FY | 2019

ANNUAL TECHNOLOGY TRANSFER REPORT

JUNE 2020

USDA UNITED STATES DEPARTMENT OF AGRICULTURE

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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 2015	FY 2016	FY 2017	FY 2018	FY 2019
	Invention Disclosures					
1	Number of new inventions disclosed	222	244	166	320	243
	Patents					
2	Number of patent applications filed	125	109	111	120	97
3	Number of patents received	94	60	68	67	69

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 2015	FY 2016	FY 2017	FY 2018	FY 2019
	Income-bearing Licenses					
4	Number of income-bearing licenses	421	439	437	471	510
5	Exclusive licenses	292	307	302	324	326
6	Partially exclusive licenses	11	9	6	7	7
7	Non-exclusive licenses	118	120	129	140	177
	Elapsed Amount of Time to Grant Licenses					
8	Average (months)	2.8	4.9	6.1	6.3	5.9
9	Minimum (months)	0.5	0.9	1.3	0.9	1.8
10	Maximum (months)	10.0	16.0	13.7	24.1	34.9

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 2015	FY 2016	FY 2017	FY 2018	FY 2019
	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	$1,756,460	$1,811,637	$1,639,557	$1,218,975	$1,579,185
13	Earned Royalty Income from top 20% of licenses	$2,856,924	$3,043,395	$2,933,342	$2,227,058	$2,655,368
14	Minimum Earned Royalty Income	$13	$5	$15	$21	$0.75

15	Maximum Earned Royalty Income	$728,017	$818,537	$769,167	$265,844	$573,545
16	Median Earned Royalty Income	$3,525	$3,966	$3,698	$3,056	$3,154
	Disposition of Earned Royalty Income					
17	Total amount earned royalty income received	$3,509,904	$3,633,239	$3,503,866	$2,715,861	$3,171,355
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 2015	FY 2016	FY 2017	FY 2018	FY 2019
	CRADAS					
21	Number Active CRADAs	301	238	330	212	278
22	Total Newly Executed CRADAs	80	79	91	61	95
23	Active CRADAs with small businesses involvement	106	76	68	81	129
24	Number of small businesses involved in active CRADAs	106	76	68	81	129
	Traditional CRADAs					
25	Active traditional CRADAs	188	161	296	182	276
26	Newly executed traditional CRADAs	52	43	77	57	94
	Non-Traditional CRADAs					
27	Active non-traditional CRADAs	113	77	34	30	2
28	Newly executed non-traditional CRADAs	28	36	14	4	1
	Other Collaborative Research Agreement[1]					
	Active other collaborative research agreements	4,730	5,628	6,125	3,369	2,204

	Newly executed other collaborative research agreements	1,383	2,316	1,968	694	1,096

[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)

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

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.

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. Food Disclosure and Labeling Division

The Food Disclosure and Labeling Division (FDLD) administers the Country of Origin Labeling (COOL) law of 2009 and the National Bioengineered Food Disclosure Standard (the Standard) of 2016. COOL requires retailers such as full-line grocery stores, supermarkets and club warehouse stores, to inform customers of the source of certain foods, including: muscle cut and ground lamb, goat, and chicken; wild and farm-raised fish and shellfish; fresh and frozen fruits and vegetables; peanuts, pecans, and macadamia nuts; and ginseng. COOL is enforced through retail store compliance reviews, supplier trace back audits, webinars and fact sheets, COOL Supplier Certification, and COOL Remote Retailer Certification. The Standard determines which foods must be labeled and reviews food technology developments to evaluate applicability of the Standard.

In FY 2019, FDLD published the final rule on labeling bioengineered foods. Since the rule was published in February of 2019, FDLD has developed and posted the following educational resources for regulated entities: fact sheet, disclosure determination tool, a webinar, and answers to frequently asked questions. FDLD staff also conducted 26 presentations on the Standard or COOL, reaching over 1,040 people. FDLD completed 63 supplier traceback audits, 3,638 retail reviews, and 3,531 new review assignments as well as an educational video aimed at consumers.

In FY 2020, FDLD plans to automate and streamline the enforcement of COOL and the Standard through the use of a database system. This system would serve as a repository for data collected through retail reviews and traceback audits as well as track any consumer complaints FDLD receives and the division's response to those complaints. In addition, the database could generate dashboards that demonstrate the division's progress against objectives in the operating plan. FDLD will also update the BE List of Foods, which identifies bioengineered crops worldwide.

1.4. National Organic Program (NOP)

USDA oversees organic agricultural products through its Agricultural Marketing Service (AMS) National Organic Program (NOP). 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. AMS facilitates international trade for U.S. organic farms and businesses and makes sure USDA-certified organic products produced domestically and around the world comply with the organic standards.
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 (CBP) agency to establish ways to better identify organic products coming into the United States using the Automated Commercial Environment (ACE) system. The ACE system facilitates the real-time collection, sharing and processing of import trade data with CBP.

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. The new AMS organic export

certificate system provides electronic certificates about organic shipments. This system can either be accessed by other governments or our data can feed into other countries' import systems. In early spring 2019, AMS launched an internal Compliance Database. The database helps to better track NOP's progress on complaint investigations and more quickly identify patterns and relationships across complaints.

Investment in organic systems directly advances AMS goals related to organic supply chain integrity, technology modernization, and customer service. The USDA is currently considering foundational needs for a global organic oversight system. The ultimate 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 products 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.

1.5. 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 as a public good. 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 near 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 (spell out) 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 2020. 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.

1.6. Laboratory Approval and 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 2019, NSL evaluated and adopted two new testing technologies that will increase the efficiency and quality of the microbiological and chemical testing services. Also, NSL expanded its aflatoxin testing service to a pharmaceutical company, analyzing a new drug being developed to address peanut allergies. In FY 2019, NSL continued to expand its capabilities in testing for economic adulteration and authenticity in food and beverages, 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 2019, LAS clarified and more clearly connected country-specific requirements and expectations for product certification in the Laboratory Approval Program for the Export of Meat and Poultry Products and monitored implementation in the 18 participating laboratories. Also, in FY 2019, LAS approved all 7 Milk Market Administrator laboratories into the Laboratory Approval Program for Federal Milk Marketing Orders, verifying that the AMS Dairy Program's quality management system provides quality assurance and control procedures that yield accurate and defensible data for payment calculation to dairy producers.

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 United States. Since 1991, PDP has tested 126 different commodities for over 640 different pesticide residues. In FY 2019, 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 2019, the Plant Variety Protection Office (PVPO) received 420 applications of new seed and tuber propagated agricultural and ornamental plant varieties, conducted examinations on 542 applications to determine if plants were a new variety, and issued more than 400 certificates of protection. In FY 2019, in addition to carrying out its mission, PVPO completed the necessary rule-making to implement the 2018 Farm Bill amendment of the PVP Act. The amendment extends plant variety protection to asexually-reproduced varieties of plants. PVPO started to offer plant variety protection for seed-propagated hemp, based on another Farm Bill change. PVPO also implemented the 5th release to update its electronic application system to allow bulk upload for applications and system integration with an international application system.

1.9. Seed Regulatory and 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 all 50 State departments of agriculture and several industry organizations to leverage its limited resources into a broad network of regulatory and marketing outreach that stabilize and support the robust 12 billion-dollar U.S. seed market.

Recent activities conducted by SRTD to facilitate domestic and international marketing include the publishing of an online Excel document containing lists of State noxious weed-seed requirements from of each of the 50 States. This revised list has been optimized to enable seed businesses to upload State requirements directly from the USDA website into their databases which will, in many cases, eliminate the need to expend resources for manual entry. In addition to optimizing this list, SRTD has updated the frequency of this publication. The list will now be updated monthly to ensure that interstate shippers trading seed in multiple States will not inadvertently violate State noxious weed-seed laws due to an outdated list.

In FY 2019, SRTD partnered with the Canadian Food and Inspection Service to develop and launch an online seed identification tool which helps seed analysts identify seeds. For FY 2020, SRTD will upload, into the online seed identification tool, more than 100 noxious weed-seed species prohibited under the Federal Seed Act. These free, publicly available, and high-quality images will enable seed scientists, regulatory officials, and educational institutions to clearly identify noxious weed-seeds that cannot be moved across State lines.

1.10. Perishable Agricultural Commodities Act Program

This Perishable Agricultural Commodities Act Program (PACA) 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 developed a modernized data management platform, ePACA, that includes 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 reduces the time it takes AMS to approve and issue a license, shortens the complaint process, and facilitate faster payment of outstanding debts to farmers and produce sellers. The ePACA system also provides enhanced search capabilities of PACA licensees with 24-hour access to real-time information that produce sellers can use to make informed business decisions.

1.11. 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 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 Commodity Management 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 Sonny 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, improving 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 (spell out) access for multiple concurrent users, enable reporting, and automate manual tasks.

1.13. Federal Grain Inspection Service (FGIS)

FGIS facilitates the marketing of grains, oilseeds, pulses, legumes and related products; ensures fair and transparent markets free from deceptive and fraudulent practices; and provides reliable descriptors of crop quality and value to promote economic health and prosperity in American agriculture. FGIS accomplishes this, in part, by establishing grain quality standards and by providing an impartial

inspection and weighing service through a network of Federal, State, and private entities. 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 2019, the grain markets serviced by FGIS represented an approximate value of $102 billion, with exports contributing about $31 billion to the U.S. economy.

FGIS maintains a strong presence both 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 businesses. 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 on testing methods 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.

Current Technology Transfer Initiatives

Inspection Lighting.

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. In FY 2019, FGIS conducted a study of three commercially available LED lights to identify the appropriate specifications that will provide inspection results that are equivalent to the current fluorescent lights. The results of this study were inconclusive and demonstrated both the complexities involved in setting LED light specifications and that further work is needed.

Falling Number Testing Program.

The falling number test measures the effect of the enzyme, alpha-amylase, on wheat. High alpha-amylase activity is associated with sprout damage and adversely affects the end-use quality of wheat. As a result, the falling number test is an important factor in the domestic and international trade of wheat. As part of a national quality assurance program, FGIS discovered that barometric pressure and sample shaking have significant effects on falling number test results. In FY 2017 and 2018, FGIS carried out an internal research project on shaking techniques and a collaborative research project with the Agricultural Research Service on barometric pressure correction. In FY 2019, FGIS implemented changes to the falling number test that will reduce overall variation in falling number results. These changes include the correction of test results to sea level based on the barometric pressure of the testing location and the requirement to use a robotic shaker for sample preparation.

Rapid Test Kits.

FGIS continues work with manufacturers to evaluate and approve rapid test kits that detect mycotoxins and GE traits in grain. Only FGIS-approved mycotoxin test kits that meet specific performance criteria can be used for official grain inspection. FGIS provides a monthly update of all approved rapid test kits on its public website. In FY 2019, FGIS evaluated 15 test kits and 11 were approved for the detection of mycotoxins in grain including, aflatoxins, deoxynivalenol, fumonisins, and zearalenone.

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. These PCR reference methods are used in a Corn and Soy Biotech Proficiency Program, wherein 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.

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 11 years, and the corn survey for 3 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.

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. 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 this CRADA is to collaborate on research and development of innovative technologies for accurate, consistent, and efficient assessment of grain quality. The research focused on specific applications for rice and wheat inspections and was concluded on January 31, 2019. FGIS plans to use the knowledge gained in the CRADA to develop performance specifications and criteria to evaluate imaging technology for official grain inspection.

Outreach Activities

Two FGIS scientists served as members 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.

One FGIS scientist participated in the United States – Japan Panel on Toxic Microorganisms and exchanged research information on mycotoxins, which have an important impact on grain quality and safety. This meeting serves to provide open communication on emerging issues on the occurrence as well as the sampling and testing of mycotoxins in grains and other foods.

At the request of the U.S. Department of State, two FGIS scientists served as members of the "Experts for the Network of Laboratories for the Detection and Identification of Living Modified Organisms." The objective of this group is to facilitate discussions focused on new detection and identification techniques, current capacities to detect and identify living modified organisms and sharing of experiences regarding the detection, identification and monitoring of the organisms, components and products of synthetic biology.

FGIS responds 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 2019, FGIS representatives traveled to Peru, Japan, Malaysia, Philippines, and Thailand to present 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. 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. 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 2019, FGIS personnel met with 18 teams from 20 countries.

Publications

The FGIS Performance Verified Mycotoxin Rapid Test Kits matrix is located on FGIS's website at:

https://www.ams.usda.gov/sites/default/files/media/FGISApprovedMycotoxinRapidTestKits.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://www.ams.usda.gov/sites/default/files/media/FGISApprovedBiotechRapidTestKits.pdf

The matrix is updated as new tests are approved.

The FGIS Biotechnology Proficiency Report is located on FGIS's website at:

https://www.ams.usda.gov/services/fgis/standardization/proficiency

The FGIS approved moisture calibrations is located on FGIS's website at:

https://www.ams.usda.gov/services/fgis/standardization/moisture-equipment

The calibrations are updated May 1 and August 1.

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 2019, AMS specialists reviewed commodity standards to ensure their accuracy in describing current products, including 21 for cotton products; 30 for fruit and vegetable products; 18 for meat and poultry products (beef, veal, and egg); and 13 for tobacco. Of note were revisions for, 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 2019.

1.15. 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.

1.16. 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.

1.17. 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 2019, AMS conducted 2,105 inspections with a compliance rate of 97.4 percent to ensure that only eggs fit for human consumption are marketed in consumer outlets.

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, 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 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 2019.

2.0.2. Combined Metric Tables

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

Wildlife Services (WS)	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**	**FY 2019**
● **CRADAs**, total active	11	9	6	7	9
- New, executed	1	2	0	1	3
▪**Amendments[1], total active**	8	7	6	4	4
- New, executed	3	2	2	0	0
▪ **Traditional CRADAs, total active**	11	9	6	7	9
- New, executed	1	2	0	1	3
▪ **Small Business Cooperators, total active**	8	6	6	7	9
- New, executed	1	2	0	1	3
▪ **Foreign Cooperators, total active**	3	2	1	1	3
- New, executed	0	0	0	0	2
● Other Collaborative R&D Relationships					
▪ **Confidentiality Agreements[3]**	69	74	33	40	39
- New, executed	10	7	5	9	8
▪ **Material Transfer Agreements[3]**	93	106	75	89	82
- New, executed	34	17	7	12	9
- Material Transfer Research Agreements	0	7	11	26	33
- New, executed	0	7	6	15	13
▪ **Other Agreements[2]**, total active	269	320	185	154	171
- New, executed	147	127	77	73	69
● **Publications**	99	107	128	198	133
-Peer-Reviewed Scientific Publications	91	99	108	175	122
-Non-Indexed Publications	8	8	20	23	11
Veterinary Services (VS)	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**	**FY 2019**
● **CRADAs,** total active	0	0	0	0	0
● Other Collaborative R&D Relationships				0	0
▪ **Confidentiality Agreements**	0	0	17	20	49
- New, executed	0	0	17	3	29
▪ **Material Transfer Agreements**	63	64	62	67	107
- New, executed	22	16	17	31	44
Material Transfer Research Agreements	0	0	5	0	0
- New, executed	0	0	5	0	0
▪ **Other Agreements[2]**, total active	89	170	154	104	112
- New, executed	86	91	84	61	63
● **Publications**	29	46	33	22	32
-Peer-Reviewed Scientific Publications	29	40	32	22	56
-Trade Journal Publications	0	0	0	0	0

Plant Protection and Quarantine (PPQ)	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
● CRADAs, total active all 3710a Agreements	0	0	1	NR	17
● Other Collaborative R&D Relationships	0	0	0	NR	N/A
▪ Confidentiality Agreements	1	0	2	NR	N/A
- New, executed	1	0	0	NR	N/A
▪ Material Transfer Agreements	9	0	24	NR	N/A
- New, executed	8	0	6	NR	N/A
Material Transfer Research Agreements	4	0	6	NR	N/A
- New, executed	4	0	2	NR	N/A
ARS Letter of Intent[3]	2	0	1	NR	N/A
▪ Other Agreements[2], total active	389	0	0	NR	NR
- New, executed	132	0	2	NR	336
● Publications	54	0	0	0	57
-Peer-Reviewed Scientific Publications	30	0	0	0	57
-Trade Journal Publications	20	0	0	0	0

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.

TABLE 2. Invention Disclosures and Patenting

APHIS-Wildlife Services (WS)	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
● New invention disclosures in FY	4	3	4	4	6
● Patent applications filed in FY, total	0	0	3	5	5
▪ Non-Provisional	0	3	1	4	1
▪ Provisional	3	2	2	1	4
● Patents issued in FY	1	2	1	1	1
▪ Life Sciences	1	2	1	0	1
▪ Chemical	0	0	0	0	0
▪ Mechanical & Measurement	0	0	0	1	0
APHIS-Veterinary Services (VS)	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**	**FY 2019**
● New invention disclosures in FY	0	1	0	0	0
● Patent applications filed in FY, total	0	0	0	0	0
▪ Non-Provisional	1	0	0	0	0
▪ Provisional	0	1	0	0	0
● Patents issued in FY	0	0	0	0	0

▪ Life Sciences	1	0	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 2015**	**FY 2016**	**FY 2017**	**FY 2018**	**FY 2019**
● All licenses, total active in the FY					
▪ **Patent licenses**, total active in FY	1	3	3	3	3
APHIS-Veterinary Services (VS)	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**	**FY 2019**
● All licenses, total active in the FY					
▪ **Patent licenses**, total active in FY	1	0	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 2015**	**FY 2016**	**FY 2017**	**FY 2018**	**FY 2019**
● All royalty bearing licenses[1]					
▪ Patent licenses	0	2	3	3	3
APHIS-Veterinary Services (VS)	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**	**FY 2019**
● All royalty bearing licenses[1]					
▪ Patent licenses	0	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 2015**	**FY 2016**	**FY 2017**	**FY 2018**	**FY 2019**
▪ Patent licenses	0	3	3	3	3
● Total Earned Royalty Income (ERI)[1]	0	0	0	0	0
▪ Patent licenses, total ERI	$0	$17,500	$5,000	$87	$158

TABLE 6. Disposition of License Income

APHIS-Wildlife Services (WS)[1]	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**	**FY 2019**
● Income distributed, total					
- To Inventors	$0	$6,625	$2,750	$87	$158
▪ Patent licenses, total	$0	$17,500	$5,000	$87	$158
- To inventors	$0	$6,625	$2,750	$87	$158

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

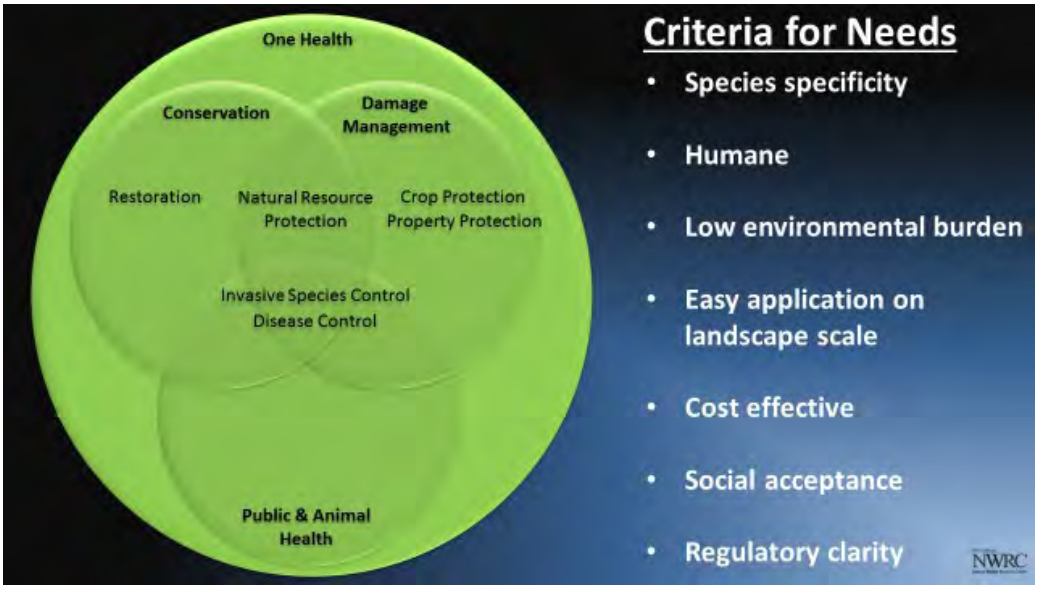
Collins, CO, headquarters and at the 8 field stations located throughout the United States. Five field stations are co-located with universities (University of Florida, Oregon State University, Utah State University, North Dakota State University, and Mississippi State University). One field station 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 specialize 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 and/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

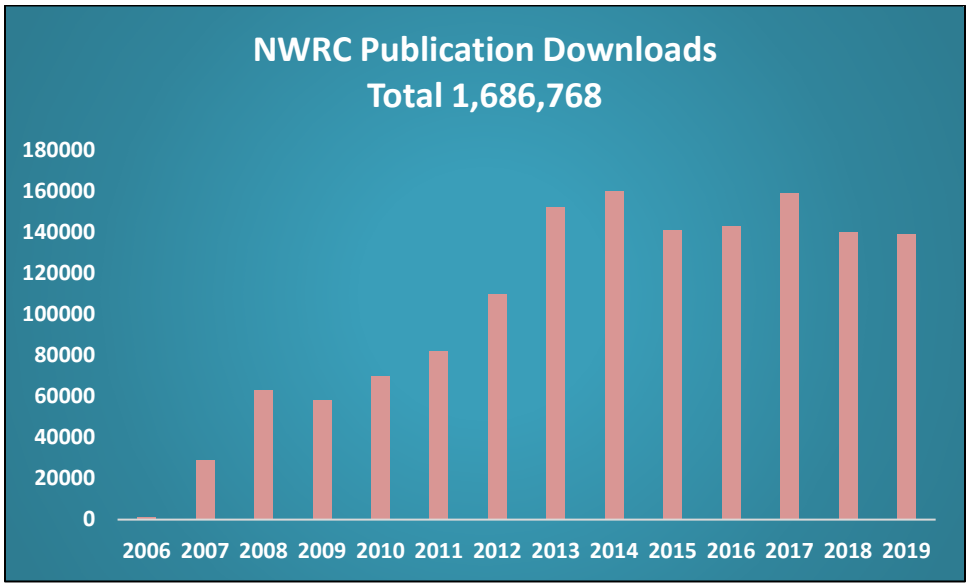
formal instruments of technology transfer, including Confidentiality Agreements (CA), Material Transfer Agreements (MTA), Material Transfer Research Agreements (MTRA), and Cooperative Research and Development Agreements (CRADA). In addition, WS transfers technology through patents and invention licenses 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 WS 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 MTRAs, 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 FY19, NWRC scientist published 122 peer-reviewed manuscripts in 76 scientific journals, and 11 trade publications or book chapters. Even more impressive though is the rate at which publications have been downloaded by external audiences, especially since NWRC only employs 30 scientists in positions where publication is required. Since NWRC began tracking publication downloads in 2006, annual downloads have steadily increased each year as our internet capabilities were built out. Over the past 8 years, NWRC annual publication download rate is approximately 140,000 downloads per year. In 2019, NWRC publications were downloaded 139,254 times. Between 2005 and 2019, 1,686,768 NWRC publications have been 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 2019, NWRC partnered or otherwise collaborated with approximately 150 individual institutions. Over the course of 5 years, NWRC partners with approximately 350 unique institutions, an impressive number given that Center employs roughly 30 Ph.D. research scientists. The majority of these collaborations were with universities, but State and local governments and private partners were highly represented. NWRC scientists and staff collaborated with over 20 foreign governments or institutions. It is expected that NWRC's external collaborations remained at this level in FY 2020.

As stated above, NWRC also enters into technology transfer agreements (CAs, MTAs, MTRAs, and CRADAs), Grants and Memoranda of Understanding (MOU) 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 FY 2019, NWRC was actively involved in 162 intellectual property protection and/or development agreements, 33 of which were initiated in FY2019. 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, both incoming and outgoing, is another important means of developing and transferring NWRC technology to universities and private collaborators. In 2019, NWRC entered into a total of 71 agreements. Incoming cooperator funding at WS NWRC averages about 15percent of the annual budget and has remained steady during the last 6 years, generating $3.5 million in 2014, $2.6 million in 2015, $2.7 million in 2016 and $2.7 million in 2017, $2.7 million in 2018 and $2.3 million in 2019.

Type	**#**	**Total**
Cooperative Agreement	30	$3,155,671.06
Cooperative Service Agreements	12	$580,348.87
CRADA	2	$0.00
Interagency Agreements		
Incoming Funding	13	$1,739,433.32
Outgoing Funding	3	$121,067.29
Material Transfer Agreements	7	$0.00
Grants	2	$10,000.00
MOU's	2	$0.00
TOTALS	**71**	**$5,606,520.54**
Total Incoming Funding		$2,319,782.19
Total Outgoing Funding		$3,286,738.35

2.1.4. Downstream Outcomes

2.1.4.1 Federal Laboratory Consortium - Federal Laboratory Director of the Year Award.

On April 24, 2019, NWRC Director Dr. Larry Clark received the 2019 Federal Laboratory Consortium (FLC) Laboratory Director of the Year Award for his outstanding contributions in support of technology transfer. Under Clark's leadership, the NWRC has successfully transferred technologies to private businesses CRADA, as well as patenting and licensing opportunities. Since becoming Director of the NWRC in 2008, Dr. Clark has strived to increase and promote NWRC's impact as the Federal national and international leader in wildlife damage management research. Under his direction, technology transfer has become a major focus of the NWRC outreach efforts. In 2013, Dr. Clark initiated the development of a robust technology transfer program, creating the NWRC's first Office of Research and Technology Applications (ORTA) and Technology Transfer Coordinator (TTC) position to coordinate intellectual property creation, protection, and transfer. Together, Dr. Clark and the TTC support the NWRC scientists in the creation of technology transfer partnerships.

Although NWRC only employs about 30 Ph.D. research scientists, it collaborates on average with 150 unique entities each year. Since 2013, NWRC has entered into nearly 400 intellectual property agreements (Non-disclosure, Material Transfer, Material Transfer Research, Data Sharing and Memoranda of Understanding Agreements) including 27 CRADAs. In total, these agreements have brought $4.5 million in extramural funding to the NWRC. Between 1944 and 2013, NWRC scientists received 25 patents (1 patent every 2.8 years). Since Dr. Clark began emphasizing technology transfer, NWRC scientists have received six patents (one patent every 1.2 years). In addition, NWRC currently has three U.S. patent applications under review. NWRC now receives annual royalties from three

licensed technologies, and it is the only entity within APHIS that has successfully licensed patented technology.

2.1.4.2 Federal Laboratory Consortium - 2019 Excellence in Technology Transfer Award.

In 2019, the NWRC and Arkion Life Sciences collaboration (see 2018 USDA Technology Transfer Annual Report, "Birds Don't Always Like What They See") won two awards from the Federal Laboratory Consortium. A FLC Mid-Continent Regional Award was received for an 'Outstanding Partnership' and a national award was received for 'Excellence in Technology Transfer. These awards were received because of the excellent partnership focused on developing, testing, registering, manufacturing, and distributing a suite of anthraquinone-based repellents for reducing bird and mammal damage to crops. The partnership has resulted in five co-owned patented technologies and associated repellent products that are cost effective, practical, environmentally safe, and are socially responsible. These products 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). 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.

2.1.4.3 Automated Aerial Bait Delivery to Control Brown Treesnakes.

Previous work has shown that invasive brown treesnake populations on Guam can be reduced by aerially delivering baits treated with 80 mg of acetaminophen to snake-infested areas. However, preparing the baits manually and applying them over large landscapes is labor and time intensive. Thus, WS, NWRC, and the U.S.

Source: USDA APHIS Wildlife Services

Department of the Interior collaborated with Applied Design Corporation (Boulder, CO) to engineer an automated bait manufacturing and delivery system. The core technology is an aerially delivered biodegradable "bait cartridge" designed to tangle in the tree canopy, making the acetaminophen bait available to treesnakes and out of reach of terrestrial non-target species. When mounted on a rotary- or fixed-wing aircraft, the automated dispensing module can broadcast bait cartridges at a maximum rate of four per second. NWRC researchers and WS Operations experts conducted the first evaluation of this system on Guam in July 2016 and demonstrated that this system can significantly reduce brown treesnake abundance after a single treatment. The WS Guam State Office now uses this system operationally to reduce the snake population within 55-hectares of forest surrounded by a snake-proof barrier on Guam. The goal is work to evaluate the possibility of using the system to eradicate snakes within the enclosure and provide a snake-free habitat for conservation restoration purposes. From October 2018 to June 2019, WS Operations and NWRC conducted multiple bait applications at this site, resulting in a greater than 80- percent decrease in snake activity. Further applications will continue to drive brown treesnake numbers within the enclosure toward zero. For the first time, land managers have a tool that can drastically reduce snake numbers throughout large areas, improving biosecurity and encouraging hopes for the eventual recovery of Guam's native species.

2.1.4.4 Web-based Model for Canine Rabies Management.

The spread of rabies by dogs remains a threat in much of the developing world. Although human infections are preventable with pre-exposure or post-exposure prophylaxis, the management and elimination of the disease in dogs is the only definitive way to eliminate human risks and the high costs of human treatment. NWRC and international researchers created a new modeling tool to investigate different rabies management options and maximize the impact of canine rabies management

Source: USDA APHIS Wildlife Services

resources at the local level. The model helps answer complex strategic questions surrounding vaccine application and timing, population control, and budget allocation. The model was characterized using data from a region of the Mpumalanga Province in South Africa. Findings suggested that the region could experience maximum benefits by vaccinating puppies and repeating vaccination campaigns annually. Furthermore, the model found that combining the vaccination and sterilization of female dogs was not cost effective given there was a constant influx of new dogs from other areas, and sterilization had little effect on dog abundance. Researchers note this new tool helps decision-makers maximize the benefits of their rabies programs, as well as estimate the minimum budget necessary to manage rabies in local dog populations.

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 APHIS - 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:

- During 2019, IS personnel from the U.S.-Panama Screwworm Eradication Program participated in the transfer of technology and protocols to USDA-ARS scientists in cryopreservation and collection of genetic material in the field.
- Screwworm personnel also assisted in the transfer of technology, protocols, education and training cooperatively with IAEA to officials from Mexico, Guatemala, Belize, El Salvador, Honduras, Nicaragua, Costa Rica, Panama, Colombia, Ecuador, Peru, Bolivia, Paraguay, Brazil, Argentina, Uruguay, and the Dominican Republic.
- IS screwworm personnel also presented seminars, webinars, and onsite support for the APHIS Science Committee and APHIS-VS workshops for the States of Georgia and Texas to increase vigilance and preparedness for potential screwworm introductions.

- In June 2019, IS personnel in the Guatemala Medfly Program (Moscamed) assisted with a training organized by the IAEA on Sterile Insect Technique and mass insect rearing for participants from 20 different countries.
- IS in Guatemala also provided Geographic Information Systems (GIS) training to 17 participants from the Guatemalan Ministry of Agriculture and stakeholder groups in Guatemala to facilitate the mapping of exotic pest species.

Caribbean

- In 2019, IS and VS continued to work with the Dominican national animal disease diagnostic 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).

- Continued cooperation through 2019 with technical experts from PPQ and the Florida Department of Agriculture and Consumer Services for plant health-related technology transfer in the Dominican Republic for Giant African Snail. Eradication operational plans and enhanced port inspection techniques were organized, but at a reduced level compared to 2018 activities due to funding constraints. To address this issue, collaborations with other technical entities such as NGOs and universities were pursued, and "train the trainer" formats for exchanges with subject matter experts were used to sustain, amplify, and maximize the benefits.

- In September 2019, the IS Trinidad office hosted a workshop for plant health regulatory professionals from 11 Caribbean countries on the Identification and Surveillance of Fruit Flies of Economic Importance to the Greater Caribbean Area.

- During the past 10 years, the Trinidad IS office has also organized the annual Caribbean Plant Health Directors' Forum (CPHD) meeting, which presents a unique and efficient opportunity to implement a wide range of technology transfer sessions in a single 1-week meeting with a diverse range of collaborators including representatives from 27 countries and territories, along with over 10 international organizations, APHIS-PPQ staffs, and 4 universities. Technology transfer sessions of note in the 2019 meeting included topics of open source distance digital diagnostics, impact of climate change on phytosanitary measures, technical aspects of trade facilitation and standards, electronic phytosanitary certification, and targeted sessions on priority pests and commodities.

Central America

- IS worked with Costa Rica's plant health department to use PPQ's Treatment Manual to conduct and monitor fumigations for efficient and effective treatments of agricultural quarantine plant commodities. Treatment methods established in the PPQ manual by APHIS' Science and Technology program are being applied to import commodities at Costa Rica's ports of entry.

Mexico

- During FY 2019, APHIS-VS paid for two officials from the Mexican National Animal Health Laboratory in to be trained at VS' National Veterinary Services Laboratories (NVSL) on Whole Genome Sequencing of M bovis and the associated bioinformatics.

- IS also sponsored a Veterinary Diagnostic Laboratory Quality Assurance Symposium, offered by the University of Delaware's Avian Biosciences Center. Thirteen government officials representing 13 countries attended this course.

2.3.3. Downstream Outcomes

International Technical and Regulatory Capacity Building (ITRCB)

The ITRCB, a headquarters staff 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. In one noteworthy example, ITRCB and APHIS' Vietnam office hosted an African Swine Fever 3-D (Depopulation, Disposal, and Decontamination) training highlighting depopulation technology in July 2019. When appropriate, ITRCB supports Agency efforts by facilitating technical cooperation activities with trading partners and developing countries. This training, including the use of new technology with foreign counterparts, comprises a significant part of ITRCB's mission. However, technology transfer is generally 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 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/).

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.

2.4.2. 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 2019, conducted training workshops for diagnosticians to build biosecurity capacity in pathogen diagnostics, seed testing, quality management, and bioinformatics. PPQ's National Plant Protection Laboratory Accreditation Program (NPPLAP) accredits NPDN, State, Federal and commercial laboratories to perform regulatory diagnostics. NPPLAP conducts proficiency testing and certification for Plum Pox Virus, *Phytophthora ramorum* and citrus greening.

Formal agreements, including cooperative and interagency agreements and memoranda of understanding, are used to formalize collaborations with other government scientists, universities, private companies, and other stakeholders. In FY 2019, S&T provided oversight of 336 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 30 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. In 2019, PPQ and the NPDN led the first quality management workshop for the National Clean Plant Network to advance a quality management initiative for network members.

2.4.3 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 FY 2019,

nearly 100 of the program's identification products are available via an open-access searchable portal (http://idtools.org). New releases in FY 2019 include Southeast Asian Ambrosia Beetle identification tool, an ID Aid for Asian citrus psyllid, a Key to Commonly Intercepted Armored Scales, pest survey aids for important beetle and moth pests, and seID, a tool designed for identification of toxic seeds for law enforcement. ITP and the Beltsville Lab also released IDphy: molecular and morphological identification of Phytophthora based on the types, ITP's first pathogen tool. ITP's image ID tool which assists with the identification of pests intercepted at ports, continues to be expanded, and currently has over 150,000 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 11 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 90percent 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.

Management Tools for Emergency Program Pests

PPQ is currently conducting 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 development of new detection and response tools to these pests, in collaboration with State and Federal partners. Recent advances for European cherry fruit fly (ECFF) include the development of a systems approach to allow cherry fruit movement from quarantine areas to reduce economic impacts to growers. S&T recently completed development of an identification method for ECFF, which can complete identification of a fly within 3 hours, and has been implemented to identify larvae collected from honeysuckle and cherries in New York. The method provides real time information to support future surveys of this invasive pest. A comparison of different traps and lures for ECFF, found that a new yellow sticky panel performed significantly better at attracting and capturing ECFF than the current program standard. For spotted lanternfly, which attacks several tree and fruit crops, PPQ 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. S&T provided two new trap designs (circle trap and Bug Barrier trap) that were commercially produced and deployed in the field in 2019. New research on biological control pathogens has resulted in field trials of a commercial product in 2019. PPQ S&T is continuing to improve management methods for these pests to State partners in order to support response and recovery efforts.

Regulatory diagnostics for National Plant Diagnostic Network

Since 2004, the PPQ Beltsville Laboratory has provided 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 2019, the Beltsville laboratory held several workshops to train 49 NPDN diagnosticians from universities, State Departments of Agriculture, Federal laboratories, commodity groups and commercial diagnostics companies. 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.

In association with the Beltsville Lab, PPQ's National Plant Protection Laboratory Accreditation Program (NPPLAP) accredits NPDN, State, Federal, and commercial laboratories to perform regulatory diagnostics. In 2019, PPQ distributed fifty-nine (59) proficiency test (PT) panels to eleven (11) laboratories for citrus greening; forty-five (45) panels to 14 (fourteen) laboratories for *P. ramorum* and twenty-six (26) panels to eight (8) laboratories for plum pox virus (PPV). 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 and techniques used for testing into the program. In 2019, this included roll out of a new, more sensitive test for the pathogen causing citrus greening to partner labs to improve survey and control efforts.

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 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 comprises 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 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 three VS science centers provide a solid scientific, technical, and analytical foundation needed to support VS' mission.

The National Veterinary Services Laboratories (NVSL)

NVSL safeguards U.S. animal health and contributes 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 by:

- Performing diagnostic laboratory testing for VS' 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.

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. 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 enhance the expertise at NVSL and in reference collections that are available for assay development and validation.

Centers for Epidemiology and Animal Health (CEAH)

CEAH explores and analyzes 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 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)

CVB implements 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:

- VS collaborated with the Institute for International Cooperation in Animal Biologics (IICAB) and held the 2019 OIE Veterinary Biologics Training Program. This program provides an overview of the scientific principles of vaccines, vaccination, and the USDA regulatory process for assuring the purity, safety, potency, and efficacy of veterinary biologics.

- VS personnel presented at the Extension Disaster Education Network (EDEN) annual meeting in College Station, Texas. to elevate awareness of the National Animal Health Laboratory Network (NAHLN) emergency management (EM) roles in support of State and regional laboratories performing surveillance testing for high-consequence agricultural and zoonotic pathogens. The

presentation was followed by discussion about how the USDANational Institute of Food and Agriculture's network of extension educators and communicators support NAHLN's EM plans during times of crisis.

- VS supported the electronic messaging of test results from NAHLN veterinary diagnostic laboratories for FMD, ASF, CSF, vND, and HPAI–52 laboratories were capable of electronic messaging as of October 2019.

- VS held a kick-off event for the National Bio and Agro Defense Facility (NBAF) Scientist Training Program (NSTP) at the Plum Island Animal Disease Center. The NSTP is a graduate training program to develop the workforce critical for the continuing and expanded APHIS mission at NBAF. The first cohort of NSTP fellows, graduate students from four universities, toured the Plum Island Animal Disease Center, participated in scientific presentations from laboratory staff, and met with Department of Homeland Security and USDA Agricultural Research Service staff regarding their role as the next generation of scientists at the NBAF.

- VS personnel attended a planning meeting for African swine fever (ASF) oral fluid positive cohort archive sample testing at the Canadian Food Inspection Agency (CFIA) in Winnipeg, Canada. This shared U.S./Canada effort evaluated the utility of oral fluids as a sample type for the early detection of foreign animal diseases, and particularly, ASF. VS personnel worked with CFIA colleagues to compare the NVSL and CFIA assays, a first step in the effort to harmonize our foreign animal disease diagnostic assays between the United States and Canada.

- VS personnel attended the World Health Organization of Animal Health (OIE) ad-hoc Group on Biological Threat Reduction Meeting in Paris, France. The group reviewed existing guidance

documents, developed a holistic and comprehensive guidance for laboratories of the VS for the identification, and considered further recommendations for veterinary authorities, regulatory authorities or other stakeholders.

- VS provided training at the ASF preparedness training exercise at the National Training Academy, Starkeville, Mississippi. This training, provided to USDA Wildlife Services (WS) personnel in feral swine dense States included the proper use of personal protective equipment, specimen collection, appropriate sample packaging and shipping, and decontamination protocols, along with an overview of ASF and key information needed by WS wildlife professionals.

- VS personnel attended the Biosafety Level 4 (BSL4) Zoonotic Disease Network (BSL4Znet) Large Animal Handling Workshop in Geelong, Australia. The USDA is a key member of the BSL4Znet, which is an imperative component for development of APHIS capabilities at the NBAF. This workshop is designed as a peer-to-peer training for handling live animals in high-containment (BSL4 Ag).

- VS personnel participated in the World Health Organization's Composition of Influenza Virus Vaccines 2019-2020 Northern Hemisphere Influenza Consultation and Information Meeting in Beijing, China. Animal virus data from national veterinary laboratories is used to update pre-pandemic candidate vaccine viruses for human vaccines against zoonotic viruses of concern, and contributes to the WHO biannual report of "Antigenic and genetic characteristics of zoonotic influenza viruses and development of candidate vaccine viruses for pandemic preparedness."

- VS personnel participated in the Defense Threat Reduction Agency (DTRA) Biological Threat Reduction Program (BTRP) Science Program Review (SPR) in Warsaw, Poland. VS was invited

by the Department of Defense (DoD) DTRA BTRP to send an expert reviewer for their SPR. BTRP recognizes the danger to U.S. and global health security posed by the risk of outbreaks of dangerous infectious diseases. BTRP strives to address this risk by promoting best practices in biological safety and security, improving partner countries' capacities to safety and rapidly detect and report dangerous infections, and establishing and enhancing international research partnerships.

- 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 United States. This technology will advance traceability, reduce time for the inspection process, provide improved worker safety, and reduce stress on animals.

- VS attended the OIE Workshop on the Database on Antimicrobial Agents Intended for Use in Animals in the Americas in Montego Bay, Jamaica, on September 26-27, 2019. The workshop included a history of OIE antimicrobial use data collection efforts and the importance of national-level monitoring, country presentations from Costa Rica, Brazil, and the Dominican Republic, and results from the 3rd OIE Annual Report on Antimicrobial Agents Intended for Use in Animals. All of the country representatives participated in an interactive workshop on mapping the national antimicrobial supply chains, obtaining kilograms of active ingredients, and obtaining animal biomass. The OIE shared their vision for the future of data collection, as well as information on the tripartite monitoring and evaluation framework for the Global Action Plan on Antimicrobial Resistance. This workshop provided opportunities to discuss antimicrobial use

monitoring programs with countries in the Americas, the level of industry involvement in their countries, and to develop new contacts at the OIE working on antimicrobial use monitoring.

- VS published a manuscript regarding *Mycoplasma bovis* infection in domestic sheep in the United States. This work was done in collaboration with researchers currently and formerly at the USDA Agricultural Research Service and Washington State University. The manuscript was published on November 1, 2019, and used survey and biological testing data from the National Animal Health Monitoring System (NAHMS) Sheep 2001 and Sheep 2011 Studies to describe the prevalence, distribution, associated risk factors, and associated outcomes of *Mycoplasma bovis* infection in domestic sheep in the United States. The article can be found at https://doi.org/10.1016/j.prevetmed.2019.104750.

- VS participated in the International Technical and Regulatory Capacity Building (ITRCB) African Swine Fever (ASF) for First Responders Training/Evaluation. A CEAH staff member was selected as a subject matter expert to participate in an evaluation of the disease response training needs and to develop an ASF training program in Vietnamin September 2019. The course imparted knowledge regarding the importance of regionalization (using Avian Influenza as an example), the economic impact of animal disease outbreaks, control of outbreaks through a coordinated system of planning, and multi-jurisdictional cooperation. The goal of this capacity building activity was to develop a transboundary animal disease training program focused on ASF to address training needs in Vietnam.

3.0 Agricultural Research Service (ARS)

3.1. Mission Statement

ARS delivers scientific solutions to national and global agricultural challenges.

3.2. Nature and Structure of Research Program

ARS is the largest intramural scientific research agency of the U.S. Department of Agriculture (USDA). 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) 2019, 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 16 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 16 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	Grass, Forage, and Rangeland Agroecosystems	Plant Diseases	Quality and Utilization of Agricultural Products
Aquaculture	Biorefining	Crop Protection and Quarantine	
	Sustainable Agricultural Systems Research		

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; 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 and 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 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 2019, there were 193 active CRADAs, 56 of which were newly executed. The 56 new CRADAs contributed $3,280,189 directly to ARS research projects, and approximately 68 percent of them are with small businesses. There were 292 active Material Transfer Research Agreements (MTRAs), 100 of which were newly executed. The 100 new MTRAs contributed $637,636 directly to ARS research projects (see Table 1 in Section 3.5 and Figures 1 and 2 in Section 3.9).

- In FY 2019, 228 new invention disclosures were received; 85 patent applications were filed; and 65 utility patents, 8 plant patents, and 3 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 5 years, this indicator suggests that approximately 66 percent of the patent applications result in an issued patent (see Table 2 in Section 3.5 and Figures 3, 4, and 5 in Section 3.9).

- In FY 2019, 51 new licenses were executed (49 percent with small businesses and 20 percent with universities). The total number of active licenses has steadily increased over the last 5 years from 404 to 497. Sixty-three percent of the income-bearing licenses were granted exclusively. The total income from all active licenses was more than $3.55 million. Most of the income in FY 2019 came from a few licenses; the median earned royalty income was $3,154. Although the year that a license is signed is not typically the year the patent is 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 40 percent of the issued patents have been licensed (see Tables 3, 4, and 5 in Section 3.5 and Figures 6, 7, 8, and 9 in Section 3.9).

- OTT reviewed and executed licenses for the Animal and Plant Health Inspection Service (APHIS) and U.S. Forest Service.

- OTT employees served as moderators/speakers/trainers in broad technology transfer activities and forums, including the Federal Laboratory Consortium national and regional meetings; National Summit on Rural Entrepreneurship; and National Association for Community College Entrepreneurship annual meeting.

- OTT held in-person technology transfer training with 283 scientists at 15 locations in 10 States.

- OTT received 106 Innovation Fund applications of which 36 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 move ARS research outcomes closer to adoption 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 FY 2019, 141 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 2019, membership grew from 250 to nearly 500. In FY 2019, there were 35 LinkedIn posts by OTT. Posts include highlighting a research topic area with 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. Most posts received more than 200 views.

- 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 to more than 150 individuals and through LinkedIn. On LinkedIn, ARP Notes receive 300 to 400 views. ARS tweets an announcement of each new issue of ARP Notes.

- OTT developed new outreach materials that include:
    - ✓ Snapshot and narrative: a single-page handout with an easy-to-read synopsis of ARS technology transfer activities for the fiscal year.
    - ✓ OTT brochure: a trifold publication that describes the OTT office and its functions.
    - ✓ Trade booth: table-top and side-panel displays for use at outreach events.
    - ✓ OTT icons: icons for each section in OTT, as well as an icon for the office.
    - ✓ Bookmarks: bookmarks describing 8 technologies within the top 20 revenue generating licenses.
    - ✓ Flipbook and brochure: a small flip book and brochure describing 17 technologies within the top 20 revenue-generating licenses.

- OTT participated in two U.S. Small Business Administration (SBA), Small Business Innovation Research (SBIR) Road Shows. The road shows visited and held workshops in five cities in the U.S. Central Plains and five cities in the U.S. Northeast. During the workshops, OTT highlighted the USDA SBIR-Technology Transfer Program that 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."
- 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. OTT took 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 an improved LabTech in Your Life, 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 developed 17 technologies throughout the house. LabTech in Your Life is hosted on the Federal Laboratory Consortium website at https://www.federallabs.org/successes/labtech-in-your-life.

- OTT created and along with the ARS Office of International Research Programs led a 4-day technology transfer workshop held in Egypt to train Egyptian academic and technology transfer professionals. The workshop included U.S. speakers from USDA, the National Institutes of Health, the Department of Energy, University of Maryland, industry (MedImmune), and research institutes (Salk).

- OTT published a peer-reviewed paper, “To Protect or Not to Protect: Guide for Deciding on Public Release or IP Protection of New Plant Cultivars and Germplasm,in Volume 54 (4) of *HortScience*.

3.5. Metric Tables

TABLE 1. Collaborative relationships for research and development					
	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Total number of active CRADAs	223	219	249	189	193
Active CRADAs with small businesses	98	70	62	73	120
Total number of newly executed CRADAs	41	39	57	51	56
Newly executed CRADAs with small businesses	31	12	17	31	38
Total funds to be received	$2,250,129	$2,113,880	$2,804,160	$3,121,739	$3,280,189
Total number of active MTRAs[2]	199	288	432	354	292
Newly executed MTRAs	62	89	101	118	100
Total funds to be received	$358,654	$373,953	$743,603	$2,267,886[4]	$637,636
Total number of active other agreements[3]	2,899	3,230	4,108	3,215	1,888
Newly executed other agreements	687	756	876	621	951
Number of newly executed MTAs	743	823	664	645	614
Newly executed outgoing MTAs	513	539	445	476	398
Total number of publications[4]					
Peer-reviewed scientific journal	4,564	4,473	4,467	4,138	3,816
Trade journal	57	65	66	68	48
Meeting abstracts	1,347	1,178	1,022	855	612

[1] Material Transfer CRADAs.
[2] Material Transfer Research Agreements. Involves collaborative research on a specific material.
[3] Includes Trust Fund Cooperative Agreements, Reimbursable Agreements, Interagency Agreements, and Non-Funded Cooperative Agreements.
[4] Number of published manuscripts.

TABLE 2. Invention disclosures and patenting					
	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Total new invention disclosures[1]	175	174	169	306	228
University co-owned	40	58	27	29	39
Non-university co-owned	27	29	21	16	18
USDA solely owned	108	87	121	261	171
Scientific discipline:					
Biological materials	32	19	8	141	86
Life science	64	73	72	55	47
Chemical	48	48	43	32	42
Mechanical & measurement	18	21	28	20	13
Plant patents[2]	3	5	5	6	2
Plant variety protection[2]	10	8	13	11	4
Plant breeder's rights[2]	0	0	0	0	1
Plant public release	39	28	44	41	33
Based upon CRADA research	23	25	22	23	14
Total patent applications filed[3]	110	92	109	108	85
University co-owned	25	10	21	31	17
Non-university co-owned	26	9	23	25	17
USDA solely owned	59	73	65	52	51
U.S.	ND	ND	ND	ND	ND
Foreign	ND	ND	ND	ND	ND
Scientific discipline:					
Life science	47	50	45	53	29
Chemical	38	24	38	30	34
Mechanical & measurement	15	10	7	14	12
Plant patents	4	6	11	3	4
Plant variety protection	6	2	8	8	6
Total patents issued[3]	84	53	68	61	65
University co-owned	12	15	22	19	16
Non-university co-owned	20	12	19	11	21
USDA solely owned	52	26	27	31	28
U.S.	ND	ND	ND	ND	ND
Foreign	ND	ND	ND	ND	ND
Scientific discipline:					
Life science	33	23	37	29	33
Chemical	20	13	13	15	17
Mechanical & measurement	10	9	6	12	4
Plant patents	15	5	6	2	8
Plant variety protection	6	3	6	3	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] In the United State, 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. International plants are protected through plant breeder's rights.
[3] 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.

TABLE 3. Profile of active licenses

	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Total active licenses[1]	404	419	426	460	497
Executed to small businesses[2]	147	150	155	161	180
Executed to start-up businesses[3]	12	6	6	6	6
Executed to universities	175	187	186	199	201
Amended in FY	5	4	4	8	4
Invention licenses[4]	339	348	351	374	377
Executed to small businesses	112	112	114	113	114
Executed to start-up businesses	12	6	6	6	6
Executed to universities	166	178	176	189	188
Other IP Licenses[5]	65	71	75	86	120
Executed to small business	35	38	41	48	66
Executed to start-up businesses	0	0	0	0	0
Executed to universities	9	9	10	10	13
Total newly executed licenses	35	29	38	40	51
Executed to small businesses	16	9	19	12	25
Executed to start-up businesses	0	0	0	0	0
Executed to universities	9	14	9	12	10
Invention licenses	20	23	29	27	17
Executed to small businesses	5	6	13	3	7
Executed to start-up businesses	0	0	0	0	0
Executed to universities	8	14	8	12	7
Other IP Licenses	15	6	9	13	34
Executed to small businesses	11	3	6	9	18
Executed to start-up businesses	0	0	0	0	0
Executed to universities	1	0	1	0	3

ND, data not available.
[1] The rest of the licenses were to medium or large size businesses.
[2] A small business, together with its affiliates, must not have more than 500 employees.
[3] 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.
[4] Invention licenses refer to patents and Plant Variety Protection certifications.
[5] Other IP licenses refer to biological materials licenses.

TABLE 4. Characteristics of income-bearing licenses					
	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Total income-bearing licenses	402	418	425	459	496
Exclusive	274	289	293	312	312
Partially exclusive	11	9	6	7	7
Non-exclusive	117	120	126	140	177
Invention licenses[1]	337	347	350	373	376
Exclusive	266	280	283	302	299
Partially exclusive	11	9	6	7	7
Non-exclusive	60	58	61	64	70
Other IP licenses[2]	65	71	75	86	120
Exclusive	8	9	10	10	13
Partially exclusive	0	0	0	0	0
Non-exclusive	57	62	65	76	107
Total royalty-bearing licenses	139	145	129	134	125
Invention licenses	121	123	107	112	105
Other IP licenses	18	22	22	22	20

[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 2015	FY 2016	FY 2017	FY 2018	FY 2019
Total income all active licenses	$5,066,988	$4,784,466	$5,713,803	$3,799,170[5]	$3,553,446
Invention licenses[2]	$4,842,256	$4,456,054	$5,377,909	$3,490,236	$3,272,205
Other IP licenses[3]	$224,732	$328,412	$325,566	$308,934	$281,241
Total Earned royalty income (ERI)	$3,509,904	$3,633,239	$3,503,866	$2,715,861	$3,171,355
Median ERI	$3,525	$3,966	$3,698	$3,056	$3,154
Minimum ERI	$13	$5	$15	$21	$ 0.75
Maximum ERI	$728,017	$818,537	$769,167	$265,844	$573,545
ERI from top 1% of licenses[4]	NP	NP	NP	NP	NP
ERI from top 5% of licenses	$1,756,460	$1,811,637	$1,639,557	$1,218,975	$1,579,185
ERI from top 20% of licenses	$2,856,924	$3,043,395	$2,933,342	$2,227,058	$2,655,368
ERI distributed					
Inventors	$1,632,130	$1,188,389	$2,443,702	$1,322,224	$1,244,190
Funds used for salaries[5]	$2,819,906	$2,051,317	$1,449,005	$1,461,164	$1,145,432
Innovation Fund	ND	ND	$483,814	$618,000	$833,500
Foreign patent filing preparation & foreign maintenance payments paid	$621,701	$393,533	$576,120	$423,948	$567,423

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 the previous fiscal year's revenue.

TABLE 6. Licensing management: elapsed execution time and termination					
Agricultural Research Service	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
All licenses					
Average (months)	2.8	4.9	6.1	6.3	5.9
Median (months)	2.5	3.7	5.1	5.5	5.0
Minimum (months)	0.5	0.9	1.3	0.9	1.8
Maximum (months)	10.0	16.0	13.7	24.1	34.9
Licenses terminated for cause	0	0	0	0	0

3.6. Downstream Outcomes

Source: USDA Agricultural Research Service

NUTRITION, FOOD SAFETY, AND QUALITY

National Programs:

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

A healthy microbiome in infants predicts better vaccine response.

Vaccination is the best approach to prevent infectious diseases, but response to vaccines can be highly variable for unknown reasons, especially when given in early infancy. ARS scientists in Davis, California, conducted a study of 306 infants aged birth to 3 years to determine whether an infant that had a microbiome colonized with greater numbers of a beneficial bacteria (*Bifidobacterium infantis)* had better responses to four vaccines (tuberculosis, polio, hepatitis B, and tetanus) also given in early infancy. The abundance of *Bifidobacterium* was positively associated with better responses to the tuberculosis, tetanus, and hepatitis B vaccines when the responses were measured in early infancy and was also associated with better responses to the tuberculosis, tetanus, and polio vaccines measured at 2 to 3 years of age. This study is the first to demonstrate that *Bifidobacteria*, which are abundant in the infant gut as a result of breastfeeding, may lead to long-term enhancement of the immune system. This

observation demonstrates that early life nutrition can improve health by enhancing vaccine memory responses. (NP 107, Project No. 2032-51530-026-00D)

Newly created atlas of epigenetic variation in humans.

More than 15 years after scientists first mapped the human genome, most diseases still cannot be predicted based on genes, leading researchers to explore epigenetics as causes of disease. The most stable form of epigenetic regulation is DNA methylation, which changes gene conformation and gene expression, but progress on this topic has been limited by lack of information on cell type specificity. ARS-supported scientists in Houston, Texas, performed deep sequencing of genomic DNA in tissues representing the three germ layers during development followed by producing a computer algorithm to identify individual regions that vary in DNA methylation. The nearly 10,000 regions the researchers mapped out, called correlated regions of systemic interindividual variation (CoRSIVs), comprise a previously unrecognized level of molecular individuality in humans. Because epigenetic marking of genes has the power to either stably silence or activate them, any disease that has a genetic basis may also have an epigenetic component. This map forms the basis of understanding about disease processes from an epigenetic perspective. (NP 107, Project No. 3092-51000-059-00D)

Improving USDA food composition databases.

USDA food composition databases are used by a diverse community to make policy decisions, investigate the impact of diet on health, develop new foods, advise patients on improving their diets, and address the general need for more information on what is in the food we eat. The USDA has been compiling data on food composition for more than 100 years, but in recent years the amount, type, and format of the data have become outdated. To rectify this problem, ARS scientists in Beltsville, Maryland, created and publicly released FoodData Central. It provides access to all USDA food

composition information—such as expanded nutrient information, links to Special Interest Databases, and links to related agricultural and experimental research data—in a single location. The USDA databases includes legacy databases, a database used for the What We Eat in America survey, data on branded food products, and Foundation Foods (the primary source of analytical food composition data from this point forward). This new database will allow the USDA to continue to be the world's foremost authority for nutritional data well into this century. (NP 107, Project No. 8040-52000-064-00D)

Intermittent feeding promotes growth more than continuous feeding in a neonatal pig model.

Every year, more than 50,000 infants born prematurely in the United States cannot eat normally and may be fed by a tube inserted into the stomach. Preemies may be fed continuously or intermittently as if one were consuming meals. So far, it is unknown whether there is a benefit of one pattern of feeding. A comparison cannot be performed in infants for ethical reasons, so to study this question under controlled conditions, ARS-supported scientists in Houston, Texas, studied neonatal pigs with implanted stomach tubes for 21 days. Even though both groups were fed the same amount of nutrients, body weight, lean mass, spine length, and muscle mass were all greater in the piglets fed intermittently. Additional results from this study suggest the pulsatile changes in amino acids and insulin contributed to the benefits. Widespread adoption of pulsatile feeding of premature infants has the potential to improve growth, reduce the length of hospital stays, and lower health care costs. (NP 107, Project No. 3092-51000-065-00D.

***Escherichia coli* O157:H7 transmission by cattle pest flies found in leafy greens.**

Leafy greens are a leading source of *E. coli* O157:H7 bacteria that cause human foodborne illness. Pest flies can carry this pathogen and may transmit it to leafy greens and other fresh produce. ARS scientists in Clay Center, Nebraska, determined the occurrence of .7:H7-positive flies in leafy greens planted up to

600 feet from a cattle feedlot, and assessed their potential risk for transmitting this pathogen to leafy greens. *E. coli* O157:H7 carriage rates of house, face, flesh, and blow flies were similar to each other and were greater than the carriage rate of stable flies. *E. coli* O157:H7 carriage rates were not different in flies found at different distances from the feedlot, ranging from 0 to 600 feet. Genetic subtyping showed that the majority of the *E. coli* O157:H7 found in the flies were of the same predominant subtypes found in the feedlot pen surface manure and the leafy greens, indicating the potential role for flies to transmit *E. coli* O157:H7 to the leafy greens. Due in part to this work and previous research, the produce industry has revised its guidelines for growers to increase the set-back distance between leafy greens fields and concentrated animal feeding operations. This information is critical for understanding the food safety risks associated with growing leafy greens in close proximity to cattle production, for determining safe distances between cattle feedlots and fresh produce that will reduce preharvest contamination and protect public health, and as potential guidance under the Produce Safety Rule as part of the Food and Drug Administration's Food Safety Modernization Act. (NP 108, Project No. 3040-32000-032-00D)

Development of hot-fill pasteurization of cucumber pickle spears as an alternative to tunnel pasteurization.

For commercial production of acidified vegetable products, a tunnel pasteurizer is typically used for thermal processes. To help reduce energy costs and water use, ARS researchers in Raleigh, North Carolina, developed a hot-fill method for pasteurizing cucumber pickle spears in 24-ounce pickle jars. The method required refilling jars multiple times with a hot brine (around 175°F). The data showed that for cucumber spears a hot-fill method could achieve or exceed temperatures typically used for commercial pasteurization of pickle by most manufacturers. These conditions exceed published values needed for the required reduction of bacterial pathogens in acid and acidified vegetable products; they

were also sufficient to meet Food and Drug Administration regulations and typical industry processing conditions needed for good quality texture and sensory properties. Although further development of processing equipment may be needed for inverting and refilling jars, the in-jar pasteurization process has potential application for cucumber spears and related products and may be used to save on the water usage and costs of currently used tunnel pasteurizers. (NP 108, Project No. 6070-41420-008-00D)

Location, season, and manure type affect pathogen survival in manure-amended soils.

The Produce Safety Rule, part of the Food and Drug Administration's Food Safety Modernization Act, states that untreated manure must be applied 90 or 120 days prior to the harvest of edible produce crops to minimize contamination from pathogens that may be present in untreated manure. However, this interval was not scientifically validated. Over 12 separate field trials conducted in mid-Atlantic States over 4 years, ARS researchers in Beltsville, Maryland, and university collaborator showed that spatiotemporal factors (site, year, and season) affect survival durations of *Escherichia coli* in manure-amended soils more than agricultural factors (manure type, organic or conventional management of soils, and depth of application) or weather effects. The results provide critical information to growers on the potential risk of produce contamination with specific raw animal manure application. The Food and Drug Administration will use these data to develop food safety standards for controlling bacterial contamination of fresh produce from soil. (NP 108, Project No. 8042-32420-006-00D)

Development of novel antibodies and detection assay to screen food samples for colistin-resistant bacteria.

The recent discovery and rapid spread of the mobile colistin-resistant gene MCR-1 in bacteria is undermining our ability to treat bacterial infections and threatening human health and safety. ARS researchers in Albany, California, developed novel polyclonal and monoclonal antibodies against MCR-

1 and MCR-2. An enzyme-linked immunosorbent assay using these antibodies was able to detect 0.01 ng/mL of MCR-1 in buffer and 0.4 colony-forming units per gram of meat, including ground chicken, pork, and beef, demonstrating strong tolerance to complex food matrices. This immunoassay could be used for rapid and reliable screening of food samples contaminated with colistin-resistant bacteria, making this an important tool for reducing the risk of foodborne infections with antibiotic-resistant bacteria. (NP 108, Project No. 2030-42000-049-00D)

Neutralization of residual antimicrobial processing chemicals in broiler carcass rinse.

The USDA's Food Safety and Inspection Service (FSIS) has established pathogen reduction performance standards for Campylobacter, a poultry associated-bacterial pathogen of significant concern both nationally and internationally, on broiler carcasses. Processors may apply antimicrobial processing aids as a spray or immersion to lower contamination on carcasses. In the United States, broiler carcasses are generally sampled by whole carcass rinse, and the potential exists for residual levels of antimicrobial processing aids to be carried over into the rinsate. It has been previously shown that, if unmitigated, such carryover can interfere with the detection of Salmonella. ARS researchers in Athens, Georgia, further demonstrated that unmitigated carryover of antimicrobial treatment can also interfere with the detection and recovery of Campylobacter in broiler carcass rinse samples. Traditional buffered peptone water was tested and found that it did not offer enough neutralizing capability to counteract residual antimicrobial activity of some post-chill processing aids (peroxyacetic acid, cetylpyridinium chloride, acidified sodium chloride, or a blend of acids) to allow full recovery of Campylobacter. A recently reported formulation for a neutralizing buffered peptone water, developed by ARS in Athens, Georgia, and currently being used by FSIS, outperformed the traditional carcass rinse medium and allowed significantly improved recovery of Campylobacter even in the presence of three of the four tested antimicrobial processing aids. Performance of the new carcass rinse medium with the fourth

antimicrobial processing aid (acidified sodium chloride) was not different from the traditional formulation. Neutralizing buffered peptone water represents a significant improvement in the broiler carcass rinse method for detecting Campylobacter. (NP 108, Project No. 6040-32000-009-00D)

New freezing technology retains fresh-like fruit quality when thawed.

Freezing is a well-established technology used to prolong seasonal fruit and vegetable shelf-life. However, current freezing technologies (both slow and fast) rupture cells, resulting in juice loss when thawed, which leads to suboptimal flavor, juice content, and texture qualities. Together with colleagues at the University of California–Berkeley, ARS scientists in Albany, California, investigated a technology first developed to preserve human organs for transplanting called isochoric (constant-volume) freezing to extend the shelf life of food products and maintain their physical and nutritional properties. The researchers evaluated isochoric freezing to preserve the quality of sweet cherries and found the technology resulted in thawed fruit that were indistinguishable from fresh cherries in terms of juice loss, texture, structure, ascorbic acid content, and antioxidant activity. The isochoric method also uses 70 percent less energy compared with conventional freezing methods. These findings promise to transform the $54 billion U.S. frozen foods market by enabling frozen products that are thawed to have extended shelf-life and fresh-like taste, texture, juiciness, and nutrition. (NP 306, Project No. 2030-41000-064-00D)

A fresh fruit and vegetable cleaning system that prevents bacterial survival.

In current commercial fresh fruit and vegetable processing plants, the accumulation of organic materials in washing tanks allows for unhealthy bacterial survival as chlorine in the water is depleted. ARS scientists in Beltsville, Maryland, invented a novel “in-flight” non-soaking cleaning system that removes organic material early in the process without damaging the fresh produce. This new process cleans all

produce surface areas and effectively removes organic matter from cut surfaces while improving processing control and efficacy, thereby allowing produce to be stored longer without bacterial decay and reducing food waste. This system uses a combination of sanitizers and a consistent concentration of chlorine that removes bacterial contamination while eliminating toxic chlorine byproduct formation found in dechlorinating washing-tank systems. This in-flight system, which has a relatively small footprint, also allows for exceptionally efficient use of space in processing plants. Working with Church Brothers Fruit Company, ARS is scaling up this technology for commercialization. (NP 306, Project No. 8042-43440-005-00D)

Fast, accurate method to detect off-flavors in farm-raised catfish.

Off-flavor in farm-raised catfish is a major quality issue, particularly in late summer and early fall. Although professional flavor checkers check samples from production ponds before harvest, off-flavored fish are found in the market place. Commercial instruments that measure off-flavor compounds are available, but their use is expensive, time-consuming, and requires highly skilled technicians. ARS scientists in New Orleans, Louisiana, developed an analytical “pass/fail” method that reduces sampling time from 10 minutes to 1 minute, does not require skilled training, and has the sensitivity of human flavor checkers. Although this new analytical method is not intended to replace the human checkers, it will allow rapid checking of large numbers of samples. Harvest Select, Simmon’s Catfish, and other processing plants in the Mississippi Delta region are testing this method for its accuracy and to determine the proportion of off-flavor fish reaching the market from each plant after its use. This information will be supplied back to the plants with the direct benefit of reducing the proportion of off-flavored fish reaching the consumer. (NP 306, Project No. 6054-44000-078-00D)

Development of a new, automated apple in-field sorting machine.

Automated in-field sorting enables low-quality or inferior fruit to be separated from fresh-market, higherquality fruit at harvest, which allows for better efficiency and control during postharvest apple storage and packing and reduces overall food loss. ARS scientists at East Lansing, Michigan, designed and constructed a new, automated in-field apple sorting system. This simple system is compact, reliable, and capable of sorting 11 or more apples per second. Laboratory tests achieved 100 percent sorting accuracy with superior grading repeatability along with no bruising damage to fruit. This infield sorting system is being tested at Schwallier's Country Basket, a commercial orchard, and has been incorporated into the ARS-developed and commercialized self-propelled apple harvester. U.S. apple growers adopting this new in-field sorting technology can achieve significant cost savings in postharvest handling of harvested fruit, improve postharvest management, and reduce postharvest fruit loss. (NP 306, Project No. 5050-43640-002-00D)

A new, food-grade corn starch mixture stabilizes appealing foods.

There is a need for improved food-grade emulsifiers that do not have limits on their use. ARS scientists in Peoria, Illinois, developed an economical food-grade emulsifier that consists of high amylose corn starch and fatty acid salts from vegetable oil. When these two materials are processed using an industry standard technique, it forms an amylose inclusion mixture. This emulsifier has great value in salad dressing, ice cream, sodas, baked goods, and other products. This new low-cost and U.S.-made food-grade starch mixture can replace expensive imported emulsifiers or petroleum-based emulsifiers that have limits on their usage. This amylose-based emulsifier will result in new applications for corn starch benefiting U.S. corn producers, processors, and consumers. (NP 306, Project No. 5010-41000-166-00D)

Almond hulls: A waste product with high-value uses.

Almond hulls can be a viable source of industrial sugars because they contain more free extractable sugar than sugarbeets; however, once the sugars are extracted, uses must be found for the remaining biomass of spent hulls. ARS scientist in Albany, California, developed a novel application for spent hulls by using them instead of nonsustainable peat moss to commercially produce mushrooms. Propagating vegetative mycelium from mushrooms generally requires a specific peat moss mix (called casing) with uniform pore distribution for gas exchange, balanced minerals, and high water-holding capacity. Spent almond hulls possess these key traits; they have a water-holding capacity of greater than 500 percent, numerous pores in the size range optimal for gas exchange, and high mineral content ideal for mushroom growth. ARS researchers and collaborators at the California Almond Board are now exploring the use of spent almond hulls as casing in commercial mushroom production at an industrial scale. (NP 306, Project No. 2030-41000-054-00D)

Source: USDA Agricultural Research Service

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**

Application of an interspecies cross to improve the efficiency of genome sequencing and assembly.

A new method for assembling genetic sequencing data into more complete genomes has been pioneered by ARS researchers in Clay Center, Nebraska, and Beltsville, Maryland, and collaborators at the National Institutes of Health, University of Nebraska, and University of Kentucky. Using the new process, an individual animal resulting from the mating of a Highland breed bull and a yak cow was used to create reference-quality assemblies of the Highland breed of cattle and the yak in a single experiment. By applying the new technique to an interspecies hybrid that maximized the differences between maternal and paternal chromosome sequences, the researchers created individual sequences for both the yak and cattle. The sequences were of equal or better quality than any existing mammalian genome assembly, including those for humans or biomedical species such as mice or rats. If generally applied, the technique to generate two genome sequences from a single individual is likely to improve

the accuracy of genomic selection of all livestock and many plant species and could impact a wide range of industries. (NP 101, Project No. 3040-31000-100-00D)

Development of a model to predict illness using swine feeding behavior.

Livestock feeding behavior is dependent on many factors, and feeding is a good proxy for assessing an animal's health because as an animal gets sick, feed consumption often drops off even before diagnostic symptoms such as fever or difficulty breathing appear. ARS scientists in Clay Center, Nebraska, and South Dakota State University collaborators used an electronic system to monitor the feeding behavior of pigs during the grow-finishing phase and applied machine learning tools to predict swine feeding behavior based on temperature and time of day. Large deviations between predicted and observed feeding behavior before a pneumonia outbreak demonstrated the potential for the model to be used in the automated early detection of a disease outbreak and other stressful events. This work will be used to develop a computer-based modeling system for swine feeding behavior. Future work is expected to lead to the development of software that will allow swine producers to use real-time feeding behavior data as an early predictor of illness and stress events in individual animals, thereby improving both animal well-being and productivity. This is an excellent example of the potential benefits of continuous monitoring of livestock for beneficial outcomes in animal health and production. (NP 101, Project No. 3040-31000-097-00D)

Characterization of the porcine mycobiome (fungus).

The microbial organisms found in the gastrointestinal tract of animals is recognized as a critical component of host health. Weaning is a period of stress, dietary changes, and a predisposition to infections, making it a time point of interest to industry. ARS scientists in Beltsville, Maryland, performed the first in-depth analysis of the fungal microorganisms present in the gastrointestinal tract of

piglets between birth and transition to postweaning life, and demonstrated that a dynamic shift occurs in fungal populations at the time of weaning, particularly a dominance of the fungus *Kazachstania slooffiae* in weaned piglets. This dramatic shift in the fungal microorganisms in piglets has not been previously reported and suggests that milk may suppress fungi in the gut. Furthermore, the consequences of the dramatic onset of fungal microorganisms in the gut after weaning is not known, but the trajectory of fungal development could influence future immune competence. Further research could support the development of interventions and dietary modifications to enhance piglet performance and increase swine herd productivity. (NP 101, Project No. 8042-31440-001-00D)

Systems biology tool for the analysis of agriculturally important bacteria.

Systems biology is the computational modeling of genes, their interactions, and the influence of the environment on the system. Until now, microbiologists and other researchers working on bacteria-related problems in animal disease, food safety, bioengineering, and other agricultural domains were not able to efficiently create realistic systems biology models. Through an ARS Scientific/High Performance Computing collaborative research initiative (SCINet) including ARS researchers in Clay Center, Nebraska, and collaborators with industry and at Iowa State University, the Pathway Tools systems biology analytical platform was customized to run on Amazon Web Services to host systems biology models of bacterial field isolates sequenced and assembled by USDA. The primary beneficiaries of this resource are researchers and others wishing to use, create, and publish systems biology models that relate bacterial genes to key bacterial functions or physical traits. These models will assist in generating evidence-based strategies to combat the effects of bacterial infection, improve food safety protocols, and promote solutions to bacteria-related problems in agriculture. (NP 103, Project No. 3040-32000-034-00D)

Understanding and detecting *Brucella abortus* vaccine RB51 shed in milk.

Brucella abortus is a highly contagious bacterial pathogen for livestock and humans and is classified as a select agent because of its potential use as a bioweapon. In the United States, a vaccine strain called RB51 is routinely used to vaccinate female calves to prevent infection and limit human exposures. Over the past 2 years, people in at least three States have been infected with the B. abortus RB51 vaccine strain after drinking unpasteurized milk. ARS scientists in Ames, Iowa, collaborated with colleagues at the Centers for Disease Control and Prevention and the USDA Animal and Plant Health Inspection Service to better understand why some cattle vaccinated as calves shed RB51 in their milk as adults. Their results showed cattle that shed RB51 in milk have a different type of immune response than animals that do not shed RB51 in their milk. ARS further developed an assay that can detect cattle-shed RB51 in milk. Due to the widespread use of RB51 vaccination in cattle, this research is critical to the work of protecting public health and understanding why some cattle become persistently infected with the vaccine strain. (NP 103, Project No. 5030-32000-224-00D)

Study reveals pigs can transmit foot-and-mouth disease (FMD) before showing signs of sickness.

The FMD virus spreads much more aggressively in pigs than previous research suggested, according to ARS scientists at the Plum Island Animal Disease Center. A new study shows that pigs infected with FMD can infect other pigs just 24 hours after becoming infected, long before showing any clinical signs of FMD. Before this research occurred, experts believed FMD transmission in pigs did not occur before visible signs of illness developed, so previous disease-dynamics models to predict disease impacts and estimate outbreak resource requirements did not account for the impact of preclinical transmission. When ARS scientists and Animal and Plant Health Inspection Service collaborators used this new information in models that project disease transmission rates, estimates for the number of U.S. farms that would be affected by FMD outbreaks increased 40 percent. This increase translates into 166

additional farms and more than 664,000 additional pigs requiring euthanasia. Failure to account for new information such as this could make the difference between preparing for a limited, well-controlled FMD outbreak in the United States costing $3 million over 2 months and a catastrophic nationwide epidemic costing $20 billion over 1 year. Infectious disease modeling is a critical part of preparedness and protection of U.S. livestock. Research such as this provides critical information to help build better models to protect livestock industries from FMD. (NP 103, Project No. 8064-32000-061-00D)

A new U.S. swine pathogen database (https://swinepathogendb.org).

In recent years, several deadly viral diseases of pigs have emerged in the United States causing hundreds of millions of dollars in economic damage. To effectively respond to these diseases or detect new disease incursions or viral variants, it is critical to have a database of currently circulating viral genetic sequences and associated tools to analyze the sequences. ARS scientists in Ames, Iowa, created such a database for porcine reproductive and respiratory syndrome virus, *Senecavirus* A, and porcine epidemic diarrhea virus using nucleotide sequences and related metadata found in GenBank, part of the National Center for Biotechnology Information, and from clinical cases detected by key veterinary laboratories. Presently, the South Dakota Animal Disease Research and Diagnostic Laboratory, Iowa State Veterinary Diagnostic Laboratory, and Kansas State University Veterinary Diagnostic Laboratory have submitted more than 2,000 sequences. A suite of web-based tools allows stakeholders, researchers, and veterinarians to quickly search for genetic sequence information, identify similar viruses, and browse virus genomes to inform their research and control efforts. Databases such as these will greatly increase researchers' understanding of endemic circulating viruses and speed response efforts by helping them to quickly identify new viral variants. (NP 103, Project No. 5030-32000-118-00D)

Easily deployed spatial repellent provides protection from disease vectors.

Standard pesticide sprays can reduce mosquito and biting fly attacks. However, they also contribute to insecticide resistance, which undermines their long-term utility. ARS scientists in Gainesville, Florida, and collaborators determined that the spatial repellent transfluthrin applied to strips of camouflage netting and geotextiles used ubiquitously by the U.S. military can be easily transported and attached to perimeters and structures to create a rapid shelter from biting and disease-vectoring insects. Significant reductions of incursions by mosquitoes, sand flies, and other biting flies were documented in protected perimeters across four ecologically distinct and militarily relevant environments. Thus, deployment of vector protection occurred without having to wait for intervention by mosquito and vector control units. In addition, the spatial repellent protected the perimeters without causing death of the targeted pests. By not killing the insects, the development of insect resistance is impeded by allowing insecticide-susceptible insects to dilute populations of insecticide-resistant pests. (NP 104, Project No. 6036-32000-050-00D)

Reduction of an invasive weed in the cattle fever tick quarantine zone.

The giant reed is an invasive weed in the cattle fever tick Permanent Quarantine Zone, where it clogs portions of the Rio Grande River and reduces border visibility. Two biological control agents of the giant reed, the arundo wasp and the arundo scale, were released in 2009 and 2010, respectively. Nine years after the release of the scale, ARS scientists in Kerrville, Texas, documented a 55-percent reduction of above-ground giant reed stands in areas where both the arundo wasp and scale were used as a biocontrol agent compared with areas where the wasp alone was used. Despite its low dispersal rate, the impact of the arundo scale as a biological control agent was augmented when used together with the wasp. Reducing stands of giant reed reduces the ideal habitat for southern cattle fever ticks, which helps maintain the cattle fever tick quarantine. (NP 104, Project No. 3094-32000-039-00D)

Salivary proteins of biting midges associated with virus transmission in livestock.

Until this research occurred, the extreme efficiency with which biting flies (midges) can transmit some viruses was not clearly understood. ARS scientists in Manhattan, Kansas, discovered that when virus-infected midges bite seeking blood, they transmit the virus as well as 45 proteins in their saliva that are critical for successful acquisition of a bloodmeal. A mouse model showed these salivary proteins promoted rapid infection and systemic dissemination of midge-transmitted viruses via the lymph system. Additionally, saliva-induced blood vessel dilation encourages virus replication and dissemination via the circulatory system. This research advances our understanding of the complex myriad of proteins in midge saliva and provides insights into their functional role in blood feeding, virus transmission, and viral disease pathogenesis. This fundamental research guides the development of methods to impede virus transmission in livestock. (NP 104, Project No. 3020-32000-007-00D)

Improved diagnostic kit in commercial development for all quarantined fire ant species.

The red imported fire ant and the black imported fire ant are invasive species that cost the United States more than $6 billion annually in damage and control measures. The Federal imported fire ant quarantine program requires commodities to be free of both species before leaving quarantine. ARS scientists in Gainesville, Florida, with Animal and Plant Health Inspection Service scientists in Biloxi, Mississippi, developed a simple-to-use and portable identification kit (analogous to a home pregnancy test) that can distinguish both fire ant species from all other ants in a single, 10-minute test. The speed of the test curtails extended delays at inspection stations by eliminating the need to send off samples for identification. Being able to distinguish the black imported fire ant is an important improvement over the previous kit (InvictDetect) the scientists developed, which detected only the red species. The improved kit provides a new tool for regulatory agencies in the United States and other countries to enforce quarantine protocols that limit the spread of one or both invasive ant species. The license for this new

technology has been acquired by Agdia Inc. and is currently being developed for commercial distribution. (NP 104, Project No. 6036-32000-048-00D)

ARS trout germplasm selected by a U.S. producer for use in commercial egg sales and production. Most rainbow trout farmers do not manage their own broodstock, but instead purchase eggs for production from outside sources. The second largest commercial egg retailer in the United States obtained trout germplasm noted for growth and utilization of plant protein feed from ARS researchers in Aberdeen, Idaho, and is now selling eggs from these lines. The company is expressly marketing eggs from the ARS line as being hardier and has demonstrated their improved growth rate under different environmental conditions compared with eggs supplied by other vendors in the United States and abroad. In addition, the company is the second-largest commercial producer of rainbow trout and uses ARS germplasm almost exclusively in its production farms. (N P106, Project No. 2050-21310-005-00D)

Comparison of growth and carcass yield of Delta Select and Delta Control strains of channel catfish.

Improved catfish germplasm will allow U.S. catfish farmers to reduce their production costs and remain competitive in the global seafood market. ARS scientists in Stoneville, Mississippi, initiated a selective breeding program to develop the Delta Select strain of channel catfish, which demonstrates a superior growth rate and meat yield, traits that are important to catfish producers and processors. A series of performance trials were conducted to compare the growth and meat yield of the Delta Select strain with those of the Delta Control strain, an unselected strain representative of channel catfish currently being grown by U.S. farmers. The Delta Select strain grew 30 percent faster and had 0.25 to 0.80 percent higher meat yield than the Delta Control strain, demonstrating that selection has improved both traits in the Delta Select strain. Approximately 150,000 2-year-old Delta Select strain channel catfish will be

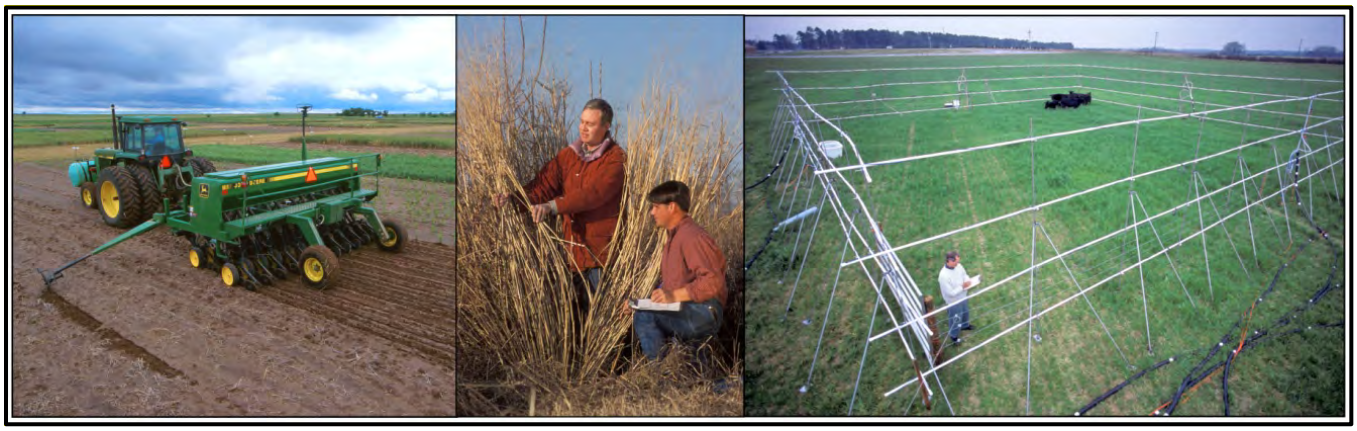
available for release to farmers during fiscal 2020 to allow U.S. catfish farmers to be more efficient and profitable. (NP 106, Project No. 6066-31000-012-00D)

Selective breeding improves resistance to bacterial coldwater disease and columnaris disease. Antibiotics are used to control these diseases of rainbow trout and few alternative control strategies currently exist. ARS researchers in Leetown, West Virginia, evaluated the genetics of resistance to both diseases in two rainbow trout populations. Resistance was found to be heritable and favorably linked, suggesting that a rainbow trout's resistance to both diseases is at least partially due to the same genes. Based on these studies, molecular genetic techniques are now being used to identify the actual genes that affect disease resistance. Commercial breeders who select rainbow trout strains for their improved resistance to only one of the diseases can expect to reduce the impacts of both diseases in their fish populations. (NP 106, Project No. 8082-32000-006-00D)

Waterborne exposure to select clay minerals protects catfish against virulent *Aeromonas hydrophila* infections.

Aeromonas hydrophila is one of the most widespread bacterial pathogens affecting freshwater fish, and a new strain has severely impacted the catfish industry over the last decade. ARS scientists in Auburn, Alabama, evaluated the effect of treatment with kaolin, an inert clay, for controlling *A. hydrophila* outbreaks. Tests revealed that kaolin clay significantly blocked the movement and binding ability of *A. hydrophila* to catfish mucus. Kaolin treatment at a level of 0.1 percent led to a significant improvement in survival (66.7 percent) of experimentally infected catfish compared with survival (28.9 percent) among untreated fish. Kaolin treatment did not alter the growth of *A. hydrophila*, but bacterial levels in test suspensions were significantly reduced within 15 minutes after kaolin treatment, indicating the rapid formation of complexes that settle between kaolin and bacteria. These findings suggest that integrating

kaolin into some production settings may be beneficial, particularly in scenarios where the use of antibiotics is not possible, or when it is likely that an *Aeromonas* outbreak could occur following stressors such as grading, stocking, or transport of fish. (NP 106, Project No. 6010-32000-026-00D)



Source: USDA Agricultural Research Service

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**

Stepped spillway design criteria adopted by Federal agencies and architectural and engineering consulting firms.

Roller-compacted concrete (RCC) stepped spillways provide embankment overtopping protection and increased capacity for aging embankment dams. An ARS researcher in Stillwater, Oklahoma, developed a systematic, step-by-step RCC spillway design guideline to rehabilitate aging embankment dams. The USDA Natural Resources Conservation Service (NRCS) is incorporating the criteria into its National Engineering Handbook and expects it to be implemented on approximately 1,200 aging USDA dams. NRCS experts say the criteria will provide construction cost savings ranging from $600 million to $1.2 billion compared with other embankment overtopping protection systems. The U.S. Army Corps of Engineers is also integrating the criteria into its revised spillway design technical manual (EM 1110-2-1603). In addition, this research has become an industry standard among architectural and engineering

consulting firms across the United States for upgrading aging dams. This technology is assisting dam safety engineers in preserving the $2.3 billion in annual benefits (i.e., flood control, rural and municipal water supplies, irrigation for agricultural production, recreation, and wildlife habitat among others) provided by USDA dams. (NP 211, Project No. 3072-13000-010-00D)

Improving water quality with field-edge nitrate removal.

Saturated riparian buffers are a promising new development in efforts to remove nitrate from farm field drainage; however, only limited data are available on the effectiveness of the practice. By monitoring 6 sites for 2 to 9 years, ARS researchers in Ames, Iowa, and Iowa State University researchers have shown that saturated riparian buffers can remove 40 to 90 percent of nitrate leaving a farmer's field before it enters a stream or river. The scientists also demonstrated that nitrate removal occurs primarily from denitrification (the conversion of nitrate to nitrogen gas) and that this conversion does not increase the generation of nitrous oxide, a powerful greenhouse gas. This research has led the NRCS to develop a new conservation practice standard for implementation on Midwest U.S. farms. (NP 211, Project No. 5030-13000-011-00D)

Alternate cropping systems can conserve groundwater.

Reduced irrigation well capacities due to declining groundwater levels in the Ogallala Aquifer will eventually limit the production of corn in the northern High Plains of Texas, which currently is one of the region's most profitable crops. Alternatively, less water-intensive crops may conserve groundwater while allowing producers to remain profitable. To solve this challenge, scientists from ARS in Bushland, Texas, and the Texas A&M AgriLife Research and Extension Service used the Soil and Water Assessment Tool, a hydrologic model, and equipped it with a newly developed irrigation program to simulate water use associated with soybean, sunflower, and grain sorghum. Results indicated that

irrigation amounts were reduced by 19, 21, and 32 percent, respectively, compared with amounts of water used to grow corn. Substituting grain sorghum for corn at 70 percent of its optimum irrigation amount resulted in greater income per acre, whereas substituting sunflowers for corn at 80 percent of the optimum irrigation amount for corn had little effect on income per acre. These results are of interest to farmers, crop consultants, and regional water policymakers who need to identify crops other than corn that can be grown where groundwater availability is limited. (NP 211, Project No. 3090-13000-015-00D)

New bank stability assessment technology helps protect rivers and streams.

The erosion resistance of streambank soils can vary significantly in space and time. Current bank erosion prediction technology does not account for this variability, which makes it difficult to select appropriate soil erosion-resistance values when assessing bank erosion. ARS researchers in Oxford, Mississippi, used stochastic analysis to develop a new way of estimating expected bank erosion by incorporating parameters such as soil erodibility and shear strength into ARS's widely used Bank Stability and Toe Erosion Model (BSTEM). The new BSTEM version is able to determine the probability that bank retreat magnitudes may be exceeded. This is crucial information when critical infrastructure is located near rivers and streams. As part of the $1.6 billion American River Common Features project, the new technology is currently being used by the Sacramento District of the U.S. Army Corps of Engineers to prioritize bank protection measures to prevent levee failure around the City of Sacramento, California. (NP 211, Project No. 6060-13000-026-00D)

Decision support tool promotes adoption of precision agricultural practices on small and medium-sized farms.

Auto-guided tractors can reduce on-farm inputs by as much as 20 percent and save producers $10.8 to $13.5 million annually through gains in equipment efficiency and enhanced yields. Moreover, auto-guided tractors also help producers reduce the possible overapplication of fertilizers and herbicides, which in turn reduces the negative environmental footprint of crop production and avoids unintentional input costs. ARS scientists in Fayetteville and Booneville, Arkansas, and University of Arkansas research partners developed a decision support tool that promotes the adoption of precision agriculture technologies such as auto-guided tractors and other self-propelled machinery that reduce overapplication of on-farm nutrients and inputs by 10 to 20 percent. Their Tractor Guidance Analysis software incorporates parameters tailored for the size of different farming operations and generates estimates for (1) reductions in seed, organic and inorganic fertilizer, and chemical inputs given differing terrain attributes; (2) efficiency gains and feasibility of technology adoption by determining break-even prices based on farming operation type, farm size, and capital investment requirements; and (3) subsequent soil health and water quality effects from reduced agricultural inputs based on in-field data. This tool was released in 2018, and scientists have provided hands-on training to farmers and agricultural workers via field days and stakeholder meetings. The Tractor Guidance Analysis software has been especially effective in advancing the use of auto-guided tractors and self-propelled machinery on small farms that have not traditionally adopted precision agriculture technologies. (NP 212, Project No. 6022-63000-005-00D)

Innovative manure treatment addresses nutrient pollution problems and creates commercial products.

Manure is often used as a farmland amendment to provide nitrogen, phosphorus, and organic matter for crops. Excess phosphorous found in some manures, however, can contaminate rivers, lakes, and bays through runoff. The recovery of phosphorus and proteins from manure prior to application to fields could be advantageous to offset treatment and storage costs, and to lessen the environmental impacts to land. ARS researchers in Florence, South Carolina, developed a new biorefinery process that recovers value-added phosphorus, proteins, and amino acids, and leftover solids from manures. An additional breakthrough came when sugars from sucrose, sugarbeet molasses, and peach waste were used as natural acid precursors to further lower treatment costs. These precursors allowed rapid fermentation, which produced abundant acids. These acids extracted nearly all the phosphorus and the acids also caused nearly all of the proteins to be concentrated in an easy-to-collect precipitate. The process is also effective at extracting phosphorus and proteins from other biological materials such as algae and soybean meal. The recovered proteins can be used to produce amino acids, and the recovered phosphorus can be used as a recycled material to replace commercial phosphate fertilizers. This innovation provides a means to create new revenue stream from farm wastes. (NP 212, Project No. 6082-12630-001-00D)

Inexpensive vegetative buffers around poultry facilities reduce air pollution.

Vegetative environmental buffers (VEBs) are composed of selected trees, shrubs, and/or tall grasses that are frequently installed near the exhaust fans of poultry houses to control and reduce the off-site transport of potential pollutants such as particulates and ammonia. NRCS has historically developed guidelines and tools for the design and selection plants for VEBs, but the effectiveness of VEBs in controlling emissions has not been adequately quantified. ARS researchers in several locations

(Florence, South Carolina; Beltsville, Maryland; Lubbock, Texas; and Ames, Iowa) in collaboration with colleagues at universities in Delaware, Iowa, Maryland, Oklahoma, and Alberta (Canada), used state-of-art laser systems and micrometeorological techniques to quantify dispersion and removal of particulates and ammonia from a poultry house surrounded by a VEB. Particulate capture efficiency ranged from 20 percent to 70 percent depending on meteorological conditions; ammonia removal was 22 percent, and net downwind ammonia dispersion was reduced 51 percent. NRCS is using these results to refine and bolster the standards that define the mitigation potential and limitations of the vegetative buffers. (NP 212, Project No. 6082-12630-001-00D)

Perennial living mulch systems increase sustainability of corn and soybean production.

Perennial living mulches are a farming management option that provide the environmental benefits of cover crops, such as reductions in both erosion and chemical runoff, but without the need to replant each year. One plant that is commonly used as a perennial living mulch is kura clover, a long-lived legume that spreads by rhizomes, but the factors affecting its agronomic performance and nutrient management are not well defined. ARS scientists in St. Paul, Minnesota, have been developing the management systems needed to successfully integrate kura clover-based living mulch systems into corn and soy production. They have also developed a novel rotary zone tillage (RZT) system that, in contrast to conventional strip tillage, create 30-cm rows, which more effectively eliminates early season kura clover and reduces corn competition for light, water, and nutrients. The scientists have also shown that due to kura's nitrogen fixation ability, first-year corn following 2 to 3 years of kura management for forage does not require nitrogen fertilizer to maximize yield and profitability, and second-year corn requires only a reduced application of nitrogen fertilizer. The net economic return from corn grain and stover in the kura-corn system averaged over two seasons was $138 per hectare more than conventional corn production. The combination of the RZT management of the kura living mulch cropping system

provides a promising system for corn growers that can return significantly greater economic and ecological outcomes. (NP 212, Project No. 5062-12000-010-00D)

Low-cost precision technology helps with peak rangeland production.

Rangeland producers need timely, reliable, and easy-to-understand information about the condition of their land to make management decisions. Critical information needed for managing grazing cattle productivity include timing of establishment, growth, peak production, and reproduction of various pasture plants. Producers traditionally collect this information during field visits, which are expensive and time intensive. Through extensive field work in dominant ecosystems of the Great Basin and Chihuahuan Desert, ARS scientists in Reno, Nevada, and Las Cruces, New Mexico, determined that inexpensive, land-based, plant phenology cameras can be used to quantify changes in mixed shrub-grasslands and meadow ecosystems. These plant "phenocams" offer producers a powerful way to improve their ability to decide when grazing time is at its peak, the best time to apply herbicides, and when to reduce vegetative fuel loads that increase the risk of wildfires. (NP 215, Project No. 2060-13610-003-00D)

Active stakeholder participation in research leads to community-focused, adaptive rangeland management.

Agricultural producers and industry personnel have diverse perspectives on production systems and environmental issues. Fully engaging them as co-developers and co-participants in agricultural research, from discovery to application to outreach, holds great promise for advancing sustainable agricultural intensification. ARS scientists in Fort Collins, Colorado, and Cheyenne, Wyoming, and partners initiated a research project in 2011 that generated practical suggestions for improving the management of complex agroecosystems and provided a model for transdisciplinary research to address

contemporary societal issues. Collaborators included scientists from the University of Wyoming, Colorado State University, and Texas A&M University, and a diverse group of ranchers, State and Federal land managers, and nongovernmental conservation organizations. Lessons learned have been implemental locally by ranchers and the Forest Service, and extended regionally by outreach engagement through the USDA Northern Plains Climate Hub, the USDA Long-Term Agroecosystem Research network, the University of Nebraska, and even internationally. With its emphasis on human dimensions and social-ecological systems, this project has been showcased by the Group of Twenty (G-20) Agroecosystem Living Laboratories effort as the primary U.S. example of stakeholder engagement in participatory research. (NP 215, Project No. 3012-21610-002-00D)

Adjusting fall grazing schedules for finishing cattle increases profits and range sustainability.

To maximize economic returns, ranchers in semiarid environments must decide each year when to move cattle from rangeland to feedlots for finishing. They traditionally do this in October. The decision is based on expected cattle weight gain given rangeland conditions and market prices, but this forecasting is increasingly challenged by changing climate and highly variable precipitation within and across years. ARS scientists in Cheyenne, Wyoming, and Fort Collins, Colorado, in collaboration with scientists from Argentina and the University of Wyoming, used livestock gain and economic market data from 2003 to 2017, which represented a range of weather conditions, to quantify differences in net revenue based on the date cattle were delivered for finishing. There was wide revenue variability, which highlights the economic challenges for individual operations and rural economies in the region. However, because livestock gains were negligible from early September to the end of the grazing season, removing cattle from pastures in early September can increase net revenue compared with typical October removal. Early removal also provides ecological advantages of more plant residue for soil cover and a longer rest

period for healthier vegetation. This information will help regional cattle producers improve their economic and ecological sustainability. (NP 215, Project No. 3012-21610-002-00D)

Mineral supplementation increases productivity and profitability of cattle grazing wheat.

Giving supplemental feed to grazing cattle is a good way for producers to increase net returns to the livestock enterprise. Wheat pasture is a unique resource in the southern Great Plains because it provides income from both the grain crop and body weight gain by grazing cattle. Given this dual income source, many producers do not supplement the cattle diet with mineral mixtures to increase cattle performance even though mineral analysis has shown that wheat herbage is deficient in calcium. ARS scientists in Woodward, Oklahoma, examined the practice of providing high-calcium and trace mineral mixtures to cattle grazing in a winter-wheat pasture to compensate for the high potassium in wheat herbage. The cattle given supplemental minerals had a 43 percent faster average daily body weight gain than cattle whose diets did not include supplemental minerals, and at the end of the grazing period supplemented cattle weighed as much as 6 percent more than cattle that did not receive supplements. Mineral intakes averaged 4.4 ounces per day, resulting in a cost of supplement per pound of weight gain of $0.09 (assuming a mineral cost of $0.025/ounce). Producers can use this information to improve cattle weight gain and increases the net return to their stocker cattle enterprises. (NP 215, Project No. 3074-21630-011-00D)

Corn and cattle profitability improved by grazing corn crop residue.

Having beef cattle graze on corn residue is a simple and economical practice for integrating crop and livestock production in the central United States. However, the overall economic value of this practice was unknown. ARS scientists in Lincoln, Nebraska, and university colleagues determined that this type of grazing annually returned $95 million to crop producers in Kansas, Nebraska, North Dakota, and

South Dakota. The annual gross value for grazing corn residue for cattle producers was $191 million in those States. Although challenges exist to expand corn residue grazing, opportunities also exist to increase the practice of this cost-efficient winter forage alternative. (NP 216, Project No. 3042-11210-003-00D)

Carbon can be removed from the atmosphere and stored in soil by intercropping bioenergy crops with trees.

Perennial herbaceous crops such as switchgrass are important sources of cellulosic biomass for the developing bioenergy industry. Assessments of how much carbon will be lost or sequestered into soil and the turnover rates of that carbon are needed to assist producers and policymakers who need to determine the long-term sustainability of biomass production. The natural abundance of soil carbon was used to calculate the quantity and turnover of soil carbon in a switchgrass/poplar intercropping system. After 4 years of cropping, soil organic carbon increased 16 percent in the 0- to 15-cm depth, and on average, 10 percent of this soil organic carbon was derived from switchgrass. The results show that intercropping switchgrass with hybrid poplar gives forest plantation landowners greater economic returns from biofuel production by improving water use and nutrient cycling. Intercropping also promotes additional ecosystem services including carbon sequestration. These benefits directly affect air, water, and soil quality, which are increasingly challenged by climate change. (NP 216, Project No. 3098-11000-001-00D)

Organic agriculture's risk of phosphorus pollution is mitigated with legume cover crops.

Manure is a potent source of both nitrogen and phosphorus. Organic systems often use manure as a nitrogen source, but this can lead to excessive phosphorus application and runoff into waterways. Legume cover crops supply enough nitrogen to reduce poultry litter application requirements in organic

corn production systems, enabling farmers to mitigate phosphorus pollution. In a 2-year study at three organic sites in Maryland, ARS scientists in Beltsville, Maryland, found that poultry litter application can be reduced by half and still achieve the same corn grain yield when used in conjunction with a legume cover crop. These results will be of interest to farmers, environmentalists, policy experts, and others concerned with the health of the Chesapeake Bay and other estuaries impacted by agricultural losses of nitrogen and phosphorus. (NP 216, Project No. 8042-21660-005-00D)

U.S. beef cattle production has a relatively low environmental footprint.

The U.S. beef industry is a major contributor to the national and global food system and economy. Increasing productivity in an environmentally, economically, and socially sustainable manner is of concern to both producers and consumers. Cattle production systems are very complex, with many components and interactions, so quantifying and measuring sustainability is challenging. Through a comprehensive national assessment, ARS scientists in University Park, Pennsylvania, in collaboration with the National Cattlemen's Beef Association, found beef cattle production emitted 3.3 percent of U.S. greenhouse gas emissions, produced 15 percent of reactive nitrogen losses, used 0.7 percent of fossil energy, and consumed 5.8 percent of its fresh water. When these figures are expressed per unit of meat produced, they compare very favorably with global averages. These data provide a baseline for comparison with future assessments and the evaluation of potential benefits of mitigation strategies. (NP 216, Project No. 8070-66000-001-00D)

Climate Hub information dissemination.

In response to extreme weather (e.g., late spring freeze, extreme cold, and flooding/wetness) in the Midwest and Northern Plains, the Midwest Climate Hub translated and packaged relevant USDA science/regional crop production information, regional partner products, and real-time National Weather

Service outlooks to provide timely decision support to crop and livestock producers. This information directly supported programming by USDA personnel, extension specialists, and producers via webinars, written outlooks, workshops, websites, meetings, talks, and various other media. A special June webinar drew about 65 attendees. Regular monthly partner webinars had 110 to 130 producers, decision-makers, and Tribe and media representatives. Eighteen biweekly agricultural outlook newsletters reached more than 1,000 people via mailing lists and thousands more via social media. Extension received weekly/monthly updates. (NP 216, Project No. 5030-11610-005-00D)

Southwest Drought Learning Network improves regional drought research and land management. The Southwest Climate Hub (SWCH), through a regionally coordinated approach to drought, communicates stakeholder concerns to researchers and translates science into actionable information and tools. In 2019, 3 drought workshops attracted more than 130 participants from USDA agencies, Tribes, and other sectors. SWCH provided drought and precipitation information at 6 additional Tribal meetings attended by more than 370 Tribal professionals in Arizona and New Mexico. The SWCH also increased precipitation monitoring across the region. Drought-related tools and resources were presented at the Universities Council on Water Resources and International Fire Behavior and Fuels annual conferences, leading to actionable science. One of the most important outcomes from these activities is expanding our knowledge of partner and stakeholder needs. These interactions inspired the new Southwest Drought Learning Network that will continue to be developed in 2020. (NP 216, Project No. 3050-11210-009-00D; C/PS)

Source: USDA Agricultural Research Service

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**

New citrus trees for U.S. growers.

Huanglongbing (HLB) disease has been devastating to the Florida citrus industry and severely threatens citrus production in other parts of the United States. The use of tolerant rootstocks and scions can be effective in ameliorating disease effects. ARS researchers in Ft. Pierce, Florida, released three HLB-tolerant citrus rootstocks that produced sweet orange trees with improved health, fruit yield, and fruit quality over multiple years in an HLB-endemic environment. ARS researchers also released the first citrus scion cultivar, called ’US SunDragon”, that has good fruit quality and tolerance to HLB disease. ”US SunDragon” is being widely tested in Florida as a breeding parent, for niche fruit, and for home-owner plantings. Initial tests of juice quality show promise for inclusion of ”US SunDragon” in orange

juice blends. The new tolerant rootstocks and scions will allow continued profitable production of citrus in the presence of HLB. (NP 301, Project No. 6034-21000-018-00D)

New tomato flavor gene discovered.

Tomatoes are the most valuable fruit crop globally and are among the most widely consumed fruit or vegetable in the United States at 70 pounds per capita annually. Tomatoes are also an important source of the antioxidant lycopene, which gives tomatoes their red color, and beta-carotene, which our bodies convert to vitamin A. However, many consumers complain that store-bought tomatoes lack flavor. ARS researchers in Ithaca, New York, identified a rare version of the TomLoxC gene that is prevalent in the wild ancestors of tomato but is absent from most cultivated lines, including the genome of Heinz 1706, the reference tomato genome sequence. TomLoxC contributes to tomato flavor by catalyzing the synthesis of aromatic compounds that taste panels show consumers strongly prefer. TomLoxC, while still rare, is seeing a resurgence in modern tomato varieties in parallel with a renewed interest in flavor by breeders attempting to address consumer demands. (NP 301, Project No. 8062-21000-047-00D)

New releases solve soybean yield and protein bottleneck while enhancing diversity.

The narrow genetic base of soybeans grown in the United States has been a known bottleneck to soybean yield enhancement, and it has increased crop vulnerability to new threats. In addition, the meal protein content of current U.S. soybean cultivars has dropped below the market standard of at least 48 percent due to the negative correlations between seed protein and yield. To stay competitive in the international market, U.S. soybean growers and processors require high-yielding soybean with at least 48 percent protein in the meal. In response, ARS scientists in Raleigh, North Carolina, released two germplasm lines that will be very useful for developing high-yielding soybean cultivars with high meal protein. One line, USDA-N7004, exhibits high yield potential and greater protein meal content. The line

traces 25 percent of its exotic pedigree from a Japanese cultivar maintained in the USDA soybean germplasm collection. USDA-N6004 is a high-yielding germplasm that traces 50 percent of its pedigree to a different Japanese cultivar. These public releases are being used by commercial soybean breeders to boost competitiveness and profitability of U.S. soybean in the world markets and to expand the diversity of soybeans in the United States. (NP 301, Project No. 6070-21220-069-00D)

Cloning wheat gene for resistance to *Fusarium* head blight (FHB).

FHB is a destructive wheat disease throughout the world, but a major gene for FHB resistance that was originally identified in Chinese germplasm, Fhb1, has since been introduced into wheat germplasm around the world. ARS scientists in Manhattan, Kansas, cloned Fhb1 and showed that the gene encodes a defective form of a putative histidine-rich calcium binding protein. The functional form of the gene, present in susceptible cultivars, appears to be a susceptibility gene that allows the fungus to spread in the spike. Cloning of Fhb1, reports of which were published in Nature Genetics, provides ideal diagnostic markers for selective breeding and opens the possibility of using bioengineering approaches to further enhance FHB resistance. (NP 301, Project No. 3020-21000-011-00D)

A new table grape.

ARS researchers in Parlier, California, have released a new early season table grape named ‘Solbrio’ that has both exceptional eating quality and reduced needs for cultural input from growers. Consumers have shown a strong interest in the new variety because of its large berry size, crisp and crunchy flesh, and fully colored berries. Many of the standard—and expensive—cultural practices used to enhance characteristics of current table grape varieties were evaluated on the new variety, but none of the treatments produced a significant change on berry quality or yield. Hence, growers are very pleased with the new variety that is both easy and inexpensive to grow. (NP 301, Project No. 2034-21220-007-00D)

Improving resistance to iron deficiency chlorosis (IDC) without lowering soybean yields.

Soybean yield loss due to IDC is estimated to exceed $150 million annually in the North Central United States. Because IDC-tolerant lines produce low yields, farmers prefer to use higher yielding, albeit IDC-susceptible lines and to apply expensive foliar sprays. ARS researchers in Ames, Iowa, and colleagues at Iowa State University aimed to develop high-yielding IDC-tolerant lines, but it first required an understanding of soybean responses to IDC. Research in model species identified IDC tolerance genes but failed to translate them into improved iron efficient agricultural crops. The scientists used novel genomic technologies to identify and characterize genes and pathways in soybean that are important in IDC tolerance. They discovered 10,000 genes that were involved in iron uptake, but that also regulated a trade-off between plant growth and stress responses, a function that is unique to soybean. Gene expression studies were coupled with observations of genetic marker differences across the genomes of 450+ diverse soybean lines to determine IDC tolerance, thus allowing mapping of the precise genome location contributing to IDC tolerance in soybean. Remarkably, this discovery further separated an unexplored IDC tolerance gene location identified more than 35 years ago into four discrete genomic locations, each containing genes regulating iron uptake, defense, or growth pathways. The markers, genes, and pathways were publicly released and provide a valuable resource for improving soybean responses to iron stress. (NP 301, Project No. 5030-21220-006-00D)

Early detection through reduced RNA integrity of seed aging in plant germplasm samples.

Plant germplasm stored in genebanks must be monitored for viability to ensure that samples are regenerated before they die. The current gold-standard test is a germination assay, which is labor-intensive, consumes much of the supply of valuable seeds, and is insensitive during the early, asymptomatic stage of seed aging. ARS scientists in Fort Collins, Colorado, developed a simple assay, based on degradation of the nucleic acid RNA, that detects the rate of aging in seeds during the

asymptomatic period. The assay consumes few seeds per sample and can be developed into a kit to facilitate automated monitoring. This new monitoring tool can accurately predict when seeds should be regenerated while preventing unnecessary consumption of seeds for testing. Knowledge of the fate of RNA in aging dry cells of seeds could enable automation of seed testing to increase plant genebank operational efficiency and reveal key information about the biological nature of seed aging. (NP 301, Project No. 3012-21000-016-00D)

World's first spinach cultivar with red leaves.

Spinach has always been known as a green leafy vegetable. Although there are currently some red spinach cultivars on the market, the red color is limited to the veins of the leaves. ARS researchers in Salinas, California, developed 'USDA Red', the world's first spinach variety with red color on the surface of the leaves. 'USDA Red' had 65 percent higher betacyanin content and 53 percent higher antioxidant capacity than red-veined spinach cultivars on average in field trials conducted between 2015 and 2018. The betacyanin adds another punch to a plant already loaded with phytonutrients, making spinach a true "super food." The red spinach may bring some excitement to the spinach market and attract consumers to the colorful new product, helping increase the consumption of spinach and aid in the fight against obesity. (NP 301, Project No. 2038-21530-002-00D)

'Castella," a new club wheat, released for the intermediate rainfall region of Washington State.

Club wheat constitutes a significant portion of the wheat export market in the Pacific Northwest, but current club wheat cultivars are either susceptible to low falling numbers or to stripe rust. ARS scientists in Pullman, Washington, developed and released "Castella" club wheat, which is resistant to stripe rust, aluminum, and Hessian fly, and possesses excellent club wheat end-use quality. A combination of single seed descent, marker-assisted selection, and multilocation field trials was used to develop "Castella"

club wheat from a cross with a diverse pedigree that included breeding lines from Arkansas, New York, and Washington. This diverse pedigree has resulted in an unusual combination of traits in ”Castella” that will increase marketing opportunities for growers. (NP 301, Project No. 2090-21000-033-00D)

New tools for breeding cold tolerance in chickpea.

Chickpea production has expanded dramatically in the United States, with a greater than 50 percent increase in the number of acres planted with the crop in 2017 compared with 2016. Export demand has been high, and domestic consumption has grown substantially, so additional production is needed. In the United States, chickpeas sown in the autumn can yield substantially more than spring-sown chickpea in regions with mild winters. To accelerate breeding cold-tolerant chickpea to expand the current geographic range of production and improve overall productivity, ARS researchers in Pullman, Washington, worked with Washington State University and Hebrew University of Jerusalem colleagues and identified the approximate locations on the chickpea genome for genes that control cold tolerance and the DNA genetic markers associated with cold tolerance. Those genetic markers will help accelerate breeding chickpeas with greater cold tolerance and thus expand the geographical range of U.S. production. (NP 301, Project No. 2090-21000-032-00D)

Canine detection of Huanglongbing (HLB) in California to mitigate an impending Statewide epidemic. Close up Statewide

HLB epidemics continue to spread worldwide and devastate the citrus industry. The key to mitigating HLB is early detection and rapid response. ARS researchers in Fort Pierce, Florida, have trained 20 dogs to detect HLB shortly after a tree has been infected (i.e., within 2 to 4 weeks after infection). The prior gold standard used to detect HLB, polymerase chain reaction (PCR), requires months to perform. The dogs can also detect infection with 99 percent accuracy, whereas the accuracy of PCR detection is

approximately 30 to 35 percent, because even though the assay is good, it is difficult for humans to select infected tissue from a tree with some 200,000 leaves. In 2018–2019, California growers, the California Department Food and Agriculture (CDFA), industry leaders, and regulatory personnel concluded that the canines were more than 92 percent accurate in detecting infection even under highly variable and inhospitable conditions. The canines are being integrated and deployed by CDFA to detect asymptomatic incipient infections of HLB for early response (tree removal). Simulations indicate how the impending epidemic is greatly mitigated by incorporating canine detection teams in early detection practices. (NP 303, Project No. 6034-22000-042-00D)

Proof that Brome mosaic virus (BMV) can cause significant yield loss in U.S. wheat.

BMV is well known to infect many plants, including wheat and other grain crops, but it has long had the reputation of being an unimportant pathogen of crops. Following repeated detection of BMV in Ohio surveys of wheat from 2012 to 2017 at incidences of up to 25 percent, ARS scientists in Wooster, Ohio, and university collaborators showed that all tested Ohio-grown wheat cultivars were susceptible to infection, and that inoculation with BMV at any of four tested growth stages resulted in up to 60 percent yield losses. Some wheat cultivars showed tolerance to the virus; therefore, cultivar selection may minimize grower losses due to this virus infection. Results of this study were published in an April 2019 edition of the journal Phytopathology. (NP 303, Project No. 5082-22000-001-00D)

Release of potato cultivar with broad-spectrum resistance to the golden nematode.

Potato cyst nematodes, including the golden nematode and the pale cyst nematode, are devastating pests of U.S. potato production. Deploying resistant cultivars is the most effective and sustainable means for combating nematode pests. ARS researchers in Ithaca, New York, and Cornell University collaborators developed and released Brodie," the first potato cultivar that confers resistance to the two pathotypes

(Ro1 and Ro2) of the golden nematode. This new resistant cultivar provides the needed materials for controlling Ro2, a more aggressive population, in the field, thereby helping maintain the success of golden nematode quarantine in the United States. (NP 303, Project No. 8062-22000-022-00D)

Replacing methyl bromide: Adaption of anaerobic soil disinfestation (ASD) for commercial production systems.

The loss of methyl bromide for soilborne pest control left few registered soil fumigants, and these fumigants are not effective for the spectrum of pests that were previously controlled using methyl bromide. This leaves specialty crop growers at risk. ARS researchers in Fort Pierce, Florida, and their cooperators conducted field trials with commercial producers to assess the efficacy of ASD through a combination of composted or pasteurized pelleted poultry manure and feedstock sugarcane molasses applied under totally impermeable film for crop production without chemical soil fumigation. Use of ASD resulted in yields that were equivalent or higher than those attained from chemical fumigation and demonstrated break-even prices, resulting in consistent, positive returns for growers. Demonstration trials on commercial farms, conducted for multiple crops and seasons, resulted in adoption of ASD, particularly in buffer zone areas in which chemical fumigants cannot safely be applied. This approach provides specialty crop producers with an option for pest control for areas in which they currently have none. ASD requires slight modifications to the pre-plant practices currently employed, but provides economic, worker safety, and environmental benefits. (NP 303, Project No. 6034-22000-043-00D)

Mite blood-feeding dogma overturned: Varroa mite feeds instead on bee fat body.

Varroa mite is the greatest factor in honey bee mortality. Reassessing the feeding habits of these parasitic mites in collaboration with University of Maryland cooperators, ARS researchers in Beltsville, Maryland, found that contrary to decades of literature, varroa mites do not feed on honey bee blood

(hemolymph), but instead feed on the insect's fat body. This has important implications for using mite control strategies that involve the bee, since any anti-mite chemical, such as those that silence mite genes, would have to be delivered not to the bee hemocoel (blood system), but rather to the fat body. Since the fat body is also where a bee's hormones are produced, it also helps to explain the mite's devastating effects. (NP 304, Project No. 8042-22000-271-00D)

Morpholinos to the rescue: New chemicals for citrus greening control.

Many bacterial pathogens in plants are difficult to target because they are protected by biofilms. A set of novel morpholino chemicals—small pieces of DNA that are antisense (i.e., oriented in the opposite direction of normal DNA)—were discovered by ARS scientists in Fort Pierce, Florida, to move through the biofilm containing the bacterium that causes citrus greening disease, thus killing the bacteria. Now patented by ARS, this strategy, which also worked in potato against Zebra chip disease, represents a new means to protect fruit, nut trees, and vegetables from numerous important plant diseases. (NP 304, Project No. 6034-22320-004-00D)

New biological control agent for Brazilian pepper tree.

Brazilian pepper tree originated in South America and then became one of the most widespread and destructive invasive species in the Florida Everglades. Efforts to control and eradicate this weed have not been effective and it continues to spread. ARS scientists in Fort Lauderdale, Florida, in collaboration with Argentinian collaborators, recently obtained authorization for field release of a thrips (the insect *Pseudophilothrips ichini*) biocontrol agent. Research has shown thrips that fed under greenhouse conditions reduced Brazilian pepper seedling growth by 80 percent. The new biocontrol agent may provide land managers and farmers with a cost-effective means of controlling Brazilian pepper tree by

reducing the current and expensive reliance on herbicidal control. (NP 304, Project Nos. 6032-22000-012-00D and 0206-22000-008-00D)

One tiny step for a nematode, one big step toward sustainable agriculture in space.

An exciting collaboration between ARS researchers in Byron, Georgia, and industry partners will send beneficial nematodes into space to the International Space Station. Nematodes are small roundworms that typically live in soil and are some of the most abundant animals on earth. The goal is to develop environmentally friendly methods for growing foods in space without using chemicals. These beneficial nematodes, also called entomopathogenic nematodes, are environmentally friendly alternatives to broad-spectrum chemical insecticides and are safe to humans and nontarget organisms because they only attack insects. The experiment will test the movement and behavior of beneficial nematodes in space to determine whether nematodes will be able to navigate through soil and infect insects. This will be the first biological control experiment in space and an important glimpse of the future when food crops will be grown there. (NP 304, Project No. 6042-22000-023-00D)

Improved mechanical blueberry harvesters.

Blueberry growers want to replace hand picking with machines to harvest blueberries. Current blueberry harvesting machines use hard fruit-catching plates that cause significant damage to the detached blueberries that fall on them. ARS researchers in Kearneysville, West Virginia, developed and patented durable catch plates allowing mechanical harvesters to harvest blueberries without bruise damage. In 2018, new catch plates for commercial blueberry harvesters were manufactured using the USDA patent and tested in California, Florida, Oregon, and Washington. U.S. commercial blueberry growers are now mechanically harvesting high-quality blueberries using the ARS patented design. (NP 305, Project No. 8080-21000-028-00D)

Oilseed cover crops reduce unwanted soil nitrogen loss.

Contamination of water from the leaching and runoff of labile soil nitrogen and phosphorus from corn-soybean cropping systems in the Upper Midwest is a major concern. This loss occurs mostly during fall and spring when the soil is left bare between summer crops. Winter annual cover crops can use leftover nitrogen and phosphorus from the previous crop and keep these nutrients from contaminating water. ARS researchers from Morris, Minnesota, in collaboration with University of Minnesota scientists, demonstrated that winter camelina and pennycress grown as cover crops are as effective as winter rye at using excess nitrogen and preventing its escape from agricultural systems into waterways. Scientists compared results of cultivating camelina and pennycress winter oilseeds with results from a typical no-till and conventional till system lacking a cover crop and found the two oilseed cover crops reduced soil water nitrate nitrogen losses by 84 percent and 91 percent, respectively. Camelina and pennycress also can be harvested as oilseed cash crops, adding yet more value to the system. This information will benefit growers interested in cover cropping, agricultural scientists, extension educators, and consultants, and is being used in developing new sustainable cropping systems. (NP 305, Project No. 5060-21220-006-00D)

Improved crop water use sensor for grapes.

Conserving water during crop production is an important environmental consideration for vineyard production systems. In areas with limited water supplies, efficient water use is critical for profitability. To reduce irrigation, growers need precise information on how much water grapevines need. In collaboration with University of California–Davis researchers and industry cooperators, ARS scientists in Davis, California, developed an inexpensive, stand-alone sensor that provides growers with low-cost, site-specific estimates of crop water use for scheduling irrigation. The new system is based on “surface renewal” methods that estimate plant evapotranspiration by measured and modeled energy balance

components to quantify vineyard water use. The new surface renewal method does not rely on calibration against other methods to obtain accurate measurements of plant water use. (NP 305, Project No. 2032-21220-007-00D)

Small hive beetle genome sequenced: Unique ability to detoxify pesticides revealed.

Small hive beetle eats through honey bee hive comb, honey, pollen, and brood, and is an important worldwide parasite of social bee colonies. ARS scientists in Beltsville, Maryland, sequenced and characterized the beetle genome and found it contains unique detoxification genes. In addition, sequencing described the proteins used by these beetles to identify each other and honey bee colonies by smell, a critical target for attempts to trap beetles. The study provides new insights into the genomic basis for local adaption and invasiveness in the beetle and a blueprint for control strategies that target this pest without harming their honey bee hosts. (NP 305, Project No. 8042-21000-290-00D)

Release of new plant germplasm and cultivars.

In FY 2019, ARS scientists released 41 enhanced germplasms and cultivars. Of these, 33 were publicly released and 8 (a spinach, barley, potato, broccoli, chickpea, wheatgrass, orchid grass, and tall wheat grass) 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 2019, 265,704 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 Arboretum (NA)	289	236	85	3
National Arid Land Plant Genetic Resources Unit (PARL)	519	331	44	10
National Laboratory for Genetic Resources Preservation (NSSL)	381	378	45	1
National Small Grains Collection (NSGC)	29,070	22,198	657	42
Natl. Germplasm Repository - Corvallis (COR)	7,032	3,434	704	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	3
Natl. Germplasm Repository - Mayaguez (MAY)	174	114	79	2
Natl. Germplasm Repository - Miami (MIA)	682	440	122	8
Natl. Germplasm Repository - Riverside (RIV)	418	256	98	9
North Central Regional PI Station (NC7)	60,703	23,025	1,398	56
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)	47,645	27,526	879	46
Plant Variety Protection Voucher Collection (PVPO)	4	4	1	1
Potato Germplasm Introduction Station (NR6)	6,839	1,785	202	13
Rice Genetic Stock Center (GSOR)	20,910	13,570	176	15
Soybean Collection (SOY)	21,242	9,578	514	29
US Nicotiana Germplasm Collection (TOB)	218	144	69	10
Western Regional PI Station (W6)	44,157	28,311	1,102	43
Total	**265,704**	**142,518**	**7,401**	**356**

Source: USDA Agricultural Research Service

NATIONAL AGRICULTURAL LIBRARY

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

Ag Data Commons and public access to digital scientific research data.

Ag Data Commons is the platform that provides public access to USDA-funded digital scientific research data. In FY 2019, the National Agricultural Library (NAL) carried out major upgrades to Ag Data Commons to meet its customers' needs for data management and access. NAL piloted ways to store and provide access to large data files in Ag Data Commons through SCINet. The Ag Data Commons continued to demonstrate its value as a key data resource for agricultural research through significant increases in all system management metrics, including registered users, unique visitors, downloads, and page views. NAL continued to gather customer perspectives on Ag Data Commons including through an agreement with a private firm that conducted an impartial environmental scan of current and potential Federal agency and land-grant university customers. Continuing strategic partnerships with ARS and National Institute of Food and Agriculture (NIFA) senior program leadership and other USDA agencies continued to improve the management of USDA-funded data. After a rigorous, Department-wide review process, NAL obtained USDA Science Council approval for the

Department's first Public Access to Digital Scientific Data Policy. Ag Data Commons can be found at https://data.nal.usda.gov.

PubAg expanding quickly.

NAL makes available USDA-funded peer-reviewed literature through the PubAg platform. During FY 2019, NAL continued technical development of PubAg and aggressively built up the content of the service. In 2019, the number of citations for peer-reviewed agriculture-related scientific articles available in PubAg reached 2.6 million citations, an increase of more than 500,000 citations from FY 2018. 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, or the publisher. NAL also increased the full-text corpus that is publicly accessible through PubAg by more than 130,000 full-text articles, for a total of more than 210,000 articles. This fulfills the Department's and U.S. Government's mandate for open access to federallyfunded research. PubAg can be found at https://pubag.nal.usda.gov/.

i5K Workspace.

As part of the i5K initiative, which aims to sequence and analyze the genomes of 5,000 arthropod species, the i5K Workspace was established as a website that arthropod genome researchers can use to curate, visualize, and share data. The i5K Workspace now contains 72 arthropod genome assemblies and related datasets. In FY 2019, the Workspace added 3 new organisms, 24 new data sets, and 98,435 new gene pages (or gene features). NAL worked with data providers to generate three Official Gene Sets via NAL's in-house pipeline and submitted these and four additional datasets to the National Center for Biotechnology Information. The number of publications citing the work of the i5K Workspace and thus now promoting it now totals 67 (up from 45 in 2018). Reporting metrics are available at https://i5k.nal.usda.gov/i5k-workspacenal-reporting-metrics.

USDA Food Composition Database and Food Data Central.

In collaboration with the ARS Beltsville Human Nutrition Research Center and major industry partners, NAL makes available nutrition information for scientific researchers, dieticians and nutritionists, application developers, and consumers. In FY 2019 NAL hosted and made available online more than 560,000 different foods with more than 8.6 million food nutrient entries in both data products. Combined, these data products generated more than 30 million page views via 4 million user sessions. Most impressively, application developers made nearly 265 million Application Programmer Interface (API) calls against these two data products in FY 2019, making the USDA Food Composition Database and FoodData Central APIs among the most popular in Government.

NAL mass digitization continues.

To make the content of the world's largest agricultural library more accessible for scientific and other forms of research, NAL is digitizing its physical collections not under copyright protection. In fiscal 2019, NAL digitized and created citation information for 13,110 items (930,432 pages), bringing total number of digitized items to 160,985 (7,692,074 pages). During FY 2019, 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. NAL also initiated a major project to digitize the USDA legislative histories maintained by the Office of General Counsel to support the national agricultural law partnership. 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.

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

Source: USDA Agricultural Research Service

AL	Soil Dynamics Research	Presentation on how cover crops and irrigation can work together to improve production for growers at Alabama Extension sponsored field day "Irrigation Technologies in Your Hands."
AL	Soil Dynamics Research	Co-organized the 2019 Southern Cover Crop Council meeting held in Auburn, AL. The conference consisted of 10 sessions led by experts, a poster session, and a ½ day field tour to showcase various aspects related to cover crops.
AL	Soil Dynamics Research	Presentation on soil compaction differences following winter stocker grazing as part of determining how grazing cover crops affects soil health at an Alabama Agricultural Experiment Station sponsored field day.
AL	Soil Dynamics Research	Presented an on-demand webinar about cover crop management considerations in the Southeast. The webinar is available at the Plant Management Network website under the Focus on Cotton webcasts tab.

AR	Harry Dupree Stuttgart National Aquaculture Research Center	Presentation on the proper procedures for biosecurity in aquaculture facilities and on research on peracetic acid as a new disinfectant for biosecurity at the Fish Farms Biosecurity Workshop at the Centro De Formacion Agroindustrial La Angostura (La Angostura Agroindustrial Training Center) in Campoalegre, Huila Department, Colombia. Attended by 60 trade school apprentices and students, aquaculture coordinators and farmers.
AR	Poultry Production and Safety Research	Presented at the "Farm Foundations: Planning for Success, Beginning Farmer Livestock Workshop." This workshop provide more than 25 beginning farmers with information on pasture management, animal health, and the business and marketing aspects of small farming.
AR	Poultry Production and Safety Research	Held World Geographical Information Systems (GIS) Day at the University of Arkansas campus. This event is internationally recognized and promotes GIS technology and its applications. GIS day is an "open house" based forum and showcased a series of presentations to student, faculty, staff, and stakeholders on current research and community developments using GIS. Approximately 60 attendees participated and attended in this event.
AR	Poultry Production and Safety Research	Hosted the Armed to Farm Bootcamp. There were more than 20 veterans and or spouses present for the week-long workshop/training program. Veterans learned about a variety of farming topics from local experts in classroom sessions and went out each day to local farms to engage in hands-on learning.
AZ	Water Management and Conservation Research	Presentations to farmers, farm consultants, and farm workers on practical information for improving farm management practices at the Yuma, Arizona Southwest Ag Summit. Topics included recommended practices for water and nutrient management for cotton crops, updated reporting on crop water use by lettuce and wheat, and opportunities for improved wastewater reuse.
CA	Agricultural Water Efficiency and Salinity Research	Presented research results on "Salt Tolerance of Almond Rootstocks" at the 2018 Almond Conference. These were second-year results on screening almond rootstocks for tolerance to salinity.
CA	Commodity and Protection and Quality Research	Presentation on ARS research at Mid Valley Nut Conference.
CA	Commodity and Protection and Quality Research	Several presentations to multiple stakeholders about control of navel orangeworm in tree nuts.

CA	Crop Diseases, Pests, and Genetics Research	Hosted eight Ukraine professionals and two faculty members from California State University-Fresno who participated in the 2018 Faculty Exchange Program, Agricultural Economics, Ukraine.
CA	Invasive Species and Pollinator Heath Research	Presentation on "Biological Control of Terrestrial Weeds of Non-Crop Areas" to about 80 pesticide applicators, Professional Crop Advisors (PCAs) and local invasive weed and natural resource managers as part of a Pesticide Applicators Professional Association Seminar. The presentation included coverage of biocontrol success stories and current projects.
CA	Invasive Species and Pollinator Heath Research	Presentation on "Plant Physiology and Weed Control" for the East Bay Municipal Utility District 2019 Integrated Pest Management Workshop.
CA	Invasive Species and Pollinator Heath Research	Presentation on "What's New in Aquatic Weed Control?" for the 2019 Wildlands Integrated Pest Management Seminar. The 2-day seminar trains approximately 200 natural area land managers and was sponsored by the California Department of Fish and Wildlife.
CA	Invasive Species and Pollinator Heath Research	Presentation on "An Overview of Aquatic Weed Management" at the University of California Weed Science School. Weed Science School provides continuing education credits to certified crop advisors and qualified applicators for all of weed science areas, including crop and non-crop applications. The school is hosted by the University of California Weed Research and Information Center.
CO	Central Plains Resources Management Research	Central Great Plains Research Station hosted a Field Day event for the local farming community. The all-day event included presentations on dry-land crop experiments and soil research findings conducted the past year.
CO	Central Plains Resources Management Research	Organized a workshop on soil health in the west at Adams State University. This was an educational workshop held to benefit small farms research and conservation efforts throughout the country. Researchers, students and farmers were included in those in attendance.
DC	Floral and Nursery Plants Research	Set up a series of demonstrations and "show and tell" exhibits at the U.S. National Arboretum to showcase ARS research impact to attendees of the annual meeting of the American Public Garden Association.
DC	Floral and Nursery Plants Research	The Nursery Crops Research Station in McMinnville, TN hosted local nursery producers and industry specialists for research tours and presentations.

DC	Floral and Nursery Plants Research	Participated in the Plant Collections Consortium of the American Public Gardens Association. This group is composed of member gardens from across the U.S. who are engaged in plant germplasm collection and conservation.
DC	Floral and Nursery Plants Research	Participated in a webinar on boxwood blight research hosted by AmericanHort.
DC	Floral and Nursery Plants Research	Presentation on "The value of germplasm collection, breeding, and genetic resources using *Prunus* as a model" at the annual meeting of the American Public Gardens Association.
DC	Floral and Nursery Plants Research	Presentation on "*Fraxinus* diversity and emerald ash borer: delineating species, engaging citizen scientists" at the annual meeting of the Society of American Foresters.
DC	Floral and Nursery Plants Research	Presentation on "The U.S. National Arboretum: using science - improving landscapes" at the Philadelphia Flower Show.
DC	Floral and Nursery Plants Research	Multiple presentations on "Woody landscape plant selection and identification" to the District of Columbia Master Gardeners and the Montgomery County Master Gardeners.
DC	Floral and Nursery Plants Research	Presentation on "Genetic diversity of cultivated *Hydrangea* using genotyping-by-sequencing (GBS)" at the 63rd Annual Southern Nursery Association Research Conference.
DC	Floral and Nursery Plants Research	Presentation on hydrangea breeding at a University of Tennessee workshop on "The A to Z of Producing Excellent Hydrangeas."
DC	Gardens Unit	Demonstrated bonsai cultivation techniques at the U.S. National Arboretum on World Bonsai Day to approximately 100 visitors.
DC	Gardens Unit	Presentation on "What's new with Hydrangeas and Magnolias?" at the Spring into Spring Master Gardner Conference.
DC	Gardens Unit	Presentation on "Selecting and planting trees for success" for the Green Spring Gardens meeting.
DC	Gardens Unit	Presentation on plant biodiversity to the Montgomery County (Maryland) Master Gardeners.
DC	U.S. National Arboretum	Participated in the annual meeting of the American Public Gardens Association, which included presentations at the meeting and hosting tours, meetings, and a dinner at the U.S. National Arboretum.
DC	U.S. National Arboretum	Presentation on "Collections breed success at the National Arboretum" at the Morris Arboretum.
DC	U.S. National Arboretum	Presentation on "From the Ground Up: Keeping horticulture alive through grounds and infrastructure management" at an

		American Public Garden Association Symposium.
DC	U.S. National Arboretum	Presentation on "Cackalacky® connections: the impact of North Carolina gardeners at the National Arboretum" at the North Carolina Master Gardener 40th Anniversary Lecture.
FL	Invasive Plant Research	Presentation to Broward County (Florida) residents on aspects of water and environment conservation.
FL	Invasive Plant Research	Presentation to landscape practitioners on biological control.
GA	Peanut Research	In collaboration with University of Georgia (UGA) engineers, conducted training sessions for UGA County Extension Agents on the use of Irrigator Pro mobile application for scheduling irrigation for cotton and peanuts.
GA	Peanut Research	Presentation on peanut introgression and pre-breeding at the National Peanut Board's symposium on "The Future of Precision Peanut Breeding."
GA	Peanut Research	Conducted training on good management practices for storing farmers stock peanuts to peanut warehouse managers, maintenance personnel, fumigation teams, procurement managers at the Integrated Pest Management (IPM) Workshop sponsored by the Food Safety and Sanitation Committee of the American Peanut Shellers Association.
GA	Plant Genetics Resources Conservation Research	Presentation on the National Plant Germplasm System and perennial peanut collection at the "Perennial Peanut Field Day" at the University of Florida-North Florida Education and Research Center.
GA	Poultry Microbiological Safety and Processing Research	Participated in the International Poultry Production Exposition.
IA	Agroecosystems Management Research	Demonstrateion of an Agricultural Conservation Planning Framework storymap, a website providing online access to field-specific conservation practice placement options, at the North Central Iowa Crop and Land Stewardship Clinic hosted by Iowa State University Extension.
IA	National Laboratory for Agriculture and the Environment	Presentation on the pathway to improving soil through the use of soil biology to Regenerative Agriculture and Gardening Workshop.
IA	National Laboratory for Agriculture and the Environment	Delivered the Sidore Lecture at Plymouth State College on the impact of climate change on agriculture and the implications for future food security.

IA	National Laboratory for Agriculture and the Environment	Presented the keynote address "Weather-Proofing Your Cropping System" at the Profitable Farming in a Changing Climate workshop sponsored by USDA-NRCS, Minnesota Department of Agriculture, Sustainable Agriculture Research and Education (SARE), and soil water conservation districts in Southern Minnesota.
IA	National Laboratory for Agriculture and the Environment	Presentation on "Fertilizer and Manure Nutrient Management with Cover Crops to Improve Impacts on Water Quality" at the Clinton County (Illinois) Cover Crop Field Day.
IA	National Laboratory for Agriculture and the Environment	Presented the keynote address "Systems Approach to Improve Soil Health, Agro-economics, and Environmental Services" to the 2019 Soil Health Conference.
IA	National Laboratory for Agriculture and The Environment	Presented a keynote address "Agriculture Practices and the Weather" at the Lake Springfield, Illinois Watershed Reduced Tillage and Cover Crops Meeting.
IA	National Laboratory for Agriculture and The Environment	Presentation on "Weeds in Iowa: What will change?" at the annual meeting of Iowa Weed Commissioners.
IA	Plant Introduction Research	Participated in a podcast hosted by the University of Minnesota Urban Forestry Outreach, Research & Extension program "Episode 3: Mad about Kentucky Coffeetrees" which explained the mission of the National Plant Germplasm System with detailed discussions on the efforts to collect Kentucky coffeetree germplasm throughout the species native range.
IA	Soil, Water, and Air Resources Research	Multiple presentations on the nature of humic products as biostimulants at annual meeting of the Humic Products Trade Association, a network of crop consultants, Ontario Fruit and Vegetable Convention, and for Ag Logic Distributors.
ID	Range Sheep Production Efficiency Research	Presented a webinar "Getting the Most Out of Your Vaccination Program" hosted by the American Sheep Industry Association. Registrants were from 46 U.S. states, six provinces of Canada, and three countries. After the webinar, approximately 20 webinar participants contacted the ARS location for further guidance on vaccinations programs for sheep.
KY	Forage-Animal Production Research	Participated in the 2019 "Annual Beef Bash" hosted by the University of Kentucky with a forage research presentation and tour stop.

LA	Sugarcane Research	Hosted the 2019 LSU AgCenter Terrebonne/Lafourche Parish Field Day. The field day showcased research on sugarcane variety development, weed control technology, precision agriculture, and billet planting cultural practices.
LA	Sugarcane Research	Presentation on cover crops and soil compaction at Louisiana State University's 2019 Iberia/Vermilion/St. Mary Sugarcane Field Day.
LA	Sugarcane Research	Presented research on "Billet Planting" at the 50th Annual Assumption Parish Sugarcane Field Day.
MD	Animal Genomics and Improvement Laboratory	Presentation on identifying the optimal test period to estimate feed efficiency using residual feed intake in dairy cattle to Select Sires, Inc. and other dairy industry stakeholders.
MD	Animal Production and Protection National Program	Presentation on transboundary animal diseases and defense research at Kansas State University's "BSL-3 (biosafety level) Summer Training Program."
MD	Animal Production and Protection National Program	Met with stakeholders from the Maryland Eastern Shore to discuss the issues and challenges facing oyster aquaculture in the Chesapeake Bay, including areas where ARS research programs could provide assistance, with an emphasis on genetic improvement.
MD	Animal Production and Protection National Program	Participated in the National Institute for Animal Agriculture Antibiotic Symposium. Presented an update of ARS research programs. Meeting attendees included other federal agencies, livestock and pharmaceutical industries, and state and local animal health officials.
MD	Animal Production and Protection National Program	Hosted the National Bio and Agro-Defense Facility (NBAF) Stakeholders and Partnerships Conference and gave presentations on ARS animal health research programs.
MD	Animal Production and Protection National Program	Participated in the Keep Antibiotics Working Coalition group meeting to discuss alternatives to antibiotics and antimicrobial resistance research.
MD	Animal Production and Protection National Program	Presentation on "Overview of USDA/ARS Veterinary, Medical, and Urban Entomology Program" at the Vector Management Workshop, sponsored by the Taiwan Pest Control Association and Asian Society of Vector Ecology.
MD	Animal Production and Protection National Program	Presentation on "Potential for New Genetics Techniques to Enhance Catfish Production" at the Catfish Farmers of America Annual Convention.
MD	Animal Production and Protection National Program	Participated in the National Pork Board, National Pork Producers Council, and the American Association of Swine Veterinarians Meeting and presented information on ARS research programs.

MD	Animal Production and Protection National Program	Presentation on "Research Priorities and the Implementation of Prevention and Control Measures in the United States" at the African Swine Fever (ASF) Workshop.
MD	Crop Production and Protection National Program	Met with members of the National Barley Growers Association to discuss their 2019 research needs and policy priorities for the U.S. Wheat & Barley Scab Initiative and Small Grains Genomic Initiative.
MD	Crop Production and Protection National Program	Met with Washington State Potato Council members to update ARS research activities.
MD	Crop Production and Protection National Program	Co-led trilateral workshop with Mexico and Canada on topics related to plant viruses and vector-borne viruses of crops of interest to all three countries.
MD	National Agricultural Library Digitization and Access Branch	Highlighted Special Collections and National Agricultural Library Materials with the Reference and the Food and Nutrition Information Center at the USDA Farmers Market.
MD	National Agricultural Library Digitization and Access Branch	Presented Special Collections materials for the USDA History Wikipedia Edit-a-thon and assisted wikimedians with resources.
MD	National Agricultural Library Information and Customer Services Branch	Multiple demonstrations to many stakeholder groups of DigiTop and other NAL services and resources.
MD	National Agricultural Library Information and Customer Services Branch	Conducted training on searching and retrieving information using the Business Source Premier database.
MD	National Agricultural Library Information and Customer Services Branch	Multiple demonstrations to many stakeholder groups of the iThenticate anti-plagiarism software which compares manuscripts with published documents.
MD	National Agricultural Library Information and Customer Services Branch	Conducted training for librarians on NAL services and resources from behind the scene.
MD	National Agricultural Library Information and Customer Services Branch	Conducted training of SAGE Research Methods database for DigiTop Liaisons and library staff.
MD	National Agricultural Library Information and Customer Services Branch	Demonstration of the National Invasive Species Information Center website and other information services to APHIS employees.
MD	National Agricultural Library Information and Customer Services Branch	Presented an exhibit booth at the 2019 Annual Agriculture Outlook Forum with information on and demonstrations of resources and services available from the library.

MD	National Agricultural Library Information and Customer Services Branch	Provided a webinar to the Department of Defense on literature searches and the history of the Animal Welfare Act.
MD	Natural Resources and Sustainable Agricultural Systems National Program	Participated in Soil Health Champion "Coffee" at the National Association of Conservations Districts.
MD	Nutrition, Food Safety, and Food Quality National Program	Discussed ARS research on innovative new uses of corn with the National Corn Growers Association Board.
MD	Nutrition, Food Safety, and Food Quality National Program	Discussed ARS research on innovative new uses of soft wheat with the wheat quality council, Eastern wheat workers, and Southern small grain workers.
MD	Nutrition, Food Safety, and Food Quality National Program	Discussed Nutrition, Food Safety and Quality Research Program accomplishments to university and industry stakeholders.
MD	Nutrition, Food Safety, and Food Quality National Program	Gave a presentation to PNC Bank agricultural leaders on ARS research on innovative new uses of food, fibers, and biorefining.
MD	Nutrition, Food Safety, and Food Quality National Program	Presentation to Dow Chem, Corning Glass, and Sherwin/Williams representatives on ARS research on innovative new uses of food, fibers, and biorefining.
MD	Nutrition, Food Safety, and Food Quality National Program	Participated in a University of Mississippi workshop on natural products to combat microbial resistance.
MD	Office of Associate Administrator	Participated in the National Alfalfa and Forage Alliance board meeting with farmers, industry and university partners.
MD	Office of Technology Transfer	Hosted a webinar on a "Farmer Round Table Discussion: Organic Row Crop Production."
MD	Office of Technology Transfer	Participated in the annual meeting of the National Association for Community College Entrepreneurship providing information on ARS research and technologies available for licensing.
MD	Office of Technology Transfer	Participated in the annual meeting Maryland Technology Development Corporation (TEDCO) providing information on ARS research and technologies available for licensing.
MD	Office of Technology Transfer	Participated in the "Lower Shore Maryland Industry Day" providing information on ARS research and technologies available for licensing.
MD	Office of Technology Transfer	Participated in the "Upper Shore Maryland Industry Day" providing information on ARS research and technologies available for licensing.

MD	Office of Technology Transfer	Participated in the annual meeting of RuralRise providing information on ARS research and technologies available for licensing.
MD	Office of Technology Transfer	Participated in SBIR Roadshow to Northeast providing information on ARS research and technologies available for licensing.
MD	National Agricultural Library	Presentation at the Federal Depository Library Program (FDLP) Conference on services and resources available from NAL.
MD	National Agricultural Library	Held an open house to celebrate the 50th Anniversary of the NAL at its current location on the Henry A. Wallace Beltsville Agricultural Research Center campus.
MD	National Agricultural Library	Participated in a webinar on "Open Data and the Ag Data Commons" hosted by Auburn University.
MD	National Agricultural Library Scientific Data Management Branch	Hosted a training webinar on the i5k Workspace to introduce users to the concepts of manual annotation and the Apollo software.
MD	National Agricultural Library Scientific Data Management Branch	Held a workshop on the process of manual annotation and the Apollo software at 2019 Arthropod Genomics Symposium.
ME	National Cold Water Marine Aquaculture Center	Hosted the Maine Hatchery Roundtable which focused on spawning and included invited speaker discussing genomic selection tools and how they are implemented in fish breeding programs such as the catfish program, sterilization techniques, cryopreservation of milt and review of spawning techniques.
MI	Sugarbeet and Bean Research	Participated in the Saginaw Valley Research and Extension Center's annual field day presenting ongoing research efforts and disease issues in the region.
MN	Soil and Water Management Research	Presented research on how denitrifying bioreactors can reduce agricultural drainage nitrate losses at a Soil and Water Conservation District meeting. Attendees included consulting engineer, contractor, and industry personnel.
MN	Soil and Water Management Research	Presentation on the impact of biochar on soil moisture interactions and magnetic field effects at the Intensive Biochar Workshop.
MN	Soil and Water Management Research	Presentation on soil health and testing options that can assist non-operating landowners in discussing management options with renters at "Digging Deeper: Managing for Stewardship Workshop".
MS	Cotton Ginning Research	Tour and demonstration of microgin to retired textile industry researchers.
MS	Cotton Ginning Research	Hosted a research tour for the 2019 American Cotton Shippers Association International Cotton Institute.

MS	Crop Genetics Research	Interviewed in a video for the Mississippi Soybean Promotion Board that highlighted research on mature seed damage and heat tolerance in soybean.
MS	Southern Horticultural Research	Held "Blueberry Field Day" for current growers and potential growers.
MT	Agricultural Systems Research	Hosted a joint Federal and State "Dryland Field Day."
MT	Agricultural Systems Research	Participated in the "Froid Field Day with on presentations on weed ID, weed management, and biocontrol.
MT	Range and Livestock Research	Held the Annual Customer Focus Group to discuss current research and what research would be useful in the future.
MT	Range and Livestock Research	Presentation on "Water mineral content: How important is it to cattle mineral nutrition and well-being?" to the public during two separate workshops.
NE	Office of the Director	Hosted the Beef Focus Group meeting. Presentations were given on current research and discussions took place to determine the best course of action moving forward. Input from stakeholders was received.
NM	Cottoning Ginning Research	Provided a ginning demonstration at the New Mexico State Fair.
NM	Cottoning Ginning Research	Hosted eight Cochran Fellows from Malawi as part of a New Mexico State University sponsored workshop for a gin tour and presentation on cotton and ARS research.
NM	Range Management Research	Workshop and field training of the Assessment Inventory Monitoring (AIM).
NM	Range Management Research	Provided training on brush monitoring training to technical service providers.
NM	Range Management Research	Provided training on climate CoCoAH to the Navajo Nation Farm Board.
NM	Range Management Research	Participated in the New Mexico NRCS "Prescribed Grazing Workshop."
NM	Range Management Research	Participated in the Ecological Side Description (ESD) State Group Meeting.
NM	Range Management Research	Hosted the 2019 Interpreting Indicators of Rangeland Health workshop.
NM	Range Management Research	Presentation on "Interpreting and Measuring Indicators of Rangeland Health" for Bureau of Land Management, NRCS, U.S. Forest Service employees, university students, and international visiting scientists.
NM	Range Management Research	Participated in the Jornada Field Botany Workshop attended by university faculty and the local community.

NY	Emerging Pests and Pathogens Research	Participated in the NY State Farm Show with a booth highlighting ARS research and hands-on insect exhibits.
OH	Application Technology Research	Presentation and demonstration on "Intelligent Sprayer Technologies to Improve Pesticide Application Efficiency in Orchards" at the Intelligent Spray Technologies and Systems Workshop organized by Penn State Fruit Research and Extension Center.
OH	Application Technology Research	Multiple presentations on "Ambrosia Beetle: Identification, Biology, Behavior, Monitoring, and Management" at the Bartlett Tree Experts & Old Westbury Gardens Annual Horticultural Forum and Annual Meeting of the Virginia Nursery and Landscape Association.
OH	Application Technology Research	Presentation on "Perfecting your pour-through procedure" to leading greenhouse growers and allied industry members at the Floriculture Research Alliance annual meeting.
OH	Application Technology Research	Met with Northwest Ohio horticultural producers to discuss horticultural research initiatives and present the next 5 years of research objectives.
OH	Application Technology Research	Presentation on "Selecting silicon amendments for soilless substrates" to leading greenhouse growers and allied industry members at the Floriculture Research Alliance annual meeting.
OH	Corn, Soybean, and Wheat Quality Research	Met with the Ohio Corn & Wheat Growers Association, Ohio Corn Marketing Program and Ohio Small Grains Marketing Program. Discussions were held one-on-one and in small groups regarding ARS research.
OH	Corn, Soybean, and Wheat Quality Research	Presentation of results on wheat virus resistance testing a diversity panel of soft red winter wheat to the Ohio Small Grains Marketing Program board.
OH	Soil Drainage Research	Presented on the importance and basic techniques for conducting ecological evaluations of the effects of conservation practices on fishes within agricultural streams at a field day held within the Upper Big Walnut Creek.
OH	Soil Drainage Research	Invited participant at the Woolpert Client Panel Discussion III with approximately 20 participants (industry and government) from across the country who met to discuss needs and issues related to aerial/satellite imagery and geographic information systems.
OH	Soil Drainage Research	Participated in the 2019 Conservation Tillage and Technology Conference and presented research on "UAVs as a Tool for Tile Mapping."
OH	Soil Drainage Research	Presented ongoing science and research on water quality to fertilizer industry representatives at the Fertilizer Outlook Technology Conference.
OH	Soil Drainage Research	Presented water quality findings from the USDA-ARS Edge-of-field Network to multiple groups, including NRCS, Ohio

		Farm Bureau, Pennsylvania Farm Bureau, Seneca County Conservation District, 4R Summit, Ohio State University (OSU) Agronomic Field Day, OSU Precision Agriculture Workshop, Harmful Algal Blooms State of the Science Conference, and AG Solutions annual meeting.
OH	Soil Drainage Research	Presentation on "Effects of Manipulating Ca:Mg Ratios on Ohio Crop Yields and Soil Health" at the Conservation Tillage and Technology Conference.
OK	El Reno Research Center	Co-hosted with Sure Crop Fertilizer, NRCS, Oklahoma Association of Conservation Districts and Oklahoma Land Stewardship Alliance a Central Oklahoma Soil Health Seminar to facilitate soil health outreach activities to regional producers and agriculture professionals.
OK	Great Plains Agroclimate and Natural Resources Research	Hosted the International Agroecosystems Living Laboratories working group. Working group includes representatives from 12 countries, under the auspices of the G-20. Presented Long-Term Agroecosystem Research (LTAR) research activities.
OK	Great Plains Agroclimate and Natural Resources Research	Organized the "Wildfire Suppression Through Prescribed Fire Workshop" in partnership with NRCS, Oklahoma Cooperative Extension and the Cheyenne & Arapaho Tribes. Eighteen fire departments from across Oklahoma participated.
OK	Great Plains Agroclimate and Natural Resources Research	Hosted the 2019 High Plains Technical Workshop on Drought Monitoring. The workshop included 25 attendees from 8 states who collectively identified a set of science and services recommendations to improve drought monitoring and impact reporting in the High Plains region.
OK	Hydraulic Engineering Research	Participated in Oklahoma NRCS meeting to discuss ARS stepped spillway design criteria.
OK	Hydraulic Engineering Research	Participated in National Dam Safety Review Board and Interagency Committee on Dams Meeting.
OK	Hydraulic Engineering Research	Participation in the Oklahoma Water Resources Center Advisory Board Meeting.
OK	Hydraulic Engineering Research	Exhibited at the Oklahoma Association of Conservation Districts Annual State Meeting. Interacted with stakeholders and provide information on current research.
OK	Hydraulic Engineering Research	Presentation at the University of Oklahoma's Water Day.
OK	Hydraulic Engineering Research	Presentation and host of the NRCS Oklahoma Engineering and Conservation Engineering Technician Meeting.
OK	Hydraulic Engineering Research	Presentation on dam research to the Federal Emergency Management Agency (FEMA) National Interagency Committee.

OK	Hydraulic Engineering Research	Hosted the Oklahoma NRCS Conservation Book Camp with field presentations.
OK	Hydraulic Engineering Research	Presentation at the U.S. Army Corps of Engineers Hydraulic Structures Workshop.
OK	Rangeland and Pasture Research	Co-hosted with the Oklahoma State Extension Service "Range Research Field Day" with presentations on using wheat pasture in a cow/calf enterprise; new technologies for measuring efficiency of beef cattle; soil and vegetation change from 75+ years of no grazing or fire'; and other topics.
OK	Rangeland and Pasture Research	Held the annual "Chilcott Conference/Stakeholder Meeting."
OK	Rangeland and Pasture Research	Participated in the Northwest Oklahoma Cattleman's Foundation trade show and presented information on ARS research.
OK	Rangeland and Pasture Research	Presentations at the 5-State Beef Conference to producers on current research.
OK	Rangeland and Pasture Research	Presentation on mineral supplementation of growing cattle grazing wheat pastures at the Oklahoma State University's Marshall Wheat Pasture Research Unit Field Day.
OR	Horticultural Crops Research	Held training on the grapevine red blotch loop-mediated isothermal amplification (LAMP) reaction detection method.
OR	Horticultural Crops Research	Presentation on alternative management strategy for spotted wing drosophila for OR and WA blueberry growers at an Oregon State University field day.
OR	Horticultural Crops Research	Met separately with the Oregon Blueberry Commission and the Washington Blueberry Commission to discuss ARS research and stakeholder needs.
OR	Horticultural Crops Research	Met with stakeholder to discuss management of gray mold disease with fungicides and shelters.
OR	Horticultural Crops Research	Presentation at Washington Red Raspberry Commission to discuss ARS research and stakeholder needs.
OR	Horticultural Crops Research	Met with stakeholders to plan research on management of mummy berry disease of blueberry in organic production systems.
OR	Horticultural Crops Research	Met with stakeholders to discuss research on the control of crown gall in blueberry.
OR	Horticultural Crops Research	Met with stakeholders to examine outbreak of cane diseases of blackberry and discuss research approaches.

OR	Horticultural Crops Research	Participated in the Oregon Wine Symposium and Grape Industry Meeting to discuss grape quarantine and certification changes proposed for the Pacific Northwest as part of Clean Plant Program.
OR	Horticultural Crops Research	Participated in the Willamette Valley Grape Growers meeting to discuss Grapevine Red Blotch Virus.
OR	Horticultural Crops Research	Met with stakeholders to discuss virus complexes in blueberry and increased disease severity.
OR	Horticultural Crops Research	Participated in the Oregon Association of Nurseries meeting to discuss research interests and concerns of Oregon's boxwood nursery industry regarding boxwood blight.
OR	Horticultural Crops Research	Presentation on future technology advances in viticulture to the California Association of Winegrape Growers.
OR	Horticultural Crops Research	Presentation on fungicide resistance at Oregon Raspberry and Blackberry Growers Annual Meeting.
OR	Horticultural Crops Research	Presentation on Red Blotch epidemiology at Oregon State University's Extension's Grapevine Red Blotch Workshop.
OR	Horticultural Crops Research	Presentation about risks of fungicide resistance and spread of soilborne pathogens in the nursery industry at an ornamental workshop.
OR	Horticultural Crops Research	Presentation about management alternatives for spotted wing drosophila at Cherry Day for cherry growers in OR and WA.
OR	National Clonal Germplasm Repository	Hosted the curator for the Chinese strawberry collection from Beijing Academy of Forestry and Pomology Sciences for a 3 -month study on strawberry conservation techniques.
PA	Pasture Systems and Watershed Management Research	Participated in the Pennsylvania Ag Progress Days. Ag Progress Days is a three-day educational outreach event held in Centre County, PA that is attended by approximately 46,000 producers and the general public. ARS exhibits featured riparian management options; inter-seeding cover crops for early establishment; the MAPHEX (MAnure PHosphorus EXtraction) Manure Treatment System; and the location' participation in the Long-Term Agroecosystem Research network and the Northeast Climate Hub.
PR	Tropical Crops and Germplasm Research	Hosted a group of teachers to learn more about tissue culture techniques. The group is part of a NASA project subcontracted through the Fairchild Tropical Botanic Gardens where they are doing research on the Space Veggies program or Growing Beyond Earth (GBE), in order to provide astronauts with the right kind of veggies which can be grown in small greenhouses in their flight cabins.

SC	Coastal Plain Soil, Water and Plant Conservation Research	Held the annual Customer/Partner Dialogue Workshop. Approximately 60 stakeholders from academia, federal agencies, industry, commodity groups, and farmers attended. Stakeholders spent time with individual scientists discussing research findings, and formal presentations were made pertaining to new research on soybean and cotton enhancement productivity with lower environmental impact.
TX	Grassland, Soil, and Water Research	Presentation on ARS oats, wheat, and barley trials at the "Bell County Central Texas Small Grain Field Day."
UT	Forage and Range Research	Participated in the "Upper Sevier Watershed Tour and Utah State University Pasture Walk."
UT	Forage and Range Research	Participated in stakeholder meeting presenting research on perennial agriculture.
UT	Forage and Range Research	Participated in the Central Utah Grazing Expo.
UT	Poisonous Plants Research	Presented information on poisonous plants to stakeholders and disseminated USDA Poisonous Plant Bulletin 415.
UT	Poisonous Plants Research	Hosted a booth at the Society for Range Management Meeting to answer questions and discuss poisonous plants.
WA	Physiology and Pathology of Tree Fruit Research	Participated in field day at the Washington State University Tree Fruit Research and Extension Center's Sunrise research orchard. Discussed ongoing research characterizing apple fruit maturation with stakeholders, research, and extension personnel.
WA	Physiology and Pathology of Tree Fruit Research	Multiple presentations on apple and pear fruit postharvest management with growers and warehouse personnel from Washington state, Pacific Northwest Pear Committee Research Review, and a group of growers and research personnel from Tajikistan.
WA	Wheat Health, Genetics, and Quality Research	Presentation on "Diversifying the Wheat Portfolio of the Pacific Northwest" as part of the 2018 Washington State University Wheat Academy. Topics included variety development, Asian noodles, waxy wheat cereal, and soft kernel Durum wheat.
WV	Innovative Fruit Production, Improvement, and Protection	Assisted in WVU Extension and Berkeley and Jefferson County Master Gardeners Tomato Fest.
WV	Innovative Fruit Production, Improvement, and Protection	Met with growers and industry representatives from at least five states and programs to learn about the research programs and advances at the Appalachian Fruit Research Station.
WV	Innovative Fruit Production, Improvement, and Protection	Presented a webinar "Transforming Pixels to Millimeters: Geometric Camera Calibration" hosted by the American Society of Plant Biologists.

WV	Innovative Fruit Production, Improvement, and Protection	Presentation to the Young Growers Alliance at the mid-Atlantic Fruit and Vegetables Convention and discussed mechanisms for sustainability managing invasive species.
WV	Innovative Fruit Production, Improvement, and Protection	Presentation on how to manage brown marmorated stink bug to approximately 50 fruit growers in Connecticut.
WV	Innovative Fruit Production, Improvement, and Protection	Presented several workshops at the 167th Air Guard Base on fruit tree pruning; planting and care of fruit trees; care and maintenance of small fruit crops; and grafting of apple trees using different budding techniques as part of the Patriot Gardens program. This program is intended to get veterans involved or interested in agricultural enterprises.
WV	Innovative Fruit Production, Improvement, and Protection	Presentation on how to manage invasive pests in fruit trees at a Utah State University growers workshop.
WV	Innovative Fruit Production, Improvement, and Protection	Held a workshop on summer pruning of blackberries at Virginia Tech Cooperative Extension Service Twilight Meeting.
WV	Innovative Fruit Production, Improvement, and Protection	Held a field tour to celebrate the 40th Anniversary of the Appalachian Fruit Research Station. More than 100 grower and stakeholder visitors from at least five states and programs toured field plots and learned about ARS research.

3.8. FY 2019 Technology Transfer Award Winners

ARS Technology Transfer Award

Scientist: *Judson V. Edwards*

Title: For development of a cotton-based wound dressing resulting in a commercial product used for battlefield and emergency response applications to trauma.

Federal Laboratory Consortium for Technology Transfer (FLC) Awards (note: the Midwest, Southeast, Far West, and Mid-Continent Regions did not have awards in FY 2019. They moved their FY 2019 Summer meetings to the Fall of the FY 2020).

Laboratory: Meat Animal Research Center

Title: Novel Sampling Methods for Beef Trim Pathogen Testing

Award: National, Excellence in Technology Transfer

Person: James A. Poulos, III

Award: National, Outstanding Technology Transfer Professional

Laboratory: Food Safety and Intervention Technologies Research and Princeton Plasma Physics Laboratory, MD and NJ

Title: Radio Frequency Pasteurization of Shell Eggs

Award: Northeast Region, Excellence in Technology Transfer

Laboratory: National Cold Water Marine Aquaculture Center, ME

Title: Genetic Improvement of Germplasm for the U.S. Atlantic Salmon Industry

Award: Mid-Atlantic Region, Excellence in Technology Transfer

Laboratory: Genetic Improvement for Fruits and Vegetables Laboratory, MD

Title: Pepper Jack, Midnight Creeper & Lil' Pumpkin

Award: Mid-Atlantic Region, Excellence in Technology Transfer

Laboratory: Plum Island Animal Disease Center, NY

Title: A Cell Line Sensitive to Foot and Mouth Disease Virus

Award: Mid-Atlantic Region, Excellence in Technology Transfer

Laboratory: Office of Technology Transfer and NIFA-SBIR Program, MD

Title: SBIR-Technology Transfer Program

Award: Mid-Atlantic Region, Interagency Partnership

Person: James A. Poulos, III

Award: Mid-Atlantic Region, Outstanding Technology Transfer Professional

3.9. Selected Metric Charts.

Figure 1. Number of new and active CRADAs and MTRAs

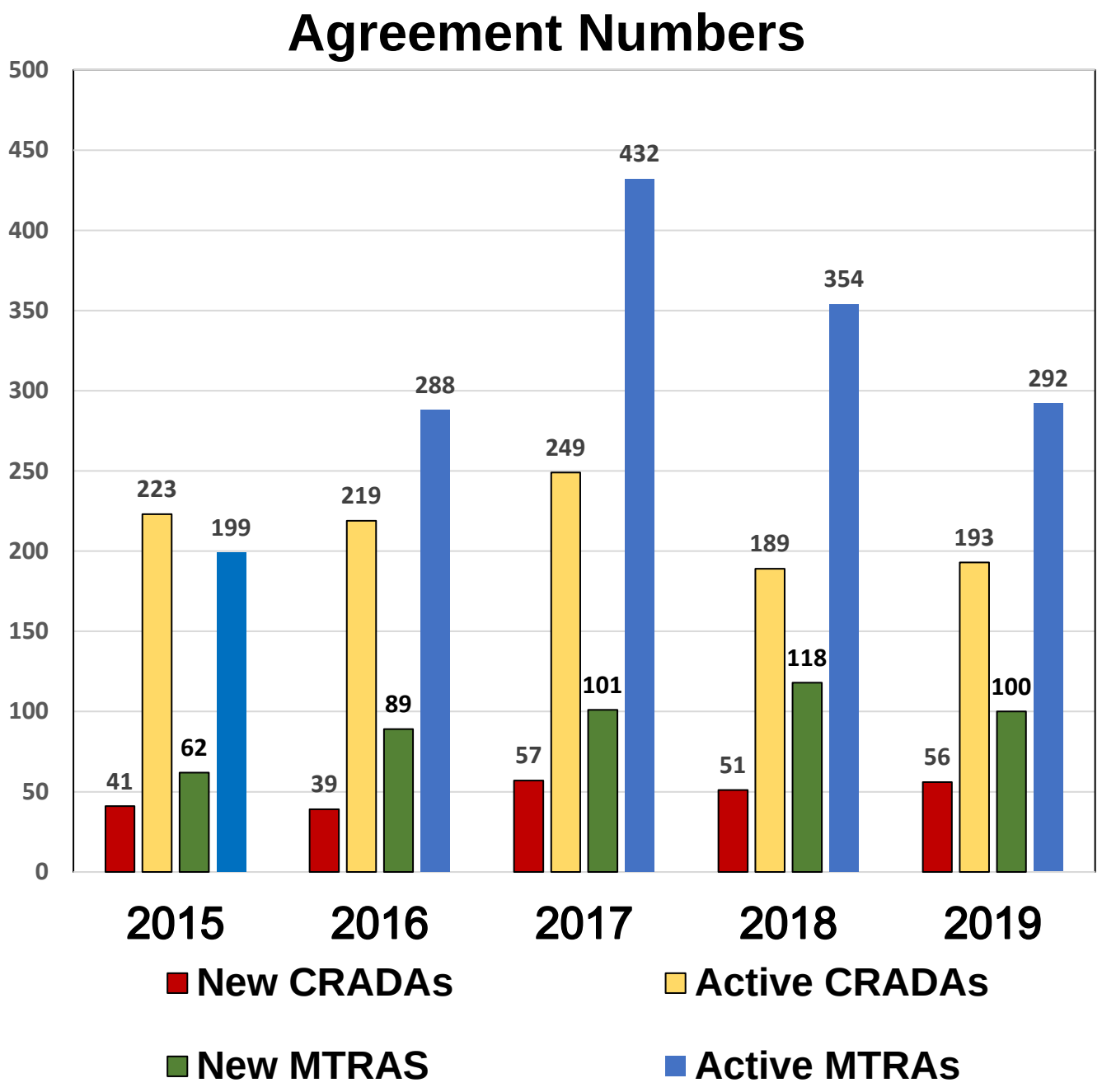


Figure 2. Number of collaborative research agreements (CRADAs, MTRAs, and other agreements, including Trust Fund Cooperative Agreements, Reimbursable Agreements, Interagency Agreements, and Non-Funded Cooperative Agreements) executed by type in FY 2019

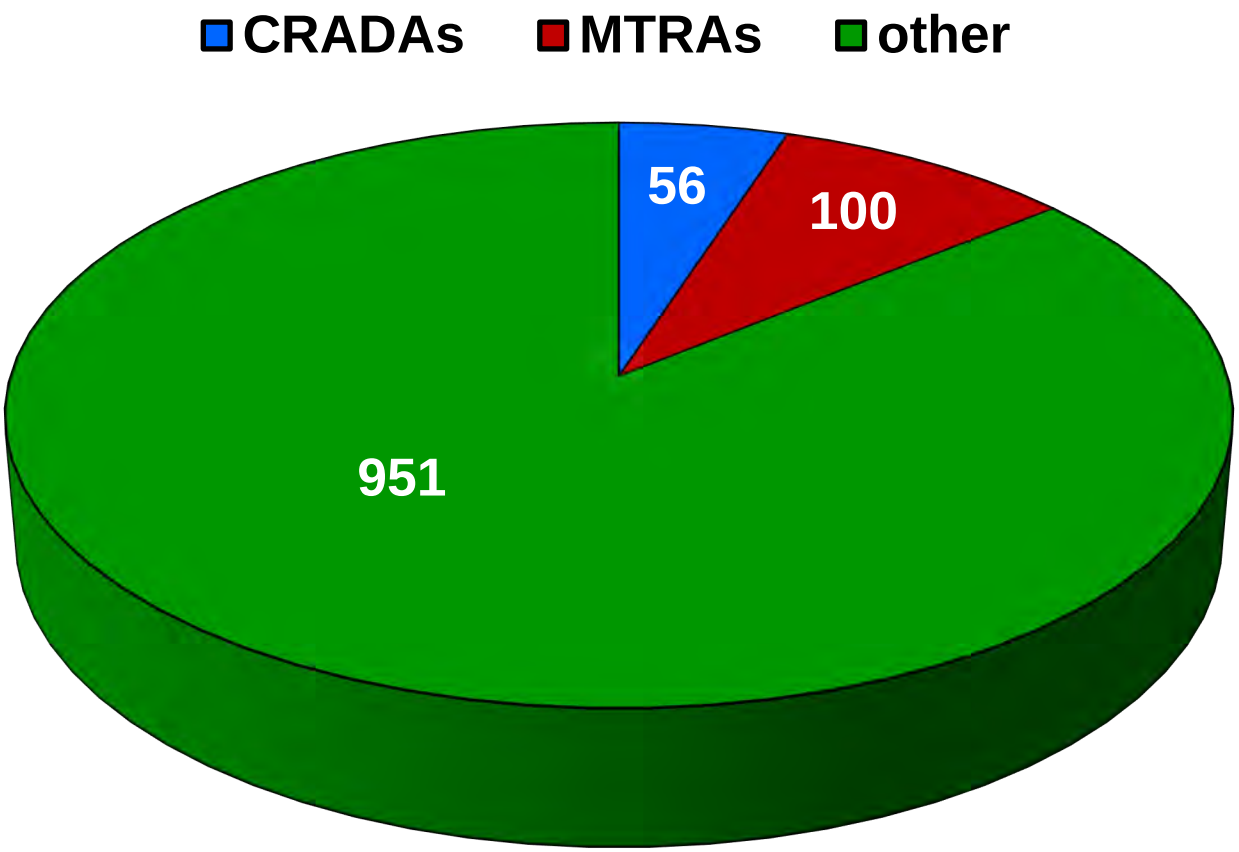


Figure 3. Number of invention disclosures, patent applications filed, and patents issued. The year in which a patent issues is not the year in which the patent is filed. The increase in the number of invention disclosures in FY 2018 was the result of a significant increase in biological materials disclosures.

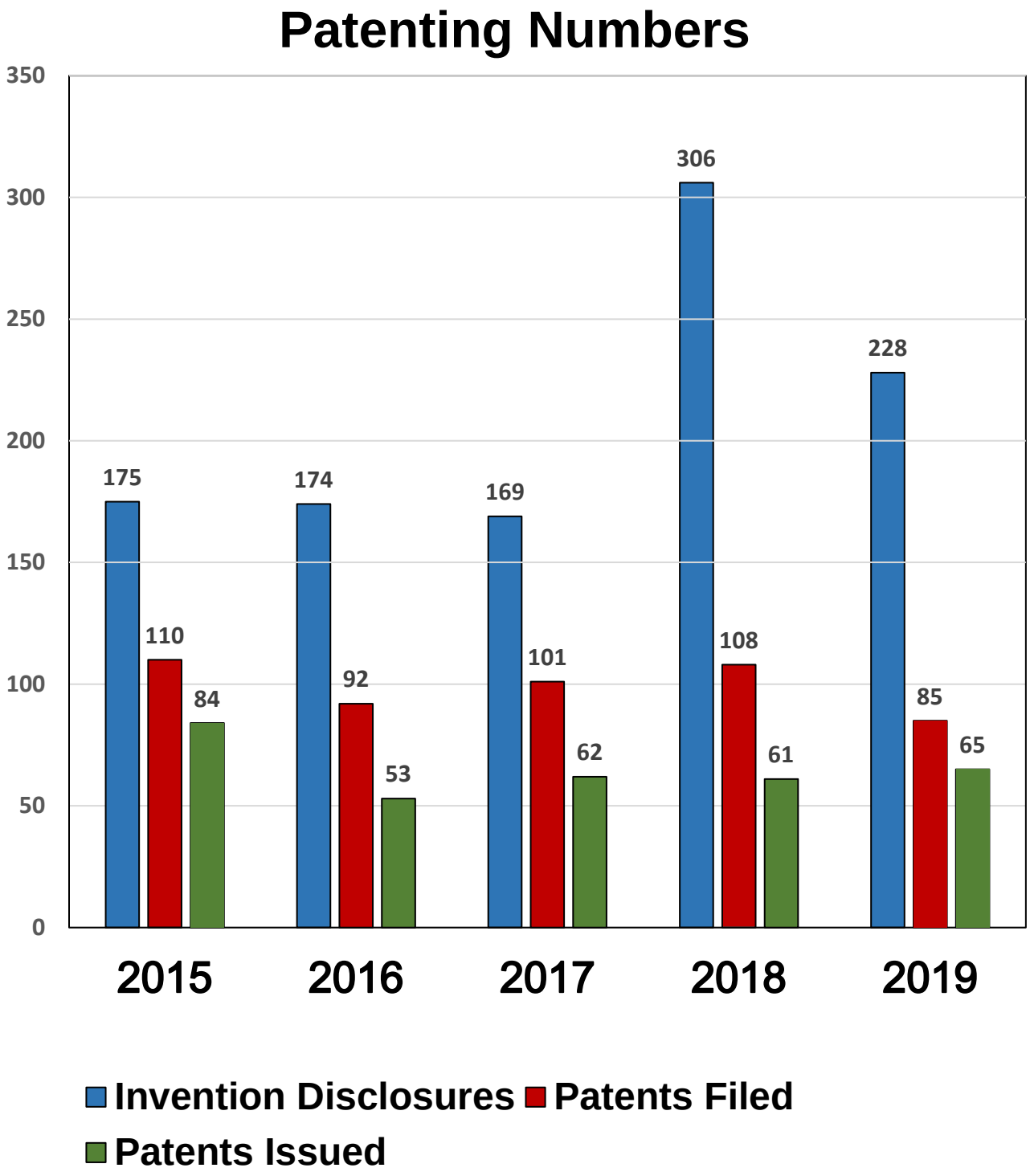


Figure 4. Percentage of patents issued in FY 2019 by scientific discipline

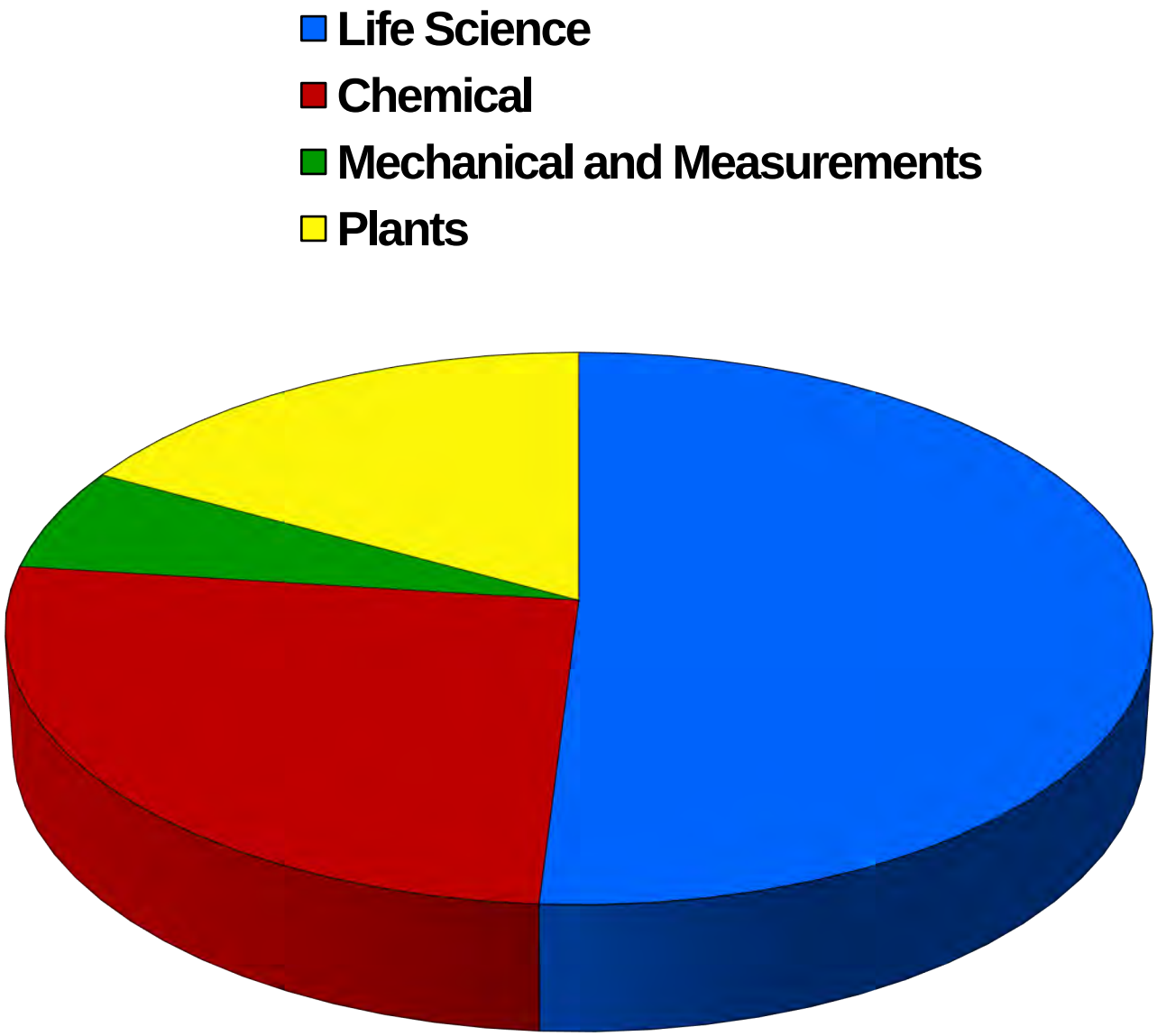


Figure 5. The ratio of patents issued over patent applications filed per year. Although the year in which a patent is issued is not typically the year in which the patent application is filed, over time the ratio of patents issued over the number of patent applications filed is an indicator of "judicious" patenting. Over the last 4 years, this indicator suggests that ~65 percent of the patent applications result in an issued patent.

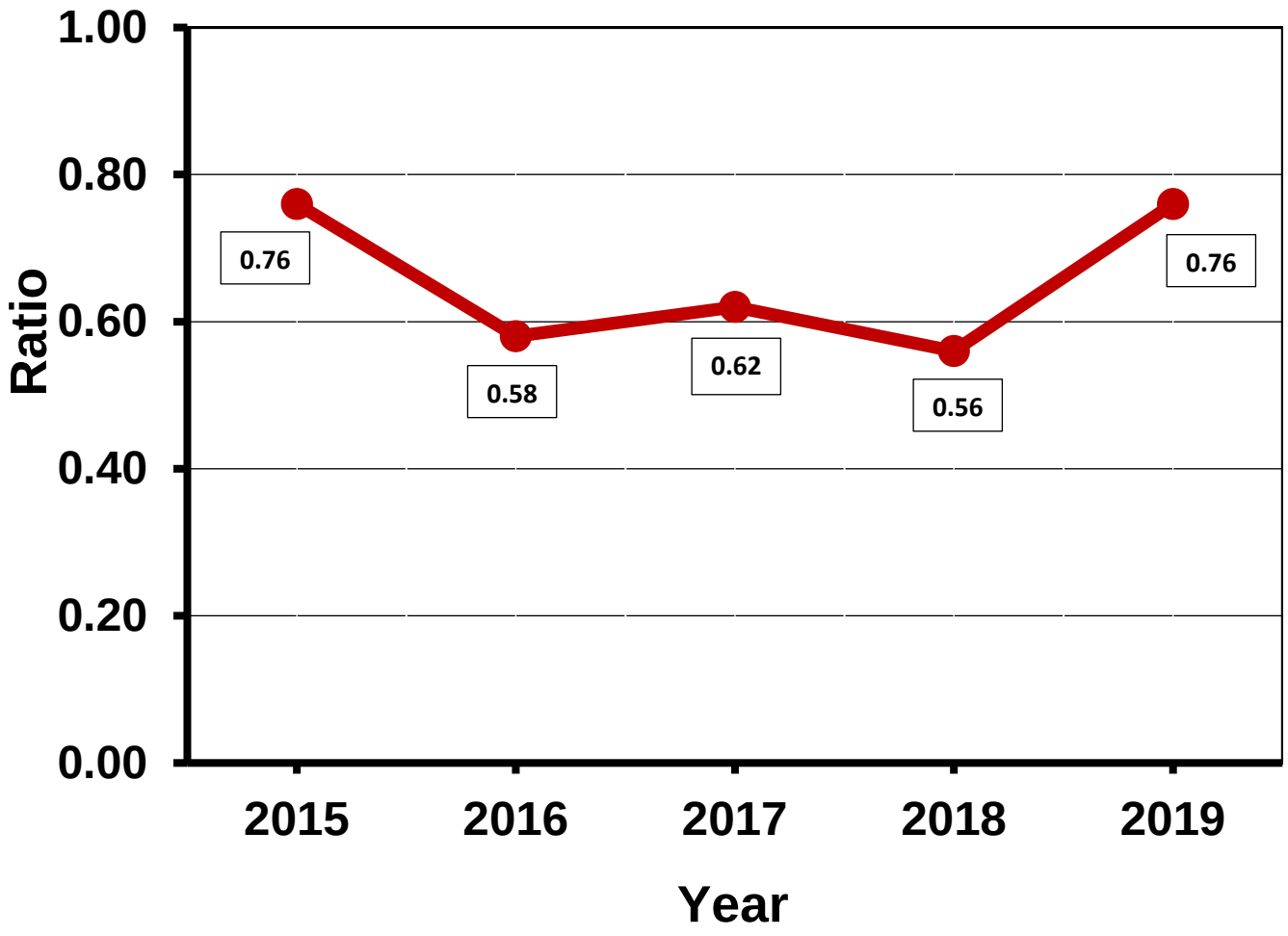


Figure 6. Number of license types per year

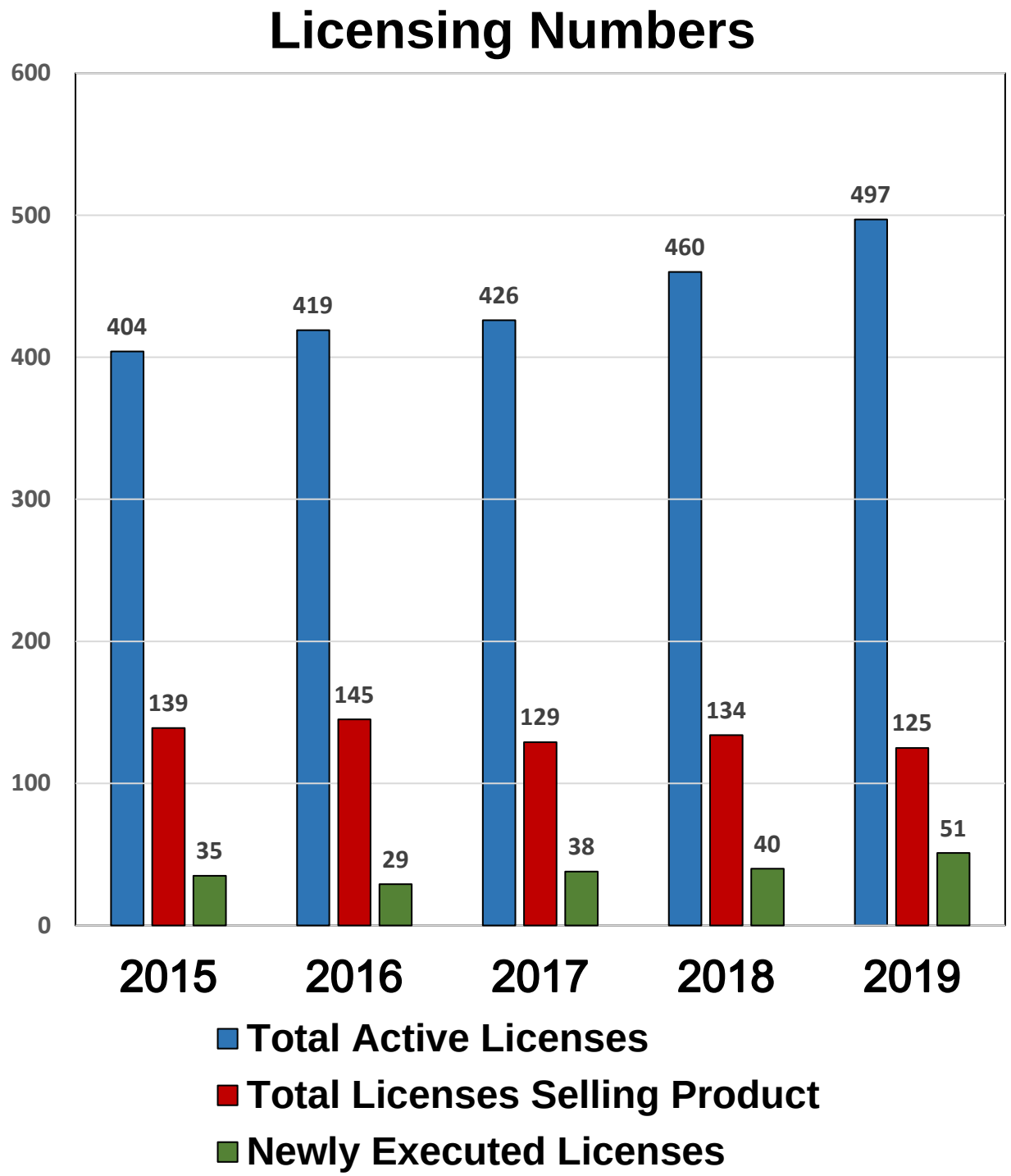


Figure 7. Earned license royalty income (ERI) over time. The lower income in FY 2018 was due to two of the top revenue generating licenses expiring in FY 2017

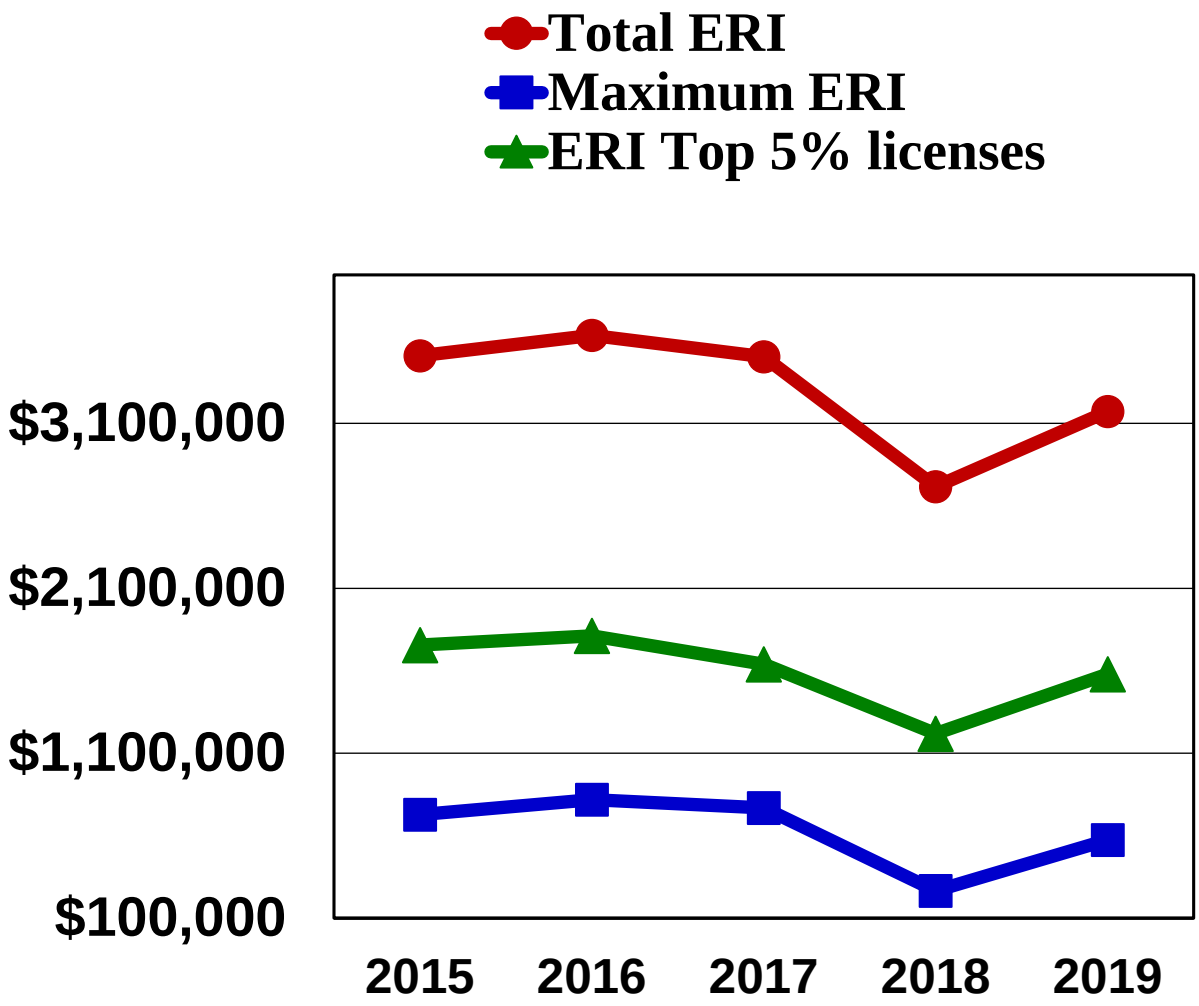


Figure 8. The number of new licenses executed in FY 2019 by business type.

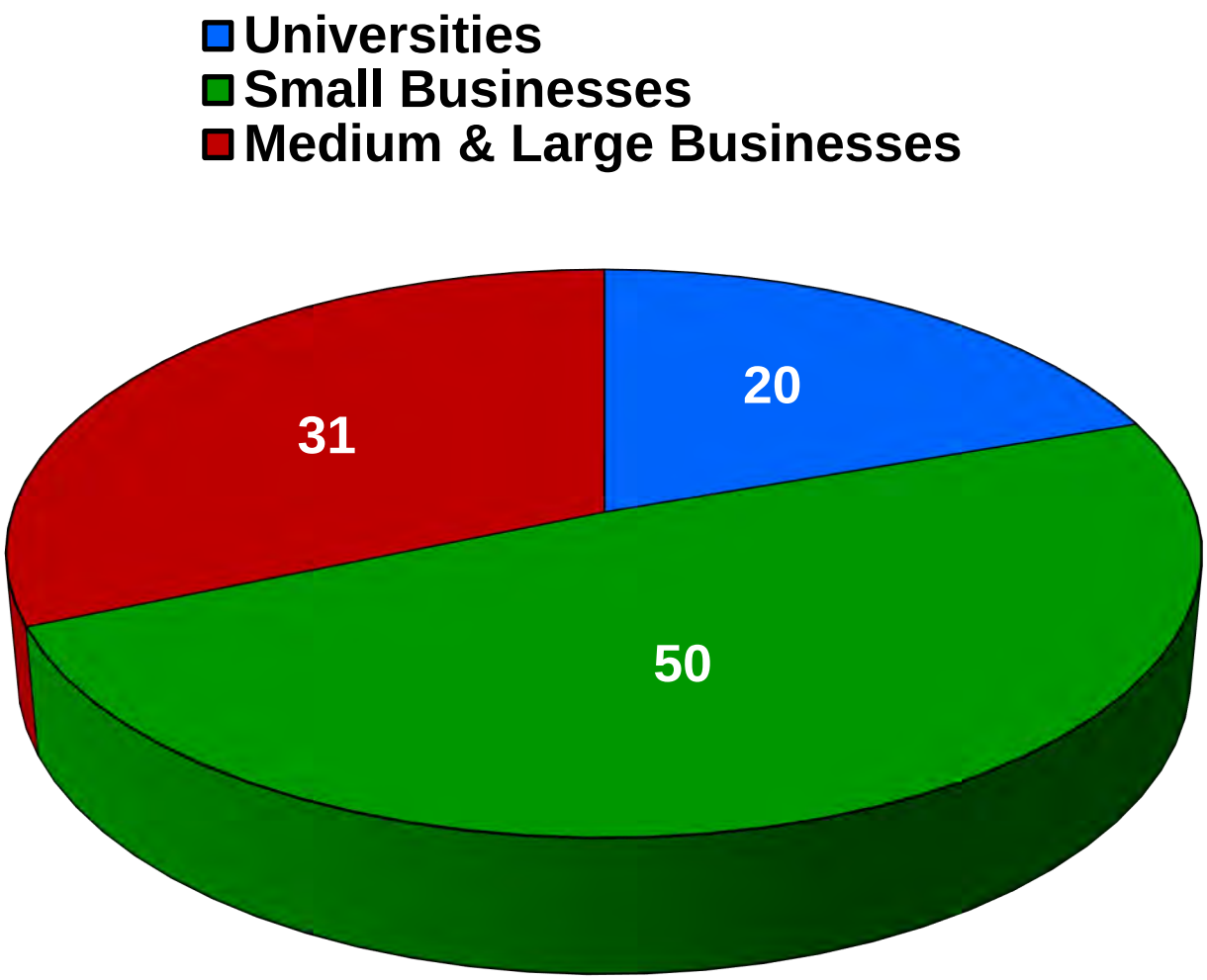


Figure 9. The ratio of newly signed invention licenses over newly issued patents per year. Although the year in which a license is signed is not typically the year in which the patent has issued, over time the ratio of newly signed licenses over the number of newly issued patents is an indicator of "judicious" patenting contemplating among other things commercial viability of the technology. Over the last 4 years, this indicator suggests that ~40 percent of the issued patents are licensed.

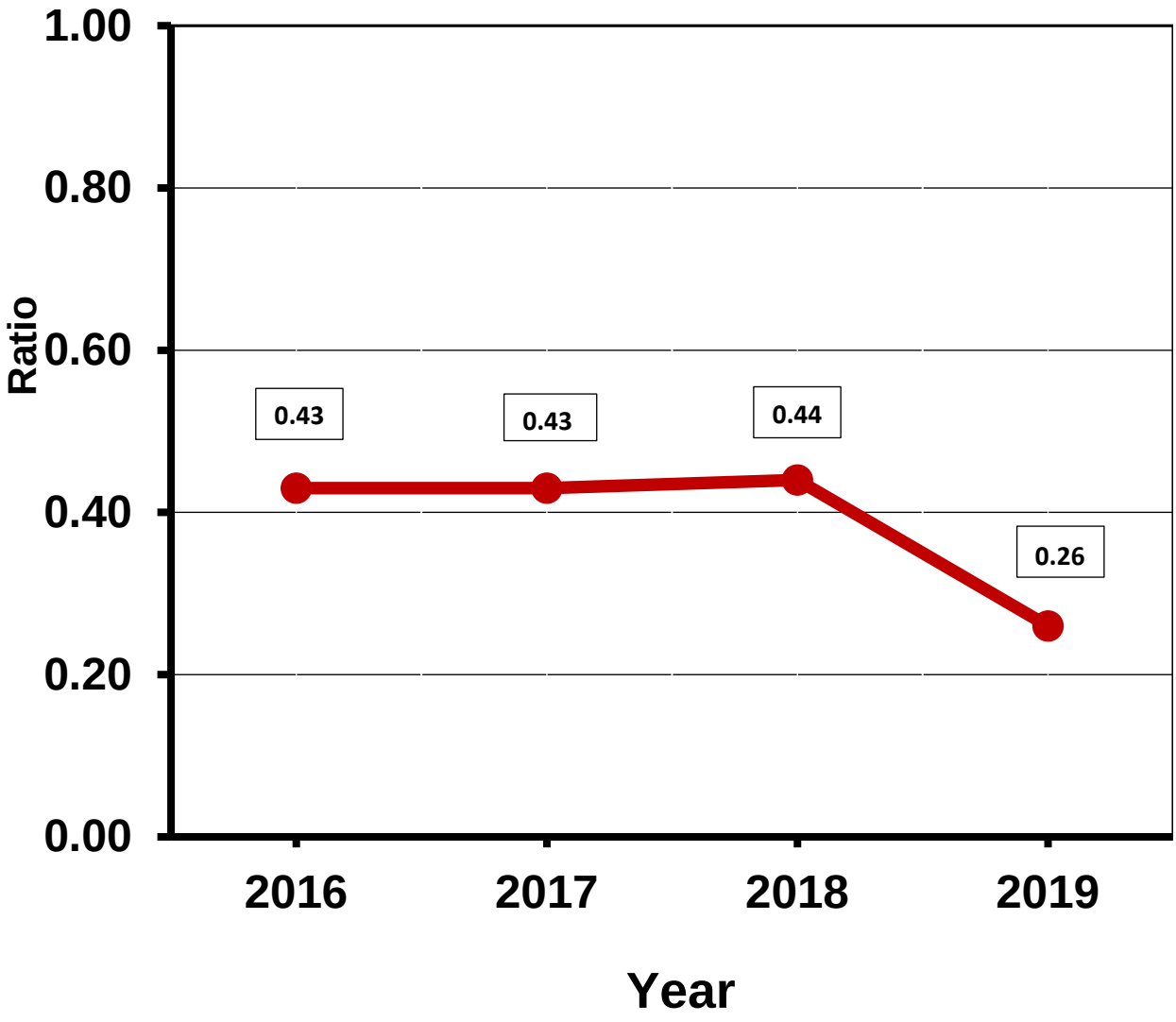
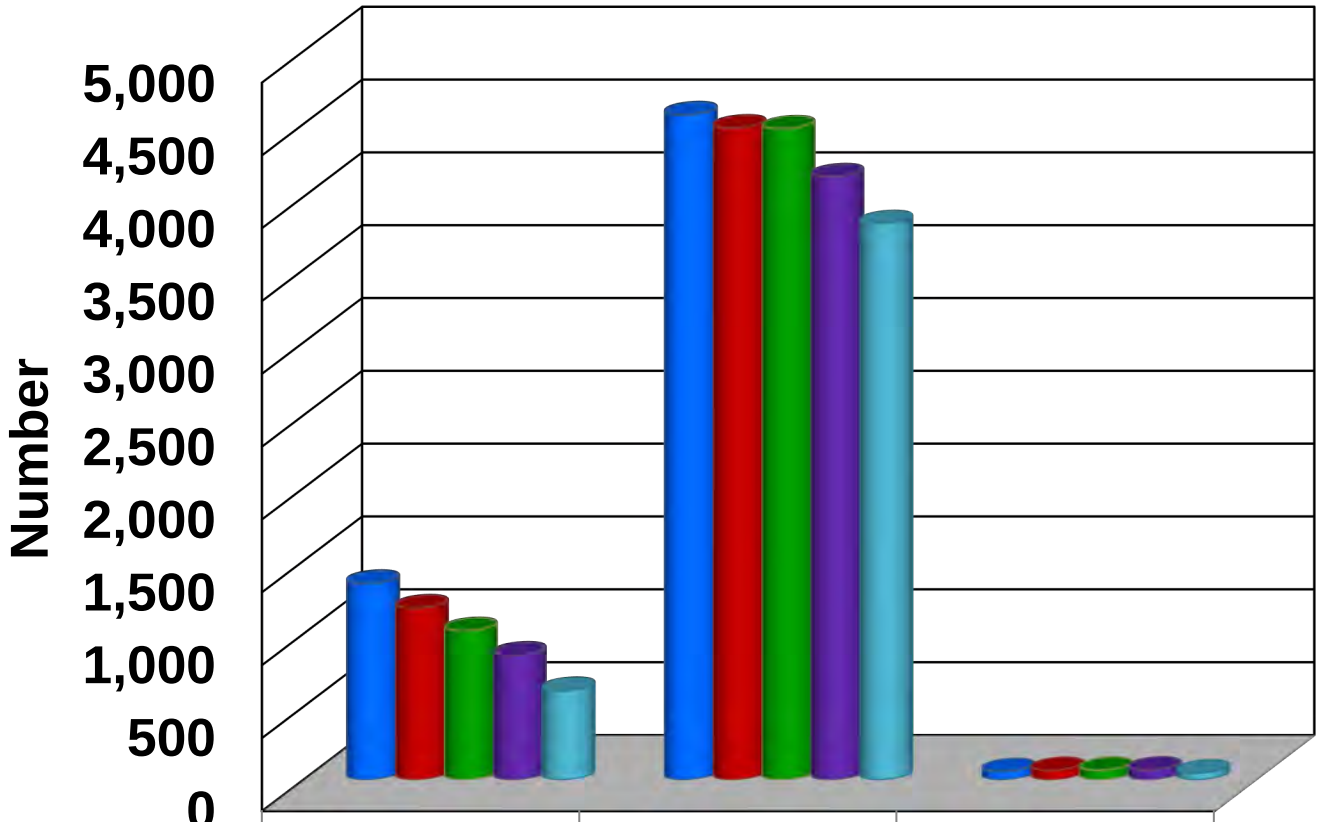


Figure 10. Number of publications per year



	Meeting Abstract	Scientific Journal	Trade Journal
2015	1,347	4,564	57
2016	1,178	4,473	65
2017	1,022	4,467	66
2018	855	4,138	68
2019	612	3,816	48

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 Kansas City, MO and Washington, DC and employs 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 FY19 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. Upgrades made this fiscal year provided improved performance (website is faster, more resilient), security, and efficiency in publishing. New features included simpler, more intuitive navigation; enhanced functionality for mobile users; and improved data dissemination, with new, more interactive user interfaces and new data APIs (Application Programming Interfaces) to enhance information delivery to customers. ERS's concerted efforts also improved on-time posting 5 percentage points to 95% and website Section 508 Accessibility by 39 percentage points.

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 2019 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 2019, 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 32,000 followers in fiscal 2019—up from 29,000 followers in 2018 and 27,000 in 2017. 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 source of data on details of Americans' food purchases and acquisitions – USDA's National Household Food Acquisition and Purchase Survey FoodAPS. Two versions of the data are being made available to the public. The restricted version, which contains all the data elements at the individual level, can be accessed by researchers from academic institutions and government agencies through a secure Data Enclave. The public-use version of FoodAPS, that masks identities of survey respondents, enables access by all interested members of the public to the valuable data for research and planning. FoodAPS is designed to fill a critical knowledge gap to support an evidence-based approach to Federal food assistance policies and programs. It is the only source of data to explain food choice behaviors of Americans that integrates multiple types of information from multiple sources on food, economics, nutrition, health, program participation, and environmental factors. 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. FoodAPS protocol are being improved for the second round to enhance the data quality and accuracy while reducing burden through electronic collection of the information.

- 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. In fiscal 2019, the Atlas was updated with the most recent county-level information on population, employment, poverty, veterans, education, migration, and income from the Census Bureau and the Bureau of Labor Statistics. New features were added to improve functionality and users' ability to delineate rural and urban data for reporting and analysis.

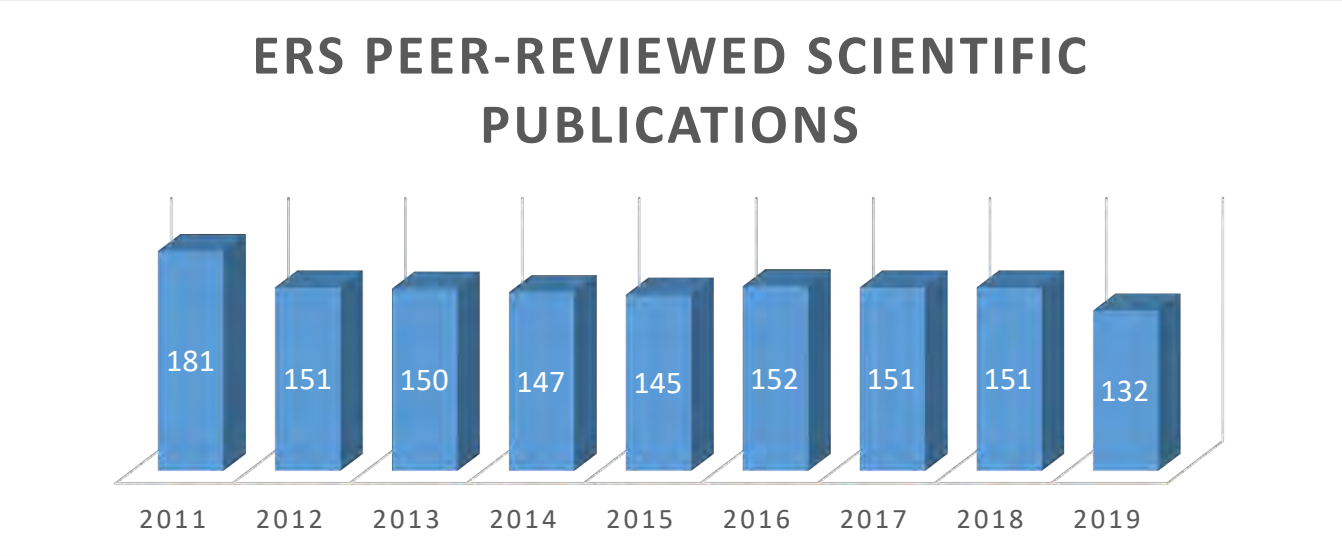
- Local officials throughout the country can easily gauge the characteristics of their food environment and target actions that alleviate problems with the availability of healthy food options for the people in their counties or State using the ERS Food Environment Atlas (http://www.ers.usda.gov/data-products/food-environment-atlas.aspx). 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. The Food Environment Atlas will be updated in winter, 2020.

- 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 8 webinars in FY 2019 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 2019, ERS produced 148 publications (research reports, Outlooks, and Amber Waves articles).


ERS PEER-REVIEWED SCIENTIFIC PUBLICATIONS
181
151
150
147
145
152
151
151
132
2011
2012
2013
2014
2015
2016
2017
2018
2019

5.0. Foreign Agricultural Service (FAS)

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

5.1. Mission Statement

FAS is a trade agency that promotes U.S. agricultural exports.

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 and provides practical solutions, and works to advance opportunities for U.S. agriculture and global food security. FAS serves as the principal coordinator of USDA's international activities, drawing on the broad expertise of USDA and U.S. agricultural organizations. While FAS does not operate laboratories, conduct research or license technologies, FAS supports adoptions of USDA innovations for 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 food and agricultural systems and participation in agricultural trade. FAS administers international fellowship programs, non-emergency food assistance programs, and other technical assistance.

5.3. Downstream Outcomes

The following summaries illustrate how FAS supported U.S. technology transfers.

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 FY 2019, the Project continued work with stakeholders in 15 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 IR4 Project by supplementing U.S.-generated data and, in some cases, completely shifting the field trial responsibilities for generating pesticide data to partner countries. Among the Project's key outcomes this year, the Codex Alimentarius established three 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. The strategic value of this approach was clearly reflected in another important FY 2019 outcome, when Global Partnership members established the Minor Use Foundation that formalized a funding and programming mechanism for collaborative international data sharing and data generation, and disseminating knowledge and information about safe crop protection, which will ultimately continue to help expand participation in agricultural trade.

Cattle Feed Formulation Software in Vietnam

Feed costs are typically 70percent of the total cost of dairy production in Vietnam, where a major limitation to productivity is knowledge of how to meet the cow's nutrition requirement with available feed, especially on smallholder farms that comprise about 60 percent of Vietnam's dairy operators. In addition, inefficient feeds can increase the cow's greenhouse gas emission intensity (emission per liter of milk). A lack of feed ration software to simulate benefits of premium feed components and guide farmers' decision making about purchasing high-quality feeds exacerbated this challenge in Vietnam. In response, the USDA Foreign Agricultural Service (FAS), with funding from the Department of State through the Enhancing Capacity for Low Emission Development Strategies (ECLEDS) program, partnered with the University of California Davis (UC-Davis) and the Vietnamese Ministry of Agriculture and Rural Development (MARD) to strengthen Vietnam's capacities for feed ration recommendations for its dairy sector. The partners' first step was to adapt and enhance a UC-Davis feed ration software by integrating over 1,000 different local and imported feeds and byproducts and nutrient requirement for dairy and beef cattle. A new feed library was established through the partners' collaborations with the Department of Livestock Production, the National Institute for Animal Science, and the Vietnam National University of Agriculture (VNUA)t that supported collection and nutritional analyses of local available feeds. The resulting new database was Vietnam's first unified national feed library, which was publicly launched

with open access for all extension officers, researchers, and farmers. Through this initiative, hundreds of extension agents received hands-on training to develop seasonal and region-specific feed recommendations in collaboration with the Vietnamese National Agricultural Extension Center and Vietnamese Department of Livestock Production. A scientist from the Department of Agriculture and Rural Development of Ho Chi Minh City, who had previously received training at UC-Davis through FAS's Borlaug Fellowship Program, independently provided complementary training to medium- and large-scale producers via a parallel Australian-funded effort. The overall sustainability of the program's impact was further enhanced through integration of the software training into the curriculum of undergraduate students at VNUA, where there were already two courses (animal feeds and feeding, and ruminant production) with seven faculty members involved to train students on using the software. Over the past 3 years, approximately 4,000 students (60percent female) have been trained through these VNUA courses. With ongoing integration of local data and clear benefits to users, the software has already become an essentially standard tool for Vietnam's dairy sector to enhance productivity, reduce environmental impact, and make better decisions about purchasing high-quality feeds. In addition, because the software helps Vietnamese producers simulate and better understand animal nutrition and compare feed efficiency in various cattle breeds, this effort is helping to stimulate Vietnam's demands for U.S. exports of high-quality feeds and cattle genetics.

Aflatoxin-Reducing Technologies in 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. FAS and its partners developed plans to deliver U.S.-based training on biological control of aflatoxin to a Pakistan delegation-- including representatives of Rafhan Maize, Government of Pakistan and CAB International-- in October 2019 through the Cochran Fellowship Program. Looking further ahead, 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)

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

The USDA Forest Service Research and Development (FS R&D) is the world's largest forestry research organization combining both basic and applied research 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 Forest Service, 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 Forest Service 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 delivering it in clear and accessible formats to fit user needs**." USDA Forest Service 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 Forest Service, a more contemporary method and thus one that is much more relevant. There is real value of this form of "science delivery" and the Forest Service is a pioneer, and it is what sets Forest Service R&D apart from universities and other academic institutions. R&D works hand in hand with managers to build knowledge together and design solutions.

6.2. Mission Statement/Description:

The overall mission of the FS is to "sustain the health, diversity, and productivity of the nation's forests and grasslands to meet the needs of present and future generations." Established in 1905, FS is an agency of the U.S. Department of Agriculture (USDA) that directly manages 193 million acres of public land in national forests and grasslands and works with State forestry agencies and other partners to assist in managing 491 million acres of state and private forest lands. **FS is the only land management agency in USDA.** Gifford Pinchot, the first Chief of the Forest Service, summed up the mission of the Forest Service "to provide the greatest amount of good for the greatest amount of people in the long run." FS is composed of four areas: National Forest System (NFS), Research and Development (R&D), State and Private Forestry (S&PF), and Business Operations.

The mission of the FS R&D is to conduct innovative and seminal research that provides sound science, innovative technologies, and practical applications to improve the health and productivity of our Nation's forests 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.

As the world's leader in forestry research, the agency is poised to capitalize on scientific developments, science deliveries, and transfer technologies to help Forest Service scientists gain recognition, deliver valued information and knowledge, protect intellectual property rights and develop research agreements to leverage academic, government and industry partnerships 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.

R&D scientists are a key part of the Nation's scientific expertise, which includes colleagues in other Federal and State agencies, universities, industry, non-governmental organizations, and even citizens with interest in science. A fundamental expectation in the scientific community is that research findings are presented in scientificallycredible forums, and that scientific publications resulting from research will undergo review by other scientists to ensure the scientific rigor of the work. Once the reviewed research is published as "scientific literature," the science-based information from those publications must be made available to the public. FS does this in several ways, and one of those is through the dedicated website, Treesearch, which posts all the published scientific research conducted by R&D scientists.

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, and the International Institute of Tropical Forestry in Puerto Rico. There are also two Technology and Development Centers run by NFS located in Missoula, Montana, and San Dimas, California.

The research program is organized into seven Strategic Program Areas: wildland fire and fuels; resource

management and use; wildlife and fish; recreation; water, air, and soil; inventory and monitoring; and invasive species. Special emphasis areas are: adaptation to climate change, biomass to energy, watershed restoration, urban natural resource stewardship, and nanotechnology.

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

FS R&D also includes the Forest Inventory and Analysis (FIA) Program, which is considered a secondary unit of the Federal Statistical System. The United States. has a highly decentralized statistical system, spanning 125 agencies spread across the Government, all of which are engaged, to some degree, in collecting data and producing statistics. The Office of Management and Budget's Statistical and Science Policy (SSP) Office, headed by the U.S. Chief Statistician, coordinates the activities of the Federal statistical system to ensure the efficiency and effectiveness of the system as well as the integrity, objectivity, impartiality, utility, and confidentiality of information collected for statistical purposes. The

FIA Program is legislated to provide the Nation's forest census, which includes forest conditions, landowner characteristics, and timber products output data. These data are fundamental to the public and private sector for policymaking and decisions about forest investments, and vital to researchers and scientists.

6.4. Role of the National Program Leaders

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

The Washington Office of Research and Development serves the Forest Service and R&D-specific missions, advancing and building support for the work of R&D and recognition of the public value that work creates. An important aspect of this is the development and representation of national research programs. Examples of national program needs include: leveraging research and research funding from other Federal agencies (typically in interagency working groups); reporting and promoting R&D to Forest Service leadership and the Department, other agencies and Congressional staff; fostering cross-station communication and collaboration among scientists; and developing working relationships with national-level 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, NPLs also distribute Washington Office (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 Forest Service uses many means of technology transfer, including marketing efforts at tradeshows and with universities; patents; webinars; workshops; partnerships; field visits; coordination and participation in several 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.

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 cooperative research and development agreement (CRADA) partner prior to filing a utility patent. This process includes working with the USDA Small Business Innovation Research (SBIR) program. The Patent Program conducts prior art searches and prepares all needed paperwork for the U.S. Patent and Trademark 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 Patent Office. Draft patent licenses are prepared by the FS Patent Program and signed by USDA Agricultural Research Service Office of Technology Transfer. FS commercial licenses are royalty based only with a priority toward making the technology available for internal Forest Service management use along with industry support. CRADAs and other technology transfer agreements for the FS are handled by the FS Grants and Agreements pecialists in conjunction with the FS TTC, with patent marketing responsibilities falling to the FS Patent Program. The Forest Service Patent Program is

changing the emphasis from utility patent filing to provisional application filing and seeking a development partner and/or extensive marketing prior to a decision to file the utility patent. Reducing the technology to practice under a CRADA greatly increases the opportunity for successful development. If a partner or a successful market plan (this could involve procurement for FS use) cannot be developed, the technology will be published and placed in the public domain. The Forest Service Patent Program's goal is the broadest dissemination of scientific outcomes, and the Patent Program desires to support not encumber or delay such dissemination.

R&D will also continue to build a 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, improving access to and highlighting field research and leadership to identify and prioritize critical management-driven needs. The data and research generated through this work are an important part of FS technology transfer, and FS R&D will continue to gather, analyze, provide, and report on data to improve management decisions. In addition to the FIA program mentioned above, FS also has "big data" residing in Star Metrics and VIVO, its fire weather modeling, its remote sensing and landscape analyses, and its tracking of weather and hydrology at the Experimental Forests and Ranges. FS will also continue to add data collection points to its internal data collections programs, RITS, iWEB, to allow better reporting, distribution and management decisions.

Publications, agreements, patents, partnerships and data will continue to provide practical solutions to problems and issues by creating technologies, tools, methods and information that serve the needs of internal customers with the National Forest System and State and Private Forestry, as well as other Federal agencies, universities and international communities.

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

Mission – To promote healthy forests and forest-based economies through the efficient, sustainable use of our wood resources. The long-term health of our Nation's forests 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 forest 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 has 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 2019:

1. **Advanced Structures**: New technologies referred to as mass timbers provide the means to engineer taller wood buildings and enable much faster assembly of multi-story buildings.

2. **Nanotechnology:** Woody cell walls can be disassembled into fundamental nano-scale particles that have applications as varied as oil well drilling fluids, barrier films, high performance composites and improved cement.

3. **Forest Biorefinery/Woody Biomass Utilization**: Particle boards, wood pulp, cellulose nanomaterials and biorefinery are commonly produced from smaller diameter wood and in some cases slash and other wood wastes. Increasing the market for smaller diameter trees will increase

value sufficiently to pay all logging and transportation costs and increase the rate at which overgrown forests can be treated.

4. **Advanced Composites**: New products like wood-plastic composites and potential products like cellulose nanomaterial-reinforced composites provide new lightweight materials for applications as varied as deck boards, lightweight vehicle parts and lightweight 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. This work in being done by the USDA Forest Service, Forest Products Laboratory in close cooperation with the APA–The Engineered Wood Association.

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.

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

Fire retardant treatment and re-dry were completed in December 2016, hygrothermal conditioning was completed by June 2017, and 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.

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. As lumber comes from both younger plantation thinning and older mature saw logs, investigating mixed populations is of interest.

The current best practice is to base strength design values so that the design strength of lumber is independent of its statistical distribution. If strength distributions could be more accurately characterized, 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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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 an 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

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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 resources, 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 90percent (357 billion cubic feet) of all the 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 predicting 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 tests on all the CLT specimens and determine the mechanical properties; and (6) analyze the results and write a 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. The timeline dates for completion are old. Should be past tense.

Cooperators

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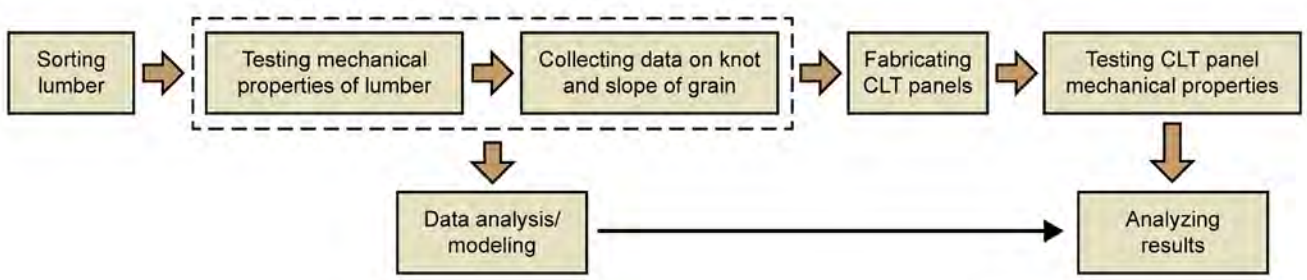
Figure: Schematic of the overall approach of the project.



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 51percent to 96percent, 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 analyses 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.

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 with tradeoffs need to be factored into decision making. The Forest Service's Community of Practice of Forest Management Decision Support Systems provides a large repository on knowledge about the construction and use of forest Decision Support Systemshttp://www.forestdss.org/)

The . Forest Service 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.

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

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

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

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

First Order Fire Effects Model (FOFEM) - FOFEM 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.

Data – Forest Service Research Data Archive (FSRDA)

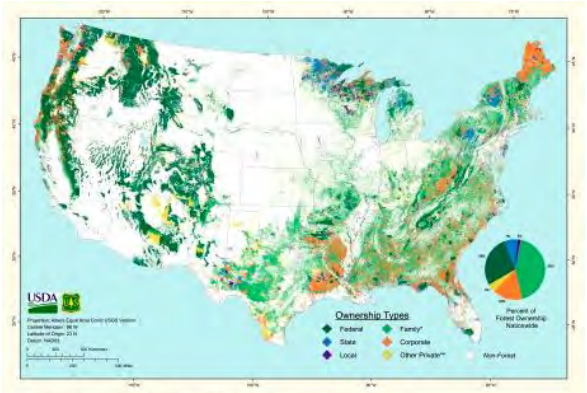
FSRDA was created in 2010 to publish and preserve digital scientific data collected from studies funded by FS Research and Development (FS R&D) and the interagency Aldo Leopold Wilderness Research Institute (ALWRI). To date, ~30percent of our publications are from Joint Fire Science Program (JFSP)-funded studies. In 2012, our scope expanded to the interagency JFSP. In 2019, we started a pilot project to provide publishing support for USDA APHIS' National Wildlife Research Center. FSRDA actively works with the network of FS experimental forests, ranges, and watersheds (EFRs) to publish and preserve the highly valuable data from their long-term studies. This work often involves converting paper-based historical data into modern digital formats.

In 2019 the FS R&D has released 63 new data publications in FY 2019. Global customer visits to our website increased >35percent over FY 2018, as did the number of customers downloading data publications. This is the eighth straight year of successive increases in our customer base. Our FY 2019 publications included the first datasets supporting the 2020 RPA Assessment. We have been actively engaged with the 2020 RPA Assessment science team over multiple years to help them learn how research data publishing works and ensure that the publishing process fully meets their needs.

FSRDA staff help to coordinate the availability of FS R&D-created datasets to National Forest System users via the FS Enterprise Data Warehouse (EDW). In FY 2019, the EDW Content Governance Board approved adding 30 datasets. FS R&D created 30percent of these datasets, despite being <10 percent of the FS budget.

FSRDA staff have a leadership role on the team guiding the FS transition to the ISO geospatial metadata standard. This supports FS compliance with a USDA departmental directive and with the Geospatial Data Act of 2018.

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 United States. 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-owned and privately-owned lands provide public benefits such as clean air, clean water, wildlife habitat, outdoor recreation, and most of the Nation's wood supply. These forests face many threats, including wildland fire, invasive species, pests and disease, and the permanent loss of working forest land to non-forest uses. The Forest Service State & Private Forestry (S&PF) division helps ensure that forest landowners have the best technical, educational, and financial assistance available to achieve their unique objectives and to keep forests

working for all of us. Below are just a few examples of S&PF Technology Transfer projects carried out in FY 2019.

Tribal Relations:

The Tribal Connections Viewer is a new geographic information systems tool available to Forest Service staff, Tribes, and others that provides a visual, interactive map identifying Forest Service-administered/owned land, Tribal lands, and ceded lands all in one place. Nearly 4,000 miles of shared boundaries between Tribal lands and Forest Service-administered/owned land are identified. Like never before Tribes and the Forest Service can now engage in shared land management activities across administrative boundaries and at larger landscape scales.

The Tribal Connections Viewer improves data-based decision making on incident and resource management for both Tribes and the agency; encourages meaningful consultation and collaboration with our Tribal partners; shares technology and knowledge across boundaries and borders; honors treaty rights and the Federal trust responsibility; and identifies opportunities for new and expanded partnerships between Tribes and the agency or collaboration on conservation projects and programs, using the best data available.

The Tribal Connections Viewer uses the most current data available from Federal Census Bureau, Forest Service, Smithsonian Institution, and other sources to provide current and historical details, such as historic treaties, for each location on the map. Having this information easily available in one online resource will improve the efficiency of agency-Tribal coordination, collaboration and consultation. The online resource helps to promote sound management of protected areas through conservation efforts,

capacity-building activities, and education initiatives. It does so through the creation of an interactive mapping tool that shows where and how lands managed by the Forest Service connect or overlap with current Tribal trust lands. We are continuously refining the accuracy of this tool through input provided by users from Tribal nations, who will note where corrections should be made, in comparison with their own local data.

The Tribal Connections Viewer is available to the public at this link:
https://www.arcgis.com/home/item.html?id=91a950377c264b7e84415ef2e91c3a49

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 Forest Services has developed best practices to enable effective, efficient, and sustainable mitigation efforts locally. Those best practices are based on the best available science, proven by experience on the ground, and shared with communities and partners nationwide.
https://www.fs.fed.us/managing-land/fire/fire-adaptedcommunities

Wildland Urban Interface Research: The community wildfire risk reduction work: the Forest Service and our partners share and focus on is based on science and verified by experience. Partners like the Joint Fire Sciences Program, the Insurance Institute for Business and Home Safety, the various Forest Service Research Stations, and Forest Service fire researchers like Dr. Sarah McCaffrey and Dr. Jack Cohen (retired) form the foundation of best practices. As an example, the Forest Service, States, and partners have longthought 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 and San Isabel National Forests, 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 one another improve on-the-ground wildfire risk reduction.

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

The Fire Adapted Communities Coalition was formed in 2009 and still functions primarily as a technology transfer information sharing effort between and among partners (and their individual

audiences) engaged in community wildfire mitigation efforts (community fire adaptation). Coalition partners share the work they are doing 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 Forest Service, the National Association of State Foresters, the National Volunteer Fire Council, The Nature Conservancy, The Watershed Center, the Insurance Institute for Business and Home Safety, the National Fire Protection Association, FEMA (spell out), U.S. Fire Administration, Department of the Interior bureaus, and the International Association of Fire Chiefs.

Forest Health Protection:

The Forest Health Protection (FHP) Program provides technical assistance on forest health-related matters, particularly those related to disturbance agents such as native and non-native insects, pathogens, and invasive plants. FHP conducts aerial surveys, remote sensing, and aerial applications 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.

FHP recently completed a 2018 update of the National Insect and Disease Risk Map (NIDRM) and has facilitated transfer of these digital data to the States in support of the 2020 State Forest Action Plan updates. The NIDRM provides a nationwide strategic assessment of the risk (hazard of tree mortality) due to insects and diseases. Values "At Risk" in the NIDRM represent the expectation that, without remediation, 25 percent or more of the standing live tree basal area will die over a 15-year (2013 to 2027) time frame due to insects and diseases. The 2018 update depicts areas where recent significant tree mortality events have occurred, removing these areas from "At Risk" conditions. Since 2012, completion of the last NIDRM, major tree mortality events from forest pest outbreaks, fire, and broad scale forest harvesting operations have reduced or in some cases eliminated risk. A major tree mortality event was defined as one or more of the following:

- Areas depicted as forest cover loss in the University of Maryland Global Forest Change dataset.

- Three or more years of mortality mapped in aerial detection surveys (ADS)

- In the Eastern United States. only, three or more consecutive years of defoliation mapped in ADS.

The 2018 update does not account for increases in risk due to recent tree growth and density, which can make additional trees susceptible and vulnerable to new forest pest attacks.

NIDRM provides the following in support of State Forest Action Plans:

- A spatially explicit dataset of areas at risk for experiencing 25percent or more tree mortality from insects and diseases through 2027.

- A critical portion of the time table of forest health, by linking historical ADS data to future projections of forest pest mortality events.

- A baseline for monitoring the current and potential extent of new and existing forest insect and disease threats.

- Early identification of areas with potential for new forest health threats to help prioritize management activities and increase the affordability and effectiveness of control strategies.

- Improved communications and awareness of forest health threats.

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 FY2019, the Urban & Community Forestry Program provided technical or financial assistance to more than 7,755 communities across the United States. Sharing FS knowledge and tools is essential to improving the management and long-term sustainability of urban ecosystems. Our partners and customers, including 63 State and territory forestry agencies, more than 35 national partners, more than 150 community tree groups, 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 also evolving as we aim to be more effective in reaching a diverse audience in communities of all sizes, and as information sharing becomes more essential. 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 FS Research & Development 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, through a grant from the Urban & Community Forestry Program, the team partnered with American Forests and the National Association of Regional Councils, to launch the Vibrant Cities Lab web platform to help policymakers, municipal executives, and urban forestry practitioners make science-based decisions about the trees that make their community healthier and more livable. Hosting more than 25,000 users to date, this platform provides curated summaries of the best available science in urban forestry and a toolkit and self-assessment that guides users as they work to improve urban forest plans and practices. In FY 2019, Lab advancements under development included a resilience section adapting Forest Service publications on storm readiness and response; a community-centered tool for prioritizing the most important urban forestry investments; and a funding finder tool on the website to help secure funding for urban forestry projects. Upcoming advancements include a toolkit to identify the complex barriers low income people of color face in entering and sustaining careers in the tree care industry, as well as provide proven or innovative solutions. Adapting this publication into an online

action guide on Vibrant Cities Lab will transform the site from a passive resource of information about jobs into a dynamic, interactive tool to help address some of the most pressing issues faced by disenfranchised populations and an industry seeking to fill a labor shortage.

Wood Innovations in Building:

Wood may be one of the world's oldest building materials, but it is also now one of the most advanced, and the Forest Service is playing a critical role in providing assistance to State, Tribal, local, and private entities on how to incorporate wood as a green building material. By building stronger markets for innovative new wood products, we are supporting sustainable forest management, helping to reduce greenhouse gas emissions, and putting rural America at the forefront of an emerging industry. One key avenue for providing technical assistance around the use of wood in building is through our partnership with WoodWorks. WoodWorks, an initiative of the Wood Products Council, provides free, one-on-one technical support to architects and engineers on wood building design. Through partnerships with the Forest Service, major North American wood associations, and other organizations, WoodWorks promotes the construction of wood buildings. The $2 million contributed by FS in 2017 leveraged an additional $4.5 million from the wood industry and Canadian government, allowing significantly greater impact than could have been achieved independently. WoodWorks provides technical expertise on a wide range of building types, including schools, mid-rise/multi-family, commercial, corporate, franchise, retail, public, institutional and more. WoodWorks hosts yearly conferences across the country and provides workshops and training opportunities on a range of topics to expose architects and engineers to wood design. In FY2017, WoodWorks has directly or indirectly influenced the use of wood in over 500 buildings.

Owner Assistance:

The FS cooperates with researchers and partners 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 (RNGR), National Seed Lab, and the National Agroforestry Center, State & Private Forestry advances technology transfer. RNGR, a unique and innovative collaboration across deputy areas, provides science-based technical expertise to 1400 native plant nurseries. RNGR helps plant professionals respond to ever-increasing demand for high-quality, ecologically appropriate plant materials to address climate change, invasive species and pests, habitat loss, and post-wildfire restoration. In addition, RNGR employs contemporary technical transfer approaches to reach diverse audiences including Federal, State, private, Tribal, and international professionals through webinars, Native Plant Propagation Protocol database, Tree Planters' Notes (international applied journal focused on plant production and establishment), and website with over 70,000 downloads annually of articles pertaining to reforestation, restoration, and native plant production.

Forest Legacy (FLP), Community Forests and Open Space (CFP), Landscape Scale Restoration, and Forest Stewardship (FSP) programs ensure information sharing on forest management and conservation is timely, relevant, and easy to access and use for partners, including Federal, State, and local agencies, Tribes, non-profit organizations, and university extension programs. The Forest Legacy program has online implementation tools and is developing a resource library for States and other partners. FLP also supports the Land Trust Alliance's Learning Center that provides critical permanent forest land

conservation information through online resources, webinars, and courses to over 900 land trust organization members.

In FY 2019 FSP, through State forestry agencies, provided technical assistance to over 602,000 private forest landowners. Through a partnership with the Forest Service, Yale University's Tools for Engaging Landowners Effectively (TELE) helps Federal, State, and local agencies, university extension, and non-profit organization staff to address complex conservation challenges using targeted marketing tools and techniques. Hosting more than 50 workshops in 39 States and Guam, TELE has trained more than 1,500 representing over 500 organizations and leading to 15,000 landowners taking action on more than 730,000 forested acres. In FY 2019, TELE developed online tools for natural resource professionals to foster peer-to-peer learning and streamline implementation of the TELE approach. Tools include marketing tips, lessons learned, facilitator's guide, and landowner engagement guide, a complete guide to designing landowner programs and communications.

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 CE-Works 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 that 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 (STEM?) education, targeting 5^{th}-$6th^{h}$ 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 STEAM (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 1,000 Prescriptions for Outdoor Activity. They have also created digital applications for outdoor activity to help motivate technology-bound children to get outside.

6.10. Water

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

- A 2014 report published by the Southern Research Station showed that clean water begins in national forests for over 19 million people in the South—roughly the population of Florida. The report provides information at a level not previously available on the amount of surface drinking water provided by national forest lands to communities in the South. This information can help support partnerships among State, Federal, and nongovernmental organizations that work to conserve the forest cover that provides the area's clean, dependable water supplies.

How Forests Provide Clean Water

Small headwater streams determine the water quality of the larger rivers, lakes, and reservoirs that they flow into. Researchers used data from Hubbard Brook Experimental Forest to study the pathways water takes from the time it lands as rain until it reaches a headwater. By tracing water isotopes, they found that the median time it takes rainwater 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 measured changes in the concentrations of dissolved substances that naturally occur in water, such as calcium, and are often what make water "hard" or "soft." They found that not only does the amount of time water spends flowing through forest soils, but also what path the water takes through the ground determines how much a forest filters the water and removes dissolved substances, thereby impacting water quality. Research like this could potentially help land managers target specific areas of a forest that provide the most filtration services for restoration or conservation to improve a forest's water filtering capabilities.

Best Management Practices Improve Water Quality and Save Money

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

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

6.11. 2019 Fire & Fuels Technology Updates Fire and Aviation

SMOKE UPDATES: links will take you to the sites showing the info & tech.

Airnow https://airnow.gov/index.cfm?action=topics.smoke_wildfires used by Air Resource Advisors to model and create public smoke forecasts, compliant with S.47 Dingle Act of 2019.

FASMEE https://www.fs.usda.gov/rmrs/projects/fire-and-smoke-model-evaluation-experiment-fasmee-fishlake-national-forest-prescribed-burn advancing the data feeding fire behavior, plume dynamics, and smoke to improve firefighter and public safety.

Monitoring 4.1

https://tools.airfire.org/monitoring/v4/#!/?category=PM2.5_nowcast&centerlat=42&centerlon=-95&zoom=4 another tool used to analyze the trends in particulate matter produced during wildfire events; assists in forecasting impact areas and advising the precautions to public health.

Bluesky https://sites.google.com/firenet.gov/wfaqrp-airfire/data/bluesky visually models the smoke columns and concentrations of smoke produced by prescribed and wildfire so fire managers can better manage the outcomes and impacts to public health.

Risk Assessment & Vegetation Mapping Tools

LANDFIRE https://www.landfire.gov/lf_remap.php updating of LANDFIRE layers and development of analysis tool.

IFT-DSS https://iftdss.firenet.gov/landing_page/ Interagency Fuels Treatment Decision Support Tool has been updated and enhanced to allow fuels managers to spatially plan, develop, and analyze fire potentials on defined landscapes. Within the IFT-DSS framework is the FTEM database, which has become the database of record for reporting Fuels Treatment Effectiveness. This system automatically detects interactions between uploaded fuels treatment layers and wildfire.

The Missoula Fire Sciences Laboratory

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

6.12. SCIENCE DELIVERY BY THE R&D WASHINGTON OFFICE AND FIELD RESEARCH STATIONS

WASHINGTON OFFICE (WO)

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

Inventory, Monitoring and Assessment Research (IMAR)

Mission:

Provides fundamental strategic data and data products for forests and related lands, and the forest sector, of the United States, and expertise in enhancing earth observation methodologies ranging from global to

national to local scales. The resulting authoritative information is used by governments and the private sector to guide forest investments, is key for determining forest sustainability, and provides a basis for research at multiple spatial scales.

Key elements

- Provides national leadership of the Forest Inventory and Analysis (FIA) program that is delivered through four units at R&D stations, as well as internal and external partners. The FIA program is a statistical unit that conducts three national surveys: the National Forest Inventory; the National Woodland Owners Survey, and Timber Products Output survey.

- Conducts research in monitoring, remote sensing, and geospatial analysis methods, and assesses results.

- Leads production of the Resource Planning Act (RPA) Assessment, which provides research to produce forest futures and projections for 12 natural resource areas. The RPA is a national, renewable resource assessment mandated by the Forest and Rangeland Renewable Resources Planning Act. The 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, outdoor recreation, carbon, land use and land use change, and urban forests.

- Conducts research on criteria and indicators of forest sustainability, to provide a comprehensive picture of forest conditions in the United States as they relate to the ecological, social, and economic dimensions of sustainability.

- Provides leadership and coordination for international monitoring and assessment activities in partnership with International Programs. This partnership effort includes U.S. leadership to 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 Forest Resources of the United States, 2017: a technical document supporting the Forest Service 2020 RPA Assessment. Resource tables present estimates of forest area, volume, mortality, growth, removals, and timber-product output in various ways within the context of changes since 1953. Additional analyses look at the resource from an ecological, health, and productivity perspective.

2. National surveys supplied information for 503 spatial data requests and delivered 310,758 online data requests. Developed estimates for U.S. Sustainable Development Goals 15.1.1 and 15.2.1 and other annual statistical reporting on U.S. forests for reporting through USDA National Agricultural Statistics Service. Built U.S. forest economics statistical framework and produced wood-products forecasts in line for submission to U.N. Economic Commission for Europe.

3. Completed and released the authoritative Tree Canopy Cover geospatial product, 2016, covering the conterminous United States, coastal Alaska, Hawaii, and Puerto Rico as our contribution to the Multi-Resolution Land Characteristics Consortium with Departments of Commerce and Interior. This baseline information is used for urban and rural planning, estimation, and wildfire analysis by many partners.

4. Developed the first interactive inventory database to harmonize forest inventories across the three nations covering North America. The harmonized North American Forest Database (NAFD) manages forest inventory data, enabling consistent, continental-scale forest assessment supporting ecosystem-level reporting and relational queries. The first iteration of the database contains data describing 1.9 billion hectares, including 677.5 million hectares of forest.

Sustainable Forest Management Research (SFMR)

Mission: To build a 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, improving access to and highlighting field research and leadership to identify and prioritize critical management-driven needs.

Key elements

- Provides oversight and coordination of forest management and ecological research needed so that landowners, resource professionals who advise them, and policy makers can make better decisions about active forest management to improve the condition of forests, facilitate rural prosperity, and foster productive use of our National Forest System lands.

- Investigates natural disturbances, stressors, and threats caused by insects, diseases, and invasive species; fire; weather (hurricanes, ice storms, droughts); climate change and physical phenomena (avalanches, landslides, volcanoes) that impact forests and grasslands.

- Studies human-caused disturbances, stressors, and threats related to fragmentation of forests and rangelands and changing weather patterns (temperature and precipitation) and impacts on biological systems, atmospheric deposition, air quality, and soil health.

- Provides national leadership in fire ecology and management to reduce wildfire risk, hazards and severity, and promote prescribed fire in restoring frequent-fire forests and grasslands.
- Researches sustainable production of forest and rangeland resources.

- Manages systems, practices, and policy options for restoring forests, rangelands, and agroforestry systems.

- Researches and manages landscape ecology issues at national, regional, and local levels.

- 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.

- Oversees use of experimental forests and ranges, research natural areas, and demonstration areas nationally. Reviews Research Work Unit Plans and Program Charters to ensure science delivery on national priorities in an efficient and integrated effort among research stations.

Recent achievements

1. Published Effects of Drought on Forests and Rangelands in the United States: Translating Science into Management Responses (2019). This report builds on the science provided in Effects of Drought on Forests and Rangelands in the United States: A Comprehensive Science Synthesis (2016), providing regional management strategies to enhance resiliency and adapt to drought.

2. Working closely with research stations, NFS, and S&PF experts to inform scenario investment planning and the shared stewardship initiative for the Forest Service. The resulting work is a nationwide library of silviculture treatments that was developed for improving forest conditions across 320 million acres and nearly 100 different forest types.

3. Published a comprehensive nationwide assessment of barriers to natural regeneration in temperate forests. This 2019 assessment addressed emerging challenges, social and political filters that determine feasibility, and past management legacies to develop management recommendations for the 21st century. Science leaders in SFMR, NRS, RMRS, PNW, and SRS in conjunction with academic partners produced this science-based and management-driven synthesis.

4. SFMR staff updated the Forest Service Manual CHAPTER 4060 - RESEARCH FACILITIES AND AREAS. Last updated in 2005, updates include clarifications regarding NEPA, treatments on experimental forests, and staff area responsibilities. The focus included enhancing Experimental Forest research flexibility.

5. Partnered with State forestry agencies to produce GIS assessment of trees outside of forests (TOF) for Nebraska and Kansas. Published online story map on TOF and on the Prairie States Forestry Project.

6. Led the Forest Sector in developing input to the Fourth National Climate Assessment and Second State of the Carbon Cycle Report providing the latest science on climate change impacts to forests and carbon cycling for use by managers and policy makers.

7. Led the build-out of the Compendium of Adaptation Practices, which will provide land managers a go-to place to easily access a full range of adaptation approaches from across the Nation, as well as links to associated literature and demonstration sites.

8. Provided Forest Service leadership for the USDA Climate Hubs, allowing USDA to develop and deliver science-based, region-specific information and technologies to agricultural and natural resource managers and communities, and to provide assistance to implement climate-smart decisions (2014-19: published over 410 peer-reviewed publications and 690 pieces of grey literature, hosted over 435 in-person events engaging over 16,000 stakeholders, hosted 237 webinars, podcasts, and other digital forms of communication engaging approximately 17,000 stakeholders, developed 36 educational curricula, and developed 25 web-based decision-support tools to help track and respond to climate variability and its impacts).

Ongoing Work:

- Urban and Wildland Urban Interface Forests and Rangelands in Changing Environment (2021)

- U.S. Forest and Rangeland Soils under Changing Conditions (2020)

- The State of Science on Smoke from Wildland Fire (2021)
- State of Science for Non-native Invasive Species (2020)

- Spring 2020 publication of a special issue of Fire Management Today on USDA Forest Service fire research

Landscape Restoration and Ecosystem Services Research (LR&ESR)

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;

- Researching 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 policymaking at multiple spatial scales in boreal, temperate, and tropical forest ecosystems.

Recent Achievements

Wildlife Research Roadmap:

Completion and roll-out of a new Wildlife Research Roadmap that provides a framework to enhance the capacity of the Forest Service R&D wildlife research program. This 2-year cross-deputy effort serves as a reference and first nationally coordinated effort to demonstrate our shared values and provides a vision for wildlife research that addresses the current status of capacity and service issues related to wildlife research in the Forest Service, and the critical role it plays in meeting agency goals.

Rise to the Future Strategy:

Completed and publicly released the cross-deputy area Rise to the Future Strategy, which identifies clear goals, objectives, and action items to improve the condition of forests and grasslands with respect to aquatic resources, including through the production, delivery, and application of scientific research. A hallmark of this strategy is that it was developed in partnership with numerous agencies and organizations and promotes shared stewardship of aquatic resources. This integrated, agencywide (close up) strategy lays essential groundwork for ensuring that the Forest Service fish and aquatic program is delivered efficiently, effectively, and with integrity and a focus on customer service.

Generic Information Collections:

Developed and received from OMB the first-ever approval for an R&D Generic Information Collection, which will allow for a wide range of social science research related to non-timber forest products. This effort gave rise to a new type of collection called a hybrid generic, which will allow the Forest Service to fast track the approval of individual collections under this generic clearance but also still have a public comment opportunity.

Water Supply From Forest Service Lands:

New research from SRS scientists using the Forest Service Water Supply Stress Index (WaSSI) model found that 12percent of the 2,427 billion cubic meters of water supply generated per year across the continental United States originated on NFS land during 2001 to 2018, with NFS contributing 30.6percent and 3.9percent to water supply generated in the western and eastern United States,

respectively. Preliminary results suggest that more than 61 million people received some of their drinking water supply from NFS lands with 11 million receiving more than 50percent from NFS lands across country. These results clearly show the importance of NFS lands in providing water for municipal drinking water supplies that serve millions of people across the United States.

eDNAtlas:

Launched the eDNAtlas, an open-access online database, to provide precise spatial information on the occurrence locations of aquatic species in the United States., 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 SFS 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 identificationand 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.

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 that 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.

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 accountability, science applications, science education, data quality, peer review, information management, and technology transfer and licensing activities 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 U.S. Secretary of Agriculture from Federal, State, university, industry, and nongovernmental organizations, the FRAC meets annually and presents recommendations to the Secretary on the FS R&D program.

- Provides information technology resources for communicating research, including the Treesearch and Forest Service Research Data Archive websites. Treesearch provides public access to about 53,000 scholarly publications by R&D scientists and collaborators; the Archive provides public access to about 450 research data publications by R&D scientists and collaborators, and by Joint Fire Science Program grantees. Both platforms provide access to over 100 years of R&D research to a global audience.

- Publishes research datasets with the documentation needed for successful re-use of the data.

- Maintains the research information systems critical to R&D's accountability reporting and which provide the content behind nearly half of R&D's 4.5 million web page views each year, making it an essential part of the agency's science delivery system.

- Maintains the R&D's most visited website "Treesearch," which provides public access to over 50,000 scholarly publications by R&D scientists and collaborators, and the Washington Office's website, visited 200,000 times last year by visitors from 200 countries. (see above—Treesearch already mentioned)

- Piloted and began sharing a new intranet-based "metrics" dashboard that joins internal and external information about research outputs, mentions, and usage at the individual and unit levels.

- Assisted development of the "REE" mission area dashboard.

- Managing Forest Service's Quality of Information (QOI) entails receiving requests for corrections to information disseminated by the Forest Service. Once received, corrections are tracked, responded to and posted to the agency's QOI website. Managing R&D's peer review involves providing guidance to station scientists on the Office of Management and Budget's (OMB) process to ascertain a study's influential scientific determination prior to the dissemination of the study's information (i.e., publication) to the public. Peer Review Agendas are posted to R&D's website for review. Year-end counts of corrections and agendas posted are submitted to OMB in a final report to Congress.

- Manages R&D patents, licensing, and technology transfer and helps incorporate research outcomes with potential intellectual property (IP) product development to industry partnerships. The use of provisional patent applications and cooperative research and development agreements (CRADAs) develop partnerships for further R&D, scale-up, market evaluation and potential products to support the NFS and the forest industry. Also, supports G&A (at each station) in the development and support of IP agreements like NDAs, MTAs, MTRAs and CRADAs.

- 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.

Some specific duties of the program staff include serving as liaison to WO Office of Communications and to communication staffs at the research stations for efforts such as report roll outs, blog postings, and strategic messaging; collecting, editing, and preparing 100-200 annual research highlights for posting online; producing the monthly national R&D newsletter and sending to nearly 12,000 readers, more than 50 percent of which are external to the agency; overseeing a web modernization effort to bring the entire R&D web presence up-to-date so users experience a modern, coordinated, seamless website that represents all of R&D; writing speeches, editorials and talking points for WO R&D staff; reviewing Power Point presentations and briefing papers for grammar and style; and producing administrative documents for the Deputy Chief's Office that include Excel spreadsheets, messages to staff from the Deputy Chief, and intranet updates.

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 FS 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 Forest Service. 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—is 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 the carousel; working with Climate Change Resource Center on web modernization of R&D site.

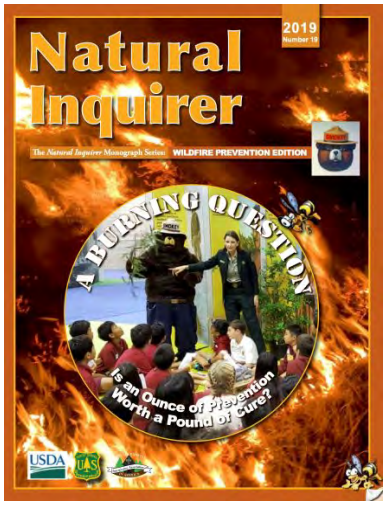
- **Conferences:**

  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.

- **FS Research Data Archive:**

Released 63 new research data publications and delivered about 7,000 data publications to customers. Use of the Archive grew for the 8th straight year, with a 35-percent increase in deliveries and customer visits over FY 2018. The Archive's customer experience was enhanced by making the website mobile-friendly. Nine R&D-generated research datasets were approved for inclusion in the FS Enterprise Data Warehouse; this constitutes 30percent of the datasets so approved in FY2019.



Source: USDA Forest Service

The *Natural Inquirer* program creates and distributes re-usable science journals and materials written for K-12 students. In FY 2019, approximately 219,423 of these products were distributed to classrooms, homeschools, and individuals 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, Sharon Parker, Ph.D., Natural Inquirer liaison, sharon.parker@usda.gov; Cradle of Forestry in America Interpretive Association, Jessica Nickelsen, Natural Inquirer program manager, jessica.nickelsen@usda.gov; WO R&D KMC, Barbara McDonald, Ph.D., Education Program Manager, 706-559-4224

Important FY 2019 Program Accomplishments

The following products were distributed in FY 2019:

- 156,017 scientist & engineer cards
- 92 “America’s First Forest” DVDs
- 101 Social Scientists Packs (4 journals and 13 cards)
- 98 *Natural Inquirer* Reader Packs (8 readers and 7 cards)
- 5,952 *Natural Inquirer* Readers
- 6,972 *Nature Science Investigator(NSI)*
- 14,378 “*(Bee A Scientist*” undo itals)Coloring Books
- 853 Spanish *Natural Inquirer* products
- 63,406 *Natural Inquirer* publications
- 8,350 Smokey Bear cards distributed from NI (Approximately, 50,000 distributed from the Cache)

- **219,423 GRAND TOTAL for all *Natural Inquirer* products (not including Smokey Bear card)**

Social Media Presence

- *Natural Inquirer* social media: 12 percent increase in followers on Facebook, and 3 percent increase on Twitter

New products

- "On the Fence" Monograph (Topic: ungulate browsing and how it affects quaking aspen)

- Spanish version of the "Meet Dr. Roman" Natural Inquirer Reader featuring Woodsy Owl

- Smokey Bear scientist card and 11x17 poster (in honor of Smokey's 75th birthday)

- Electronic versions of all Natural Inquirer (italics) Readers uploaded to NI website (including Spanish translations)

- "Batter Up" monograph (Topic: Research on the best wood for baseball bats)

- "A Burning Question" monograph (Topic: Wildfire prevention education/Smokey Bear's 75th birthday)

- World's Forest 3 Natural Inquirer (italics) journal

(Natural Inquirer italics) products distributed at the following events (Please note this list captures only some of the events where NI materials are distributed.)

- National Girl Scout Conference
- Georgia STEM Forum
- Society for American Foresters Conference
- National Conference for Science and the Environment
- AgOutlook Forum
- Boston GreenFest
- National Science Teachers Association National Conference
- Cradle of Forestry in America (CFAIA) visitor sites & campgrounds
- CFAIA Pisgah Explorers Club
- Forest Service Southern Research Station

- Schenck You Event
- New England State Fair "The Big E"
- Experience UGA (University of Georgia outreach event for K-1 students)
- Women of Color STEM Awards
- Bio-Cultural Blitz in Hawai'i
- National Association for Interpretation (NAI) conference
- Flagstaff Festival of Science "Taking Pulse of our National Parks" event
- National Public Lands Day
- Forestry Institute for Teachers in California

Partnerships:

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

- Forest Service Southern Research Station (Hidden Figures partnership)

- Forest Service Northern Research Station (Production of Time Warp monograph series)

- 4-H (Forest and Agriculture monograph series)

National History Program

The Chief Historian on the KMC (spell out) staff completed several projects, presentations, and service across all deputy areas and external partners and the general public. These activities include:

Producing Work Products and Managing Assignments:

- Completed several posts on research for Research and Development national newsletter.

- Wrote statement on President G.H.W. Bush for national Agency webpage for Chief's Office.

- Assisted WO Office of Communications (OC) with multiple requests for information from public and Congress.

- Responded to multiple requests for information from Legislative Affairs staff.

- Responded to multiple requests from National Forest Service Library and Rocky Mountain Research Station.

- ‘Serves in numerous service capacities for several different professional history organizations.

- Continued to deliver presentations to several agency and inter-agency trainings including National Lands Training and Middle and Senior Leader programs.

- Published two articles for (Fire Management Today) italics.

- Administered Grey Towers Scholar in Residence Program for State & Private Forestry.

- Delivered “bite-sized science” talk at Rocky Mountain Research Station.

- Published two additional articles for Fire Management Today(italics).

- Published an invited book review in Great Plains Quarterly.

- Published an invited book chapter for University of Nebraska Press.

- Filmed interview for Rocky Mountain Public Broadcasting Service film on Colorado forests.

- Served as Associate Editor of Journal of Forestry for Society of American Foresters.

- Developed portions of National New Employee Orientation to include agency history for 2019.

- Developed and delivered panel titled “De-Coding Forest Service Planning” for national Ecosystem Management Coordination conference, Albuquerque, NM June 2019.

- Served in a 120-day promotional detail as Program Manager for Human Dimensions staff at Rocky Mountain Research Station.

Managing Internal Work Assignments

- At request of Chief’s Office, completed and delivered 65-page history of workplace hostility toward women in Forest Service report for Chief Christiansen.

- Volunteered for and accepted 120-day promotional detail as Program Manager of Human Dimensions staff, Rocky Mountain Research Station beginning August 2019.

    - Detail involved re-charting the Human Dimensions staff and participating in Chief’s Review of the station.

Partnerships

- One additional volume in a project with faculty at Arizona State University was published in FY 2019:

    - *Slopovers: Fire Surveys of the Mid-American Oak Woodlands, Pacific Northwest, and Alaska* by Stephen Pyne. Published by the University of Arizona Press.

- Improving relationship with Forest History Society.

    - Secured $10K in funding for procurement contract to produce a short book on the history of the Weeks Act for distribution at the National Forest Service Retiree Reunion. Project successfully completed.

    - Secured $25K in funding for challenge cost share agreement for a digitization pilot project of Forest Service records held at Forest History Society.

- Working with U.S. House of Representatives Agriculture Committee to write a history for the committee's 200th anniversary.

    - Organized and leading a team of historians from USDA to produce the book length report.

- Obtained funding for largest funded project in program history.

    - Obtained $200K in funding for new history of the Forest Service from 1960-2020.
    - Completed partnership agreement with History Department at Colorado State University to complete 4-year project.

- Directing Colorado State graduate student on land use history of California Park on Routt National Forest in joint Rocky Mountain Research Station/National Forest System ecosystem restoration project.

- Delivered a series of invited talks and lectures at universities and conferences including:
    - Colorado State University School of Journalism.
    - Colorado State University environmental art program.
    - Organization of American Historians annual conference.

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 provide technical assistance to land owners.

Work at the Center includes research and technology transfer 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;

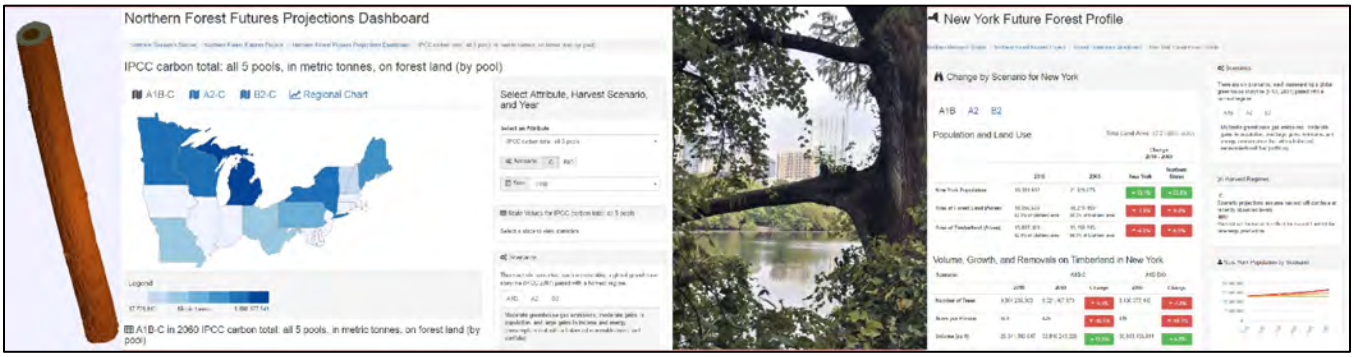
- **Alley cropping** to augment landowner income before trees are mature enough to harvest and/or produce fruit, berries, or nuts, and/or;

- **Forest farming, or multi-story cropping,** to produce food, herbal, botanical, or decorative crops under the protection of a managed forest canopy**.**

Accomplishments in FY 2019 included strengthening USDA cooperation in agroforestry through the release of the 2019-2024 USDA Agroforestry Strategic Framework and the Enhancing Rural Economies through Agroforestry workshop report. In addition, the Center increased customer access to USDA agroforestry resources by upgrading our website, by co-leading the North American Agroforestry Conference, and by supporting regional agroforestry working groups. The latter included support for a new multi-partner agroforestry network in the southwestern United States.

In addition, the Center provided agroforestry training in agroforestry in several U.S. regions, including the first-ever agroforestry training for the Pacific Northwest. Research was advanced in several areas including agroforestry for pollinator conservation and the mapping of trees outside of forests across the Great Plains.

NORTHERN RESEARCH STATION (NRS)



Source: USDA Forest Service

The Northern Research Station provides the science land managers, city planners and policy makers need to improve the condition of the Nation's forests and grasslands. In a region extending from Maine to Minnesota and from Missouri to Maryland, Northern Research Station science aims to understand all the elements of forests and related landscapes. Part of the Forest Service Research and Development program, the Northern Research Station is one of 7 Forest Service research units conducting research within all 50 States as well as in U.S. territories and commonwealths.

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

- Participation in and contribution to hundreds of consultations with national forest and State forest managers and other partners in efforts to improve access to and use of Station science.
- Publishing in peer-reviewed journals and Station technical reports; providing access to over 15,000 publications authored or co-authored by current or former 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 Mart and other tools, giving our stakeholders in State agencies, private industry, and other Federal agencies alternatives for generating tables and maps.

The Station manages 22 of the 81 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 the Nation's forest land sets the FS apart as a natural resource agency.

This chapter includes selected technology transfer products developed by Station scientists over the past year. Science priorities include:

- Forest health and disturbance
- Forest restoration and management
- Water, wildlife, and fish conservation
- Resilient communities and economies

- Forest inventory, monitoring & assessment

NRS SCIENCE DELIVERY

Scanning the Horizon for the Future of Forestry

The Northern Research Station's Strategic Foresight Group, working with the University of Houston Foresight Graduate Program, designed and implemented a formal horizon scanning system for the USDA Forest Service, with the goal of increasing strategic foresight. An accompanying report contains the complete guide written for those volunteering to do the scanning, including the development of a method to identify useful scanning sources pertinent to forest futures, ways to analyze horizon scanning "hits," or signals of change, and distinguishing between current and emerging issues for the Forest Service. This collection will acquaint forest planners, managers, and policy-makers with horizon scanning and how they can use it as an integral step in anticipating the consequences of potential change and making better decisions in a rapidly changing environment.

Climate Change Atlas Reboot Improves Current and Future Habitat Suitability Maps for 125 Tree Species

Whether they manage 1 million acres or 1 acre of forest land, managers benefit from information related to the current and potential future suitability of habitat in the eastern United States. Northern Research Station scientists created the Climate Change Atlas, a popular online tool developed for 125 eastern United States tree species under current conditions and six scenarios of climate change, to meet this need. In 2019, scientists updated data used in statistical modeling to improve the Climate Change Atlas.

Various products, including maps, regional summaries, and species-level information, are being used to update the NRS Climate Change Atlas Website.

Station scientists overhauled models for 125 tree species by using an approach that leverages the spatial density of Forest Inventory and Analysis (FIA) plots to define the modeling grid. Forty-five environmental variables (i.e., climate, elevation, and soil) and more than 84,000 FIA plots were used to develop models under current conditions and predict potential changes under 6 scenarios of climate change by the end of the century. Because newly suitable habitat can be great distances from the species' current habitat, researchers also simulated colonization likelihoods using various migration rates to identify sections where assisted migration could be beneficial and where refugia may persist. The models have been made accessible from the Forest Service Data Archive, with various products including maps, regional summaries, and species-level information made available for update on the NRS Climate Change Atlas Website. This recent effort seeks to improve understanding of potential changes in the coming decades by refining the spatial resolution of the models and providing more localized summaries for managers and decision-makers. Information related to these models is popular, as the Atlas receives about 775,000 page views annually.

Collaborative Management Guides Enable the Resurgence of Oak and White Pine in New England

Northern red oak and white pine are treasured New England tree species with timber, wildlife habitat, aesthetic, and historic significance in the region. Past landscape disturbances shaped their presence and extent; those disturbances have diminished. Northern Research Station scientists used a shared

stewardship approach to produce ecology and management guides for New England resource managers, consulting foresters, and wildlife biologists.

Northern Research Station scientists collaborated with University of New Hampshire Cooperative Extension, and others in New Hampshire to produce ecology and management guides for both northern red oak and eastern white pine (in review) in addition to hosting Northeast Silviculture Institutes on oak-pine silviculture for natural resource managers, consulting foresters, and wildlife biologists. The historic events that resulted in the origin of abundant white pine and oak cannot be replicated. However, scientists can recommend silvicultural methods that mirror those early effects: timing of regeneration efforts with good seed crops, maintenance of nearby high-producing seed trees, burying of pine seed and acorns using ground disturbance techniques, early release of seedlings, prevention of oak browsing by deer using large areas and other control methods, and prescribed fire. These and related methods appear to be working to maintain oak and pine on the New England landscape.

Scientists, Tribes Collaborate to Design a Tribal Climate Adaptation Menu

Staff from the Northern Research Station contributed to the development of a new resource that incorporates indigenous perspectives and traditional ecological knowledge into climate change adaptation planning. This resource is being used to help Tribal natural resources professionals develop climate adaptation plans and to help nonTribal organizations communicate with Tribal communities. Traditional and indigenous knowledge and perspectives have not often been recognized in climate adaptation for natural and cultural resources. Staff from the Northern Research Station and the Northern Institute of Applied Climate Science worked with a diverse team representing Tribal, academic, interTribal, and Federal entities in Minnesota, Wisconsin, and Michigan to create “Dibaginjigaadeg

Anishinaabe Ezhitwaad: A Tribal Climate Adaptation Menu" to make a stronger connection between indigenous values and climate adaptation planning. The Tribal Adaptation Menu is an organized collection of climate change adaptation actions for natural resource management, designed to help land managers identify suitable actions for their situation. A companion Guiding Principles document describes considerations for working with tTibal communities, such as the importance of respect and reciprocity in interactions with people and the natural world. The team is using the menu in workshops to help natural resources staff brainstorm appropriate adaptation actions, and as a communication tool for persons or organizations interested in the needs and values of diverse Tribal communities. The menu will be released in an editable format to allow tribes from around the country to tailor it to their own needs.

New Tools Improve Biosecurity Operations Targeting the Invasive Asian Gypsy Moth

Asian gypsy moths continue to pose a high risk for introduction to North America through international trade. Predicting where and when biosecurity measures need to be applied and when targeted stages are present are vital to preventing the establishment of these potentially higher risk biotypes of gypsy moth and limiting the cost of management.

Currently, ships and cargo that could potentially move egg masses of the Asian gypsy moth are inspected to help prevent new introductions and the potential establishment of this invasive species. Inspections are time consuming and costly, and resources for inspections can be limited. To help target these inspections, NRS scientists have developed phenology models that can predict the timing of Asian gypsy moth flight for a broad range of international ports where female moths may infest ships and cargo before they are sent to North America. Northern Research Station scientists have also revised a

model that predicts the development and hatch of North American gypsy moth eggs to help predict when and if Asian gypsy moth eggs laid on ships and cargo may develop and hatch. This information, combined with data describing the survival of newly hatched caterpillars, can help predict when moths may have a high potential for establishment in North American ports. Should the Asian gypsy moth become established, these models can also help determine the timing of eradication tools and measures.

NRS Researchers Help Europe Prepare for an Invasive North American Wood Borer

The twolined chestnut borer, a native pest of chestnut and oak trees in North America, recently invaded Europe and now threatens European chestnut and oak trees. Northern Research Station researchers helped the European and Mediterranean Plant Protection Organization (EPPO) prepare for this new pest by summarizing its biology, management, and outbreak history in the United States and participating in a formal Pest Risk Analysis at EPPO headquarters.

The two scientists quickly prepared a review paper and compiled over 60 years of twolined chestnut borer outbreak history in the Great Lakes region. The review paper, to be published in the EPPO Bulletin, formed the basis for EPPO's formal Pest Risk Analysis (PRA) of twolined chestnut borer that was held at EPPO headquarters in Paris in December 2018,. The outcome ranked twolined chestnut borer as a high-risk pest to Europe and, after approval by various EPPO committees, the insect was regulated as a quarantine pest within the 52 EPPO member countries beginning in October 2019.

Defining and Mapping Land Types Encourages Shared Stewardship and Oak Management

Northern Research Station (NRS) scientists used data derived from hundreds of field plots in conjunction with high resolution digital elevation data to map 15 land types for a 17-county region of southeastern Ohio. Research Map NRS-10 (RMAP) is a foundational document for cross-jurisdictional management using shared stewardship approaches. Authorities vested in agencies now allow for landscape-level approaches to management regardless of ownership, and "wall-to-wall" mapping such as Research Map NRS-10 is needed to facilitate such management. This tool is particularly timely because managers are increasingly interested in oak regeneration in the east-central United States and will be helpful for both public and private managers. The research map includes a document describing the ecological, geological, climatological, and topographical attributes of each land type and each of five subsections within the Southern Unglaciated Allegheny Plateau Section of the Eastern Broadleaf Forest Province. The document and mapped land types also provide a basis for assessing productivity, predicting species assemblages, and designing research or monitoring projects. The RMAP should be helpful for both public and private persons interested in southeastern Ohio, but also as an example for persons interested in promoting shared stewardship approaches anywhere in the Nation.

Decision-Support Framework for the Ozark Highlands Region

Planning for sustainable landscapes is hampered by uncertainty in how species will respond to conservation actions amidst impacts from landscape and climate change, especially when those impacts are also uncertain. Scientists with the Northern Research Station, University of Missouri, and U.S. Fish and Wildlife Service developed a decision-support framework that integrates dynamic-landscape metapopulation models and structured decision making to help guide landscape conservation design.

They worked with a team of partners representing 12 organizations to apply the framework to the Ozark Highlands Region to choose a restoration scenario that best met desired wildlife and conservation objectives under climate change and urbanization. The team identified focal species to represent priority ecosystems, designed alternative scenarios, and modeled the consequences of each with concurrent impacts of climate and landscape change. The planning team identified a scenario that targeted nearly 3 million acres of restoration across private and protected lands based on predicted future landscape conditions and that best reduced the average risk of decline across species. Researchers demonstrated that planning for viable populations across broad scales can be achieved under global change. The integration of models and structured decision-making enabled decisions to be more objective and transparent, and thus more defensible.

New Method Refines Methods for Determining Tree Loss Compensation

A new method has been developed that determines the number of trees required to compensate for the loss of a healthy, urban tree. This method bases compensation on the loss of future tree values and enhances our ability to adequately compensate for tree loss.

When healthy, urban trees are removed from a landscape, one common question urban forest managers face is: How much should the tree owner be compensated for the loss of the tree? Various formulas estimate the value of a tree, but these formulas are often based on tree size and thus compensate for services already received. The key to determining adequate compensation is to estimate the amount of future services lost due to the removal of a healthy tree. The procedure developed by Northern Research Station scientists considers the future benefits provided by both the removed tree and newly planted trees to determine compensation. Compensation can be in number of trees to be planted or equivalent

dollars to plant the trees. The compensation rates vary with tree size and estimated remaining life span. This technique can improve existing procedures to help provide adequate and proper compensation for the loss of healthy trees. While the method was developed for urban trees, it can be applied to tree loss in any situation.

Managing Deer Across Landscapes and Ownerships

Research on landscape-wide forage availability, also known as the "foodscape," is helping land managers evaluate potential impacts of deer on tree seedlings and plants across a landscape. On the Allegheny National Forest, for example, managers are using GIS(spell out) mapping to evaluate forage availability in order to target areas for additional forage creation through timber harvesting activites. This could reduce overall deer browsing impacts on forest understories across the landscape, which should promote increased sustainability of forest stands across the forest. State and industry partners in the region are also considering ways to incorporate this method into management.

Fire and Fuels Monitoring Workshop

Fire severity and pre- and post-fire consumption research results, and general fire protocols developed with NRS science, were all incorporated into a 3-day Fire and Fuels Monitoring Workshop at the Cloquet Forestry Center (Minnesota) for 30 land and prescribed burn managers. Participants learned how to select metrics to match management and restoration objectives; develop site-specific protocols for sampling; develop monitoring handbooks and protocols/programs for local ecosystems; and establish long-term monitoring and data for wildfire risk assessment.

PACIFIC NORTHWEST RESEARCH STATION (PNW)

Source: USDA Forest Service

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

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

The PNW Research Station has strong partnerships with universities, national forests, State agencies, nonprofits, private industry, and other Federal agencies. With these partners, we address key questions associated with 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 Forest Service 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 20th 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 becoming more suitable for large wildfires.

Scientists with the PNW Research Station and collaborators extrapolated and contrasted what is considered 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. Forests 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)

Source: USDA Forest Service

The Pacific Southwest Research Station represents FS R&D in the States of California and Hawaii and the U.S.-affiliated Pacific Islands. The region has the lowest, driest desert in the country, the highest elevations within the 48 contiguous States, and the wettest tropical forests. It is home to an abundant diversity of native plants and animals and nearly half of the Nation's threatened and endangered species. PSW scientists are engaged in research across a network of 14 experimental watersheds, ranges and forests and 8 research facilities. PSW scientists conduct a broad array of natural resources research to achieve our mission to "develop and communicate science needed to sustain forest ecosystems and their benefits to society." Research is organized into five research units: conservation of biodiversity, ecosystem function and health, fire and fuels, urban ecosystems and social dynamics, as well as Pacific Islands forestry. For more information, visit fs.fed.us/psw.

PSW SCIENCE DELIVERY

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 Forest Service'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 Forest Service'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:

- Forest Service 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 3 years, projected high-risk locations in 2018 are mostly driven by high levels of beetle pressure, regardless of precipitation levels in the last 4 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 >90percent 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)

Source: USDA Forest Service

RMRS researchers work in a range of biological, physical and social science fields to promote sustainable management of the Nation's diverse forests and rangelands. The Station develops and delivers scientific knowledge and innovative technologies with a focus on informing policy and land-management decisions. Our researchers work in collaboration with a range of partners, including other agencies, academia, nonprofit groups, and industry. The Rocky Mountain Research Station serves the Forest Service as well as other Federal and State agencies, international organizations, Tribes, academia, non-profit groups and the public.

Research has been part of the Forest Service mission since the agency's inception in 1905. The Rocky Mountain Research Station (RMRS) is an integral component of USDA Forest Service Research and Development (R&D), which is the most extensive natural resources research organization in the world. Forest Service R&D is comprised of five regional research stations (RMRS, Pacific Northwest Research Station, Pacific Southwest Research Station, Southern Research Station, and Northern Research Station), 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 Forest Service Regions: Northern Region (Region 1), Rocky Mountain Region (Region 2), Southwest Region (Region 3), and Intermountain Region (Region 4).

RMRS administers and conducts ecological research on 14 experimental forests, ranges and watersheds over the 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

Enabling Local Monitoring of Landscape Change Across Eastern Africa

The Rocky Mountain Research Station (RMRS) led a 3-year initiative to raise the capability of an East African remote sensing center to use Landsat satellite imagery to map and estimate land cover change. RMRS Drs. Sean Healey and Zhiqiang Yang worked with the Regional Centre for Mapping of

Resources for Development in Nairobi to create and serve annual 30-m land cover maps for eight countries in East Africa. They built visualization and time series analysis tools using a cloud-based platform called Google Earth Engine that allowed access to a tremendous volume of imagery with minimal local infrastructure. This effort was funded by the NASA SERVIR program and was completed in conjunction with SilvaCarbon, the United States Government mechanism for carbon monitoring technical transfer. It was capped by a series of delivery workshops (see Table 1 below). It is expected that the land cover change maps provided by local partners will support efforts in each country to assess illegal logging, food production, water use, and urban growth.

Table 1. East Africa remote sensing product delivery calendar

City	**Country**	**Dates**	**Meeting Report**			
Kampala	Uganda	14-15 May, 2019	https://sites.google.com/site/rcmrdservir/third-training-uganda			
Dar el Salaam	Tanzania	16-17 May, 2019	https://sites.google.com/site/rcmrdservir/fourth-training-tanzania-1			
Kigali	Rwanda	20-21 May, 2019	https://sites.google.com/site/rcmrdservir/home/fifth-training-rwanda			
Addis Ababa	Ethiopia	29-30 Aug, 2019	https://sites.google.com/site/rcmrdservir/sixth-training-ethiopia			

Lilongwe	Malawi	2-3 Sep., 2019	https://sites.google.com/site/rcmrdservir/seventh-training-malawi
Lusaka	Zambia	5-6 Sep., 2019	https://sites.google.com/site/rcmrdservir/eighth-training-zambia
Antananarivo	Madagascar	7-9 Oct., 2019	https://sites.google.com/site/rcmrdservir/ninth-training-madagascar-1

International Wildfire Hazard Mapping Collaboration

In FY 2019, the Fire Modeling Institute (FMI) and the Wildland Fire Management Research, Development, and Application Group (WFM RDA) hosted three fire specialists from Morocco's High Commission (HC) on Water, Forests, and Combating Desertification for a 1-week study tour at the Rocky Mountain Research Station Missoula Fire Sciences Laboratory. This study tour was as a continuation of collaborations between the HC and the Forest Service that began in 2007, facilitated by FS International Programs. FMI fire behavior specialists and spatial analysts helped develop spatial layers needed to model fire behavior for Moroccan landscapes.

Wildfire Adapted Missoula

Wildfire Adapted Missoula is a Joint Chiefs Landscape Restoration Partnership Project designed to address shared wildfire risk by mitigating current wildfire hazards using fuels reduction treatments

through prescribed fire and thinning maintenance. Risk mapping performed by the Fire Modeling Institute (FMI), located within the Rocky Mountain Research Station Fire, Fuels, and Smoke Science Program, informed the 2018 update of the Missoula County Community Wildfire Protection Plan (CWPP), one of the foundational documents of Wildfire Adapted Missoula. FMI is also working with county geospatial analysts to update the CWPP with the most recent risk modeling information. https://www.nrcs.usda.gov/wps/portal/nrcs/mt/programs/financial/eqip/ec385d24-3215-4fd5-a41b-a9c0ab9cb7e4/

Wildfire Risk to Communities

Wildfire Risk to Communities is a joint partnership effort between Forest Service Washington Office Fire and Aviation, Rocky Mountain Research Station (RMRS) Fire Modeling Institute, Pyrologix (a geospatial analysis company headquartered in Missoula, MT), and Headwaters Economics (a research nonprofit based in Bozeman, MT). This program was directed by Congress under the 2018 Omnibus Act to help communities understand, manage, and mitigate wildfire risk. Spatial products are geared towards a number of groups including elected officials, land use planers, fire collaborative, and fire marshals. Products include maps showing wildfire likelihood, home risk, and wildfire source areas. Maps are expected to be available by March 20, 2020. RMRS is represented by several Fire Modeling Institute staff www.wildfirerisk.org (not active until 2020)

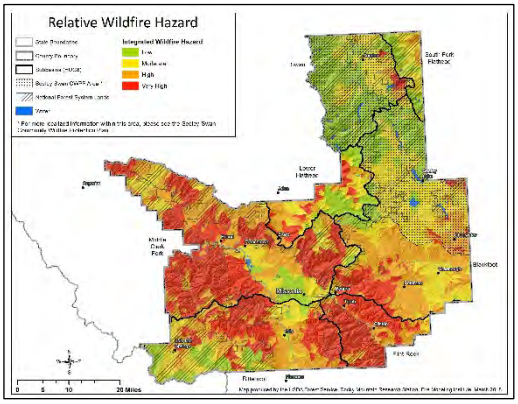
Community Planning Assistance for Wildfires

Community Planning Assistance for Wildfire (CPAW) is a program managed by Headwaters Economics which provides land use planning solutions to communities to help them better manage their wildland-

urban interface (WUI). The Rocky Mountain Research Station (RMRS) partners with Headwaters Economics, Wildfire Planning International, and Wildland Professional Solutions by helping select community applicants for the program each year and developing specific risk mapping products for selected communities. Knowledge co-production is integral in the process of modeling and mapping wildfire hazard in each community, as discussions with local subject matter experts guide model parameterization and map product specifics. The RMRS Fire Modeling Institute is leading the CPAW analyst. https://planningforwildfire.org/

FSim Modeling

The foundation for numerous risk mapping efforts is the Fire Simulation (FSim) system developed at the Rocky Mountain Research Station (RMRS) Missoula Fire Sciences Laboratory. FSim provides national burn probability and conditional fire intensity levels for the conterminous United States and includes modules for weather generation, wildfire occurrence, fire growth, and fire suppression. The RMRS Fire, Fuels, and Smoke Science program and the National Fire Decision Support Center is leading the development of FSim data in partnership with Pyrologix, a geospatial analysis company headquartered in Missoula, MT.



FSim maps model the way fire spreads across the landscape given topography, weather, and fuel data

https://www.fs.usda.gov/rds/archive/catalog/RDS-2016-0034.

The following blog post describes more about FSim products: https://www.tracplus.com/blog/mapping-us-wildfires/

S-490 Advanced Fire Behavior Calculations

Science developed at the Missoula Fire Sciences Laboratory, part of the Rocky Mountain Research Station, has served as the foundation for fire behavior courses sponsored by the National Wildfire Coordinating Group since the 1980s. As best available science changes over time a diligent effort is required to ensure the latest science is transferred to field practitioners throughout the interagency fire management community. S-490 (Advanced Fire Behavior Calculations) has been the target course over the last few years as science is outdated and therefore not adequately preparing field practitioners. The Fire Modeling Institute has collaborated with lead instructors from all geographic areas to ensure the redesigned S-490 provides the best available science in an experiential learning environment. S-490 is a required course for Type 1 Burn Boss (RXB1), Long Term Fire Analyst (LTAN), and Fire Behavior Analyst (FBAN). https://nationalfiretraining.nwcg.gov/catalog/detail/code/S490

Training Development and Presentation related to NFDRS2016

The National Fire Danger Rating System has been updated for the first time in 40 years. The last major revision was in 1978, with a few modifications in 1988. The new NFDRS2016 model has been developed, and both FireFamilyPlus and the Weather Information Management System are being updated to include the new science. To inform agency personnel about the changes to the system, two initiatives were undertaken. The first is a series of workshops in every geographic area that introduces the new science to local land managers and assist them with creating or updating local Fire Danger Operating Plans. Scientists and staff with the Missoula Fire Sciences Laboratory, part of the Rocky Mountain Research Station, assisted in creating workshop materials and presented at workshops aimed at developing local fire danger experts. The second initiative is a complete rewrite of the NWCG course

S491 (Intermediate National Fire Danger Rating System) using scenario-based training. Upon completion of this course, the student will demonstrate the knowledge and skills necessary to operate, interpret, and apply the United States National Fire Danger Rating System.

New tools to map snag hazard after fire can improve firefighter safety

Through a combination of remote sensing, field-based estimates of mortality and snag fall rates, and analytics, Rocky Mountain Research Station and Oregon State University researchers developed a series of snag dynamics statistical models for common tree species in dry conifer forests of the America West. These models were then applied to six recently burned landscapes to develop maps that summarize 50 years of projected fire responder exposure to snag hazards. Starting conditions for modeling after each fire were strongly influenced by fire severity, where snag density in high-severity patches was more than double that of low-severity patches. Larger fires also tended to have larger patches of high-severity fire with increased snag hazard. To characterize risk to fire responders, the model results were summarized by snag height and density to produce a simple index of responder exposure through time.

FIRE-BIRD: A GIS tool for applying habitat suitability models to inform land management planning

To conserve and promote biological diversity, land managers must identify suitable habitat for species of conservation concern. Managers can then restrict potentially detrimental activities (e.g., salvage logging) to areas of lower habitat suitability, and target beneficial activities (e.g., restoration) where habitat suitability is higher. Rocky Mountain Research Station (RMRS) scientists and their Forest Service and external partners developed FIRE-BIRD, an ArcGIS tool, to map habitat suitability for

disturbance-associated woodpeckers of conservation concern to inform postfire management and restoration treatments in dry mixed-conifer forests. Habitat suitability models can inform forest management for wildlife species of conservation concern. Models quantify relationships between known species locations and environmental attributes, which are used to identify areas most likely to support species of concern. Managers can then limit negative human impacts in areas of high suitability or conduct habitat improvements in areas of marginal suitability. RMRS scientists and their collaborators developed FIRE-BIRD, an ArcGIS toolbox, to map habitat suitability for disturbance-associated woodpeckers of conservation concern to help inform locations for management activities in predominantly burned forests of the Inland Northwest and Northern Sierras. The suite of species currently included black-backed [*Picoides arcticus*], white-headed [*Dryobates albolvartus*], Lewis's [*Melanerpes lewis*], and hairy [*D. villosus*] woodpeckers) makes the GIS tool best suited for postfire management and restoration treatments in dry mixed-conifer forests.

To Masticate or Not: Useful Tips for Treating Vegetation

Scientists at the Rocky Mountain Research Station prepared a general technical report that synthesizes state of the knowledge on mastication as a forest management tool. They found that excavators, skid steers, and tractors can all be carrier machines and different types of vertical and horizontal cutting heads exist that can be front-end mounted or boom-mounted, each with its own advantages and disadvantages. The scientists provide a summary of the ecological effects of mastication. Although costs widely vary depending on machine size, the physical setting, size and configuration of pre-treatment biomass, and operator skill, mastication does have market and non-market benefits. Depending on the management objective, if mastication is an option, then a thorough site evaluation should consider slope, nonnative species invasions, vulnerability of soils to erode or compact, and treatment costs.

A Science Framework for Conservation and Restoration of the Sagebrush Biome

An unprecedented conservation effort is underway across 11 Western States to address threats to sagebrush ecosystems and the many species that depend on them. In 2019, the U.S. Department of Agriculture and the U.S. epartment of the Interior released the Science Framework for Conservation and Restoration of the Sagebrush Biome (Part 2), led by Rocky Mountain Research Station scientists, to assist these efforts. The *Science Framework* provides a transparent, ecologically responsible approach for making policy and management decisions for sagebrush landscapes. Widespread concern about conservation of sagebrush ecosystems and sage-grouse creates expectations that natural resource agencies will manage sagebrush habitat effectively to conserve sage-grouse across the 11 Western States encompassed by the sagebrush biome. An extensive, collaborative State and Federal partnership of more than 30 individuals has led to a two-part Scientific Framework for addressing threats to sagebrush ecosystems and associated species. Part 1 of the Science Framework provides tools for prioritizing areas for management and determining effective management strategies across the sagebrush biome. Part 2 of the Science Framework focuses on management considerations and tradeoffs for applying the scientific information, geospatial analyses, and decision-support tools in Part 1.

"'Chem Herding'" to Improve Biological Control of Saltcedar (Tamarix Spp.) in the Northern Rockies

Rocky Mountain Research Station scientists and collaborators evaluated the use of aggregation pheromone lures to establish new populations of tamarisk leaf beetles (*Diorhabda spp.)*, a biological control insect that has significantly reduced saltcedar infestations in the southwestern United States. Saltcedar (*Tamarix* spp.), a complex of invasive shrub and tree species, is now the third most prevalent

group of woody riparian species in the southwestern United States. Abundant populations of *Tamarix* damage may be intensified through 'chem herding', where aggregation pheromones are deployed to artificially increase the number of *Diorhabda* beetles reproducing on and attacking saltcedar in the Northern Rockies. This study evaluated the role of pheromones in spatially manipulating beneficial insects, specifically the colonization success and increased efficacy of weed biological control agents. The use of lures in conjunction with smaller releases still resulted in establishment of new populations.

Proactive Limber Pine Conservation Strategy for the Greater Rocky Mountain National Park Area

The Rocky Mountain Research Station, along with collaborators, developed a proactive conservation strategy that addresses the unique situation of limber pine in the Greater Rocky Mountain National Park Area (GRMNPA). The GRMNPA is at the infection front for white pine blister rust (WPBR) where populations were also impacted by the recent mountain pine beetle epidemic and are threatened by climate change. This is the first proactive conservation strategy for a five-needle pine species in North America. It focuses on timing specific monitoring efforts and interventions to sustain healthy limber pine populations and ecosystems during invasion and naturalization of WPBR, thereby putting limber pine on a trajectory that reduces the probability of ecosystem impairment in the future. The strategy outlines recommendations to promote (1) ex situ and in situ limber pine conservation and protection, (2) increased limber pine population size and sustained genetic diversity, (3) treatments to maintain durability of genetic resistance to WPBR, (4) monitoring forest health conditions for early detection of WPBR and changes in pathogen virulence, and (5) coordinated management actions within and among agencies. The recommendations apply to the GRMNPA and possibly to all the southern Rockies; the approach used can be applied further. The recommendations herein are expected to be relevant for at least 20 years. https://www.fs.usda.gov/treesearch/pubs/57621

Rare Carnivore Detections from Environmental DNA in Snow

(leave as is) innovative new project has discovered that animal footprints contain enough DNA to allow for species identification. Scientists have traditionally relied on snow-tracks and camera traps to monitor populations of rare carnivores, like Canada lynx, fishers and wolverines. These traditional techniques can tell part of, but not the entire story of an animal population, and are sometimes difficult to validate species identification. A study, led by the Rocky Mountain Research Station, collected snow samples within animal tracks from known locations of collared or photographed animals. DNA was extracted from these samples and analyzed with cutting-edge genomic tools and newly developed molecular genetic assays to identify each species. Researchers found these assays positively detected the DNA of each species in various snow samples and outperformed traditional lab techniques on previously undetectable genetic samples, which suggests that this method could revolutionize winter surveys of rare species by greatly reducing or eliminating misidentifications and missed detections. Monitoring for rare carnivores in the winter, using traditional methods, can be time intensive, expensive, and dangerous. What this means for managers is gained efficiency and accuracy, and that better information will be available to help conserve these species of concern. A short film, *Tracking Snow*, showcases this project. The film was created by the International Wildlife Film Festival Filmmaker Labs and is hosted by the National Geographic Short Film Showcase. https://www.fs.usda.gov/rmrs/news-releases/new-way-look-winter-footprints https://www.fs.usda.gov/rmrs/publications/using-environmental-dna-methods-improve-winter-surveys-rare-carnivores-dna-snow-and

Socioecological Impacts of Multiple Forest Insect Outbreaks in the Pinaleño Spruce-Fir Forest, Arizona

Rocky Mountain Research Station evaluated the socioecological impacts of multiple high-severity insect outbreaks and wildfires that dramatically altered the character of the Pinaleño high-elevation forests. The Pinaleños are a small mountain range positioned close to large population centers, but not so close that any large industry is dependent on their resources, so regional and local impacts of the insect outbreaks to provisional resources were minor. There were qualitative impacts to cultural services, particularly to recreation, but no documented economic impacts. Effects on carbon and fuels were significant but affected firefighting operations more than wildfire severity. The Pinaleños are positioned in an area of high biodiversity and impacts on habitats of unique species were sometimes positive but also sometimes severely negative, especially on a relict population of Engelmann spruce and the critically endangered Mount Graham red squirrel. The Pinaleño situation illustrates how ecological disturbances can have a minor immediate economic impact but severe impacts on ecosystems and ecosystem services.

Citizen Science Water Quality Monitoring Program

The Rocky Mountain Research Station has partnered with the 501(c)3 non-profit Coalition for the Poudre River Watershed to set up a citizen science monitoring program in the upper Poudre River watershed. The program focuses on gathering baseline watershed conditions, assessing post-fire recovery, and prescribed fire monitoring. Citizen science volunteers collect water quality data in small streams and in the upper watershed at least four times a year.

https://www.poudrewatershed.org/citizen-science

Spicing Up Native Plant Restoration

Have you ever touched a hot pepper and then rubbed your eyes? Chances are you will not want to go near the pepper again. A study lead by the Rocky Mountain Research Station found that you can use this same concept to deter rodents from eating seeds, thus protecting investments in native plant restoration efforts. Rodent granivores, like deer mice, eat seeds as their main food source, which can inhibit restoration efforts in a variety of plant communities. The researchers used the active ingredient that creates heat in peppers, capsaicin, and coated native plant seeds with the same active ingredient, hoping to deter rodent granivores. The 4-year project included both laboratory and field experiments with the seeds – placing the seeds in controlled conditions, as well as in sites of prolonged exposure to the outside elements. They found that applying a capsaicin coating to spring-germinating seeds sown in late winter increased native plant recruitment. It also reduced the total cost per established seedling. The work done on this study demonstrates the possibilities hot peppers can play in successful restoration practices.

After the Fire – Wood Waste Put to Work

Biochar, or wood waste, is a porous carbon substance that results from burning wood in the absence of oxygen. It is typically created when burning chunks of wood are covered by ash, soil or a lid, which insulates the coals and starves them of oxygen. This fire remnant provides a valuable addition to soil for agriculture and gardening purposes as well as contributing to overall forest health. Despite its usefulness, biochar is difficult to produce in large quantities for agricultural, forestry, or commercial use. With healthy forests in mind, the Rocky Mountain Research Station (RMRS) and Air Burners, Inc. teamed up to optimize biochar production for the marketplace. RMRS has partnered with the Air

Burners, Inc. through a cooperative agreement to help find a solution to this problem. The company's commercial fireboxes, used for processing wood and vegetative waste, are being modified to produce high-quality biochar.

https://airburners.com/resource-center/news/

Forest Biomass and the Bioeconomy Conference

Rocky Mountain Research Station scientists served as the lead organizers of the Forest Biomass and the Bioeconomy: Using forest residues for profit, carbon sequestration, and soil restoration considerations Conference in April 2019 (Vancouver, Washinton). Participation was excellent with over 100 participants in the room and 30 streaming participants from industry, Tribes, Forest Service,r , Bureau of Land Management, The Nature Conservancy, and universities.

https://westernforestry.org/wp-content/uploads/2019/02/Biochar-2019-brochure-v5.pdf

Forest Service Fosters Global Native Plant Nursery Community of Practice

The USDA Forest Service frequently provides international technical assistance and capacity building in support of native plant nurseries. In an ongoing effort to meet the global need for high-quality, sustainably produced native plant seedlings to address local ecological and economic challenges, shared practices are being used across an informal network of nurseries around the world. In collaboration with Oregon State University, the Forest Service recently co-sponsored a study tour in Cape Town, South Africa, for 10 nursery practitioners from Lebanon, Jordan, Zimbabwe, Togo and Morocco. This study tour is part of a collaborative program with a variety of international nursery practitioners to critically

examine restoration practices, exchange experiences and enrich forest nursery practices through field visits and interactive discussions.

The study tour included a focused workshop, as well as participation in the World Conference on Ecological Restoration. Instructors included agency personnel affiliated with the National Center for Reforestation, Nurseries, and Genetics Resources (RNGR), scientists from the Rocky Mountain Research Station and the Pacific Northwest Regional office. The National Center for RNGR is a cross-deputy Forest Service program whose mission is to supply people who grow forest and conservation seedlings with current technical information and to provide links to other organizations and individuals with similar interests.
https://www.fs.fed.us/inside-fs/delivering-mission/apply/forest-service-fosters-global-native-plant-nursery-community

Tribal Plant Nurseries Are About More Than Growing Plants

Numerous Tribes throughout the United States are growing native plants for reforestation and restoration. For many of them, however, there are deeper connections with the plants they are propagating. The plants fulfill an ecological purpose for the projects they are intended for, but often there can be deeper cultural connections as well. That is, seedlings intended for a restoration project may contain species of plants the Tribe used traditionally. Tribes have a rich history and intimate connection with the landscape, and historically, the land provided everything they needed to survive. Much of what they depended on were plants, and they used them for food, shelter, textiles, medicine, and ceremony. To do this, they needed to be in tune with the seasons and use their traditional ecological knowledge to harvest and manage native plants in a sustainable manner.

Fast forward to current times and you'll find that Tribes are still in the native plant business, but some of the contemporary management objectives have changed. In the context of restoration and reforestation, native plants are being grown for wildlife habitat improvement, invasive species mitigation, bioengineering purposes, erosion control, and post-wildfire rehabilitation to name a few. All this with the added spin of keeping ties with the plant roots and how they were used traditionally. Consequently, projects confer additional Tribal benefits that may include efforts to preserve culture, help educate, improve plant availability or provide economic benefit.

Many of the Tribes that produce native plants are involved in the Intertribal Nursery Council. This group is a USDA Forest Service-managed, triballyguided, organization for advancing the interests of native peoples involved with plant production in nurseries. The group was originally formed at the request of Tribes, with the intent of providing a platform where Tribal nursery professionals could collectively share and learn information and meet annually, much like the other professional nursery associations already in the United States. Again, the added twist is the infusion of traditional knowledge and experiences.

The Intertribal Nursery Council provides a unique opportunity for like-minded Tribal (and non-Tribal) practitioners to celebrate native plant propagation and use both from a management and cultural perspective. Activities are facilitated by the agency's Reforestation, Nurseries, and Genetic Resources Team with the ultimate objective of deploying functional species on the landscape.

https://www.fs.fed.us/features/tribal-plant-nurseries-are-about-more-growing-plants

SOUTHERN RESEARCH STATION (SRS)

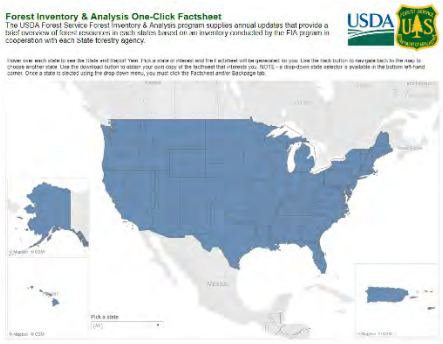
The Southern Research Station (SRS) includes research work units across 13 southern States and employs more than 300 people, including 91 research scientists. SRS research advances many areas of forestry science: the use of prescribed fire; hardwood and softwood silviculture, harvesting, and utilization; protection of drinking water supplies and water quality; sustainable management of wildlife habitat; and the control of insects, diseases, and invasive plants. SRS partners with the Southern Region of the National Forest System to conduct research on a network of 19 experimental forests.

Throughout FY19, SRS focused on research and technology that would foster productive, sustainable use of public and private lands. SRS shared these innovations with partners and stakeholders, including:

- 464 scientific publications
- 117 tours to educational and professional organizations
- 238 presentations to lay organizations
- 435 presentations to research and professional organizations
- 58 articles in the SRS online science magazine, CompassLive
- 150+ posts to more than 5,500 followers on Twitter
- 25+ posts to more than 10,000 followers on Facebook

Some highlights of these outreach, science communication, science delivery, and technology transfer efforts are listed below.

FIA One-Click: automated annual factsheets for every State



The USDA Forest Inventory and Analysis Program has developed a series of One-Click Factsheets that summarize State-level estimates of forest land for each State. The factsheets are automated, frequently pulling updated information from robustly vetted data sources, including Timber Products Output and the National Woodland Owners Survey. The factsheets link to interactive maps where users can browse summaries for each State, along with regional and national statistics. One-Click Factsheets require significantly less effort to develop than previous resource updates, which allows FIA scientists to focus on regional and national products while collaborating with other USDA scientists and external researchers, to the benefit of every American who relies on forests. Increasingly, FIA scientists and scientists from universities or other organizations are working to apply FIA's repeated measurement data to answer broad-scale questions about timber supply, biodiversity, and risk from invasive plants. For more information: https://doi.org/10.2737/FIA-One-Click-State-Report-v1.2

Role of mechanization in fire risk reduction and application

Fire and fire surrogate treatments are critical tools in management, restoration, and risk control across a wide variety of forested ecosystems. Reducing hazardous fuels mechanically could lower costs and increase productivity, allowing for huge increases in the amount of land that can be treated either with

prescribed fire or a surrogate. Understanding conditions where mechanization can be successfully applied is key to its adoption. SRS researchers identified the general ranges of productivity and costs for most potential mechanized fuel reduction treatments. In addition, researchers examined how specific site conditions might affect operations. The study also addressed costs and key aspects of production measurement that are important to decision-makers. The researchers evaluated different options for removing fuels, creating firelines, and recovering costs with biomass feedstocks. For more information: https://www.srs.fs.usda.gov/pubs/58338.

New urban forest research sheds light on the risk of pest invasions

Urban forests are often where non-native invasive pests are first introduced via global trade. From there, they can spread into natural forests. Urban forests are highly susceptible to these pests. Unfortunately, the make-up of urban forests in the United States is not always available. What trees are there, where are they, and how many? SRS scientists and colleagues developed a modeling approach that uses existing data to estimate numbers of trees in the thousands of urban areas across the eastern and central United States. that don't have inventories. The scientists did this for three prominent genera: ash, oak, and maple. The scientists modeled relationships between tree inventory and canopy cover, climate, and demographic trends. They are now adapting the approach to model urban distributions of other trees, such as palms. Palms are common street trees in places such as south Florida and would be susceptible to pests such as the coconut rhinoceros beetle or the red palm weevil, which have not yet invaded. The ongoing research facilitates better assessment of the spread and potential impacts of invasive urban forest pests. For more information: https://www.srs.fs.usda.gov/pubs/57093.

Natural loblolly pine stands offer potential for biofuels

The southern United States has tens of millions of acres of loblolly pine plantations–along with at least as much natural-origin loblolly. These natural stands have considerable potential for advanced biofuel feedstocks, especially when produced in low-value silvicultural treatments. SRS scientists gathered and chipped low-value harvest residues, including pre-commercial thinnings, branches, tops, and slabwood from sawlogs from two naturally regenerated stands in southern Arkansas. The team analyzed the materials, and their results clearly demonstrated that these harvest residuals and manufacturing byproducts may be an attractive prospect for bioenergy applications. A number of logistical challenges exist in their acquisition and processing, but thinned small trees, slabs, topwood, and branches offer opportunities for bioenergy feedstocks that can increase the utilization of forest residues without threatening more traditional uses of wood in lumber, panels, and paper. As the southern pulp and paper industry continues to decline, biofuel feedstocks provide an alternate management opportunity for southern landowners. For more information: https://www.srs.fs.usda.gov/pubs/58176.

Back-to-nature forestry in Missouri, Arkansas, and Louisiana

SRS hosted a 5-day field tour for a group of forest researchers and forest managers of the Arbeitsgemeinschaft Naturgemäße Waldwirtschaft, from Germany, Switzerland and Austria. The group visited the privatelyheld Pioneer Forest, Missouri, to see Ozark oak-hickory-pine stands managed using uneven-aged silvicultural methods. They toured the Shortleaf Pine-Bluestem management area on the Ouachita National Forest in western Arkansas, which is managed on 120-year rotations using thinning and prescribed fire. The group saw even- and uneven-aged management of southern yellow pine at the Crossett Experimental Forest in south Arkansas and the restoration and management of longleaf pine

using the shelterwood method and prescribed fire in Louisiana, on the Kisatchie National Forest and the Palustris Experimental Forest. SRS Silviculturist Jim Guldin prepared, coordinated, and led the tour.

Do snakes get tangled up in blankets?

Across the United States, roadsides are protected with erosion control blankets during construction projects to prevent soil loss and encourage seedbed regeneration. These blankets are generally made of mesh to allow plant regrowth, but wildlife, especially snakes, can get trapped in the openings. SRS scientists and colleagues conducted a literature review, field surveys, and an experiment to examine what factors increase a snake's risk of becoming entangled in erosion control blankets. The review produced reports of 175 reptiles entangled in mesh products, 89 percent of which were snakes. Almost 44 percent of snake entanglements occurred in erosion control products. Field surveys found 10 entangled snakes, 2 alive and 8 dead. The experiment results showed that erosion control blankets with fixed-intersection, small-diameter, polypropylene mesh were significantly more likely to entangle snakes than blankets with larger diameter polypropylene mesh or mesh made of natural fibers. Larger snakes were more likely to get tangled up. These results help to construct a predictive framework to guide the choice of erosion control blanket materials and determine species and individuals that are most vulnerable to entanglement. For more information: https://www.srs.fs.usda.gov/pubs/58294.

Electronic noses detect disease in plants, animals, and humans

Electronic noses can noninvasively detect disease in plants, humans, and animals, as SRS researcher Dan Wilson has shown. Wilson has been at the forefront of e-nose technology for decades. He recently identified the smellprint of ash trees infested with emerald ash borer larvae – potentially providing a new

tool for early detection of the destructive beetle. Wilson has also shown that e-noses can noninvasively detect the fungal pathogen *Pseudogymnoascus destructans* on bats. The fungus causes white-nose syndrome and has killed millions of bats. Wilson is working to identify the volatile organic compounds associated with different cave types, the fungal pathogen, white-nose syndrome, disease biomarkers, and at least eight WNS-susceptible bat species. Originally a plant pathologist, Wilson studied human physiology in order to understand bat physiology. He has made major contributions to the biomedical field, publishing on everything from forensic science to gastrointestinal disease and biomarker metabolite signatures. For more information: https://www.srs.fs.usda.gov/pubs/59066.

Bats of Arkansas booklet

Eighteen species of bats are found in Arkansas, and teachers, naturalists, wildlife biologists, and others now have a detailed new resource – the Bats of Arkansas, an 89-page book published by the Center for Bat Research, Outreach, and Conservation at Indiana State University. The book contains information on each species found in Arkansas, including their identification, natural history, county-level distribution, and their echolocation calls. The book also discusses threats to bats and how people can help protect them. SRS wildlife biologist Roger Perry and researchers from Environmental Solutions and Innovations, Inc. wrote the book, which is part of a series. Other books in the series focus on the bats of Kansas, Illinois, and Missouri. The book uses plain language and abundant photos to help individuals identify, understand, and appreciate bats. For more information: https://www.batgoods.com/item/Bats-Of-Arkansas-1805.

Tailoring prescribed fire to benefit private landowners and longleaf pine restoration efforts

Strides to restore fire-adapted longleaf pine ecosystems depend on private landowner buy-in. Often landowner objectives demand more than longleaf survival and ecosystem restoration; they also require an acceptable rate of wood production. Ongoing research has provided detailed information about prescribed fire and the conditions necessary for rapid regrowth of scorched foliage in seedling and sapling stands of longleaf pine. Two physiological mechanisms that regrow scorched foliage are seasonally available starch reserves and net photosynthesis in unscorched foliage. SRS researchers and cooperators found that conservation of some foliage on longleaf pine trees during prescribed fire promotes regrowth of scorched foliage. Between March and May, both starch reserves and net photosynthesis support post-scorch foliage regrowth. Beyond May, the regrowth of scorched foliage depends on net photosynthesis. When foliage conservation is unlikely due to seedling or sapling stature, prescribed fire should be applied between March and May. This information can guide fire application as early as the second growing season after planting. Controlling woody competitors during the period is critical to longleaf pine success. SRS scientists have shared these findings at technical and nontechnical forums. Additionally, the relationship between foliage and plant growth is universal. Thus, the principles of this research are applicable to all fire-adapted forest systems. For more information: https://www.srs.fs.usda.gov/pubs/57365.

Predicting southern pine beetle outbreaks

A new tool can help managers anticipate and reduce beetle damage from the most destructive insect in southeastern United States–the southern pine beetle. Broad scale outbreaks can last several years if not suppressed and have resulted in more than a billion dollars in timber losses over the past few decades.

Forest land managers need better information to identify and prepare for beetle outbreaks so that they can focus their limited resources on quick treatment. Understanding where beetle outbreaks are most likely to occur is important for early detection. SRS scientists and experts from State & Private Forestry and the National Forest System developed the tool. The joint research project led to the development of a model that can predict new southern pine beetle outbreak areas with 72 percent accuracy as early as 9 months in advance. This new tool was first used during the 2019 growing season and was shared with forest managers in high and moderate risk areas. For more information: https://www.climatehubs.usda.gov/hubs/southeast/topic/forecasting-short-and-long-term-southern-pine-beetle-risk-southeastern-us

A new approach for identifying human communities at risk from climate and land use change

Identifying vulnerable human communities is critical for climate change planning and mitigation. Shifts in streamflow, due to future climate and land use change, may threaten communities. Projecting the spatial distribution and impacts of these risks requires consideration of biophysical and socioeconomic factors. Models like the Soil and Water Assessment Tool can project spatial distributions of hydrologic risk due to shifting biophysical factors like climate and land use, but they cannot account for socioeconomic factors. Socioeconomic factors influence a community's capacity to adapt to future streamflow changes. To address this limitation, SRS scientists and cooperators developed a risk matrix that integrated a social vulnerability index with future streamflow projections in response to land use and climate change. The matrix was used to classify high-risk sub-basins in the Yadkin-Pee Dee River watershed in North Carolina. Projections of future streamflow suggest large increases in extreme high flows. The increases occurred in middle and lower parts of the river basin. Socially vulnerable communities are distributed throughout. The research identified several sub-basins with vulnerable

communities that are projected to experience future increases in streamflow due to climate and land use change. These results serve as a starting point for subsequent climate change adaptation planning. For more information: https://www.srs.fs.usda.gov/pubs/58292.

A practical guide for ecological restoration to curb biotic invasion

Restoration programs often include conservation and economic goals. To achieve both, restoration must curb biotic invasions, even under ongoing climate change, and mitigate continued human disturbance. SRS scientists and cooperators reviewed the literature to identify common, feasible ecological practices that can help ecosystems resist new invasions and suppress the dominance of existing invasive species. Common practices for invasive species control and management include physical, chemical, and biological approaches. The biological approach includes biocontrol and the ecological approach. The ecological approach may be the safest and most practical choice. It has two major components: restoring native plant species and managing the restored community to achieve and maintain viable populations. The literature review focuses on the last decade and examines ecological approaches that involve biodiversity, biomass, and productivity–three key ecosystem variables that reciprocally influence one another. The scientists conclude that, because of the strong influence from exotic species pools in neighboring areas, local restoration and management efforts would benefit from considering the regional context and projected climate changes. For more information: http://www.srs.fs.usda.gov/pubs/58155.

Improved multiple-funnel trap for detection of bark and woodboring beetles

Many species of forest insects pose invasive risks worldwide, necessitating early detection trapping programs. Intercept or multiple-funnel traps are typically used and were originally designed for bark and

ambrosia beetles. Many woodboring species, such as the invasive Asian longhorn beetle, are larger and the lures to catch these beetles are often too large to fit within the funnels as originally designed. SRS scientists and cooperators enlarged the center holes of each funnel, which allows lures to be placed within the funnels. The modification resulted in significant increases in catches of numerous species of longhorn beetles, several species of bark beetles, reproduction weevils, flatheaded woodborers, and beetle predators. Hanging lures within the trap allows odors to escape from each funnel rather than a single point when attached to the outside of the trap. This increases the interaction area with flying insects and thus improves detection efficiency. The modified trap is also lighter, resulting in reduced shipping costs and easier installation. Based on these results, Synergy Semiochemicals, a major distributor of traps and lures for bark and woodboring beetles, modified its standard multiple-funnel trap by shortening the size of each funnel. For more information: https://semiochemical.com/funnel-trap-ii/.

Strategies for successful engagement of African American landowners in forestry

In 2012, the Sustainable Forestry and African American Land Retention Program was initiated by the U.S. Endowment for Forestry and Communities and the USDA Forest Service and Natural Resources Conservation Service. Community-based pilot projects began in North Carolina, South Carolina, and Alabama. After 4 years, SRS scientists studied the pilots to identify lessons for success. This was in contrast to prior research that had described the problem and made recommendations but had not analyzed what worked well. Researchers conducted qualitative interviews with 33 individuals associated with the projects, including African American landowners, natural resource professionals from State and Federal agencies, cooperative extension agencies, and forest industry professionals. The team identified processes to enhance awareness and education about forestry, to address ownership issues and heirs' property, to improve participation in financial assistance programs, and to increase returns from timber

harvesting. The study also identified a 10-step process for gradually increasing landowners' engagement with sustainable forest management. Lessons for success include establishing community-based networks to provide coordinated outreach and education, linking legal assistance for heirs' property with forestry assistance, patiently engaging landowners through a process of forestry awareness and action, addressing obstacles identified by prior research, and resolving difficulties and maintaining momentum with regular feedback and problem solving. For more information: https://www.srs.fs.usda.gov/pubs/58938.

Eastern Band of Cherokee Indians gathers plants in the Great Smoky Mountains National Park based on traditional ecological knowledge

A collaboration with the Eastern Band of Cherokee Indians (EBCI)and other partners has demonstrated that traditional harvesting techniques for the edible plant sochan enhance plant populations. EBCI recently signed a plant gathering agreement with the National Park Service – the first of its kind in the Nation. Community members can gather the edible spring green, sochan (*Rudbeckia laciniata*) within the Great Smoky Mountains National Park boundaries. Research supports the agreement by demonstrating that traditionally harvesting the young leaves of sochan at moderate rates does not harm plants. Rather, this practice stimulates more vigorous growth and leads to increased flower and seed production. EBCI has partnered with SRS scientists to communicate the traditional ecological knowledge (TEK) and sustainability of plant gathering practices necessary for the agreement. Interviews with community members about sochan harvesting contributed to the development and testing of a sochan monitoring protocol and helped to identify potential gathering sites within the park. A limited body of research exists on plant species important to Native American Tribes. The cultural and

ecological information put together by the scientists directly informed and resulted in the sustainable harvest policy.

FIA partnership for tick surveillance

Diagnosed cases of tick-borne diseases are increasing at an alarming rate. Surveillance is needed to understand tick distribution and seasonality, to detect invasive ticks such as Asian longhorned tick, and to understand disease risk and epidemiology. SRS and the University of Tennessee (UT) partnered in an unprecedented surveillance effort targeting southeastern ticks. Forest Inventory and Analysis (FIA) crews travel far and wide, working throughout the United States in all habitats and land ownerships to collect tree and vegetation data on tens of thousands of permanent plots. From 2014 to 2017, FIA crews checked themselves for ticks after completing a plot and logged all encountered ticks. UT researchers identified all ticks by species and life stage. During the study, FIA crews encountered nearly 1,200 ticks–including lone star ticks with *Ehrlichia* pathogens, American dog ticks, blacklegged ticks, and cayenne ticks. The study provided seasonal phenology and regional distribution of tick encounters in sampled areas of the Southeast. Results indicate that passive surveillance can be used to generate useful data for pathogen detection. For more information: https://www.srs.fs.usda.gov/pubs/58358.

Mapping Phytophtyora root rot resistance genes in American chestnut

Phytophthora root rot (*Phytophthora cinnamomi*, a soilborne oomycete) is a lethal pathogen of American chestnut (*Castanea dentata*). The microbe is particularly damaging to chestnut and chinquapin in the southern United States. Developing resistant genotypes is the most practical solution for disease management. SRS scientists and cooperators used backcross families derived from crosses of

American chestnuts with two resistant Chinese chestnut genotypes (‘Mahogany’ and ‘Nanking’) to genetically map quantitative trait loci for resistance to *P. cinnamomi*. In total, 957 plants representing 5 cohorts of 3 hybrid backcrosses were genotyped by sequencing and phenotyped using artificial inoculations. The results imply that the genetic architecture of resistance to *P. cinnamomi* in Chinese × American chestnut hybrids resemble the *P. sojae*–soybean pathosystem. The gene map is helping chestnut breeders and genetic engineers improve chestnut for planting on impacted sites. For more information: https://www.srs.fs.usda.gov/pubs/59025.

Melding science and management to achieve oak forest restoration: The Cold Hill Silvicultural Assessment

A broad-scale study of applied silviculture to improve forest health and resiliency on the Daniel Boone National Forest in Kentucky continues to bring together researchers and managers to address restoration goals. Research forester Callie Schweitzer leads an interdisciplinary team that includes partners from the Northern Research Station, the University of Tennessee, and the University of Kentucky. Amid changes in disturbance regimes and forest dynamics, the group is examining treatments to create conditions conducive to sustaining oak trees. Oak is highly valued for its economic and ecological attributes. In essence, small oak trees are being outcompeted by other tree species, and oaks are likely to lose their prominence in eastern hardwood forests. Managers and researchers recently amended the project plan, assessed the environmental impacts, and engaged with the public through field tours and social media. Researchers will examine forest response as the silviculture prescriptions are applied; provide continuity for long-term monitoring; and add analyses related to American chestnut restoration, the impact of forest pathogens, and the consequences of prescribed fire. The project has created a culture in which building long-term interactions and interdisciplinary teams is the preferred model to approach forest

management. For more information: https://www.srs.fs.usda.gov/compass/2018/02/22/the-cold-hill-silvicultural-assessment/.

Biological control of the walnut twig beetle using insect-killing fungi

Thousand cankers disease causes branch dieback and mortality of eastern black walnut. The disease is caused by the joint action of the walnut twig beetle and a pathogen it carries. Because black walnut trees produce nuts that are consumed by both humans and wildlife, options to protect trees with traditional, synthetic insecticides are limited. SRS researchers and cooperators investigated a more ecologicallyfriendly control alternative, two naturallyoccurring species of insectkilling fungi: *Beauveria bassiana* and *Metarhizium brunneum*. In a series of experiments, scientists sprayed commercial formulations of these fungi on the bark of walnut logs. The logs were then exposed to walnut twig beetles in the laboratory and the field. The sprays infected more beetles with the insect-killing fungi, and the fungi greatly reduced the number of beetles emerging from walnut logs. The results demonstrate the potential use of insect-killing fungi as a biologicallybased tool for reducing the impact of thousand cankers disease. For more information: https://www.srs.fs.usda.gov/pubs/58291.

Assessing the vulnerability of tree species to insect and disease threats

Diseases and insects, particularly those that are non-native and invasive, threaten North American forests. Tree species, however, differ in life-history strategies and population dynamics, which could drive varying responses to these threats. To address this challenge, SRS scientists implemented a national framework to prioritize forest tree species for conservation, management, or monitoring. The team compiled a list of the most serious insect and disease threats affecting each of 419 native tree

species and then assigned a severity rating for each of the 1,378 combinations between tree hosts and insect and disease agents. The results include maps of geographic hotspots of potential forest impacts associated with insects and diseases. Next, the researchers combined this list with trait data for each tree species as part of the Project CAPTURE framework (Conservation Assessment and Prioritization of Forest Trees Under Risk of Extirpation). Data-driven and guided by expert opinion, Project CAPTURE groups species into vulnerability classes that may require different management and conservation strategies. This effort identified 15 species that require the most immediate conservation intervention, as well as others that could be targets for less urgent management actions. For more information: https://www.srs.fs.usda.gov/pubs/58289, https://www.srs.fs.usda.gov/pubs/58290.

Improving hurricane damage assessments with new satellite technology and outreach

Damage assessments are crucial in the immediate wake of extreme hurricanes such as Hurricane Michael, which struck the southeastern United States. in late 2018. The destruction caused by such severe storms typically restricts accessibility, and this, along with the huge scale of the impacted area, makes accurate and rapid assessments from ground observations impossible. Newly available high-frequency, high-resolution satellite technology is a game changer for rapid forest assessment. The European Space Agency's Sentinel 2 twin satellites provide ten-meter observations at 5-day intervals that can result in remarkably early and efficient damage insights. With the help of cloud computing and some technical expertise, these high-resolution forest maps can identify damage in hardwood and conifer areas. SRS scientists worked with State and Fderal forestry agencies to develop repeated assessments after Hurricane Michael and refine on-the-ground understanding of the damages. This collaborative effort improves the way storm damage can be quantified. Using a similar approach, this technology can also document forest recovery and post-storm salvage logging and the effects of multiple

disturbances as part of a systematic landscape monitoring approach. For more information: https://hiform.org/.

Forest Service helps emerging scientists assess drought impacts in urban forests

SRS scientists served as research advisors and collaborators with a team of NASA DEVELOP program participants, guiding early-career scientists through novel research and helping them connect their work with local users. DEVELOP projects bring early career and student scientists together with scientists in partner organizations to co-develop research that uses earth observation data to understand pressing environmental issues. SRS researchers served on a team project called Analyzing Drought-Related Impacts on Urban Tree Inventory Conditions and Recovery in Texas. Urban forests promote human health and well-being and provide a myriad of ecosystem services such as pollution reduction and carbon sequestration, but prolonged drought events can interfere with those services and inflict significant damage to tree inventories. To gain insight on the effects of the historic 2011 Texas drought, the team partnered with the Texas A&M Forest Service and used satellite imagery and high-resolution aerial imagery to understand relationships between general vegetation characteristics and urban tree canopy stress. The project focused on using imagery to analyze stress and mortality over time and interpret patterns of urban forest recovery after the historic drought event. The project was named the winner of the program's national Virtual Poster Session competition.

TECHNOLOGY AND DEVELOPMENT CENTERS

Missoula & San Dimas

Source: USDA Forest Service

History

The Missoula Technology and Development Center (MTDC) began as the support facility for Forest Service fire management in the late 1940 (take out apostrophe), when a small group started developing techniques for parachuting men and cargo. In the early 1960s, the center's role was expanded to a Service-wide technical center with a nationwide program that now encompasses all Forest Service equipment needs. Today, MTDC works with Federal and State agencies, universities, private firms, and research groups to meet its responsibilities to resource managers.

What is MTDC?

MTDC is one of four detached units of the Engineering Staff in Washington, DC, and serves Forest Service Regions and cooperating Federal and State agencies. MTDC makes equipment, information, concepts, and ideas available so Federal and State agencies can better manage the millions of acres of public land. The Center:

- Interviews Forest Service personnel to help identify real needs.
- Surveys commercial markets and tests promising products.
- Designs, builds, and tests prototype equipment.
- Cooperates with private industry to develop commercial sources.
- Maintains specifications and standards for fire and safety equipment.
- Disseminates publications, fabrication drawings, project films, and audiovisual programs.

Personnel

Wide-ranging problem solving in resource management demands varied skills. Equipment specialists, engineers, writers, foresters, draftsmen, technicians, illustrators, and photographers all work as project team members to accomplish goals.

Staff members have worked on projects in fire and aviation, timber, occupational safety and health, engineering, forest pest management, range and disturbed land rehabilitation, watershed, wildlife, cooperative forestry, forest residues, recreation, and law enforcement.

The team approach has resulted in these recent accomplishments:

- Tree nursery pickup system
- Chunkwood chipper for utilizing slash
- Audiovisual on crew supervision and safety
- Satellite navigation and position locating system
- The Salmon Blade scarifier
- Improved firefighters' clothing and equipment
- Improved aircraft restraint system for cargo and smokejumpers
- Electronic tree measurement devices
- Placement guide for traffic control devices

- Orchard netting retrieval machine
- Audiovisual showing how to order and inspect Forest Service signs
- Improved aerial ignition equipment
- Disk chain for range improvement
- Fire shelter training facilitator's guide
- Sign maintenance guide for Forest Service signs.

History

The San Dimas Technology and Development Center (SDTDC) was established in 1945 to standardize fire equipment. At that time, the Center—known as the Arcadia Fire Equipment Development Center—was located in Arcadia, California. It consolidated all Forest Service fire equipment problem-solving efforts into a "laboratory sufficient to serve the fire control requirements of the Western Regions." Southern California was selected due to the large fire activity in the area, its evolving industrial and academic centers, and the availability of space in an existing Los Angeles County Forest Service facility.

Additional program sponsors brought new work to the Center and its name was changed to Arcadia Equipment Development Center. In 1965, a new facility, 13 miles east of Arcadia, was designed and constructed to house the Center. In conjunction with the move, the Center's name was changed to the San Dimas Equipment Development Center. For the past 10 years, the Center has been known as the San Dimas Technology and Development Center.

Who We Are?

SDTDC is a national program of the Forest Service Engineering staff in Washington, DC, and serves emerging technological requirements of the Forest Service and its cooperators.

Personnel

To support the Technology and Development program's mission of resource management problem solving, the Center has a cadre of personnel with far reaching skills. Engineers, technicians, foresters, draftsmen, writers, and desktop publishers all work as project team members to support the problem-solving goals of the Center. Program areas include fire and aviation, recreation, engineering, watershed, and timber. The Center's team approach to creative problem solving has resulted in some unique and innovative projects.

Projects

These projects include the development of:

- A "Scenic Byways Roadside Improvement Guidebook" to help managers develop successful scenic byways.

- The only spark arrester qualification facility in the world.

- Self-monitoring water treatment systems for remote sites.

- A new series of publications entitled "Water/Road Interaction" to provide guidance in all aspects of the ways roads affect the hydrology of forested watersheds.

- Re-engineered chemical toilets that do not smell.
- Bear-proof food lockers for forest campsites.

- Soil hardeners that stabilize trails for universal access.

- A digital tally meter for estimating timber yields.

- Biological odor control filters.

- The "Plastic Road" for crossing wet sites on soils of low bearing capacity.

Other projects

- Qualification testing for fire chemicals, water handling fire equipment, general purpose and locomotive spark arresters, and multiposition small engine exhaust systems.

- Field demonstrations of "Mobile Rock Crusher" technology to determine the capabilities of road reconditioning equipment.

- Demonstrations of the "Soil Nail Launcher" to expand this technology nationally.

- The use of transponders for marking timber boundaries.

- Composting as an alternative method of waste disposal.

- Noise control on National Forest lands.

Source: USDA Forest Service

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 U.S. 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 Forest Service 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 practiced in the region. Today, the programs of the Institute support the Forest service mission in the only tropical forest in the National Forest System,

the El Yunque National Forest. 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.

6.13. Metric Tables.

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

Forest Service (FS)	FY2015	FY2016	FY2017	FY2018	FY2019
Total number active CRADAs[2]	79	73	74	22	58
Number newly executed CRADAs	20	33	34	9	36
Newly executed amendments[1]	13	12	3		8
Newly executed traditional CRADAs	7	9	30	6	35
Newly executed non-traditional CRADAs	13	24	4	3	1
Newly executed CRADAs with small businesses	ND	ND	ND	ND	ND
Total number active MTRAs	4	7	1	9	ND
Newly executed MTRAs	4	5	1	8	ND
Total number of active other agreements[3]	1,083	1,274	1261	ND	ND
Newly executed other agreements	261	322	642	ND	
Number newly executed MTAs	3	5	3	10	ND
Newly executed outgoing MTAs	3	5	3	5	ND
Total number of analysis publications	2,013	2,022		ND	ND
Peer-Reviewed Scientific Publications[4]	1,151	1,169	1,214	ND	ND
Trade Journal Publications[5]	798	862	853	824	ND
Abstracts[6]	N/A	N/A	N/A	N/A	ND
Total number of data publications	34	63	37	65	ND
Customers Accessing Data Publications	1,547	2,500	3,874	4,498	ND
Percentage Increase in Customers Served	55%	61%	55%	26%	ND

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. (spell out CRADAs, MTRAs,)
2. Starting in FY 2019, the Forest Service will count all agreements under the authority of 15 U.S.C. 3710a as CRADAs
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. Starting in FY 2019, publications will be shown in a separate chart to reflect the REE requested guidelines.
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)	FY2015	FY2016	FY2017	FY2018	FY2019
Total number new invention disclosures[1]	13	24	20	10	9
University co-owned	4	2	7	1	2
Total number patent applications filed[2]	9	12	11	7	7
University co-owned	6	7	6	0	1
Total number patents issued	4	9	5	5	3
University co-owned	1	4	4	4	0

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)	FY2015	FY2016	FY2017	FY2018	FY2019
Total number active licenses	21	19	19	9	11
Executed to small businesses1	3	2	2	1	0
Executed to startup businesses2	1	1	1	1	0
Executed to universities	17	16	16	1	0
Invention licenses3	21	19	19	9	11
Executed to small businesses	3	2	2	1	0
Executed to startup businesses	1	1	1	1	0
Executed to universities	17	16	16	1	0

TABLE 4. Characteristics of Income-Bearing Licenses

Forest Service (FS)	FY2015	FY2016	FY2017	FY2018	FY2019
Total number of income-bearing licenses	21	19	19	9	11
Exclusive	20	18	18	9	11
Partially exclusive	0	0	0	0	0
Non-exclusive	1	1	1	0	0

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

Income from Licensing

*ND-no data available.

Forest Service (FS)	FY2015	FY2016	FY2017	FY2018	FY2019
Total income all active licenses	$2,230	$2,878	$2,634	$3,122	$800
Invention licenses	$2,230	$2,878	$2,634	$0	$800

FY 2019 FS Accomplishment Metrics in support of the REE Action Plan

Fiscal Year: 2019		
Products (Software/Web & Multimedia), Peer Reviewed and Non-Peer Reviewed Publications		
Generated: 10/7/2019		
REE Subgoal	***Product Type***	***Total Entries***
Subgoal 2A. Responding to Climate Variability	Data Products	14
	Non-refereed Publications	29
	Peer reviewed journal publications	320
Subgoal 2B. Bioenergy/Biofuels and Biobased Products	Data Products	4
	Non-refereed Publications	6
	Peer reviewed journal publications	134
Subgoal 3A. Water Availability: Quality and Quantity	Data Products	3
	Non-refereed Publications	13
	Peer reviewed journal publications	108
Subgoal 3B. Landscape-Scale Conservation, Management, and Resiliency	Data Products	5
	Non-refereed Publications	29
	Peer reviewed journal publications	129

REE= Research, Education, and Economics

7.0. Food Safety and 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, microbiological and physical hazards in meat, fish of the order siluriformes, poultry, and egg products. FSIS also facilitates the application of new food safety technologies to food production by industry. In addition, the Agency uses various strategies and technologies to conduct educational outreach to consumers (see section 7.3).

FSIS collects scientific information and data using our laboratories, as well as through partnerships with Federal Agencies, universities, and industry. FSIS generated data can be found on our website: https://www.fsis.usda.gov/wps/portal/fsis/topics/science

The Agency prioritizes and communicates its research 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. The list of current FSIS research priorities includes:

- Developing analytical methods to increase the efficiency of laboratory analyses;
- Identifying and understanding emerging chemical and microbiological 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.

For more information on FSIS Research Priorities, see link below:

https://www.fsis.usda.gov/wps/portal/fsis/topics/science/food-safety-research-priorities

In FY 2019, FSIS proposed four new food safety research studies, associated with existing priorities. These new research studies include improving the specificity of markers for veterinary drugs, evaluation of extra-intestinal sources of endogenous pathogens, increased understanding of pre-harvest sources of pathogens and improved food processing techniques for FSIS regulated products. In FY 2019, the FSIS Research Priorities and Food Safety Research Studies pages on the FSIS website were each accessed on more than 9,700 occasions. About 50percent of page views were by new visitors. About 85 percent% of visitors were referred by search engines or partner agency websites.

7.3. Activities in FY 2019

Facilitating the Application of New Food Safety Technologies to Food Production

FSIS encourages continued improvement and innovation in food safety technologies by industry. During FY 2019, FSIS evaluated new technologies aimed at enhancing food safety, including new commercial pathogen interventions, process innovations, and the use of new ingredients. 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 2019, FSIS completed 73 new technology submissions. New technology submissions included use of new or reformulated ingredients, online reprocessing systems (OLR), offline reprocessing substances (OFLR), and waiver requests to participate in the *Salmonella* Initiative Program (SIP).

Facilitating the Application of Food Safety Research Findings Tto Produce Safe Food

In FY 2019, FSIS **published 73 new and revised notices and directives, concerning both inspection and Agency administration and** released three guidance documents to assist industry with identifying and applying relevant scientific findings to produce safe meat, poultry, and egg products.

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

- **FSIS Guideline: Modernization of Swine Inspection System: Developing Microbiological Sampling Programs in Swine Slaughter Establishments.** This guidance document is designed to help all swine slaughter establishments meet the sampling and analysis requirements under the final rule to modernize swine slaughter inspection.

- **Guideline for Training Establishment Sorters Under the New Swine Slaughter Inspection System**. This guideline is designed to help establishments that choose to operate under the New Swine Slaughter Inspection System (NSIS) train their employees on sorting and removal of animals infected with diseases or other conditions that render them unfit for slaughter, before FSIS ante-mortem inspection. It further provides guidance on identifying and removing defects on carcasses and parts before FSIS post-mortem inspection.

- **FSIS Guideline for Industry Response to Customer Complaints.** This guideline is designed to provide meat and poultry establishments with reference material on best practices to develop a written program for responding to customer complaints of adulterated and misbranded meat and poultry products.

In addition, FSIS collaborated with FDA, EPA, and APHIS on issues related to chemicals, residues, and pesticides. Approximately 174,000 samples of FSIS-regulated products are screened each year under the National Residue Program, with a violation rate of less than 0.4 percent. This has shown a downward trend since 2016.

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

In FY 2019, FSIS conducted 13 focus groups, with 66 participants from retail establishments and State/local regulators and 5 from academia, to gain feedback on the content quality and distribution methods of *Listeria monocytogenes*-related information, including the *Listeria monocytogenes b*Brochure, the *FSIS Best Practices Guideline for Controlling Listeria monocytogenes (Lm) in Retail Delicatessens*, and the Self-Assessment Tool. The focus groups provided numerous recommendations on how to improve access, clarity and usefulness of the content.

FSIS supports effective policy implementation through the askFSIS database, which provides online answers to technical, inspection-related questions.

- In FY 2019, askFSIS was visited 644,020 times, with 227,369 searches being conducted, and 742,097 published answers being viewed.

The askFSIS database also provides online answers to consumers.

- In FY 2019, askFSIS answered questions from consumers on recalled products, how to report food safety issues, time/temperature concerns/abuse, residues in poultry, food safety concerns of meat products, and general requests for information on food safety.

FSIS provides a significant amount of outreach and technical resources to small and very small plants – both Federal and State Inspected. The Small Plant Help Desk continues to serve small plant owners and

operators with valuable technical assistance. In FY 2019, FSIS combined the Small Plant Help Desk function with askFSIS to increase efficiency and address customer feedback.

- In FY 2019, FSIS answered 2,095 inquiries through the Small Plant Help Desk and 5,367 emails and on-line inquiries through the askFSIS system from small and very small plants.

FSIS gave multiple presentations at the 2019 International Association for Food Protection Annual Meeting, as listed below:

Category	**Title**	**FSIS Speakers**
Special Presentation	U.S. Regulatory Update on Food Safety	Mindy Brashears
Roundtable presentation	Scientific Modernization of Meat Inspection – The International High-Speed Train – Catch It or Get De-Railed	Carmen Rottenberg
Roundtable presentation	Panel Title: Improving Postmortem Inspection of Beef for Human Health Protection	Melanie Abley
Roundtable presentation	Panel Title: Home Delivery of Food: The Last Mile Is Not What It Used To Be	Melanie Abley
Symposium presentation	Session: Fact or Fiction: Combatting Consumer Perceptions of Food Safety Myths with Data; Presentation: Utilizing Consumer Handling Data on Poultry Washing and Thermometer Use to Develop Methods Address Myths	Aaron Lavallee
Symposium presentation	Session: Poultry Vaccines: What is working, what are the gaps, and what is on the horizon? Presentation: When the Vaccine is Also the Target Pathogen: Lessons Learned	Stevie Hretz

Symposium presentation	Session: The Use of Rapid Microbial Methods by Government Agencies for "Official" Testing; Presentation: USDA FSIS Process to Accept the Use of Rapid Microbial Methods	Emilio Esteban
Symposium presentation	Session: Science & Regulatory Guidance Update; Presentation: FSIS Guidance Update and Ongoing Lethality and Stabilization Efforts	Suzy Hammons
Symposium presentation	Session: Is Cell-Cultured Meat *Really* Meat?; Presentation: Is There a Strategy for Regulating These Novel Food Products? What Role Will USDA-FSIS Play?	Roberta Wagner
Symposium presentation	Session: Challenges and Promises of using quantitative data for controlling *Salmonella* in poultry; Presentation: Role of Quantitative Data in QMRA to Measure and Improve Process Control during Raw Poultry Production	Eric Ebel
Symposium presentation	Session: Seek and You Shall Find: The Intricacies of a Robust Listeria Environmental Monitoring Plan; Presentation: Experiences with *Listeria* to Inform Risk Assessments and Other Guidance Documents	Lindsay Ward-Gokhale
Symposium presentation	Session: Challenges in Campylobacter Detection and Control; Presentation: Efficacy of Control Measures – Lessons Learned and Regulatory Aspects	Michael Williams
Symposium presentation	Session: Foodborne Disease Outbreak Update; Presentation: Multistate Outbreak of Shiga Toxin-producing E. coli O103 Infections Linked to Ground Beef	Doug Noveroske
Poster	Correlating Salmonella Isolates: Multi-drug Resistance and Serotype Concordance between CDC PulseNet Illness Clusters and FSIS-regulated Establishment Samples	Wu San Chen, Jeoffrey Levine
Poster	Frequency of Multi-Locus Sequence Types in FSIS-regulated Ready-to-Eat Products	Carrie Clark, Mary Katherine Crews, Glenn Tillman, Mustafa

		Simmons, Jamie Wasilenko, Udit Minocha, Yoel Izsak, Scott Seys, Stevie Hretz, Meryl Silverman
Poster	Food Safety and Inspection Service Nationwide Raw Pork Product Exploratory Sampling Study	Maria Scott, Stephanie Buchanan, Naser Abdelmajid, Jennifer Webb, Jennifer Green, Paul Dolan
Poster	Investigation Into The Detection Of Semicarbzide (SEM), A Nitrofurazone Indicator, In Chicken	Randolph Duverna, Rita Kishore, John Johnston, John Jarosh, Catalina Yee
Poster	*Salmonella* and *Campylobacter* in Religious Exempt and Low-Vvolume Poultry Products	Erika Stapp-Kamotani, Neal Golden, Wayne Schlosser, Nathan Bauer, Susan Schmidt
Poster	Use of Whole Genome Sequencing, Epidemiologic, and Traceback Data to Link a Multistate *Listeria monocytogenes* Outbreak to Ready-to-Eat Pork Products	Udit Minocha, Jennifer Freiman, Jovita Haro, Glenn Tillman, Mustafa Simmons, Meryl Silverman, Maria Scott, Brad Webb, Amanda Conrad, Danielle Donovan, Vivienne Heines, Brenda Rue, Natalie Christophe, Sakina Hamdani,
Technical Talk	Effects of Interventions on Indicator Organism Levels in Beef Slaughter	J Mark Carter, Naser Abdelmajid, Christian Gonzalez-Rivera, Rachel Whitaker and Scott Seys
Technical Talk	Evaluation of Commercial Molecular Screening Platforms for the Detection of Foodborne Bacterial Pathogens by Food Safety and Inspection Service Field Service Laboratories	William Shaw and Emilio Esteban

Workshop presentation	Using Data and Statistical Analysis to Guide Food Safety Decision Making	Stephen W. Mamber

FSIS gave several PowerPoint presentations on whole genome sequencing (WGS) technology and policies:

(1) At the Iowa Food Safety Summit, Des Moines District Office, March 28, 2019;

(2) At the Raleigh District Office's Enforcement, Investigations and Analysis Officer (EIAO) meeting, April 3, 2019; and

(3) At the Raleigh District Office's Frontline Supervisor meeting, May 8, 2019.

(4) At PITTCON Conference & Expo, Philadelphia, PA, 2019, (Stephanie Defibaugh-Chavez, "Regulatory and Surveillance Applications for Use of WGS Data – How the Data is Changing the Way We Assess Regulatory Compliance and Food Safety Hazards")

FSIS conducted a meeting with the beef industry to discuss practical recommendations and interventions for controlling non-O157 Shiga toxin-producing *Escherichia coli* (STEC) in their establishments.

Use of Information Technology Systems to Share Information

FSIS continued the phased expansion of Public Health Information System (PHIS) Export Module, which allows industry to file electronic export applications and receive electronic certification. On May 20, 2019, FSIS added an additional 21 countries to the export component, as part of phase 2 of the

rollout. In addition, FSIS made several updates to the import module of PHIS, which enables inspection program personnel (IPP) to conduct import reinspection more efficiently and effectively.

FSIS continued efforts to develop and maintain automated data exchange capabilities with Customs and Border Protection (CBP). To date, over 182 customs brokers are participating in the FSIS data exchange, and 72 percent of all import applications received by FSIS are now filed electronically. FSIS continues outbound message capabilities in Automated Commercial Environment (ACE), which provides messages back to importers on the status of shipments being re-inspected by FSIS. FSIS also developed and implemented the capability for customs brokers to submit corrections to previously submitted electronic applications when needed.

Facilitating International Trade

An International Meat, Poultry, and Processed Egg Products Inspection Seminar was held in Miami, Florida, in collaboration with USDA's FAS Cochran Fellowship Program. This 5-day seminar was in Spanish for 14 meat and poultry inspection officials from Costa Rica, Panama, and Paraguay, on FSIS's regulations, policies, inspection procedures and the FSIS equivalence process and Self-Reporting Tool (SRT).

FSIS provided outreach by hosting 5 webinars (3 in English and 2 in Spanish) on the 2019 SRT and new FSIS policy notifications. FSIS further elaborated on guidance documents for the annual certified establishment list, sampling program frequencies and reporting tables for the chemical residue control program, and microbiological sampling and testing program. Four of the five webinars focused on the annual documentation requirements for countries with an ongoing equivalence determination from FSIS.

These webinars took place in April, May, and September, and representatives from 34 countries were in attendance.

The 2019 Food Safety and Inspection Seminar for International Government Officials was held in Washington, DC on September 2327, 2019. During the seminar, FSIS provided 16 PowerPoint presentations, including an overview of FSIS policy development and rulemaking process, and the equivalence process.

FSIS, in collaboration with Colombia's Instituto Nacional de Vigilancia de Medicamentos y Alimentos (INVIMA), hosted a 3-day seminar in Spanish for government officials from Central and South American countries seeking initial or reinstatement equivalence in meat or poultry inspection. The seminar was held in Bogotá, Colombia from September 17–19, 2019 with participation of officials from Colombia, Dominican Republic, El Salvador, Guatemala, and Paraguay. FSIS presentations included information on the 2019 SRT and microbiological testing programs. The seminar also provided opportunities for participants to discuss FSIS issues specifically related to the food safety inspection system in their countries. Participants were assisted in obtaining level 2 eAuthentication credentials allowing them to access the web-based SRT.

Consumer education

FSIS continued an annual research effort to better understand how the public handles food in the kitchen. This year a second observational study was completed, analyzed, and publicized to better

understand consumer behavior regarding washing poultry before cooking, and the impact on food safety. The results offer unique insights into consumer behavior. Key insights include:

- Seventy-six percent of participants did not attempt to clean and sanitize the sink immediately following chicken washing or rinsing. Of those that did, 96percent were not successful at both cleaning and sanitizing the sink.

- Handwashing was not attempted 74percent of the time it was required, and 99percent of those attempts did not contain all steps of correct handwashing. This was similar to findings from the year 1 observational study.

- Twenty-six of the salads were contaminated by those participants that washed the chicken.

- Food safety educational materials developed by OPACE recommending that consumers not wash raw poultry before cooking were effective at improving consumer behavior by a statistically significant amount. Only 7percent of participants who received food safety messages washed their poultry, whereas 61percent of participants who did not receive food safety messages washed their poultry.

Meat and Poultry Hotline:

The USDA Meat and Poultry Hotline is a toll-free phone, chat and email system that answers food safety questions from consumers. This year, FSIS transitioned informatoni technology(IT) systems to manage the Meat and Poultry Hotline, including calls, frequently asked questions, chats and emails. The

hotline became Ask USDAand incorporated information from the previous system Ask Karen. This is part of the Department's ongoing customer experience improvement project and a key initiative of Secretary Sonny Perdue. FSIS was the first agency in the Department to transition to this system. Ask Karen answers were converted into Ask USDA knowledge articles for public use on the new Ask USDA website.

- During FY 2019, FSIS received 71,073 calls through the USDA Meat and Poultry Hotline, a 25percent increase over FY 2018 (56,504 calls). FSIS answered 2,716 chats and 6,470 emails in FY 2019 (compared to 3,292 chats and 5,077 emails in FY 2018). More than 3.7 million answers about food safety questions were viewed through FSIS' frequently asked questions database.

- The hotline staff spoke to over 1,200 consumers about improperly handling food (such as improper holding temperatures), to nearly 2,000 people about safely storing food in the refrigerator and freezer, and to more than 4,600 people who were concerned about safety and sanitation at a retail food store or restaurant. These types of important conversations with consumers can directly prevent a foodborne illness.

- FSIS announced 136 recalls and public health alerts this year. The hotline answered over 1,200 consumer calls and 600 online inquiries (chats and emails) about recalled foods; 5,900 recalled product answers were also viewed in Ask Karen. The hotline's ability to provide information about recalls and to quickly answer consumer questions about the safety of FSIS inspected products is an important component in our food safety outreach efforts.

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 more than 650 food items. More than 55,000 downloads of the application in FY 2019 brought cumulative download totals of the application to more than 250,000.

Social Media:

FSIS used a variety of social media networks to broaden engagement with key stakeholders to educate the public on recalls, foodborne illness, and safe food handling practices. FSIS primarily used Twitter (including Twitter in Spanish) and Facebook to promote food safety on social media. This year, FSIS also had the opportunity to amplify food safety messages using their Instagram account. Food safety messages appeared in the Stories feature of Instagram where consumers were able to interactively test their food safety knowledge. FSIS used pop culture topics like International Women's Day, Earth Day, and the MLB All-Star weekend to promote food safety messages to audiences discussing those trending topics.

- Major spikes in social media impressions and engagements are often related to information about FSIS recalls. Across Twitter and Facebook, FSIS generated a total of 556,715 engagements (up 30percent compared to 426,000 engagements in FY 2018) and 22,116,232 impressions (similar to the 22,147,153 impressions in FY 2018).

The Use of Whole Genome Sequencing to Detect and Respond to Outbreaks

In April 2019, FSIS laboratories discontinued pulsed-field gel electrophoresis (PFGE) and fully transitioned to whole genome sequencing (WGS), a powerful tool to compare genetic similarities among bacterial isolates with greater accuracy and detail than PFGE. In addition, FSIS organized "Comparative Genomics" training to ensure staff throughout the agency have a basic understanding of how WGS data are used.

FSIS and public health partners such as CDC use WGS to detect and investigate foodborne disease outbreaks. This starts with identifying cases of human illnesses where bacteria from human clinical samples and food samples are closely related genetically. From this, investigators generate a hypothesis about whether the food isolate is causing illness. An epidemiological investigation is needed to ensure that the hypothesis is valid.

Examples of the use of WGS to investigate outbreaks are below:

- FSIS investigated two *Listeria monocytogenes* (*Lm*) outbreaks in 2019, the first multistate *Lm* outbreaks associated with FSIS-regulated products since 2005. These were both small outbreaks, including four case-patients each, and WGS played an important role to detect the outbreaks and provided important evidence to guide investigators and establish a link between human illnesses and FSIS-regulated products. Both outbreaks resulted in voluntary recalls, removing affected product from commerce and preventing additional illnesses.

- FSIS investigated one outbreak during FY19 which involved a common *Salmonella* PFGE pattern. Early in the investigation, WGS provided additional clarity and showed that there were three distinct and simultaneous outbreaks that were indistinguishable by PFGE. One outbreak included approximately 430 *Salmonella* illnesses. WGS was important to detect the outbreak and link illnesses to ground beef, resulting in a recall of approximately 11 million pounds of product to prevent additional illnesses and protect public health.

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. In FY 2019, FSIS validated and adopted several significant new and revised chemistry and microbiology methods. These methods improved the Agency's ability to monitor for potentially hazardous concentrations of chemicals (e.g., antibiotics, pesticides, environmental contaminants, growth promoters) and microbiological pathogens (e.g. Shiga toxin-producing *E. coli* (STEC), *Salmonella*, *Listeria monocytogenes,* and *Campylobacter*) in food. For microbiological pathogens, the FSIS food testing laboratories and the Laboratory Quality Assurance Staff completed extensive work revising and validating food pathogen testing protocols in the Microbiology Laboratory Guidebook (MLG). MLG chapters 4, 8, and their associated appendixes were updated to include instructions for using molecular detection systems for initial screening of samples for *Salmonella* and *Lm*. Further, the FSIS laboratories adopted the iQ-Check® system for initial molecular screening of regulatory samples for STEC and updated the MLG to reflect this. Finally, the FSIS microbiology laboratories adopted a streamlined workflow for the rapid molecular screening of

regulatory samples for *E. coli* O157:H7 and non-O157 STEC; this combined method uses a single initial screen for all regulated STECs.

For chemical residue testing, a next-generation multi-residue method was validated and implemented, allowing for the analysis of up to 107 unique veterinary drug residues in a single sample. The method is suitable for muscles and kidneys of multiple species, as well as egg products. This new method is designed to be the primary screening tool for chemical residues across the three FSIS laboratories. Also, a new method for the analysis of 16 unique per- and polyfluoroalkyl substances (PFAS) was validated and implemented for bovine muscle as a monitoring tool. Additionally, a method for the quantification of antimicrobial dyes such as crystal violet and malachite green in Siluriformes muscle has been put into place, strengthening the laboratory's ability to report dye amounts found in Siluriformes fish. The FSIS laboratory system also extended the metals method to include arsenic, bringing the total number of metals that can be analyzed from a single sample to 18.

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' 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 used model-based estimation, based on capture-recapture methods, to produce official estimates for the 2012 Census of Agriculture. Since then, NASS has expanded its use of model-based estimation techniques to improve the statistical reliability of published forecasts/estimates and to provide accurate measures of uncertainty.

  Forecasts of yield for corn, soybean, wheat, and cotton yields derived from Bayesian hierarchical models are now being produced for each crop's largest producing States in parallel with NASS operational survey processes, and the results are 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 are generated by integrating MODIS Land Surface Temperature (LST) products through modeling.

Small area models have been developed to improve the county-level estimates of acreage, yield, and production. The corn, soybean, cotton, and wheat county-level models have been reviewed by field staff. Models for other crops with federally mandated reporting requirements are being reviewed. Those crop models for which the review process has been completed will be implemented for the 2020 crop year. The small area model for county-level cash rental rates is being further evaluated based on annual data collection with the goal of implementing an improved model for 2021. A new small area model was developed for the agricultural labor program. NASS has worked collaboratively with outside consultants to develop these models.

A decision-support application, which should eventually lead to crop phenology being more explicitly accounted for in the yield models has been extended to all States. After the current review is completed by the Regional Field Offices, the goal is to have the decision-support system provide the foundation for NASS Crop Progress and Condition Report for the 2020 crop season.

A National Academy of Science workshop in May 2019, considered the various modeling approaches NASS has considered for modeling hog production. The primary focus was on the development of a model that honors the biology of the system and captures a disruption in the system, such as a disease outbreak. Based on the feedback obtained, NASS is continuing to develop such a model. 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 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 FY19, NASS continued to explore the feasibility of using web-scraped lists of farms in conjunction with the NASS list frame to replace the current methodology underpinning the June Area Survey. The study was conducted in four States: Kansas, Nebraska, New York, and

Pennsylvania. The initial analysis of estimates of the number of farms indicate that they may be slightly biased downward. Current efforts are focused on assessing the use of the web-scraped list to measure the undercoverage of the NASS list frame for each of the NASS surveys.

- **Geospatial Products:** NASS completed its 48-State Cropland Data Layer (CDL) in 2010 for the 2018 crop year, making 11 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 2019 for the 2018 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 Hurricanes Barry and Dorian, as well as flooding in the Midwest during the spring of 2019. The geospatial data products were derived from remotelysensed satellite and meteorological information obtained from NASA, European Space Agency (ESA), and National Oceanic Atmospheric Administration (NOAA). 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.

- **Data-Collection Enhancement for the Census of Agriculture and NASS Surveys:** NASS implemented a new, responsive, web data collection system for the 2017 Census of Agriculture. By the end of FY 2019, all NASS surveys had been moved into the new system, which 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. The goal is to provide an enhanced experience for the respondent that reduces burden while also improving data quality.

- **Subsampling of Nonrespondents in the 2017 Census of Agriculture:** Although extensive efforts were made to increase public awareness and participation, the 2017 Census of Agriculture response in the initial phase of data collection was significantly lower than reasonably anticipated given the Census of Agriculture's history. As a result, the nonrespondent pool was too large for NASS's traditional census nonresponse follow-up method in the available timeframe. To address the nonresponse bias and remain within the resource constraints, NASS adopted a subsampling design to meet precision-related benchmarks.

- **Integrating All Data into NASS Estimation Processes:** Currently, the NASS Agricultural Statistics Board receives estimates and information from multiple sources for some of its

programs. These include survey estimates, remote sensing estimates, and weather information. The Agricultural Statistics Board combines this information using expert opinion to produce official estimates. In FY 2019, NASS initiated a pilot study in Illinois to explore the use of all available data, including survey, remote sensing, administrative, weather, and precision agriculture data, to produce early season estimates of planted acreage. Remote sensing data at 3, 10, and 30-meter resolution will be evaluated to determine the relative value of higher resolution satellite imagery. To integrate these diverse data, NASS must make major revisions in its processes. To integrate the survey data with the other types of data, which are all geo-spatial, NASS must geo-reference its farms. The volume of the fine-resolution remote sensing data exceeds current NASS storage and computing capacity; thus, all data and the subsequent analyses must be done in a cloud environment. The goal is to address these challenges and produce early season estimates of planted acres by crop type for Illinois during the 2020 crop season. All methods used will be fully scalable to the national level.

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 2019 Data Users Meeting was held in Chicago, Illinois, on April 23, 2019. 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.

8.5. Publications

Peer-Reviewed Scientific Publications.....14 entries

- Boryan, C., Yang, Z., Sandborn, A., Willis, P. (2019). "Operational Flood Monitoring of Agriculture During Hurricanes Harvey and Irma with RADAR data." *ESRI Map Book*, 34, pp. 96-97.
- Coffey, S., Reist, B., & Miller, P. (2019). "Interventions On-Call: Dynamic Adaptive Design in the 2015 National Survey of College Graduates." *Journal of Survey Statistics and Methodology*. https://doi.org/10.1093/jssam/smz026
- Colliander, A., Yang, Z., Mueller, R., Sandborn, A., Reichle, R., Crow, W., Entekhabi, D., Yueh, S. (2019). "Consistency between NASS surveyed soil moisture conditions and SMAP soil moisture observations." *Water Resources Research*, 55, 7682–7693.
- Cruze, N.B., Erciulescu, A.L., Nandram, B., Barboza, W.J., Young, L.J. (2019). "Producing Official County-Level Agricultural Estimates in the United States: Needs and Challenges." *Statistical Science*, 34, no. 2, 301--316. https://doi.org/10.1214/18-STS687
- Erciulescu, A.L., Cruze, N.B., Nandram, B. (2019). "Model-based county-level crop estimates incorporating auxiliary sources of information." *Journal of the Royal Statistical Society*, Series A, 182, 283-303. https://doi.org/10.1111/rssa.12390
- Gao, F., Anderson, M., Daughtry, C., Johnson, D. (2018). "Assessing the Variability of Corn and Soybean Yields in Central Iowa Using High Spatiotemporal Resolution Multi-Satellite Imagery." *Remote Sensing*, 10(9), 1489. https://doi.org/10.3390/rs10091489.
- Johnson, D. (2019). "Using the Landsat archive to map crop cover history across the United States." *Remote Sensing of Environment*, 232: 111286.

- Liu, L., Zhang, X., Yu, Y., Gao, F., Yang, Z. (2018). "Real-Time Monitoring of Crop Phenology in the Midwestern United States Using VIIRS Observations." *Remote Sensing*, 10: 1540.
- Nandram, B., Erciulescu, A.L., Cruze, N.B. (2019). "Bayesian benchmarking of the Fay-Herriot model using random deletion." *Survey Methodology*, Statistics Canada, Catalogue No. 12-001-X, Vol.45, No. 2. https://www150.statcan.gc.ca/n1/pub/12-001-x/2019002/article/00004-eng.htm
- Rosenblum, M., Miller, P., Reist, B., Stuart, E., Thieme, M., & Louis, T.A. (2019). "Adaptive Design in Surveys and Clinical Trials: Similarities, differences, and opportunities for cross-fertilization." *Journal of the Royal Statistical Society Series A*, 182(3), 963-982. https://doi.org/10.1111/rssa.12438 (Article was selected for presentation at the 2019 Royal Statistical Society International Conference)
- Sartore, L., Toppin, K., Young, L., Spiegelman, C. (2019). "Developing integer calibration weights for Census of Agriculture." *Journal of Agricultural, Biological and Environmental Statistics*, 24(1), 26-48.
- Torbick, N., Huang, X., Ziniti, B., Johnson, D., Masek, J., Reba, M. (2018). "Fusion of Moderate Resolution Earth Observations for Operational Crop Type Mapping." *Remote Sensing*, 10: 1058.
- Wulder, M., Loveland, T., Roy, D., Crawford, C., Masek, J., Woodcock, C., Allen, R., Anderson, M., Belward, A., Cohen, W., Dwyer, J., Erb, A., Gao, F., Griffiths, P., Helder, D., Hermosilla, T., Hipple, J., Hostert, P., Hughes, M., Huntington, J., Johnson, D., Kennedy, R., Kilic, A., Li, Z., Lymburner, L., McCorkel, J., Pahlevan, N., Scambos, T., Schaaf, C., Schott, J., Sheng, Y., Storey, J., Vermote, E., Vogelmann, J., White, J., Wynne, R., Zhu, Z. (2019). "Current status of Landsat program, science, and applications." *Remote Sensing of Environment*, 225: 127-147.
- Young, L.J. (2019). "Agricultural crop forecasting for large geographical areas." *Annual Review of Statistics and Its Applications* 6: 173-196. https://doi.org/10.1146/annurev-statistics-030718-105002.

Book Chapters.....2 entries

- McCarthy, J. (2019). "Planning your Multi-Method Questionnaire Testing Bento Box: Examples from the 2017 Census of Agriculture Testing." Paul C. Beatty (Editor), Debbie Collins (Editor), Lyn Kaye (Editor), Jose-Luis Padilla (Editor), Gordon B. Willis (Editor), Amanda Wilmot (Editor). *Advances in Questionnaire Design, Development, Evaluation and Testing*, pp. 723 – 748, New York: Wiley.
- Willimack, D.; McCarthy, J. (2019). "Obstacles and Opportunities for Experiments in Establishment Surveys Supporting Official Statistics." Paul J. Lavrakas (Editor), Michael W. Traugott (Editor), Courtney Kennedy (Editor), Allyson L. Holbrook (Editor), Edith D. de Leeuw (Editor), Brady T. West (Editor). *Experimental Methods in Survey Research: Techniques that Combine Random Sampling with Random Assignment*, pp. 309 – 326, New York: Wiley.

Scientific Meeting Proceedings .....11 entries

- Benecha, H.; Sartore L.; Cruze, N.B. (2019). "Model-Based Crop Yield Forecasting: Covariate Selection and Related Issues." In *Proceedings of the 2019 Joint Statistical Meetings*. Denver, CO: American Statistical Association.
- Boryan, C.; Yang, Z.; Willis, P.; Sandborn, A. (2019). "Early Season Winter Wheat Identification Using Sentinel -1 Synthetic Aperture Radar and Optical Data." In *Proceedings of the 2019 IEEE International Geoscience and Remote Sensing Symposium (IGARSS)*. Yokahama, Japan: IEEE Geoscience and Remote Sensing Society.
- Corral, G.; Wilson, T. (2019). "Using Machine learning Algorithms to Reduce Data Collection Costs." In *Proceedings of the 2019 Joint Statistical Meetings*. Denver, CO: American Statistical Association.

- Dau, A.; Miller, D. (2018). "Dancing with the Software: Selecting Your Imputation Partner." In *Proceedings of the 2018 Joint Statistical Meetings*. Vancouver, Canada: American Statistical Association.
- Miller, D.; Dau, A.; Zakzeski, A. (2019). "Evaluating Imputation Methods for the Agricultural Resource Management Survey." In *Proceedings of the 2019 Joint Statistical Meetings*. Denver, CO: American Statistical Association.
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- Sandborn, A.; Mueller, R.; Boryan, C.; Johnson, D.; Yang, Z.; Ebinger, L.; Rosales, A.; Willis, P.; Seffrin, R.; Jennings, R.; Deaton, M.; and Hamer, H. (2019). "NASS Geospatial Applications from the Cropland Data Layer." In *Proceedings of ISI World Statistics Conference*, Malaysia.
- Wilson, T.; Ball, S.; Reist, B. (2019). "Blasting Farmers with Email and Text Survey Notifications: Modeling Response Rate Effects." In *Proceedings of the 2019 Joint Statistical Meetings*. Denver, CO: American Statistical Association.

- Yang, Z.; Boryan, C. (2019). “Impact of Non-Proportional Training Sampling of Imbalanced Classes on Land Cover Classification Accuracy with See5 Decision Tree.” In *Proceedings of the 2019 IEEE International Geoscience and Remote Sensing Symposium (IGARSS)*. Yokahama, Japan: IEEE Geoscience and Remote Sensing Society.Statistical

Software Published……2 entries

- Luca Sartore (2019). spMC: Continuous Lag Spatial Markov Chains. R package version 0.3.10 <URL:https://CRAN.R-project.org/package=spMC>
- Luca Sartore (2019). inca: an R package for integer calibration. R package version 0.0.4 <URL: https://CRAN.R-project.org/package=inca>.

Trade Journal Publications.....0 entries

9.0. National Institute of Food and Agriculture (NIFA)

http://www.nifa.usda.gov/

9.1. 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."

9.2. Nature and Structure of Research Program

NIFA's two key mechanisms for accomplishing its mission are:

- National program leadership. NIFA helps States identify and meet research, extension, and education priorities in areas of public concern that affect agricultural producers, small business owners, youth and families, and others.
- Federal assistance. NIFA provides annual capacity grants to land-grant universities and competitively granted funds to researchers in land-grant universities, other universities, and other partner organizations.

NIFA collaborates or has formal working partnerships with many institutions and individuals. Our key partners are the institutions of higher learning making up the Land-Grant University System. However, we also partner with other Federal agencies, within and beyond USDA; non-profit associations; professional societies; commodity groups and grower associations; multistate research committees;

private industry; citizen groups; foundations; regional centers; the military; task forces; and other groups.

NIFA and its partners focus on critical issues affecting people's daily lives and the Nation's future. The advanced research and educational technologies NIFA supports empower people and communities to solve problems and improve their lives on the local level.

Among the many programs NIFA leads, many are currently focusing efforts on the following societal challenges:

- Advance our ability to provide global food security through increased productivity and profitability in American agriculture
- Create a resilient and environmentally sustainable agricultural system responsive to climate change
- Catalyze value-added innovations in agriculture
- Ensure the availability of affordable, nutritious, and safe food and increase the public’s knowledge of and trust in their food supply and nutritional needs

NIFA accomplishes these goals 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 117-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.

9.3. 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.

9.4. 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 2019, 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.

9.5. 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 FY 2019 and is now being reported (see Table 1).

Table 1. Patents Issued in FY 2019 Based Upon Competitive NIFA Funding.

Institution Name	**Award Number**	**Patent Number**	**Issue Date**	**Invention Description**
University of Wisconsin, Madison	2005-35205-15556	10,337,067	7/2/2019	COMPOSITIONS AND METHODS FOR DETERMINING THE LIKELIHOOD OF TWINNING
University of Wisconsin, Madison	2007-35205-17884	10,294,528	5/21/2019	COMPOSITIONS AND METHODS FOR DETERMINING

				LIKELIHOOD OF AN INCREASED SUSCEPTIBILITY TO CONTRACT JOHNE'S DISEASE
University of Wisconsin, Madison	2004-34141-14498	PV201700447	2/19/2019	A HIGH YIELDING POTATO CHIPPING VARIETY
University of Wisconsin, Madison	2004-34141-14498	PV201700285	2/19/2019	LONG STORAGE CHIPPING POTATO LINE WITH RESISTANCE TO COMMON SCAB AND VERTICILLIUM WILT
University of Wisconsin, Madison	12-CRHF-0-6055	10,184,155	1/22/2019	GENETIC TESTING FOR IMPROVED CATTLE FERTILITY
University of Wisconsin, Madison	11-CRHF-0-6055	10,314,816	6/11/2019	ANTIMICROBIAL COMPOUNDS, COMPOSITIONS AND METHODS OF USE THEREOF
University of Wisconsin, Madison	12-CRHF-0-6055	10,323,284	6/18/2019	SINGLE NUCLEOTIDE POLYMORPHISMS

				ASSOCIATED WITH BULL FERTILITY
University of Wisconsin, Madison	12-CRHF-0-6055	10,098,332	10/16/2018	METHODS AND COMPOSITIONS FOR DETERMINING BOVINE OVULATION RATE
Carnegie Mellon University	2012-67021-19958	10,217,013	2/26/2019	Methods and system for detecting curved fruit with flash and camera and automated image analysis with invariance to scale
University of Illinois at Urbana-Champaign	Hatch	10,098,964	10/16/2018	Inclusion Complexes and Methods of Making the Same
University of Missouri, Columbia	2007-35607-17790	10,231,383	3/19/2019	Crop Resistance to Nematodes
University of Missouri, Columbia	2007-35607-17790	10,246,722	4/2/2019	Crop Resistance to Nematodes
University of Missouri, Columbia	2014-68022-21596	10,274,492	4/30/2019	HIGH SENSITIVITY IMPEDANCE SENSOR
University of Nebraska, Lincoln	2013-31100-06031	10,280,431	5/7/2019	NOVEL ACYLTRANSERASES

				AND METHODS OF USING
University of Nebraska, Lincoln	2012-31100-06031	10,100,325	10/16/2918	Method for the production of a high saturate, low polyunsaturated soybean oil
University of Maryland, College Park	2011-67015-30136	10,383,936	8/20/2019	Infectious laryngotracheitis virus (ILTV) vaccine using recombinant newcastle disease virus vector
University of Minnesota	2009-34427-19959	10,324,090	6/18/2019	Mycobacterium Biomarkers and Methods
University of Minnesota	2011-68005-30416	10,119,027	11/6/2018	Compositions Including Lignin
University of Minnesota	2008,34360-19469	PP29847	11/20/2018	Grape Vine Plant Named Itasca
University of Minnesota	2006-55606-16629	PV201700119	11/29/2018	Shelly
Oklahoma State University	2007-35504-18244	10,266,814	4/23/2019	Systems and Methods for Production and Use of Fungal Glycosyl Hydrolases
University of Connecticut School of Medicine/Dentistry	2012-67020-19380	10,101,312	10/16/2018	Emulated Soil Micromodels for Pore-Scale Determination

				of Microbially-Mediated Drying Resistance
Penn State University	Hatch	10,085,436	10/2/2018	Bed Bug Control
Penn State University	Hatch	10,202,517	2/12/2019	Improved Biopolymer Composite Materials
Penn State University	Hatch	10,308,947	6/4/2019	A Method to Facilitate RNA-guided Multiplex Genome Editing and Other RNA Technologies via the tRNA processing system
Penn State University	Hatch	10,316,295	6/11/2019	Paramyxovirus Virus-Like Particles as Protein Delivery Vehicles
Penn State University	Hatch	10,233,209	3/19/2019	Inhibitors of the Farnesoid X Receptor and Uses in Medicine
Colorado State University	2011-67015-20067	10,288,625	5/14/2019	Early Determination of Pregnancy Status in Ruminants
University of Hawaii	2009-65503-05786	10,111,452	10/30/2018	Method of Supercooling Perishable Materials
Iowa State University	2013-68004-20374	10,087,461	10/2/2018	Glycine Max Resistance Genes(s) and Use Thereof to

				Engineer SDS Resistant Plants
Iowa State University	2013-68004-20374	10,087,462	10/2/2018	Arabidopsis Nonhost Resistance Genes(s) and Use Thereof to Engineer SDS Resistant Plants
Kansas State University	2007-38624-18571	PV2018000066	6/28/2019	KSR07363
Kansas State University	2013-38624-21525	PV201600400	11/29/2018	HyCLASS225W
Michigan State University	2010-34469-20997	10,201,165	2/12/2019	Formulations and Methods for Antifungal Activity from Prunus Maackii Periderm
North Dakota State University	2007-38202-18597	10,329,377	6/25/2019	Highly Functional Epoxidized Resins and Coatings
Oregon State University	2012-34141-20184	PV201700061	3/28/2019	PVP Potato 'Terra Rossa'
Oregon State University	2012-34141-20184	PV201700060	3/28/2019	PVP Potato 'Smilin' Eyes' (POR02PG26-5)
West Virginia University	2012-670113-19384	10,370,689	8/6/2019	Production of lysergic acid by genetic modification of an industrially relevant fungus

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 2019 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 2019 are under development.

9.6. Downstream Outcomes

Sims Brothers, Inc. is located in Union Springs, AL and they received support from SBIR to test the ability of a Sericea lespedeza leaf meal pellet to control internal parasitic diseases of the intestinal tract of goats and sheep that can lead to death if the animals are left untreated. Leaves of Sericea are rich in tannins and tannins in the leaf meal pellet are able to provide a protective barrier in the animal's stomach and prevent the parasite from binding to the host. Studies have shown that consumption of a 75percent leaf meal pellet was highly palatable and offered good control of the parasites. The pellets are currently being sold to many farmers in the southeast as well as several zoos and the Disney World Animal Park. In ongoing studies, the pellets have also shown good efficacy in controlling parasites in poultry.

ISCA Technologies is a California-based company that has received a number of SBIR awards to develop integrated pest management (IPM) solutions that are based on the use of semiochemicals or natural pheromones where the effect is specific to the targeted pest. They have developed a product called Specialized Lure and Pheromone Application Technology (SPLAT), which is a flowable wax-like emulsion that can be applied by hand from a paint gun or mechanically by sprayer (including from planes). The company has great organic chemistry expertise and they have synthesized a number of different semiochemicals and pheromones. One of their products is designed to disrupt mating in the gypsy moth. The Forest Service uses this product exclusively in their program to combat the spread of the gypsy moth, and it has been sprayed on hundreds of thousands of acres. Other products area targeted to the control of the mountain pine beetle, which has destroyed millions of acres of pine trees in the west, and the Asian Citrus Psyllid, which is the key vector for citrus greening. The company has grown from just a few people to over 20 full-time employees and annual revenues have increased to over 7 million.

Azavea is located in Philadelphia and has received several awards from SBIR. The focus of Azavea is urban forestry. In recent years, there has been increased interest in urban trees. These trees have a very broad and important influence on urban life. Benefits provided by urban trees include (1) energy costs are reduced due to the cooling effect of trees, and in New York City, it is estimated that each healthy tree results in a cost savings of $47 per tree or nearly $30 million citywide;(2) removal of air pollutants by the leaves and thereby eliminating 784,000 tons of pollutants nationwide; (3) in the United States, urban trees store 770 million tons of carbon and have far reaching impacts on global climate change;(4) the preponderance of concrete and asphalt causes a heat island effect and urban trees can lower temperature by several degrees and lead to a 40-60percent increase in pavement life due to the cooling effect of shade; and (5) trees intercept rain by leaves, branches, and roots and thereby lead to a

substantial reduction in storm water runoff. In order for cities to provide proper management of their urban trees, they need to have an accurate inventory of the number of trees, their exact location, and their condition. Azavea has developed OpenTreeMap, which is a web-based application that enables real-time tree entry and edits from multiple concurrent users, including non-experts. The software has been sold to a number of different communities. Azavea has grown from just a few people to over 40 employees and annual income of over $4 million.

Whole Trees is located in Madison, Wisconsin, and they have received several awards from the SBIR program. Most wood-based construction makes use of sawn lumber and smaller diameter trees, and branched timber have been largely unused. Whole Trees has partnered with the Forest Service Forest Products Laboratory and shown that branched timbers are actually stronger than sawn lumber. They have also pioneered the use of small diameter round wood and branched timbers in various building projects and thus provided a new market for this resource. In one project, a new grocery store was built in Madison that utilized timber they provided. In the main part of the store, there are a dozen or more wood columns that are not just decorative but are holding up the roof. These columns are mature American Ash trees that were recently killed by the emerald ash borer. They selected trees that were about 12 inches in diameter and used the main part of the trunk including some branch joints near the top. They were debarked, treated to resist mold and partially air dried. They also used smaller round timbers to build a large number of roof trusses that were used in the building construction. They have received several awards for their innovative designs and have seen their annual revenue increase to over $2 million.

Firsthand Foods is located in Durham, North Carolina, and has received support from SBIR. They have created a food hub that involves local farmers and a variety of wholesale and retail outlets where

the local meat can be sold. Their network of local farmers is growing and now numbers over 65. They work with the farmers to schedule when animals will be slaughtered. Their farmers are raising heritage breeds that may not be as productive as commercial breeds but they have higher quality and better taste. Four large companies control over 80percent of the beef market and over 60percent of the pork market. This creates a real challenge for a small company to gain significant market share. One of the positive moves this company made was to use Firsthand Foods as their brand. Customers have become familiar with this brand, and it has helped them grow their business. Revenues have grown steadily and area expected to reach $2million this year.

Intralytix is located in Baltimore and they have received support from SBIR. The focus of Intralytix is on the development and commercialization of bacteriophage-based preparations for various food safety, environmental, veterinary and human clinical applications. They use naturally occurring lytic bacteriophage to reduce or eliminate levels of pathogenic bacteria in various specific settings. What makes bacteriophage so special is that they are species or strain specific and thus can be very precisely targeted to a particular bacterial pathogen. Bacteriophage are considered "green" and can be used on organic crops. They have commercialized bacteriophage preparations that are specific for Listeria monocytogenes, *E. coli* 0157:H7, and Salmonella. They also have a CRADA with ARS to develop a bacteriophage preparation that is specific for Vibrio, which is a serious pathogen of both East and West Coast oyster larvae. Intralytix has been very successful in raising investment income, and they have annual sales of well over $1million.

Capstan Ag Systems is located in Topeka, Kansas, and they have received four different SBIR awards. Ken Giles is a professor at UC Davis,and he developed the concept of pulse width modulation (PWM) for sprayer flow control and UC Davis received a patent on this concept. Capstan Ag Systems engaged

Ken Giles as a consultant and licensed the PWM technology from UC Davis. They then applied to SBIR and they were able to successfully develop the PWM technology and show that it was possible to control both flow rate and droplet size from individual spray nozzles. Today PWM technology is used on most spray equipment and has become the standard for the industry. Capstan Ag Systems has grown to nearly 70 employees and annual sales of over $12 million. All of the SBIR supported work has focused on land-based spray technology, but they are now moving into aerial spray technology which holds great promise for future growth.

NIFA awarded Dr. Bruno Basso at **Michigan State University** a Water for Agriculture Challenge CAP in 2014. He and his team focused on recent extreme weather events that provide insight into future challenges for agricultural systems across parts of the United States due to increasing climate variability. Growing irrigation demand, significant declines in groundwater levels across the High Plains, and inefficient use of fertilizers leading to nitrate leaching, N2O emission, and pollution of surface water are threats to the U.S. corn-soybean-wheat systems and the industries and ecosystems that depend on them. They proposed to: (i) develop and improve management strategies for a water-, nutrient-, and climate-smart agriculture; (ii) create and disseminate decision-support tools to help farmers use “Big Data” (e.g., yield maps and UAV sensors) to adapt to climate variability and increase their resiliency; (iii) evaluate the economics of smart agriculture technologies and practices. Their research integrated and experimentally tested a novel suite of biophysical and socioeconomic systems models to quantify interactions between climate, hydrology, and socioeconomic drivers of agricultural practices across the Upper Midwest and High Plains regions. Research, education, and extension activities in this project provided accurate information for practical use by the general public, students, farmers, and decision-makers to enable sustainable adaptation to and mitigation of temperature extremes, drought, and flooding. They improved and deployed crop system models to evaluate a wide range of management

options to optimize crop productivity while reducing water, N, and C footprints across spatial scales under a changing climate. The transdisciplinary effort built from a strong team of agronomists, crop physiologists, soil scientists, hydrologists, climatologists, system modelers, economists, extension specialists, and educators. “This is the first time anyone has been able to quantify how much small-scale yield variability there is in the United States Corn Belt,” said Bruno Basso. “Our findings allow farmers to know exactly which portions of their farm fields have stable yields – which allows them to better manage their variable fields to save money, reduce fertilizer losses and lower greenhouse gas emissions.” The research, recently published in Nature’s Scientific Reports, is the first to quantify nitrogen losses from the low-producing areas of individual fields. Basso’s team used satellite imagery to measure 8 years’ worth of sub-yield fields for 70 million acres of farmland in the Midwest. The analysis provided the researchers with a finely resolved image of the entire Midwest’s corn production, Basso said. To validate the satellite imagery, the team compared the satellite data against 10 years of high-resolution yield data collected by sensors mounted on combine harvesters from more than 1,000 farms. “In total, about 50percent of the subfield areas we analyzed were stable and high-yielding. The underperforming and the unstable areas each represented about 25% of total farmland.” By assessing how much Corn Belt farmers spend on fertilizer that goes unused, the authors concluded that the best outcome–both for farmers and the environment–is to avoid fertilizing the underperforming areas of each field.

4-H National Headquarters staff within Division Youth and 4-H, **4-H National Headquarters**, in collaboration with Rutgers (NJ) 4-H and NASA GLOBE Observer, released the “Exploring Clouds 4-H Activity Guide” to support learning and making citizen science cloud observations submitted to NASA 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. They presented their

work in 2019 at the National Youth Healthy Living Summit and the Esri International GIS conference, with two 4-H youth maps receiving Esri conference mapping honors in the youth category. **West Virginia University, 4-H National Headquarters and National 4-H Council** in partnership with Google, collaborated on the 2019 4-H National Youth Science Day project "Game Changers." In events across the country, the activities challenged youth to use coding to create games and use coding to help solve important problems. **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 2019 National 4-H Conference.

FY 2018 Fellowship awards.

- 2018-07756; Creation of Biodegradable Nonmigratory Active Packaging via Reactive Extrusion for the Reduction of Food Waste and Limited Environmental Impact; **Cornell University;** Joshua Herskovitz. The contributions of the proposed research are expected to be through the application of polymer science to create a biodegradable food contact material with nonmigratory functionality for food packaging applications. This approach will limit waste and environmental impact from packaged food products by extending the usable time of the food itself while ridding the accumulation of packaging plastics in landfills via decomposition.

- 2018-07840; Microfluidic Device for High-throughput Activity Screening and Optimization of Mutant Carbohydrate-active Enzyme; **Iowa State University of Science and Technology**; Nathaniel Kallmyer. Our long-term goal is to improve the efficiency of biomass pretreatment processes by developing more efficient and more robust enzyme biocatalysts. This may be

achieved by developing a microfluidics tool that screens hydrolytic activity enzyme mutants, separates high-activity mutants, and records activity values associated with each candidate modification.

New Technologies for Agricultural Extension (NTAE)

Michigan State University was the recipient of NTAE funding, hosting eXtension, which demonstrated the following impact regarding learning and capacity building on behalf of the Cooperative Extension System:

- Hundreds of projects developed by 220 teams involving 473 team members.
- 27 Fellows funded to address Diversity, Equity & Inclusion, Food Security,
- Behavioral Health, Opioid Response, and numerous innovative technologies from augmented reality to customer relationship management and mobile apps.
- 469 online courses offered 24/7/365 from 40 institutions.
- 23,560 new user accounts created since September 1, 2018.
- 57,600 active users registered between January 1, 2018, and May 1, 2019.
- 29,600 Certificates of Completion issued since September 1, 2018, an increase of 149% from 11,880 the previous year.
- Approximately 1,500 webinars hosted since September 2015.

Regional Rural Development Centers

a. **Mississippi State University** hosts the Southern Regional Rural Development Center (SRDC). In the July 2016-June 2017 reporting period, the SRDC's Extension Community

Development Programs reported an impact of 28,554 jobs created or saved across 12 universities. In addition, 2,601 new business plans were created, retained, or expanded, and 7,260 participants reported new leadership roles.

b. **Pennsylvania State University** hosts the Northeast Regional Center for Rural Development (NERCRD). Northeast Center research projects last year resulted in 18 published scientific papers and 30 presentations to national and international audiences, reaching over 600 individuals directly and countless others indirectly. Three scientific articles written by NERCRD and collaborating researchers were cited in the U.S. President's 2019 Economic Report. Chairman Kevin Hassett of the U.S. Council of Economic Advisers described these articles as being "critical" to the completion of the 2019 Report. A press release for a scientific paper on rural economic mobility received over 57,000 upvotes by Reddit users nationally.

Enhancing Agricultural Opportunities for Military Veterans

The Houston, Texas-based Hope Farmer Training for Veterans runs a 7- acre urban farm that offers veterans practical farming experience and the necessary financial training required to run an agricultural-based business. The program includes both a 40 hour/week 1-year program and a 20/hour per week 2-year part-time program. The curriculum is offered in three tracks, two full- time, one part-time, and includes immersive hands on learning in high-yield urban permaculture, business planning, financial management, tech tools, supply chain management, marketing, distribution, sales, and some college-level academic coursework.

The No More Silos project administered by **California Poly Pomona University** provides immersive multi-disciplinary experiences to 100 underrepresented students across the California State University System. Students develop scientific and professional competency by engaging in mentored fellowships in science, big-data analytics, agricultural journalism, and public policy. Four 5-day data intensive workshops will teach 80 students Big-data analytic skills. Students receive career mentoring through leadership and scientific communication workshops. Students emerge with measurably greater discipline-specific knowledge and skills, improved critical thinking and problem-solving skills, improved knowledge of multi-disciplinary team approaches to problem-solving and personalized roadmaps that articulate career goals and the steps needed to achieve them.

Avanzando en La Frontera addresses the need to advance knowledge of sustainable range management and livestock selection in arid, remote regions. **Sul Ross State University-Alpine** (68 percent Hispanic) serves the geographically diverse Trans-Pecos region of west Texas, including the Chihuahuan Desert, Davis Mountains, and Big Bend. Achievement of three primary goals and objectives will result in positive outcomes for underrepresented students in FANH, including community college transfers and graduates of rural public schools. *Avanzando* will integrate technology into livestock nutrition studies and care of livestock adapted to desert environments. Key strategies include a focus on agribusiness, student research, and experiential learning.

The **University of Houston-Downtown (UHD)** program is designed to Support Undergraduate Sustainable Technology and Agricultural Instructional Needs (SUSTAIN). The program includes a new course in Urban Agriculture, moving 5 sustainability focused courses online and offering an Undergraduate Certificate in Sustainability. The SUSTAIN program also includes a cross-disciplinary, year-long experiential learning program for eight undergraduates where the UHD students mentor urban

agriculture students from a local high school, create sustainable technology that solves an urban agriculture problem and engage in a summer internship at a local urban farm, renewable energy company or relevant scientific lab.

The **Expanded Food and Nutrition Education Program (EFNEP)** is a Federal Extension (community outreach) program that currently operates through the 1862 and 1890 Land-Grant Universities (LGUs) in every State, the District of Columbia, and the six U.S. territories – American Samoa, Guam, Micronesia, Northern Marianas, Puerto Rico, and the Virgin Islands. Funded by the U.S. Department of Agriculture, National Institute of Food and Agriculture (USDA/NIFA), EFNEP uses education to support participants' efforts toward self-sufficiency, nutritional health, and well-being. EFNEP combines hands-on learning, applied science, and program data to ensure program effectiveness, efficiency, and accountability.

Collectively, 76 land-grant universities conduct EFNEP and reach roughly 200,000 low-income adults and 450,000 low-income youth in rural and urban communities each year through Cooperative Extension. Consistently, annual data shows that more than 90 percent of adults and 80 percent of youth report improved behaviors following EFNEP involvement, such as improving their diets and nutrition practices, stretching their food dollars farther, handling food more safely, and increasing their physical activity levels.

With a sustained history of programmatic success – EFNEP celebrates its 50th[h] anniversary in 2019 – EFNEP is also attentive to the future. In 2017, EFNEP adopted a new policy to systematically include contemporary technology in a way that strengthens and improves programming, maintains relevancy, and expands program reach and impact, while staying true to EFNEP's legislative intent. In 2019, all

universities submitted updates to their 5-year plans, which included a technology element. Proposed new approaches ranged from incorporating lowlevels of technology, such as text messaging as reminders of meetings and content taught and integration of existing apps into programming, to medium- and high-level approaches, such as use of technology to provide content for make-up lessons, remote classes, and interactive digital lessons with peer educator engagement. Participant change utilizing these new approaches will be monitored to ensure that programmatic success achieved through more traditional learning approaches is retained.

An AFRI seed grant to **University of New Hampshire** is studying novel control strategies for plant-parasitic nematodes which are a major cause of reduced agricultural productivity ($80-$100 billion in crop damage annually). The goal was to identify novel compounds that effectively target plant parasitic nematodes without adverse consequences to plants or other animals. We identified potential nematicidal targets as members of the phosphodiesterase (PDE) enzyme family that degrade cyclic nucleotides involved in cellular signaling pathways important for growth and development, sensory perception (especially chemosensation), and locomotion. Bioinformatic analyses of nematode genomes identified 6 of the 11 vertebrate PDE families; these six PDE families are found in all nematode species for which data is available, including plant and animal parasitic nematodes. Relying on PDE inhibitor compounds already developed for therapeutic uses in humans, we determined that nematode PDEs can be inhibited by these same compounds, although with lower potency than for human PDEs. Using atomic-level simulations of the binding of human and nematode PDEs to specific inhibitor compounds allowed us to detect differences in the inhibitor binding pocket. This work is an important step in the design of next-generation nematicides that target plant parasitic nematodes without adverse effects on plants or animals. Such compounds will benefit U.S. agriculture by reducing crop damage, improving

the sustainability of farming operations, enhancing food security, and eliminating adverse environmental and public health impacts associated with traditional nematicides.

9.7. Outreach Activities

- A number of NIFA's SBIR staff attended National SBIR Conferences in Boston, Massachusetts, and Tampa, Florida, 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 30 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 Colorado, Maine, and Tennessee.

- In FY 2019 the USDA SBIR program in conjunction with the Small Business Administration (SBA) had staff participate in three SBIR Road Tours and participated in three regional SBIR focused conferences which included 2 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 an estimated 1,900 attendees in total, provided on average 30-35 one-on-one meetings with small business entrepreneurs at each meeting, and covered the following States: AZ, CO, IA, KS, MD, ND, NJ, NM, NY, OK, PA, SD, TX, and VT.

10.0. The Natural Resources Conservation Service (NRCS)

10.1. Mission Statement

The Natural Resources Conservation Service (NRCS) 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 applied natural resources conservation approaches and technology. NRCS maintains 171 National Conservation Practice Standards. These standards and supporting documents are NRCS' principle vehicle for transferring the latest science and technology directly to America's farmers and ranchers.

10.2. 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 (ARS) 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 and Plant Science Division and the Plant Materials Centers. 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.

10.3. 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 USDA NRCS recently completed its participation in the U.S. Environmental Protection Agency (EPA) National Wetland Condition Assessment, which is a periodic assessment on the Nation's wetlands conducted by the EPA at the direction of Congress. The project inventoried wetlands at more than 1,000 representative sites throughout the United States to determine their health and to look for factors which may be having a negative impact on the function of the wetlands. Factors which contribute to the function of the wetlands including plants, hydrology, and soils were assessed according to carefully established standards at each site. SPSD soil scientists assisted with soil descriptions, soil sampling, and soil analysis. Soils were described and individual soil layers were sampled to a depth of about 1 meter at each site with the NRCS SPSD's Kellogg Soil Survey Laboratory (KSSL) receiving bulk and core samples from over 4,000 layers. Twelve analytical procedures which produced 48 different analytical results were done on each sample. This was a very significant analytical project for the KSSL with the sample volume for this project being equivalent to the sample workload in a 'normal' year. The results of the soil analyses will be incorporated with the other observations of other factors at each site to give a snapshot of the health of each site and to identify factors which may be degrading or impacting the function of the Nation's wetlands. Results will be compared to those from a similar study in 2011.

Alternative Crops in Colombia – Cacao for Peace

The SPSD is collaborating with the U.S. Agency for International Development (USAID) through the USDA Foreign Agricultural Service (FAS) and Pennsylvania State University (Penn State) 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, South America. NRCS's role is to build capacity by providing technical assistance in traditional 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 as an alternate crop to coca. These training efforts will help address the U.S. opioid epidemic from the supply side. Due to concerns about high cadmium in cacao from the region, NRCS and partners are also investigating the spatial and vertical distribution of cadmium in soils within the project area. Through these efforts, NRCS will conduct digital soil mapping and soil erosion modeling in the spring of 2020 using field Colombia-specific soils and weather information collected in the spring of 2019. This 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 develop a soils information system platform 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. During 2019, a new version of the Ecosystem Dynamic Interpretive Tool (EDIT) was released. The tool is a collaborative project with USDA ARS Jornada Experimental Range and New Mexico State University. The newly released version includes automatic links to soil survey information through the SoilWeb application. EDIT is also available to users who want to enter and

manage site-specific data through the Land Potential Knowledge System (LandPKS). EDIT information is available at https://edit.jornada.nmsu.edu/.

PLANTS Database

Established in 1990, the PLANTS (Plant List of Accepted Nomenclature, Taxonomy & Symbols) database and website (https://plants.sc.egov.usda.gov) are an international standard for plant information. PLANTS serves many agencies throughout the Federal Government, as well as State and local agencies, private organizations, the general public, and global users that make up its over 3 million unique users per year. PLANTS provide data for approximately 35,000 plant species occurring in the United States and its possessions. Plant data include scientific names, geographic distribution, photographs and illustrations, scientific references, legal status information (endangered and threatened, invasive, noxious, wetland), and other characteristics important for conservation planning.

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. In fiscal year (FY) 2019, the KSSL conducted analysis and validation on more than 8,700 soil samples collected from individual soil horizons that represent more than 700 soil profiles (pedons). The KSSL scientific soil archive now contains over 250,000 samples. The soil samples analyzed in 2019 come from NRCS and other agency clientele that include soil survey field offices, State soil scientists, resource soil scientists, university cooperators, nongovernmental organizations, plant materials centers, the Natural Resource Inventory (NRI) Soil Monitoring Network, the National Ecological Observatory Network, and outreach activities such as collegiate soil judging. During 2019, the KSSL recorded more than 208,000 analytical results on chemical, physical, mineralogical, and biological soil properties by more than 50 different analytical methods. This quantitative data is essential for the National Cooperative Soil Survey (NCSS)

and NRCS programs such as conservation planning. National programs and research projects depend on KSSL data for soil classification, soil screening and assessment, soil health, and dynamic soil properties.

KSSL is the primary laboratory providing quantitative analyses to support NCSS and NRCS activities around the Nation. In addition, the KSSL develops and maintains standard soil laboratory procedures specifically applicable to soil survey and soil health programs, it provides technical consultation and reference samples to other soil laboratories, and it participates in lab testing comparisons. In 2019, the KSSL provided leadership in the standardization of analytical methods through participation in the United Nations-Food and Agriculture Organization-Global Soil Laboratory Network (GLOSOLAN). The quantitative soil data produced by the KSSL serves as input for models and interpretations for land use and management, baseline data to assess soil health, and measured values to determine effectiveness of conservation practices and programs (e.g., Conservation Effects Assessment Project (CEAP), Environmental Policy Integrated Climate model, Revised Universal Soil Loss Equation).

Over the last 8 years, the KSSL has been assembling a mid-infrared (MIR) spectral library, similar to international efforts using soil spectrometry as a low-cost tool for the rapid prediction of soil carbon and other properties. The growing KSSL MIR spectral library represents over 80,000 legacy samples from the KSSL soil archive, the largest public collection in the United States with over 400,000 specimens. Geographically and taxonomically constrained calibration models are being developed for use by NRCS soil survey field offices in proof-of-concept pilot projects for rapid prediction of organic carbon and organic matter, a topic of great interest for soil health and soil resource assessment. For the first pilot project, calibration models were prepared from several thousand Mollisol samples from the Great Plains. Results show low error of prediction for soil organic carbon and soil organic matter. MIR spectrometry allows rapid data collection while assuring data quality and consistency with a tool that any NRCS field soil scientist can use for soil survey and soil health investigations. An updated, publicly available version of the NCSS Characterization Database was published in FY 2019. It delivers a comprehensive soil laboratory dataset of chemical, physical, and mineralogical properties from over 64,000 sample sites, which are the result of 120 years of inventorying soils of the United States and territories. The database is used by a wide a range of customers, including farmers, ranchers, internal USDA staff, other Federal agencies, nonprofit organizations, local governments, and university partners.

NRCS Investments in University Research

The SPSD has invested $1.9 million in 15 collaborative research agreements with 14 universities in 2019 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 2019 included development of soil survey methods for urban areas, informing science-based management decisions for increased soil carbon sequestration and soil health, quantification of blue carbon stocks in tidal freshwaters and coastal marine wetlands, developing a dust risk index in the desert southwest, and building soil science capacity through research at University of Texas-Rio Grande Valley, a premier Hispanic-serving institution.

Planning for Resilience: Hurricane-Related Soil Mass Movement Assessments

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. In 2019, the SPSD supported Puerto Rico with funding to the University of Puerto Rico-Mayaguez to investigate and develop an assessment to identify potential areas for soil mass movement. The information from this study will improve the soil mass movement risk model developed by SPSD.

Soil Health Interpretations on the Web Soil Survey

New soil interpretations developed by the SPSD in collaboration with Soil Health Division (SHD) and other agency technical specialists are available through 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 influence of inherent soil properties (such as texture, minerology, depth, climate, and slope) on the likelihood of developing management-caused soil health resource concerns. In addition to interpretations that address specific issues such as the likelihood of subsurface compaction, organic matter depletion, soil surface sealing, and soil salinity, the Fragile Soil Index (FSI) was developed to provide a more comprehensive assessment that incorporates multiple factors that can leave a soil susceptible to management-induced degradation. Fragile soils are those that are most vulnerable to management induced degradation such as reduced organic matter and potentially unstable or weak soil aggregates. The FSI can be used in conservation and watershed planning to assist in identifying soils with greater vulnerability to degradation. An interpretation was also developed to identify the suitability of locations for siting farm and garden composting facilities. In addition, several of these interpretations have been integrated into the Conservation Assessment and Ranking Tool (CART) for use by agency staff in conservation planning.

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. In 2019, the SPSD closed out the agreement 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.

Conservation Assessment Ranking Tool (CART)

The newly developed Conservation Assessment Ranking Tool (CART) modernizes and streamlines NRCS's conservation planning and program delivery, reduces workload on field staff, and improves the

customer experience by creating an efficient application process. The tool combines and analyzes geospatially-referenced data and site-specific information provided by the landowner within a decision support system (DSS) framework. CART will assist NRCS conservation planners to identify the most likely resource concerns associated with the landscape and farm operation and the suite of potentially applicable conservation practices. The tool will provide the landowner with a robust context within which they can identify the most appropriate mix of conservation activities that will meet their objectives while addressing the relevant natural resource concerns. This informed conversation will lead to wider acceptance of conservation planning recommendations and increased adoption of conservation management practices on the ground. Soils and related data and information are key components of CART. In FY 2019, a team of soil scientists and other technical professionals developed a suite of web services that provide real-time soils data to CART v1.0. In addition, they developed a suite of soil-based interpretations that will help planners and land owner/operators to identify the likelihood that resource concerns are present in a selected management area. NRCS staff will use this information to inform field visits, on-farm assessments, and farmer discussions. These focused efforts will lead to more efficient and effective identification of priority resource concerns that can be addressed in collaboration with NRCS. Soil scientists and other technical specialists throughout the Nation continue to collaborate on additions and improvements that will be included in future versions of CART.

10.4. 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 Plant Materials 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 2,850 technical documents downloaded more than 1.5 million times per year. Plant Materials Program studies resulted in the addition of 86 new technical documents to the website in 2019.

- Plant Materials Program staff conducted 92 technical training sessions for over 2,000 field staff and conservation partners in 2019. 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; restoration after invasive species removal; 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. PMCs provided field days, tours, and presentations to 1,074 participants including NRCS employees, Federal and State Government employees, farmers, ranchers, and the general public.

- 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 (EQIP), Conservation Stewardship Program (CSP), and Conservation Reserve Program (CRP).

Conservation Plants

PMCs have released 745 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 2019, 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.

Neches Germplasm splitbeard bluestem (*Andropogon ternarius*) was released by the PMC in Nacogdoches, Texas. Neches Germplasm is a native, warm season perennial bunchgrass for use in conservation cover, critical areas, and wildlife plantings. Neches Germplasm is intended for use in conservation plantings and long leaf pine restoration projects in eastern Texas, western Louisiana, and southwestern Arkansas of the Western Coastal Plain.

Starr Germplasm longspike silver bluestem (*Bothriochloa longipaniculata*) was released by the PMC in Kingsville, Texas, in cooperation with the South Texas Natives program of Texas A&M University-Kingsville. Starr Germplasm is a native, warm season perennial bunchgrass for use in upland wildlife

plantings, highway rights of way, energy exploration reclamation, and range seeding mixes. Starr Germplasm has fair-to-good livestock forage and competes well with exotic grasses such as buffelgrass. Starr Germplasm is intended for use in the Rio Grande Plains and Sand Plain ecoregion (major land resource area (MLRA) 83) as well as the Gulf Prairies and Marshes ecoregion (MLRA 150) of Texas.

Progress on Current Activities

PMC information and products directly impact the success of conservation programs, practices, and activities and benefit many natural resource concerns.

- Cover Crops to Improve Soil Health and Cropland Resiliency.—Cover crops provide the ecological services of improving soil health, reducing soil erosion, retaining nutrients onsite, and suppressing weeds. PMCs are leaders in the development of cover crop information to support the use of cover crops and the NRCS soil health campaign. PMCs focus on the adaptation and application of cover crops to support agricultural production. In 2019, PMCs prepared final reports and regional technical notes on evaluations of 58 varieties of commercially available cover crop species at PMCs across the United States. This information helps field offices and producers select appropriate cover crops for their area and cropping systems, therefore increasing the success of soil health efforts. PMCs continue to develop and improve recommendations for planting dates, seeding density (rates), use of cover crops in arid areas, cover crop mixes, effects on soil health, methods for termination of cover crops, and demonstrations of cover crops in rotation with commodity crops. PMCs disseminated this information through trainings, workshops, field days, tours, and presentations to over 1,800 producers, NRCS employees, and the public in 2019. Several PMCs are working with producers to integrate cover crops into vineyards and almond orchards. PMCs are also working with the USDA ARS breeding project to develop legume cover crops with improved winter hardiness and biomass, reduced hard seed (less weediness), and improved disease resistance. PMCs are increasing seed for further testing and are evaluating new germplasm lines for regional adaptation in different environments.

- Restoring Productivity to Salt-Affected Soils.—High salinity soils impact tens of thousands of acres of rangeland and cropland. In 2019, the PMC in Bismarck, North Dakota, prepared

a regional technical note describing the salinity tolerance of grasses on degraded cropland. Long-term use of perennial grasses assists with rebuilding soil quality while providing for continuous ground cover, forage for livestock, and habitat for wildlife. Other PMCs, including Aberdeen, Idaho, and Bridger, Montana, continue similar work to identify appropriate species for degraded range sites. The PMC in Cape May, New Jersey, continues efforts on using native grasses to maintain the productivity of coastal lands where saltwater intrusion is a concern.

- Improving Grazing Lands to Benefit Livestock Production.—Productive range and pasture is critical for livestock and to maintain the viability of private grazing lands. Many PMCs continue to evaluate plants for grazing and to improve the management of grazing lands. The PMCs in Knox City, Texas, and Bismarck, North Dakota, have completed studies on stockpiling forage (i.e., managing summer grazing to reserve quality grass for winter forage). Drought is an increasing concern on grazing lands given the variable weather the United States has faced in recent years. The arid southwest has been hit particularly hard. The Tucson, Arizona PMC is working cooperatively to determine adequate environmental conditions for aerial seeding grasses in northern Arizona to improve establishment and grazing potential of these lands, much of which is Navajo Tribal land.

- Enhancing Pollinator Habitat.—Adequate pollinator and insect habitat is important for pollination of many crops, providing reservoirs of beneficial insects for crop protection, and broad environmental benefits. PMCs continue to select new plant materials and identify improved methods for establishing pollinator habitat. In 2019, the PMC in Bridger, Montana, updated recommendations for spring and fall seeded pollinator habitat. The PMCs in Aberdeen, Idaho; Lockeford, California; and Elsberry, Missouri, are evaluating methods for improving the establishment of milkweed needed by Monarch butterflies. The PMC in Aberdeen, Idaho, prepared a new technical note on processing milkweed seed. The PMC in Corvallis, Oregon, prepared a fact sheet for establishing pollinator habitat in vineyards.

- Culturally Significant Plant Materials.—Several PMCs continue to support efforts to preserve the Tribal heritage of using native plant materials. The PMC in Corvallis, Oregon, provided training for Tribal interns on harvesting and propagating plant materials. The PMC

in Cape May, New Jersey, provided similar training on plant propagation and production for Tribes in the northeast United States. The PMC in Tucson, Arizona, maintains a demonstration garden on the Tohono O'odham Nation and provides annual training on plant identification and production.

10.5. Conservation Engineering

Using Regional Architect-Engineering (A&E) Contracts to Meet 2018 Farm Bill Requirements

The Conservation Engineering Division (CED) issued task orders to three private consultants using the regional Indefinite Delivery, Indefinite Quantity (IDIQ) contracts to transfer current natural resources conservation approaches and technology directly to America's farmers and ranchers through NRCS Conservation Practice Standards (CPSs). NRCS maintains 171 National CPSs and these standards and supporting documents are NRCS's principle vehicle for transferring the latest science and technology directly to our stakeholders. The consultants were tasked with conducting current literature reviews of 87 CPSs. The resulting reports will support the 2018 Farm Bill requirement of reviews of all NRCS CPSs to ensure the completeness and relevance of the standards to local agriculture, native and managed pollinators, specialty crops, bioenergy crop production and forestry. In addition, the literature review reports will provide new technology and provide information to support the determination that the standards provide the optimal balance between conservation needs and minimizing the risk of design failure, while increasing the flexibility to ensure equivalent natural resources benefits.

Collaboration with the American Society of Civil Engineers

NRCS collaborated with the American Society of Civil Engineers' (ASCE's) - NRCS - ASCE myLearning On-Demand Training to offer training for NRCS engineers, geologists, and landscape architects to ensure they have necessary tools and knowledge to perform their jobs effectively and to maintain their professional licensure. NRCS obtained access to 600 individual training webinars and as of September 2019, the agency employees completed 356 online training courses offered through ASCE. This enables NRCS engineering staff to provide our stakeholders with high quality engineering solutions based on current approaches and technology. NRCS plans to renew the contract for 2020.

NRCS National Engineering Handbook

CED continuously updates the National Engineering Handbook (NEH) series to provide NRCS staff and stakeholders with current approaches and technologies for engineering solutions.

- CED updated the NEH, Part 630, Hydrology, Chapter 4, Storm Rainfall Depth and Distribution. Storm rainfall depth is the quantity of rain falling within a storm of a specific duration distributed uniformly over the watershed area.

- CED published the new NEH, Part 637, Environmental Engineering, Chapter 4, Solid-Liquid Separation Alternatives for Manure Handling and Treatment. This new chapter aids in the design of manure solid-liquid separation equipment used on livestock and poultry operations to better facilitate the handling of manure for nutrient management, improved odor control, and optimize the design of storage facilities.

National Design, Construction, and Soil Mechanics Center–Soil Mechanics Laboratories

The Soil Mechanics Laboratories consists of two laboratories that perform state-of-the-art soil mechanics testing, geotechnical analyses, and design and construction 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 geotechnical engineering support to all NRCS State and field offices, the Emergency Watershed Protection Program (EWPP), Watershed Rehabilitation Program, Watershed Operations Program, and Environmental Quality Incentives Program (EQIP), 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 21 dams with notable dam safety concerns.

- The laboratories performed geotechnical design analysis, geotechnical testing, and prepared reports for 148 conservation-related engineering structures funded under the mandatory farm bill programs.

- The laboratories updated and compiled all soil and rock testing data into a database used to develop engineering material and varying geologic formation site correlations for research, development of NRCS National CPSs, and geotechnical analysis for individual site conditions.

- The laboratories provided testing for the development of American Society for Testing and Materials (ASTM) standards which include Crumb Dispersion, Double Hydrometer and Pin Hole Dispersion testing.

- The laboratories developed specialty testing to optimize the amount of lime to mix into soil needed to stabilize earth embankments constructed of high plastic clay soils.

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 (EWPP), Watershed Rehabilitation Program, Watershed Operations Program, and Environmental Quality Incentives Program (EQIP) and rehabilitation of aging watershed structures. A few examples include—

- Assisted the Farm Production and Conservation Business Center (FPAC-BC) Employee Development Section (EDS) in providing quality technical instruction for NRCS personnel through formal training courses.

- Performed 42 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).

10.6. Watershed Protection and Dam Safety

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 the damage survey report (DSR) preparation and submittal, to project and funding approval. In FY 2019, the EWPP Tool was improved by reducing input time required for EDRs and DSRs as well as streamlining the approval process and improving project tracking.

Windows Dam Analysis Modules (WinDAM).—NRCS collaborated with scientists at the USDA ARS, Hydraulic Engineering Research Unit and Kansas State University to develop WinDAM 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 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 to prepare for potential events at

the dams. DamWatch alerts essential personnel through 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.

10.7. 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). Another CESU agreement with Portland State University support the parameter input to PRMS. The NWCC has a cooperative agreement with the USDA ARS in Boise, Idaho, to develop a physically based, distributed snowmelt model. Advanced work includes integrating the National Aeronautics and Space Administration's new Airborne Snow Observatory flight data into the ARS model. These contracts improve the NWCC's ability to forecast water supplies.

10.8. Soil Health

Adoption of soil health practices, especially soil health management systems (SHMS), provides benefits for agricultural resilience to weather and pest challenges, risk, production economics, yields, crop quality, nutrient cycling, water quality and quantity, and climate change adaptation and mitigation. Soil health is foundational to the agency's work. 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 the national Soil Health Division (SHD). The SHD provides training, direct assistance, science and technology integration, and leadership to soil health efforts within the

agency, with partners, and customers across the country. NRCS's soil health activities have expanded significantly at State and national levels, and interest in soil health has spread rapidly to partners and stakeholder groups, including the corporate agricultural sector and large landowners making decisions on millions of acres of land. The NRCS Conservation Practice Standard Cover Crop (Code 314) was again the number one EQIP cost-shared practice in FY 2019.

Since SHD's inception in late 2014, the division performed soil health-related outreach and tech transfer reaching over 175,000 people through presentations, workshops, technical assistance, staff and partner trainings, and demonstrations. Thousands of additional participants attend State-led soil health events annually. The division has redesigned and updated the 3-day Soil Health and Sustainability for Field Staff course, required for conservation planners, to include interactive soil health scenario-based problem-solving activities that are producing locally applicable SHMS templates for use by conservation planners. In 2019, SHD staff conducted 49 formal courses, training 1,361 NRCS planners for certification, and numerous additional informal courses with the same or similar content that included agency partners and customers. SHD staff provided training on a wide range of soil health assessment and management topics through over 600 events, reaching a conservative estimate of well over 25,000 participants, including over 7,000 NRCS staff participation instances. Additionally, 15 new soil health-related webinars were added to over 80 soil health-related webinars that are available to the public on demand at the NRCS Science and Technology Training Library: http://conservationwebinars.net. The new webinars attracted over 6,000 attendees. NRCS's Science of Soil Health videos, available on YouTube, have been viewed over 140,000 times.

SHD leads Science of Soil Health efforts collaboratively across the Science and Technology, Soil Science and Resource Assessment (in particular Soil and Plant Science Division), and Programs Deputy Areas within NRCS, as well as USDA Agricultural Research Service (ARS) and USDA National Institute for Food and Agriculture (NIFA), university partners, and other research and implementation organizations to enable rapid integration of the newest soil-health science into the NRCS's processes and services. One significant outcome of these cooperative efforts is the publication of Technical Note 450-03 "Recommended Soil Health Indicators and Associated Laboratory Procedures" which describes the first ever standard methods for measuring soil health. Significant progress is also being made on the development of a national tool for cover crop management decisions that will be housed at the National Agricultural Library, through collaboration between NRCS, ARS, land-grant universities and the four

Cover Crop Councils (Midwest, Northeast, Southeast, and West) and their members. Partnership with these councils is providing structure for compiling the practical science from across the cover-cropping community and transferring it to farmers, ranchers, and other landowners across organizational boundaries.

Additional national soil health leadership from NRCS includes the following products:

- A national template for In Field Soil Health Assessment to identify these resource concerns was developed and is currently progressing through the agency publication process.

- Technical Note 450-04, "The Basics of Addressing Resource Concerns with Conservation Practices within Integrated Soil Health Management Systems on Cropland" was published.

- A new Soil Health Management Conservation Activity Plan (CAP 116) and Soil Testing Conservation Activity Standard (CAS 216), as well as two interim practice standards Soil Remediation 807 and Soil Carbon Amendment 808 have been developed to be made available this fiscal year to meet several 2018 Farm Bill mandates.

- The first cohort of Conservation Innovation Grants (CIG) Soil Health Demo Trials has been selected–based on agency technical priorities related to soil health implementation. This subset of CIGs is the first ever that will produce a national outcomes dataset, including soil health status, management, and economic, environmental and social outcomes.

10.9. National Technology Support Centers

NRCS has three national technology support centers (NTSCs)—East NTSC in Greensboro, NC; Central NTSC in Fort Worth, Texas; and West NTSC in Portland, Oregon. NTSCs have two primary functions:

- To collaboratively provide technology transfer, training, and direct assistance to NRCS States and the Pacific Basin and Caribbean Areas, and

- To acquire, develop and support science and technology that efficiently meets the needs of the NRCS conservation delivery system.

The NTSCs are also charged with developing and maintaining national conservation practice standards (CPSs) and other technological procedures and references. Reviews are generally conducted on a 5-year rotation. As part of the 2018 Farm Bill requirement, most NTSC staff were involved with the review and update of all 171 conservation practice standards within the last year. The purpose of the review was to ensure, to the maximum extent possible, the completeness and relevance of the CPSs to local agriculture, specialty crops, native and managed pollinators, bioenergy crop production, forestry, and other needs.

With NRCS moving to a new planning approach utilizing the Conservation Assessment Ranking Tool (CART), a large number of the NTSC staff also contributed many hours in developing and reviewing the resource concern assessment portion of the tool. The CART development process included high-level assessment of resource concerns, assigning general credit for existing conditions, and finally assigning detailed credit for conservation practices. Potential geospatially-referenced data layers were evaluated to determine the most efficient approaches to streamline this new planning process.

The NTSCs are a critical vehicle for technology transfer from NRCS technical specialists down to State and area offices. States submitted 500 technical assistance requests to the Central NTSC, 300 to the East NTSC, and 500 the West NTSC to address subjects such as agronomy, engineering, fish and wildlife, manure management, plant materials, soils, water quality, wetland determinations, Monarch butterfly, planning/Field Office Technical Guide (FOTG), economics and social sciences, energy, and CPSs. Conservation implementation partners, such as conservation districts and State departments of agriculture, frequently participate in NTSC training sessions alongside NRCS employees. Over 12,000 individuals participated in training sessions in 2019.

NTSCs also provide critical support to the models and tools used by NRCS for conservation planning. A few examples include—

- The NTSCs continue to provide leadership for improvement, testing and training for three web-based applications that make maintaining CPSs and the Field Office Technical Guide more

efficient at the national and State levels. Those applications are Conservation Practice Document-Document Management System (CPD-DMS), Conservation Practice Date Entry System (CPDES), and FOTG ver. 5.0. The new design allows integration of both the FOTG and CPDES with the CPD-DMS to improve the user experience and encourages consistency in document organization. The FOTG revision advances the NRCS mission with improved delivery of high-quality science and technology for private lands conservation. NRCS State office staff were provided hands-on training with the new CPD-DMS and CPDES software to manage CPSs. The National Handbook of Conservation Practices was updated to cover changes to the process instituted as a result of CPD-DMS.

- The National Water Quality and Quantity Team (NWQQT), one of the national technology acquisition and development teams, provides assistance to States and National Headquarters (NHQ) with both water quality and quantity issues. The NWQQT works on both agronomic and engineering solutions and training to address water-related natural resource issues. Activities and technology software include—

    - The NWQQT led the development of a Windows Pesticide Screening Tool (WIN-PST) AgLearn course for conservation planners and their crop consultant partners. The way that pesticide risk is addressed in conservation planning versus integrated pest management (IPM) planning needs to be carefully coordinated. This course will help NRCS and the private sector work together to integrate environmental protection into efficient crop production.

    - The NWQQT also updated the Pesticide Properties and Toxicity Database supporting the Conservation Effects Assessment Project (CEAP) pesticide modeling and WIN-PST. WIN-PST is deployed to every NRCS field office and is also available to partners, technical service providers (TSPs), and the public. It is the accepted screening tool for pesticide risk for the application of the NRCS CPS Integrated Pest Management (Code 595).

- The National Animal Manure and Nutrient Management Team (NAMNMT), one of the NTSC national technology acquisition and development teams, provides assistance to States and NHQ

with animal manure- and livestock-related issues. The team has partnered with the University of Nebraska to convert many of the national Comprehensive Nutrient Management Plan (CNMP) course technical modules to online applications. These online modules will be prerequisites for the classroom session which will focus on development of a CNMP. 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.

- 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 USDA ARS and improve the efficiency and effectiveness of field-level predictions of wind and water erosion during the conservation planning process.

- NTSC economists have developed benefit-cost templates to assist in determining the cost-effectiveness of all 171 NRCS CPSs. Each one-page document has the same format and data categories, making it is easy to compare practices. Each document contains general talking points enabling the conservation planner to easily review and discuss the benefits and costs of each conservation practice with the client. Each document contains qualitative information, quantitative data including dollar costs and benefits are added later when the planning site, resource concerns and goals and objectives of the client are identified. The use of the templates is described in the Economics Technical Note TN 200-ECN-1, “Basic Economic Analysis Using T-Charts” (August 2013). The initial benefit-cost information came from the CPSs and the

Conservation Practice Physical Effects matrix. Using the template is the first step towards a full economic or financial analysis.

10.10. Science and Technology Training Library

NRCS's national technology support centers work with partners including the U.S. 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 diverse topics, including forestry, climate change, bioenergy, wildlife, soil health, conservation planning, and organic agriculture. Some of the webinars are developed by NRCS staff, others by partners. These webinars may be viewed live or on-demand. In FY 2019, these webinars were viewed by over 11,000 individuals, including both NRCS and non-NRCS participants. More than 4,000 continuing education units (CEUs) were issued to maintain professional certifications for NRCS employees, partners, and other participants.

10.11. 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 was 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 also worked on developing a set of standards to reflect the degrees of success a plant species has with respect to contaminant removal. The database provides a listing of NRCS Conservation Practice Standards to be used in conjunction with phytoremediation processes. Brooklyn College presented this work at the 14th International Phytotechnologies Conference in Montreal, Canada, in September 2017 and at the National Cooperative Soil Survey (NCSS) National Conference in Narragansett, Rhode Island, in June 2019.

10.12. 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) has been released and is undergoing evaluation by State resource inventory coordinators. 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, as well as the use of machine learning and artificial intelligence to speed up the monitoring of land use change.

10.13. 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. A component of NRCS's Environmental Quality Incentives Program (EQIP), CIG 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 benefits 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 700 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.

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 $220 billion and investments upwards of $28.6 billion in 2019 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 however, the agency does oversee the Biorefinery, Renewable Chemical, and Biobased Product Manufacturing Assistance Program (Section 9003), 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.

The 2018 Farm Bill transfer the Biobased Markets Program (a.k.a. Bioprefered) to Rural Development. The program's purpose is to spur economic development, create new jobs and provide new markets for farm commodities. The increased development, purchase, and use of biobased products reduces our nation's reliance on petroleum, increases the use of renewable agricultural resources, and contributes to reducing adverse environmental and health impacts. While the BioPreferred Program does not provide financial support for its participants, USDA's Rural Development agency offers loan and grant programs that may be applicable.

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 are support connecting rural communities to the future through broadband and e-connectivity projects. Other examples include, advanced

manufacturing, business incubators, renewable energy systems and energy efficiency improvements. Examples of how producers and small businesses are using RD programs to implement technology advances include: distance learning and telemedicine, lighting, refrigeration, high efficiency heating, ventilation and air conditioning systems, cooling or refrigeration units, electric, solar or gravity pumps for sprinkler pivots, and replacement of energy-inefficient equipment. Additionally, RD funds are being used to support new technology in the processing and marketing of value added food products that are contributing to the development of a more robust local and regional food system.

11.4. Strengthening Current Activities

Through a diverse portfolio of programs and 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 foresees the Biopreferred program as an opportunity to highlight the use of alternative technologies and expand consumer awareness to support the bioeconomy. Biobased products are derived from plants and other renewable agricultural, marine, and forestry materials and provide an alternative to conventional petroleum derived products. Biobased products include diverse categories such as lubricants, cleaning products, inks, fertilizers, and bioplastics. For the purposes of the BioPreferred Program, biobased products do not include food, animal feed, or fuel. Many of the products included in

the Biopreferred program are the result of the incorporation and commercialization of new and innovative technologies.

RD continues to enhance its Web presence to make information and programs more accessible to the public as well as concentrate outreach efforts to ensure that businesses and communities in greatest need have access to the necessary resources to be competitive.

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