewater of two cattle slaughterhouses was characterized; in addition, two alternative wastewater treatment and energy recovery methods [dark fermentation (hydrolysis and acidogenesis) and microbial fuel cells] were investigated. Results showed that viscera processing has the largest wastewater load and any improvement in this process could enhance impact the sustainability of cattle processing industry. When fermenting lactic acid wastewater, the highest hydrogen yield was achieved at 45°C . The highest energy recovery was achieved when feeding the overall slaughterhouse wastewater to membrane microbial fuel cells and carcass wash wastewater membrane-less microbial fuel cells. Combining dark fermentation with microbial fuel cells for lactic acid wastewater improved the overall organic removal and energy.

**AgroClimate**, supported by USDA NIFA and NOAA through the Southeast Climate Consortium, provides a wide range of tools for the Southeastern United States for managing climate risk. These include tools for drought, water availability, and water usage. While tools primarily target agricultural producers, the Lawn and Garden Moisture Index can assist homeowner in irrigation decision. Water Footprint Calculator allows growers to estimate the amount of water used to produce a crop. This

decision support tool can be used to by crop producers to decide what crop to grow in their region, based on water availability and the amount of water a crop will use.

NIFA Postdoctoral Fellowship 2016-67012-28381. **STALK LODGING: DEVELOPMENT AND VALIDATION OF NOVEL DEVICES TO MEASURE STALK STRENGTH. UNIV OF IDAHO**. Robertson, D. J.

- Goal: Provide plant breeders with new tools to enable development of lodging resistant corn and sorghum. Objective 1. Validate and enhance a previously designed portable electro mechanical device for measuring stalk strength and bending stiffness.• Thirty devices have been created and have been used at 18 locations by Monsanto Company, as well as in field trials of corn and sorghum at Clemson University, Texas A&M, Iowa State University, and University of Nebraska. The devices can predict stalk strength with four times the accuracy of other commonly used methods of assessing stalk strength. A patent application has been filed for the devices and industry partners are currently conducting extensive field test to evaluate licensing potential. As part of this award calibration techniques for the devices will be developed and the user interface will be enhanced.

**NIFA's Agricultural Science for Climate Variability and Change programs** work toward helping production systems learn to cope and lessen impacts through new knowledge and tools. These include technologies such as improved forecasting tools to help predict impacts at useful scales for producers and landowners. Forecasts are also needed for indirect effects such as risk pathways for pests,

vulnerability to diseases, and changing environments as extreme events alter the landscape for plant and animals. NIFA's portfolio of projects work to provide management options for producers to reduce energy, nitrogen, carbon, and water from production systems, while providing information to find the best animal and plant varieties for the regional conditions, and provide innovations in the food system and supply chain to adapt to impacts on consumers and economies . The division manages the New Technologies for Ag Extension program supporting the Cooperative Extension System's new Electronic Extension ($E^2$) initiative, building upon the eXtension infrastructure to deliver information to the public and provide professional development opportunities online. The AFRI Climate Variability and Change portfolio includes $31 million in projects, continuing awarded work from previous years.

A project out of **Cornell University** entitled, New Tools and Incentives for Carbon, Nitrogen, and Greenhouse Gas Accounting and Management in Corn Cropping Systems, now in its fourth year, seeks to provide small- to large-scale corn growers with low-cost soil C assessment and greenhouse (GHG) accounting tools, and provide policymakers with an evaluation of the current and long-term costs and benefits of various policy incentives for this sector of the agricultural economy (see http://www.adapt-n.com/). Milestones achieved: The Adapt-N tool will be available online to corn growers in 26 states for and includes new output data on greenhouse gas emissions including N2O. Interest in Adapt-N includes both agricultural industry and environmental protection groups. Workforce development: The project involves three graduate students and four undergraduates. Outcomes: The Climate Team developed capacity to produce downscaled climate projections from a set of GCMs driven by the IPCC's four Representative Concentration Pathways (RCPs). These are being used to drive DayCent and PNM crop-soil biogeochemical models, the outputs of which are being linked to economic performance and mitigation policy efficacy at nationally integrated scales. Collectively, soil C assessment results indicate that tillage has a greater impact on soil organic C in the top 30 cm than crop rotation or residue removal.

Potential Impacts: Increased carbon sequestration would decrease greenhouse gases mitigating climate change.

**Investigation of Selected Issues in Farming Industry via Application of Technology -** With funding from the 1890 Evans-Allen Program, scientists at **Alcorn State University,** will investigate three major research aspects in collaboration with scientists from the areas of imaging, nuclear instrumentation, GIS, and radiation physics. The primary objective of the project is to use technology-based research aspects (Image processing, GIS, and Nuclear Instrumentation related) in the field of agriculture to provide some concrete information to the users (researchers, farmers, and other involved with the farming industry) that can provide valuable resources to the industry. The project is proposed with the following objectives: 1)Assess #39; radioactivity levels in fertilizers and provide users with amount of radioactivity introduced into farmlands per acre of land and type of plant product and levels of exposure received by users from usage of selected fertilizers in the farming industry; 2) Experimentally assess #39; radioactive transfer factor of isotopes from soils into the edible parts of the plant resulted into the atmosphere as a result of man-made radiation related activities (specifically nuclear plants) and naturally occurring radioactive materials (NORM) present in soils; 3)To develop an airborne imaging and analysis system (AIAS) with objectives - to quickly estimate canopy coverage of orchards and vineyards; to improve fruit production and protect the environment; and to be able to predict the fruit (or crop) yields and fruit sweetness in the near future. After completion of this project, it is expected that results from this study will provide researchers and farmers with reliable information on some of the topics investigated in this research that focuses on food safety, workers safety, the inter-tree space, total leaf area, and the total dry leaf weight of a given plant. More importantly, at least 5-10 graduate students per year are involved in research and at least 8 scientific research articles are expected to be published.

**NC170: Personal Protective Technologies for Current and Emerging Occupational and Environmental Hazards -** Laundering of pesticide-contaminated clothes is critical to reducing pesticide handler's #39's exposure to pesticides and minimizing/preventing potential of cross-contamination of pesticide residues to the clothing of family members. Laundering studies will be conducted as part of Objective 1 of the NC-170 project. This project has been approved as NC170 multistate research project. The **University of Maryland-Eastern Shore (UMES)** will participate in Objectives 1 and 3. Objective 1 is to investigate factors that impact selection, use, care, and maintenance of PPE products and protective clothing, including hand, foot, and headwear. UMES will focus on decontamination of protective clothing for pesticide handlers. Objective 3 is to develop/revise and implement research-based performance guidelines and standards for items and systems of personal protective equipment and protective clothing. UMES will focus on test methods and performance standards related to PPE for pesticide operators. This research is expected to serve as the basis for recommendations to be used by pesticide safety educators in training. The research will be conducted in collaboration with extension specialists and other stakeholders in the US as well as researchers in other countries working on similar projects as part of the international consortium activities. Research to support revision and development of standards will be conducted as part of Objective 3 of the NC-170 project. UMES will work with collaborators to develop and validate the surrogate test chemical to be used to replace the commercial product currently used for testing. Research will also be conducted to support revision of spray method to be used for evaluation of whole-body garments.

The **Servicemember Agricultural Vocation Education (SAVE)** - Farming for the Future program is based in Manhattan, KS. Funded under the Enhancing Agricultural Opportunities for Military Veterans competitive grants program, 170 transitioning service members or veterans are receiving training in maintaining cropland, rangeland, and livestock at SAVE's 320 acre diversified regional training center

including 20-acre plots of cereal crops, soybeans, and alfalfa, 15 acres of orchard for produce, a commercial honey harvesting apiary, and pasture for various ruminants, hogs, poultry, and horses.

Through the **New Technologies in Ag Extension funding, a University of California-Davis** team is creating an ontology for Cooperative Extension as a part of the Knowledge Project. The purpose of creating the ontology is to have a common language to link Extension programs and people across Extension's distributed systems. An ontology is a formal naming and definition of the types, properties, and interrelationships of entities in a domain. Ontologies are used in artificial intelligence, informatics, and library science to narrow the complexity within domains (e.g., crop science, nutrition). The UC team developed thirteen classes or broad terms that describe Cooperative Extension and its work. The process of creating an ontology is complicated and tedious. For demonstration purposes, the UC team will build lists for 6 of the classes. They will use existing online resources and competencies developed by select CES services to build these lists. The overall goal is to make Cooperative Extension's work, its resources, and its people easier to find.

The **Southern Rural Development Center, in partnership with USDA Rural Development and Cooperative Extension,** administered the Stronger Economies Together initiative in over 100 multi-county regions across the U.S. Through the SET process, regions have identified common needs and opportunities and successfully garnered funding to capitalize on their regional interests. To date, regions in the SET process have leveraged over $754 million, much of which has gone to support efforts to improve regional infrastructure. Visit the website at http://srdc.msstate.edu/set/.

Led by **Vermont University in partnership with all four Regional Rural Development Centers**, the goal of HIREDnAg, a multi-state project led by Shoshanna Inwood of the University of Vermont with a

national group of collaborators, is to understand how health insurance policy influences farmers' decisions to invest, expand and grow their enterprises, and how these decisions contribute to workforce vitality, development and security in the food and agricultural sector, state by state. As part of the research activities, the team distributed a survey to farmers and ranchers in Vermont, Massachusetts, Pennsylvania, Michigan, Nebraska, Mississippi, Kentucky, Washington, Utah and California. The researchers received 1,062 responses, and in July released preliminary findings, which included information gleaned from interviews of up to 10 families in each of the study states. The research team hosted a webinar in October to offer an in-depth explanation of their findings. It is archived online at http://hirednag.net/webinars. The report citation and link are: Inwood, S., A. Knudson, F.A. Becot, B. Braun, S.J. Goetz, J.M. Kolodinsky, S. Loveridge, K. Morris, J. Parker, B. Parsons, R. Welborn, and D.E. Albrecht. 2018. "Health Insurance and National Farm Policy." Choices. Quarter 1. http://www.choicesmagazine.org/choices-magazine/submitted-articles/health-insurance-and-national-farm-policy.

**State Extension leaders from the 12 North Central 1862 land grant universities** developed common indicators for reporting the impacts of community development educational programs. More than $202 Million of 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.

### 10.7. Outreach Activities

- On February 9, 2018 the SBIR program and the USDA Office of Technology Transfer presented a webinar titled "Partnership Pays: Building a Research Partnership with U.S. Department of Agriculture (USDA) Agricultural Research Service 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.

- September 12, 2018 the USDA SBIR program in coordination with the USDA ARS Office of Technology Transfer was awarded the Interagency Partnership award by the Federal Laboratory Consortium. This award showcases the formal collaboration between the USDA SBIR program managed by NIFA and ARS's Office of Technology Transfer. This formal collaboration known as SBIR-Tech Transfer was designed to encourage both ARS and NIFA to provide partnerships and licensing opportunities to potential SBIR applicants by connecting them with ARS researchers and technologies.

- A number of NIFA's SBIR staff attended National SBIR Conferences in Anaheim, CA and Tampa, FL with formal presentations on the USDA SBIR program which included information about the Office of Technology Transfer. Additionally, the USDA SBIR program staff conducted one-on-one meetings with over 35 small business entrepreneurs at each conference and discussed opportunities for both SBIR and Office of Technology Transfer. In addition, the USDA SBIR program participated in live events and webinars for New Mexico and Kansas. Site visits were conducted

with 23 SBIR companies in the following states, AR (2), FL (6), GA, IA, KY (2), MA, MI (2), MN, MO, NE (2), SC, TN, VA, and WI.

- In FY 2018 the USDA SBIR program in conjunction with the Small Business Administration (SBA) had staff participate in 3 SBIR Road Tours and participated in 6 regional SBIR focused conferences which included two SBIR National Conferences. The focus of these tours and regional conferences were 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 Office of Technology Transfer. The road tours provided outreach to approximately 1744 attendees in total, provided on average 20-30 one-on-one meetings with small business entrepreneurs at each meeting, and covered the following states AK, CT, DE, ME, NC, NH, NY, OH, OR, PA, RI, WA and WV.

# 11.0 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 $225 billion and investments upwards of $31.1 billion in 2018 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 and accelerators, 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.