USDA
United States Department of Agriculture

RESEARCH, EDUCATION, AND ECONOMICS

ACTION PLAN PROGRESS REPORT, 2016

CONTENTS

PREFACE

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In recent times, the United States has enjoyed an abundant food supply and the vast richness of its natural resources–water, trees, plains, and parks. Yet, only 75 years ago, during the second World War, the United States found it necessary to impose food, fiber, and other resource rationing. Action by the Government, as well as ingenuity by industry, and sacrifices of the American people turned the harsh conditions around. In fact, the end of WWII inspired new industries--like recycling--and new opportunities such as volunteerism to grow. Beyond our shores, other parts of the world are currently in crisis, making food security an emerging national security issue on the minds of our leaders. A safe and abundant food supply and natural resources are critical to our Nation. We cannot take them for granted: our own health and well-being as well as that of our foreign partners is at stake.

The challenge we face is to produce enough safe and nutritious food – both in the United States and abroad – in the face of emerging crop and livestock diseases, finite arable land and fresh water, more severe weather, and increased fire and drought. With the projected growth in global population expected to surpass 9 billion by 2050, we must increase current agricultural production dramatically while simultaneously reducing food loss and waste. USDA is committed to growing the bioeconomy in which agriculture is providing alternatives to fossil fuels. To achieve this goal, USDA is pursuing the use of agricultural biomass as the source of chemical feedstocks for fuel, pharmaceuticals and other industrial products. The challenges and opportunities in modern agriculture must be addressed with a dedication to long-term sustainability of the planet and a focus on environmentally sustainable, healthy food production. These are just some of the vital – and most debated – issues the REE Mission Area tackles.

While the challenges are vast, USDA's emphasis on integrating basic and applied research and its scientific contributions and breakthroughs over the last 6 years are contributing to positive change. In fact, in its report, "Innovation, Agricultural Productivity and Sustainability in the United States" (December 2016), the Organization for Economic Co-operation and Development (OECD) states, "the United States is the world leader in food and agricultural research and innovation . . . the advances they have made have strengthened U.S. agriculture productivity and benefitted global agriculture." But the OECD analysis foretells that "growing societal and consumer concerns regarding new technologies, production practices and animal welfare will require new approaches to build public trust in the solutions that innovation may provide." Trust in the scientific process comes from public understanding which is rooted in the transparency of scientific practices. USDA prioritizes open data and shares its tools, capabilities, and research innovations through many domestic and international partners and collaborators.

While the U.S. public sector has been the leader of agricultural research and development worldwide (according to OECD), the USDA Economic Research Service (ERS) concludes that private sector investment, which has risen rapidly in recent years, now surpasses the public investment. Furthermore, the decline in public sector funding and the rise in investments made by other governments (notably China and the EU) have reduced the U.S. share in the global agricultural

research and development enterprise. Although this trend has negative implications for the future of agricultural productivity growth at present, the United States is the top producer of agricultural research and development as measured by patents and academic journal articles. In 2016, REE and the Forest Service together produced over 26,000 in peer-reviewed journals.

Since 2009, we've invested $19 billion in intramural and extramural research, which has resulted in 883 patent applications filed, 405 patents issued, and 1,151 new inventions. Some excellent examples of these results can be found in USDA's 2015 Technology Transfer Report, produced by the Agricultural Research Service (ARS). Those innovations range from an apple-picking robot to mosquito-repelling military uniforms and all-wood computer chips. The annual technology report provides an important reminder that USDA research not only contributes knowledge to the farming and ranching communities, but also innovations which can help spur economic growth across the private sector. Agencies have gained significant benefit from funds contributed by other Departments, Agencies and organizations on co-funded projects totaling nearly $2.5 *billion* above what the USDA National Institute of Food and Agriculture (NIFA) and ARS invested in 2016 alone. These leveraged funds, in turn, attract significant State and local funds to supplement Federal funding and significantly enhance the level of research and knowledge Extension activities that can be performed to create positive impacts. REE agencies processed 82 Federal Register Notices, the official record of Federal agency rules, proposed rules, and public notices, enabling the public to participate in rulemaking.

Behind these impressive statistics, REE scientists contributed to scientific breakthroughs including an effort focused on Big data with 21 land-grant universities (LGUs) and the National Academy of Sciences (NAS). The collaboration resulted in the *National Animal Nutrition Program,* a publicly accessible database with over 1.5 million feed ingredients for use by research, extension personnel, producers, regulators, and other industry professionals. Groundbreaking discoveries were made in preventing the Porcine Epidemic Diarrhea Virus (PEDV), which is responsible for nursing swine mortality rates between 70 and 100 percent, including the significant mitigation of its airborne transmission. New prevention measures will help save some of the $1.8 billion losses in the industry. Other discoveries related to plant fungi and animal disease are helping to support healthier plants and livestock.

Results from REE social science studies are helping families eat healthier meals and prevent disease. Newly developed climate tools, such as those involving remote sensing data, are helping farmers and ranchers make more informed and timely decisions to reduce risks associated with agronomic production. Scientists have developed innovative treatments and processes for using agricultural and natural resource co-products like wood chips—which were once simply considered waste products–as new sources for the generation of biofuels.

The productivity of the Nation's working lands – agriculture, forest, pasture, and range – depends on the work of pollinators, which have been struggling due to multiple stressors, including pests, pathogens, and reduced habitat. Findings from USDA-supported research have demonstrated the

USDA's Research, Education, and Extension Achievements By the Numbers:

405 Patents Issued (since 2009)

1,151 Inventions (since 2009)

26,750 Peer-Reviewed Publications (2016)

$121 million to support Minority-serving Institutions (2016)

$2.5 billion Leveraged in Partner Projects (2016)

key role of habitat diversity in promoting and sustaining pollinator health, and that without pollinators, essential habitats are in crisis. The honey bee population adds more than $15 billion in value to agricultural crops each year. This knowledge along with specific tactics is being shared widely so that pollinator health can be improved.

Ongoing research supported by USDA, along with collaborative and transparent relationships, ensures that the best available science informs agricultural policy and other critical decisions needed to support the cost-efficient and environmentally sustainable production of current and future food supplies. A description of some of the collaborations, partnerships, and other accomplishments is included in this report.

In the years to come, one thing is certain–we must harness the capabilities and resources from all sources to sustainably feed a world of more than 9 billion people. Through partnerships and collaborations involving public and private sectors, Federal institutions, academia, and global governments, as well as private citizen groups, we can meet the challenge.

Ann Bartuska, Ph.D.
Acting Under Secretary for Research, Education, and Economics
United States Department of Agriculture

INTRODUCTION

USDA has created a robust infrastructure to perform world-class science, deliver classroom and community education, and transfer technologies from the laboratory to the private sector for the benefit of the Nation. Tracking our progress is essential to advancing our contributions and meeting consumer demands. After surveying the research environment, prioritizing customer needs, and assessing USDA's own capabilities and capacity, REE first documented its goals and objectives in the 2012 REE Action Plan, then in a 2014 revision. Each year REE produces an REE Action Plan Progress Report so that the mission area and its stakeholders can clearly track annual performance in the form of accomplishments and performance metrics. This information can be used to guide future decisions, priorities, and resource allocations. Tracking performance is essential for maintaining a focus and charting a path for the future. This is especially important in a dynamic global environment with ever-changing opportunities and challenges, constrained resources, and new emerging threats, even while the fundamental need to feed people throughout the world remains a key research priority.

This 2016 REE Action Plan Progress Report demonstrates progress in support of the REE Action Plan. The agencies reporting significant accomplishments in 2016 in support of the REE Action plan include:

The ***Agricultural Research Service (ARS),*** the largest intramural research agency of USDA. ARS has a workforce of approximately 8,000 employees, including 2,000 life and physical scientists, engineers, and veterinarians who represent a wide range of disciplines and work at more than 90 locations across the country and at 5 overseas laboratories. The ARS research agenda is broad, with about 700 research projects organized under 4 major program areas: Nutrition, Food Safety, and Quality; Animal Production and Protection; Natural Resources and Sustainable Agricultural Systems; and Crop Production and Protection.

The ***Economic Research Service (ERS)***, USDA's primary source of economic information and analysis and economic and social science research. The mission of ERS is to inform and enhance public and private decisionmaking on economic and policy issues related to agriculture, food, the environment, and rural development.

The ***National Agricultural Statistics Service (NASS)***, USDA's statistical agency. NASS conducts hundreds of surveys every year and prepares reports covering virtually every aspect of U.S. agriculture. The statistical data provided by NASS is essential to the public and private sectors for making effective policy, production, and marketing decisions on a wide range of agricultural commodities. NASS also conducts statistical science research on survey design, sampling, and other methodological issue areas. NASS works closely with the States in determining their agricultural profiles.

The ***National Institute of Food and Agriculture (NIFA)***, the primary extramural research, education, and extension funding agency of USDA. Its mission is to invest in and advance agricultural research, education, and extension to solve societal challenges. Some of funding opportunities are specific to the Land-Grant University System, and others open to participation by other academic institutions, government agencies, non-governmental organizations, and even private sector entities.

Other USDA Organizations: While other USDA organizations, such as Forest Service (FS) Research and Development (R&D), do not directly fall within REE mission area jurisdiction, their contribution is vital to USDA's science agenda. Forest Service R&D provides the basic and applied science that underpins the agency's efforts to promote resilient forests and sustainable communities that can adapt to forest threats such as climate change, fire, and insect and disease infestations. The knowledge and information gained from this research benefits the American public by improving the health and productivity of the Nation's forests, and the quality of life of communities by providing protection from fire, improving water and air quality, and supporting other ecosystem services in urban and rural communities.

REE Action Plan Framework

The REE Action Plan is designed to guide and help coordinate research activity across the Department and inform other agricultural research entities. It provides further delineation of USDA's research priorities and remains the roadmap for promoting innovations related to agricultural science and education. The Action Plan describes the seven goals that reflect the full scope and variety of REE activities:

- Goal 1: Local and Global Food Supply and Security
- Goal 2: Responding to Climate and Energy Needs
- Goal 3. Sustainable Use of Natural Resources
- Goal 4. Nutrition and Childhood Obesity
- Goal 5. Food Safety
- Goal 6. Education and Science Literacy
- Goal 7. Rural-Urban Interdependence and Prosperity

The following pages contain brief descriptions of some recent REE successes for each of the seven goals achieved from the USDA investment in food, natural resources, and agricultural research; education; and technology transfer. The last section of this report also contains a specific metrics chart.

GOAL 1.
SUSTAINABLE INTENSIFICATION OF AGRICULTURAL PRODUCTION

SUBGOAL 1A: CROP AND ANIMAL PRODUCTION

REE Objective: *Invest in research, development, and extension to safely, sustainably, and humanely increase the production capacity, production efficiency, and nutritional value of food animals and crops.*

Data and Discovery Help Feed the World. One of the global community's most pressing issues is feeding the world's growing population, which is projected to reach 9.7 billion by the year 2050. Food producers constantly assess current practices, striving to improve quality, efficiency, and environmental sustainability. They rely on the high-quality and up-to-date information and data products generated by USDA's REE agencies to innovate and advance.

Developing improved diets for agricultural animals requires understanding animal nutrient needs and feed capacity. Improvements may increase livestock well-being, promote the safety and nutritional value of livestock feeds, and reduce greenhouse gas emissions and waste. Recognizing the need for reliable data to inform and support these improvements, 21 land-grant universities worked together with REE scientists and the National Academies of Sciences, Engineering, and Medicine to create the first online, interactive, U.S.-based feed composition database (https://nanp-nrsp-9.org/). The National Animal Nutrition Program makes data on more than 1.5 million feed ingredients openly accessible in an up-to-date, downloadable system for use by research and extension personnel, producers, regulators, and industry professionals.

This dynamic database of previously isolated information is rapidly becoming a sought-after global resource and has had a far-reaching impact. It is routinely accessed by organizations in more than 30 countries to develop improved livestock feeding strategies, and producers use the data to improve the cost-effective incorporation of biofuel production byproducts into animal diets, which benefits both livestock production and environmental protection. Researchers, teaching communities, and private-sector stakeholders have easy access to millions of records of screened and sorted feed composition information, which can be used to model how animals will respond to different feeding strategies. The process of developing the feed database has also resulted in workshops, summits, and Webinars that have engaged over 30,000 stakeholders from different and sometimes competing sectors, fostering cross-sector information exchange and collaborations.

Livestock producers regularly face dynamic animal feeding challenges. The cost of traditional feeds, for example, fluctuates with the use of corn in biofuel-based energy production. Similarly, forage shortages caused by drought in 2012 drastically raised feed prices, forcing many dairy farmers to find alternative feed ingredients. REE research gives producers a variety of options to mitigate the effects of climate change and market fluctuations. For example, scientists found that crude glycerin, a byproduct of biodiesel production, can replace alfalfa hay, reducing feed costs without negative impacts on animal growth. Additionally, USDA-supported researchers in Madison, Wisconsin, and at Cornell University found that dairy cows consuming low-forage diets with less expensive byproduct feeds produced milk yields that were similar to standard high-forage diets, giving farmers a cost-effective option when feed prices temporarily rise.

Wiping Out Antimicrobial Resistance in Feed Animals. Livestock producers can use antibiotics to promote animal growth, but with the rise of antimicrobial resistance (AMR) in human pathogens, researchers, producers, and stakeholders are investigating alternatives to antibiotic use for the safe and efficient production of healthy animals. As part of the National Strategy for Combating Antibiotic Resistant Bacteria, USDA is developing practical strategies to reduce AMR. REE agencies have partnered with USDA's Animal and Plant Health Inspection Service (APHIS) and Food Safety and Inspection Service (FSIS) to develop a coordinated research plan to reduce AMR, including the development of alternative feed ingredients that provide the benefits of antibiotics without promoting resistance. USDA supports researchers at a number of academic institutions who are investigating AMR and antibiotic alternatives. Work includes studies by researchers at Clay Center, Nebraska, who determined that feeding the antimicrobial enzyme lysozyme to nursery pigs is as effective as antibiotics in increasing growth and feed efficiency. Kansas State University (KSU) researchers are using risk analysis and epidemiologic studies to examine antibiotic alternatives in animal production. Researchers at Iowa State University are developing technologies to generate quantitative data on antibiotic-resistance genes in environmental samples. These and other approaches will ensure the future safety and availability of animal products.

Realizing Agricultural Potential in New Ways. Urban agriculture provides jobs for new farmers and brings fresh and healthy foods closer to neighborhoods where they are eaten. Old warehouses, rooftop gardens, and abandoned properties are being used in production, research, and education to reduce hunger in food-insecure communities. For instance, Virginia State University Cooperative Extension purchased an empty warehouse and converted it into a 52,000-square foot aquaponics production center that combines raising tilapia and trout (aquaculture) with using the nutrient-rich water and low-energy LED greenhouse lighting to grow fresh tomatoes and lettuce without soil (hydroponics). This indoor urban farm provides research facilities, classrooms, and an in-house produce market to take the harvest into food deserts where citizens have limited access to food. At the University of the District of Columbia (UDC), USDA funding supports a 20,000-squarefoot green roof garden, which produces insect-pollinated crops like strawberries, promotes energy efficiency, helps cool buildings, and reduces storm water runoff.

Understanding Our World Inside and Out Through Microbiome Communities. Studies of microbiomes–the communities of bacteria, viruses, and fungi believed to have mutually beneficial relationships with all living organisms--indicate these complex communities can significantly affect nutrition, metabolism, and immunology. REE's cross-agency science perspective can support research partnerships investigating the role of microbiome communities in agricultural production systems, human health, and animal health, and can use these findings to improve agricultural production. For instance, REE researchers have begun studying complete agronomic systems to learn more about how soil microbiomes affect plants—and, by extension, how they affect the animals and humans consuming the plants. REE researchers and the National Science Foundation (NSF) are developing technologies to improve microbiome studies, while Michigan State University researchers are using genomic technology for food microbiome investigations. Pennsylvania State University researchers are discovering how broccoli can change the human stomach microbiome; Cornell researchers are developing crop microbiomes for enhanced nitrogen utilization; Texas A&M University scientists are discovering plant-microbe interactions involved in promoting plant health and bioenergy production; and REE scientists have discovered that microbial communities in the gut microbiome of agriculturally important bees can affect their susceptibility to parasites.

SUBGOAL 1B: CROP AND ANIMAL HEALTH

REE Objective: *Mitigate losses from animal and plant diseases that impact people worldwide. Develop sustainable food production systems that enhance crop and animal health while minimizing environmental impacts.*

Discoveries and Advances in Prevention of Porcine Epidemic Diarrhea Virus. In 2013, a highly contagious intestinal disease known as porcine epidemic diarrhea virus (PEDv) posed a serious threat to the U.S. swine industry. Mortality rates for nursing pigs infected with PEDv have ranged from 70 to 100 percent, and it has become one of the most devastating swine diseases challenging producers. In less than 3 years, it has caused annual economic losses of up to $1.8 billion to the U.S. swine industry.

Many aspects of PEDv, including immune response, infection routes, diagnostic tools, and its socioeconomic impact, were virtually unknown when PEDv infections began causing significant losses in U.S. swine production. To assess these knowledge gaps, USDA's REE agencies provided critically needed research and funding to better understand the disease, with the long-term goal of developing effective strategies to control, prevent, and mitigate its impact. Collaborative research between USDA scientists, NIFA-funded university research scientists, State agricultural experimental stations, and the APHIS National Veterinary Services Laboratories (NVSL) has resulted in groundbreaking discoveries.

One critical aspect of research was the natural immune response in pigs–when does the immune system start to show a response to PEDv and how long does this response last? Researchers were able to use natural infections in young and older swine to demonstrate the importance of maternal passive immunity and immune responses. Researchers also unveiled essential mechanisms that facilitate PEDv's ability to evade the swine immune response, findings that became key to developing a treatment.

Another monumental discovery revealed that PEDv spreads through airborne transmission. This led to new biosecurity protocols to protect uninfected farm herds from the entry and spread of the virus. These protocols were developed based on risk communications responses that included analyzing the most effective communications strategies designed to change behavior. Industry groups provided daily or weekly communication that helped the swine industry recover from the PEDv outbreak. Computer modeling revealed the epidemiology of PEDv and provided a better understanding of new infection sources and critical farm entry points, which further enhanced biosecurity control measures. More sensitive and specific laboratory diagnostic tools were also developed that facilitated early PEDv detection and supported the rapid implementation of these measures.

To raise public awareness of PEDv and increase acceptance of the new and more effective biosecurity control measures, innovative computer software games were developed that helped people understand how changes in human behavior can dramatically reduce the impact of PEDv. The games also helped researchers to assess the socioeconomic impact of changes associated with PEDv and the measures employed to mitigate and control the virus. Social media platforms designed for use on Twitter and Amazon Mechanical Turks were developed and used to recruit participants for the online experimental games. Forty-three of 100 expected participants played

the game and completed a post-game survey. All of the discoveries resulted in the proactive implementation of effective biosecurity control measures and helped curtail the further spread of PEDv in the United States.

Precision Management System Protects Strawberries From Fungal Diseases. Anthracnose Fruit Rot and Botrytis Fruit Rot are major diseases affecting strawberries, and producers must frequently apply fungicides to control the diseases and produce marketable crops. With support from NIFA's Specialty Crop Research Initiative (SCRI), plant pathologists at the University of Florida developed the Strawberry Advisory System (SAS), a disease management system also referred to as "precision management." Growers receive SAS electronic alerts about specific regions that may need fungicide applications because upcoming weather conditions could favor fungal growth. This information allows producers to apply fungicide only when and where it is needed. Growers following SAS guidelines reduced fungicide applications by 50 percent and achieved the same disease control level as growers who applied fungicides on a fixed schedule. About 65 percent of Florida strawberry growers currently follow SAS recommendations and the advisory system usage has expanded to North Carolina, South Carolina, Iowa, and Ohio. Florida economic risk analysis has shown that following recommendations from SAS could add $1.7 million in gross income over 10 years to 26-acre farms. These findings have greatly contributed to the long-term sustainability of the strawberry industry and to reducing potential adverse effects of pesticides on sensitive species and the environment.

Preventing the Spread of Texas Cattle Fever. Bovine Babesiosis (cattle fever) is a protozoan disease transmitted by two tick species. Disease symptoms include acute anemia, high fever, and enlargement of the spleen and liver. Texas cattle fever was eradicated in the United States by 1943, but the ticks still thrive in Mexico and are occasionally re-introduced to the United States, where they cause limited outbreaks of the disease. If outbreaks were to persist, the economic impact is estimated to be $1.2 billion, a potentially devastating loss to the U.S. beef and dairy industry. USDA-supported researchers are developing population genetic tools that support efforts to manage the disease, including the expedited development of genetic tools to rapidly detect outbreaks. With this information, APHIS inspectors can pinpoint critical areas for tick eradication efforts.

Major New Threat to Wheat. Wheat is vital to human nutrition, the U.S. economy, and to global food security, and the value of the U.S. wheat market is estimated to be more than $10 billion per year. However, U.S. wheat production is continually threatened by devastating plant diseases. Wheat blast is a new disease in South America caused by the pathogen *Magnaporthe oryzae* (Triticum population). It has recently been detected in Bangladesh, but is not present in the United States. Scientists at KSU and USDA are identifying South American wheat varieties with resistance to the disease and are developing tools for rapid disease detection and control. Screening of U.S. wheat germplasm in Bolivia and Paraguay has resulted in the identification of several promising sources of resistance, and rapid identification of the different strains of the wheat blast pathogen is now possible with newly developed genomics-based marker discovery and diagnostic tools.

SUBGOAL 1C: CROP/ANIMAL GENETICS, GENOMICS, GENETIC RESOURCES, AND BIOTECHNOLOGY

REE Objective: *Generate new fundamental knowledge through research in genomic sciences and applications to crop and animal production.*

New Versatility for Growing and Preparing Nutritious Beans. In order to heighten public awareness about the nutritional benefits of common beans and other pulse crops, the 68th United Nations General Assembly declared 2016 the International Year of Pulses. USDA research significantly supports research on common bean breeding and production.

Common beans are an ancient crop of the First Americans; even when grown on relatively poor soils, they contain high seed protein and other nutrients. But bean production is limited by several agronomic issues, which makes it challenging to increase yields. To address this challenge, scientists from USDA and State Agricultural Experiment Stations partnered in the "Breeding Common Beans" Project to develop higher yielding beans that help keep grower income steady and consumer price low, and support special diets. The project attracts collaboration from growers' associations and the public and private sectors.

Field-grown beans may vary in their nutritional value in part because of the conditions in which they are grown, which complicates long-term efforts to identify high-quality bean cultivars. The USDA-funded Bean Coordinated Agricultural Project (BeanCAP) uses molecular markers and genomic approaches to search bean collections and identify field-grown bean seed genotypes that are high in nutritional value. The results are documented in PhaseolusGenes, a new on-line public database of molecular markers linked to bean traits. Breeders and researchers can use the database to find genes and gene markers that can be used to create bean varieties with improved nutritional traits.

Though beans provide vital levels of protein, they can take ten times as long to cook as other foods such as cornmeal, so they are not a favored food source in many parts of the world where firewood and water are scarce. USDA scientists work with partners to develop beans that cook faster and use less fuel. They used genome-wide association studies to search bean germplasm collections at USDA and the International Center for Tropical Agriculture (CIAT) for molecular markers associated with cooking time. The markers were then used to develop new bean varieties that cooked in 15 minutes instead of 1-2 hours. The research group includes national bean researchers in Africa, Central America, and the Caribbean, who are breeding the trait into local bean varieties.

In the United States and globally, beans are typically grown in medium-arid regions where water stress is expected to increase; as a result, bean growers might need to begin irrigating crops or perhaps stop production altogether. BeanCAP researchers have released bean lines that need less water to be grown, which will help growers maintain production if water supplies decline.

UC Davis scientist Dr. Paul Gepts studies diversity to generate more resilient bean crops.

Creative Disruption Through Genetic Diversity for Climate Resilience. Breeding success requires genetic diversity, but beans were originally domesticated from only a few lines, so most trait diversity is still found mainly in wild beans. Intercrossing domesticated beans with wild relatives to bring more of that diversity into farmer varieties is slow–a genetic form of "creative disruption." USDA-funded research at the University of California, Davis combines next-generation DNA sequencing with Geographic Information Systems (GIS) data to identify candidate genes in wild bean for stress tolerance.Researchers on the same project are designing less disruptive ways to move these valuable genes into domesticated beans. Ninety genetic variations have been correlated with climatic variables, and these genetic traits are being tested for tolerance to heat or low rainfall.

Healthier Dairy Cows. Whole-genome sequencing and low-cost DNA markers have transformed animal breeding. Guided by genetic algorithms, USDA researchers assessed DNA markers for milk production and other traits in Holstein dairy cattle and used their findings to breed more productive cows. Milk yields in new breeds increased 50-100 percent, and other gains were observed in hard-to-improve traits such as fertility, life span, and health. The USDA-supported "Functional Annotation of Animal Genomes" (FAANG) project is discovering markers for various traits across all breeds which can be used with precision breeding methods such as genome editing.

The Amazing Role of Genetic "Dark Matter" in Crops. Some 40 percent of genetic variation in critical maize (corn) traits, such as yield, stress tolerance, and starch content, link to DNA regions of unknown function. These regions are known to researchers as "genetic dark matter." USDA scientists and university collaborators adapted a method from medical research to measure DNA coiling in corn chromosomes and study the 1 -2 percent of corn DNA that is *not* tightly coiled. The un-coiled "open chromatin" was discovered to correspond to genetic "dark matter" and contain regulatory DNA that turns trait genes "on" and "off." The discovery opens a broad new frontier in crop science and in plant sciences.

A New Open Data Resource for Animal Sciences. The National Animal Germplasm Program (NAGP) conserves animal genetic resources, including the preservation of important source information in the Animal-GRIN (Genetic Resources Information Network) database. But researchers were without a publicly accessible database for genomic data from completed projects. NAGP has now developed a new genomics component of Animal-GRIN, including "beta-testing" with genomic data from multiple cattle projects. Further Web-interface work is planned for FY 2017.

SUBGOAL 1D: CONSUMER AND INDUSTRY OUTREACH, POLICY, MARKETS, AND TRADE

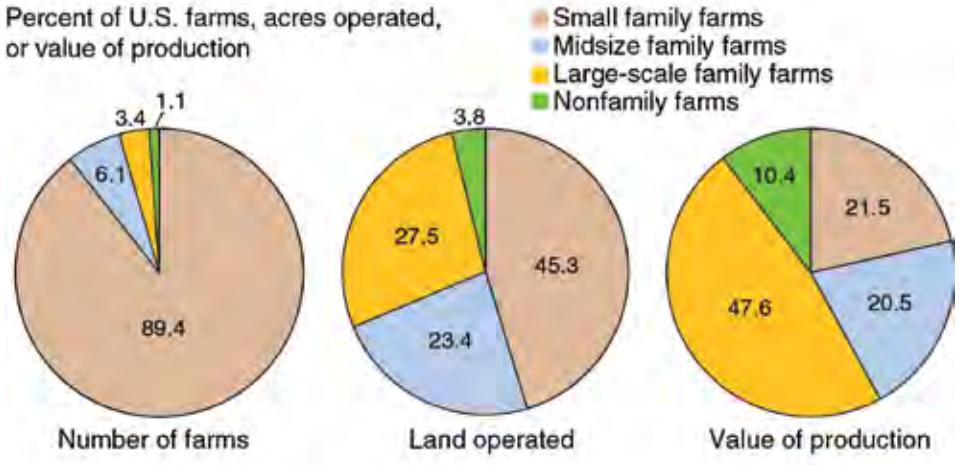
REE Objective: *Invest in data development, analysis, and dissemination to improve the understanding of agriculture markets, domestic and foreign trade policies, and other factors that impact food systems.*

Farm Income Rising. Median farm income has been on the rise and exceeds nonfarm sector income. While income and wealth in the farm sector have improved over time, the good news isn't distributed equally. Farm and rural income and employment varies by region and farm type (see chart):

- Eighty-nine percent of farms are small and account for 45 percent of the land occupied by farms, but only account for only 22 percent of production;
- Midsize and large-scale family farms account for most (68 percent) of production;
- Family farms of different types together account for 99 percent of farms and 90 percent of production;
- Nonfamily farms account for the 1 percent of remaining farms and 10 percent of remaining production

The diverse economic activity in rural areas partially results from various barriers to economic opportunities. The White House Rural Council directed efforts towards ensuring rural communities benefit from the production of food, fiber, and energy by facilitating the flow of capital in those areas. This is accomplished by facilitating regional economic opportunities in energy, recreation, and conservation activities, while addressing the economic obstacles that prevent the regeneration and revitalization of rural areas.

Distribution of farms, value of production, and land operated by farm type, 2014



Source: USDA, National Agricultural Statistics Service and Economic Research Service, 2014 Agricultural Resource Management Survey.

Information and Analysis–Critical Steps in Creating Economic Opportunity. All participants in the rural sector—producers, consumers, and policymakers—need authoritative data collection and analysis to inform their discussions and decisions about economic development activities and opportunities. Through an integrated approach, USDA agencies collect and distribute data, and perform and support research that helps advance economic opportunity in the agricultural and rural economy. Surveys such as the *Tenure, Ownership, and Transition of Agricultural Land (TOTAL)* survey provide a snapshot of the economic status of the sector and an accounting of land ownership in tenure, enabling the direction of new investments and interventions to where they will have the most impact. The publication *Trends in U.S. Local and Regional Food Systems* highlights the opportunities and barriers for farm and rural entrepreneurs as they create and participate in new markets and provides information about new options for investment and extension. Other reports about rural opportunities include:

- *Immigrant Led Community Based Organizations*
- *Opportunities for Extension: Linking Health Insurance and Farm Viability*
- *Connecting Farms and Universities*
- *Armed to Farm.*

Armed To Farm: Strategies For Military Veteran Farmers. Two million U.S. veterans are younger than 35, and nearly 45 percent of those veterans come from rural America. Most have expressed interest in returning to their hometowns, and U.S. census data indicates that most returning vets will choose to live in the southern United States. While veterans in this region have the highest unemployment rate in the country, farming fortunately offers a viable economic alternative. With multi-year support from USDA, the University of Arkansas led a team of experts in developing targeted training programs for veterans that emphasize business practices and building sustainable farms, including the identification of specific needs and how to meet them. This year, 30 participants went "on-farm" to veteran-owned Across the Creek Farm to learn about production operations strategies first-hand, including business planning and financial decisionmaking. To minimize the veterans' financial risk, grants pay for workshops and boot camps, and online courses are free. This helps ensure that if a veteran determines farming is not his or her calling, he/she can pursue other careers without incurring major debt. "…Farming is not for everyone," says program director Dan Donoghue. "[But] we're giving these men and women who served our country an opportunity to see if it's right for them."

Keeping Current With Trends: Local and Regional Food Systems. In recent years, Federal, State, and local governments have been responding to growing consumer interest in and demand for local food, an issue that has also influenced USDA priorities and goals. To meet the critical need for information about local food systems, U.S. Congress mandated and the U.S. House Agriculture Committee requested production of the report *Trends in U.S. Local and Regional Food Systems*. This report draws on USDA surveys, censuses, statistical analyses, and available academic literature to provide the latest information on the economics of local and regional food systems. It uses the latest *Census of Agriculture* data to describe local food producer characteristics, including geographic distribution and business survival and growth rates; summarizes findings from the USDA Farm to School Census; and provides data that USDA uses in awarding $90 million in grants and loans to support local food systems. Agricultural Resource Management Surveys also provide a larger sample of local food farms than previous research.

GOAL 2:
RESPONDING TO CLIMATE AND ENERGY NEEDS

SUBGOAL 2A: RESPONDING TO CLIMATE VARIABILITY

REE Objective: *Develop science-based knowledge to address climate variability; position agricultural communities to reduce emissions of greenhouse gases and enhance carbon sequestration.*

Translating Climate Science Research into Essential Products and Tools. Changes in climate, temperature increases, increasing carbon dioxide (CO_2) levels, and altered precipitation patterns are affecting U.S. water resources, agriculture, land resources, and biodiversity. Climate change will continue to significantly affect these resources over the next few decades and beyond. The effects of climate change on ecosystems will affect the services that ecosystems provide, such as purifying water and removing carbon from the atmosphere, but much more information is needed in order to project the timing, magnitude, and consequences of many of these effects. Thus, climate change introduces major uncertainties into the planet's current and future capacity to produce food, feed, fiber, and fuel for the ever-growing global population.

The 2010 USDA Climate Change Science Plan (CCSP) defined the Department's approach to climate change research and outreach and supports the development of regional climate change adaptation consortia to align the efforts of decisionmakers and information providers. The USDA Climate Hubs are at the center of the USDA's activities to support the CCSP and serve pivotal roles in all the REE Action Plan goals, including a broad commitment to developing the next generation of climate solutions. The Hubs provide research, outreach, and information to farmers, ranchers, forest landowners, and resource managers on ways to mitigate risks; public education about the risks climate change poses to agriculture, ranchlands and forests; regional climate risk and vulnerability assessments; and centers of climate forecast data and information.

The USDA Climate Hubs have succeeded in developing strong regional networks that coordinate and compound the value of scientific research and results for land managers. The 10 regional hubs, led by FS and ARS, coordinate the climate science investments of FS, ARS, NIFA, and Nat-

Source: USDA Climate Hubs website: https://www.climatehubs.oce.usda.gov/

ural Resources Conservation Service (NRCS), as well as other Federal agencies, including National Oceanic and Atmospheric Administration (NOAA), U.S. Geological Survey (USGS), and U.S. Fish and Wildlife Service (USFWS), and many university partners.

The Hubs have produced eight regional vulnerability assessments and a "Toolshed" for working land managers; hosted 14 workshops for agriculture professionals to learn the "Building Blocks for Climate Smart Agriculture;" and established the eXtension Climate Learning Network. Technology and knowledge transfer efforts have also become more efficient as the regional hubs work with the program agencies of USDA and State Cooperative Extension programs. These research investments have also leveraged ongoing partnerships with the Crow Valley Livestock Cooperative, Inc., NSF, Environmental Defense Fund, Nature Conservancy, and several regional land-grant universities.

Agroforestry Practices Support Carbon Storage. Creative implementation of agroforestry systems represents one strategy for reducing potentially destructive carbon emissions.

USDA supported research on the carbon capture and storage potential of agroforestry windbreak practices in nine U.S. regions over a 50-year time horizon, and results demonstrated and quantified mean carbon storage potentials across species and regions. These findings are critical because they bolster our capacity to better predict the carbon sequestration potential of windbreaks associated with whole farm and ranch operations in the United States.

Computer Modeling Helps Us Understand and Plan for Variability. Many agricultural policy issues stem from agricultural production and its interface with the environment. In 2016, USDA successfully developed an analysis platform for the USDA Regional Environment and Agricultural Programming (REAP) model that could more realistically represent production uncertainties associated with climate change and annual weather variability, as well as the market implications of those uncertainties. The new platform significantly advances the model's capacity to address questions of uncertainty and risk, extreme events, and producer resilience to variability under climate change. These advances may contribute to the efforts of non-governmental stakeholders and USDA agencies to understand potential production variability under climate change and the implications for programs, such as the crop insurance program, as they evolve and adapt under changing climate conditions.

New Genetic Resources Supporting Grain Production. Versatile crop options are important to help producers adapt to variable climate conditions and water shortages. USDA research conducted in College Station, Texas, resulted in the development of newly converted tropical sorghum lines that will thrive in temperate climates and have the genetic potential for high grain yields in the United States. The work is important because sorghum is becoming a critical option for staving off hunger overseas and an attractive alternative to U.S. crops that require more water.

Improving Estimates of Soil Moisture for More Informed Decision. Technologies are needed by producers, land managers, and strategic decisionmakers for adapting agricultural production to the wide swings of precipitation associated with changing climate, including resulting droughts and floods. New algorithms developed by USDA researchers in Beltsville, Maryland, are used to process data from several satellites and provide more accurate information about landscape moisture status. This information can be used to improve famine early warning systems, crop yield forecasting, identification of disease outbreaks driven by variable soil moisture, irrigation scheduling, forest fire risk assessment, drought monitoring, and estimates of grassland degradation.

SUBGOAL 2B: BIOENERGY/BIOFUELS AND BIOBASED PRODUCTS

Objective: *To lead global agricultural innovation to achieve energy efficiency and independence by integrating economically, environmentally, and socially sustainable region-based biomass production systems into existing agricultural systems.*

From Chips to Fuel. History was made in November 2016 when wood chips fueled Alaska Airlines Flight 4 flying from Seattle to Washington. A USDA-funded research grant supported this alternative fuel initiative—specifically, the jet-fuel blend that contained 20 percent renewable biofuel made from logging scraps. Renewable jet fuels offer an opportunity for domestically produced, sustainable agricultural crops to diversify the U.S. fuels supply, and create new jobs and economic gains in rural communities.

This biofuel project is a cool concept but making it mainstream is a long way off. The high cost of biofuels and bioproducts is discouraging the use of biobased products as viable energy alternatives. Other low-cost alternatives, such as petroleum, which has benefited from technological advances in shale oil extraction, have further discouraged the adoption of biobased fuels. USDA has recognized this challenge and has put the ingenuity of its scientists to the task. We are now seeing results—rewards for hard work and collaborative problem solving.

Over the past 5 years, USDA has committed $156 million to seven Coordinated Agricultural Projects (CAPs) across the United States to facilitate the development of regional industries that produce biobased products. CAPs brought together academia, industry, government, and non-governmental institutions in regional consortia to identify innovations and test the feasibility of sustainable systems that include the entire supply chain from feedstock production to product. USDA programs enable public access to the research data.

The success of the CAP model is illustrated by the Northwest Advanced Renewables Alliance (NARA) at Washington State University. NARA created an environment where diverse researchers come together and solve difficult problems. With a $40 million AFRI grant, NARA built a supply chain within Washington, Oregon, Idaho, and Montana that was based on turning forestry leftovers into biofuel for airplanes. The primary goal was efficiency–in forestry operations, conversion processes, and in the creation of new bio-based products–while maintaining economic, environmental, and social sustainability. In addition, NARA engaged in dialog with all stakeholder groups and supports bioenergy literacy for all learners. As the program wraps up this year, NARA's success is due in part to working with partners: GEVO, Inc. technology helped NARA successfully produce 1,000 gallons of jet fuel; feedstock was provided by Weyerhaeuser, the Confederated Salish and Kootenai Owned Tribal Lands, and Cosmo Specialty Fibers; and Partners Boeing and Alaska Airlines signed an MOU with the Port of Seattle to bring alternative jet fuel to SEATAC International Airport.

Commercial Scale Biochar Spreader. Biochar, the charred material that remains after bio-oil has been extracted from plants and other organic matter, can be used to restore forest, range, or mine soils. It can be produced using forest restoration woody waste products and hazardous fuels byproducts. When applied to the soil, biochar resists decomposition, effectively sequestering

the applied carbon and mitigating carbon dioxide emissions. Biochar amendments to soils also increase soil water holding capacity, which protects soils from the effects of droughts or floods.

One barrier to using biochar has been the lack of a cost-effective method for applying it to the forest floor. Researchers from the USDA Forest Service Rocky Mountain Research Station worked with partners at the USDA Forest Service Missoula Technology and Development Center, Washington State University, and John Jump Trucking, Inc., to develop a high-capacity biochar spreader that can be mounted easily on logging equipment and used on trails and landings. Field trials demonstrated the innovative method efficiently applies biochar to forest sites at commercial scales.

Napier Grass Doubles Ethanol Production Yields. Napier grass continues to be a highly productive energy grass, according to a study by USDA scientists in Illinois and Georgia. Napier grass--also known as elephant grass or Uganda grass--is ideally suited as a bioenergy crop for the Southeast United States because it is established with just one seeding, requires very little water or added nutrients, and develops deep root systems that improve soil fertility and minimize erosion. With so few agronomic requirements, Napier grass can be cultivated on marginal farmlands and serve as a refuge for wildlife since it is a year-round crop. Napier grass is also known to "pull" corn pests from corn and improve corn yields. Napier grass holds potential for use as a feedstock in the production of a variety of liquid transportation fuels, including renewable jet fuel.

Nylon From Orange Peels. USDA scientists in Albany, CA created a "nano-platform" comprised of multiple enzymes to convert orange peel wastes and other sources of untapped sugars into organic acids from which adipic acid is produced. Adipic acid is important to producing nylon, a popular and useful family of polymers. In this project, a USDA-funded team of NASA and USDA scientists showed that enzymes tethered to a nano-scaffold were more effective in multi-step reactions than untethered enzymes or enzymes in isolation. The strategy mimics structures seen in nature. Furthermore, the result is an example of the evolution of a USDA nanotechnology grant that ultimately garnered the interest of commercial partners.

USDA Scientist Explains Complex Relationships Between the Price of Oil, Land Use Commodity Prices, and Biofuel Demand. USDA publishes research that supports a better understanding of complex agricultural economic relationships. For example, in a recent study, a USDA economist looked at changes in ethanol production resulting from oil price changes and how those changes affected agricultural land use. The economist found that when oil prices are higher than average, demand for ethanol increases, leading to increased sugarcane production and an increase in corn prices. Sustained low oil prices bring about the opposite effect, and land previously planted to sugarcane becomes available for planting other crops.

Public Access to USDA Research. In support of the Federal open data initiative, scientists funded through USDA research programs gave Feedstock Readiness Evaluation and life cycle inventory datasets to the National Agricultural Library (NAL), which began making the information available to the public in 2016 through the USDA Life Cycle Assessment (LCA) Commons.

GOAL 3:
SUSTAINABLE USE OF NATURAL RESOURCES

SUBGOAL 3A: WATER AVAILABILITY: QUALITY AND QUANTITY

REE Objective: *Provide research and decision support tools to: increase the effectiveness of USDA conservation policies, programs, and practices; raise the ratio of conservation benefit/conservation investment; and facilitate the transfer of research advances to practical implementation.*

Water availability—quantity, quality, timing, and distribution–is a critical factor in our everyday lives, but water resources are finite and supplies are vulnerable to climate change and climate variability. As demands on available water supplies increase, so does the need to develop tools and techniques that accurately assess available water supplies and help reduce water use. Preventing future water shortages depends on understanding water scarcity and balancing water supply with demands. Eighty percent of all the water currently consumed in the United States is used for agricultural production. USDA research on water scarcity and sustainability has supported the development of tools and innovative approaches that help ensure our future water supply is safe and sufficiently abundant to meet all U.S. demand—agricultural, residential, commercial, and recreational.

Careful irrigation management is critical to avoid crop losses. With the goal of saving water by irrigating only the crops that need it most, USDA scientists and partners developed two low-cost and energy-efficient wireless sensors for use on the ground. One is an accurate soil water sensor and the other is a temperature sensor that detects when the plant canopy is under stress from lack of water. The sensors help producers reduce water use by adjusting irrigation rates as needed given soil and water conditions. They have been incorporated into a patented system for variable rate irrigation (VRI) and have been adopted by large agribusinesses.

High-Tech Success for REE Scientists and Researchers. A NASA satellite was launched in 2015 that dramatically changed our ability to know how much water is in the soil across the globe. Thanks to algorithms developed by USDA scientists, a satellite instrument called Soil Moisture Active Passive (SMAP) was created. SMAP has already generated highly accurate and timely soil moisture information that helps USDA, NOAA, and other agencies provide agricultural land managers with more accurate assessments and forecasts.

USDA scientists also developed and combined three remote sensing data analysis programs to fuse data from multiple satellite platforms and produce daily detailed maps of crop growth, daily water use, and plant stress. USDA is exploring the use of these datasets in reports on domestic crop progress and conditions, while crop consultants can use the datasets to help growers adjust production management as needed to meet crop water demands.

Long-Term Temperature Stress Hurts Crop Productivity. Despite higher temperatures and considerable regional variation in production response, integrated USDA science research indicates that irrigated field crop acreage and water use tend to decline with long-term climate change. Changes in crop growth due to temperature stress, changes in growing-season precipitation, and shifts in surface-water supply availability are driving this decline. Changes in the relative profitability of dryland and irrigated agriculture will also alter regional irrigation water demands.

According to a new Forest Service study combining 76 years of climate, vegetation, and water

yield measurements, water yield from southern Appalachian watersheds has declined as much as 22 percent since the 1970s. Changes in water yield were mostly related to changes in climate, but disturbance-related shifts in forest structure and species composition may have also decreased water yield by up to 18 percent in a given year. The study findings have implications for managing forested watersheds to ensure adequate water supply under future climate change scenarios.

A USDA pilot program called Science-based Trials of Rowcrops Integrated with Prairie Strips (STRIPS) is helping to transform portions of agricultural landscapes to perennial plant communities, enhancing environmental quality and socioeconomic vitality. STRIPS integrates small contour buffer strips and edge-of-field filter strips of prairie vegetation at strategic locations within corn and soybean fields. Farmers and landowners converting just 10 percent of cropland planted with annuals to diverse native perennial plants can reduce field soil losses by 90 percent and field nitrogen runoff by up to 85 percent.

New Water Resources and Tools Aid in Land Conservation. In a new book on forest hydrology, USDA scientists present cutting-edge information and assessments across all latitudes and terrains, including state-of-the-art modelling techniques and methodologies.

In another recent book focused on the competition for water resources, USDA economists advise the future sustainability of irrigated agriculture will depend partly on: 1) producers adopting more efficient irrigation systems integrating water management practices with irrigation application systems; and 2) conservation policy that integrates on-farm water conservation with watershed -scale management encouraging market-driven water reallocations and real water conservation.

NAL's Water Quality Information Center has a new name and makeover. It is now the Water and Agriculture Information Center (WAIC) and its redesigned website reflects the broader scope of information now available on both water quality and quantity issues.

Rainfall measurements from the Long-Term Agroecosystem Research (LTAR) program are now available in near-real time via NAL's LTAR Data Website. The data can be viewed in customizable maps and interactive graphs and are accessible via download for modeling or custom analysis.

Datasets and tools from federally funded scientific research projects and initiatives are meant to be used, so NAL has taken the lead in cataloging and releasing new findings through its Ag Data Commons pilot. Water and water issues are key topics in the Agroecosystems and Environment section, which contains more than 100 datasets.

SUBGOAL 3B: LANDSCAPE-SCALE CONSERVATION, MANAGEMENT, AND RESILIENCY

REE Objective: *Develop the best available science and technologies to inform U.S. Government policies and programs and support application of land management practices.*

Pollinators and Their Essential Role in Sustaining Productivity of Working Lands. The productivity of the Nation's working lands – agriculture, forest, pasture, and range – depends on the work of pollinators. Honey bee pollination alone adds more than $15 billion in value to agricultural crops each year. Pollinator survival, in turn, depends on healthy landscapes. In 2016, USDA agencies continued their cutting-edge research efforts supporting the "National Strategy to Promote the Health of Honey Bees and Other Pollinators." USDA research agency teams identified crucial issues to be addressed and then initiated pertinent scientific investigations that resulted in new and important information for agricultural producers and hive owners.

In 2016, USDA inventoried the U.S. honey bee colonies to establish baseline information, identify health trends, and determine how pollinator health and habitat can be improved on U.S. working lands. The report provides a statistically strong baseline about honey bee loss, which is crucial for guiding future research and honey bee management decisions. For example, in the January-March 2016 timeframe, USDA research found that of the 2.59 million colonies located on operations with 5 or more colonies, 429,000 (17 percent) were lost. Of those colonies lost, 113,930 were reported to have symptoms of Colony Collapse Disorder. Varroa mites were reported as the top colony stressor by operations, and 34.3 percent of the lost colonies were affected during that quarter. Overall, there was an 8-percent drop in the number of colonies located on operations with 5 or more colonies from January 1, 2015 to January 1, 2016. An accurate understanding of the causes of honey bee decline is essential before agricultural producers and hive owners can make land management decisions that protect these colonies.

With this statistical baseline in place, USDA scientists are documenting the importance of flowering plant diversity across the landscape and its benefits to pollinators. Using 30 years of National Resources Inventory data, the USDA reported that in just the last decade, land use changes have reduced pollinator habitat quality in the Northern plains, a region where many beekeepers take their hives in the summer to provide pollination services. To determine how pollinators are affected by this loss in habitat quality, an REE-funded research project at the University of Minnesota examined and quantified the impact of agricultural landscapes on honey bees. The availability and diversity of floral resources within a 2-mile radius of the bee colonies significantly impacted annual colony survivorship and health. Colonies on sites surrounded by "uncultivated land" experienced the highest survival over the summer and through the winter when the colonies were transported to California for almond pollination (88 percent survivorship). In contrast, colonies surrounded by mostly corn, soybeans, and other grains experienced as low as 50 percent survivorship across the 3 years of the study.

USDA scientists found a similar result in a study of wild bee health near apple orchards in Wisconsin. Wild bee abundance increased when orchards were surrounded by more diverse landscapes and a greater amount of woodland habitat. Greater landscape diversity also increased the number

of bee species within the orchard. The landscape research demonstrates that different habitat types within diverse landscapes supported wild bees by providing different types of flowers and providing flowers at different times throughout the spring. The take-home message from USDA science for policymakers, land managers, natural resource professionals, beekeepers, and even homeowners is *landscape matters*. Pollinator abundance increases as available habitat diversity increases, and a greater abundance of pollinators is more likely to survive as a result.

Coexistence of Genetically Modified Organisms (GMOs) and non-GMO Crops. Questions and concerns continue to be raised about the coexistence and proximity of organic crops, genetically engineered (GE) crops, and non-GE crops. These questions largely focus on the economic impacts of cross-pollination between GE and non-GE crops. A 2016 USDA report documented the economic issues related to the coexistence of organic, GE, and non-GE crops, and the markets for these crops in the United States. Producers of organic and conventional non-GE corn and soybean face challenges in preventing accidental commingling with GE crops and pollen, which could affect the premium prices paid for organic produce. This analysis revealed that buffer strips, an agroforestry practice, are used on 69 percent of organic corn and soybean fields to reduce the risk of comingling and pesticide drift from adjacent non-organic fields.

Biological Weed Control Contributes to Landscape Productivity and Habitat Diversity. Annual grass weeds such as "cheatgrass" degrade wildlife habitat, reduce the capacity of the landscape to produce useful crops and forage, increase the likelihood and intensity of wildfire, and cause soil erosion and degradation. Using chemicals to control these weeds is costly and challenging. USDA researchers have identified and studied a native soil bacteria that provides selective control of these weeds. The "breakthrough" strain, identified as *Pseudomonas fluorescens* (ACK55), is extremely effective at controlling cheatgrass and other noxious weeds such as jointed goatgrass and medusahead. In fact, a single application appears to be adequate for providing almost complete long-term (4-5 years) elimination of these annual weeds, in part by disrupting annual seeding. ACK55 is undergoing testing for EPA approval; if approved, it could have widespread beneficial impact across vast areas of the western United States.

Using Windbreaks for Soil Health and Carbon Sequestration. Windbreaks provide many functions, including the potential reduction of wind erosion on 75 million acres and increasing habitat for wildlife and pollinators. The trees that make up windbreaks also mitigate greenhouse gases by sequestrating carbon from the atmosphere, but it was unknown how much carbon could be captured this way. In FY 2016, the USDA Forest Service published research that better approximates how much soil carbon is stored as a result of windbreak trees. After testing a variety of models, researchers identified a biomass model that provided the most accurate approach to estimating carbon storage in windbreak trees. This research contributes to a better understanding of how trees and their carbon storage potential can contribute to management practices responsive to climate change impacts and how the dynamics of agroforestry systems contribute to the global carbon cycle and the Nation's carbon budget.

GOAL 4:
NUTRITION AND CHILDHOOD OBESITY

REE Objective: *Promote health and reduce malnutrition and obesity in children and all individuals with emphasis on high-risk populations*

Tracking Trends To Improve the Diets of Children. The Federal Government has collected information on U.S. food consumption since the 1930s. Surveys provide objective data on what Americans eat and how diets have changed over time, allowing nutritionists to identify dietary problems and track progress in resolving them. Food consumption surveys conducted by USDA and the U.S. Department of Health and Human Services (HHS) between 1977 and 2012 reveal a dramatic shift away from foods prepared at home to foods prepared away from home, including sit-down restaurants, fast-food establishments, and other locations. This trend was observed in both children and adults; in 1977-78, 19 percent of children's diets consisted of food prepared away from home, but that level rose to 35 percent in 2011-12.

The major source of "away" food also changed. In the 1990s, fast food overtook school food as the largest source of food in children's diets prepared away from home. However, school foods have remained a more important source of calories for lower income children than for higher income children. As shown in the figure here, in 1977-78, school meals provided 10.1 percent of the calories consumed by lower income children eligible for free or reduced-price school breakfasts and lunches and 7.5 percent of total calories consumed by higher income children. In that same year, fast food provided 4.5 percent of higher income children's average daily energy intake and 3.2 percent of lower income children's calories. School food continued to provide about 10 percent of lower income children's total calories in 1994-98 but, by 2011-12, this fell to 8.1 percent and the fast food share rose to 14.2 percent.

ARS uses data from its National Nutrient Data Bank (NNDB) to compute the nutrient profiles of foods reported in food consumption surveys. These data indicate that food prepared away from home is typically less nutritious and higher in fat and saturated fat than home-prepared food. This information has helped USDA target strategies for improving children's diets, including revising USDA National School Lunch Program and School Breakfast Program nutrition standards to provide nutritious school meals, coupled with research on strategies to encourage children's acceptance of healthy foods.

Parents Can Make a Positive Difference. Studies show that children will eat more vegetables if parents develop four practices: (1) actively involve the child in selecting vegetables, (2) maintain a positive vegetable environment, (3) communicate positively about vegetables, and (4) avoid parental control of eating choices. In a study of more than 300 parents of preschool children, the ARS Children's Nutrition Research Center found the first three factors accounted for half the variance in vegetable intake, and that involving the child in vegetable choice showed the strongest association. Findings also indicated that forcing a child to eat something is counterproductive to developing healthy eating habits, and psychosocial variables beyond parenting practices had limited influence. Cumulatively, these results suggest that changing habits of parents to include eating more vegetables, involving their children in selecting vegetables, and talking about the benefits of eating vegetables will encourage greater vegetable consumption by children.

A group of 129 Latina mothers and their children in Head Start programs were assessed at baseline and then again 18 months later. Four feeding styles were identified: authoritative, authoritarian, indulgent, and uninvolved. Mothers with an indulgent feeding style had children who gained the most weight. Those parents are sensitive to their child's desires during meals but provide little structure and allow children extensive freedom. This was the first study to investigate the impact of feeding styles on children's weight status over time. It was previously believed that parents responded to behavior of children during meals or their weight status, but this study suggests the parental pattern of behavior is the driving factor in these relationships.

Adding Recommendations for Young Children. One of the gaps in dietary recommendations is the lack of science for dietary advice aimed at children from birth to 24 months of age. Researchers from the USDA Children's Nutrition Research Center collaborated with investigators at Deakin University in Australia to analyze dietary intake reported by mothers for 2,740 infants and toddlers from 2005 to 2012. In children under 1 year of age, infant formulas and baby foods were the leading source of calories and nutrients. In the children from 12-24 months, milk, 100 percent juice, and grain-based mixed dishes were important sources of food, but a number of foods with low nutritional quality contributed to energy intake, including sweet bakery products, sugar-sweetened beverages, and savory snacks. Non-flavored milk and ready-to-eat cereals were the most important contributors to micronutrient intakes. These data will help formulate future recommendations to be included in the 2020 Dietary Guidelines for Americans.

Promote Healthy Behaviors. To enhance health curricula with nutrition education for K-2 students, the School Enrichment Nutrition Education Program to Promote Healthy Behaviors for Children offers school enrichment kits with lessons emphasizing the role of reinforcement in changing behaviors. The kits allow teachers to provide accurate and current nutrition information and increase the amount of classroom time spent on health and nutrition. Nutrition knowledge increased significantly in all three grades, from 59 percent in the pre-test to 81 percent in the post-test. Students were more aware of nutrition and were making healthier meal and snack choices as a result of the program.

Involving Children and Parents. USDA funded a program to involve 9-10 year-old children in activities that contribute to good health. The "iCook" 4-H program is a five-State partnership among researchers and Extension faculty who used a community-based participatory approach to reduce childhood obesity in rural, low-income populations. Youth reported they spent more quality time with their family and were more active in meal planning, recipe selection, grocery shopping, table setting, and helping parents prepare family meals. Adults reported the program helped them with healthy meal planning, cooking more with their children, and communicating more during meals with less TV time. The top five influences on a positive family meal experience included: (1) enjoying the food served, (2) being together, (3) having fun and not fighting, (4) good conversations, and (5) the absence of time constraints during meals. Youth also reported increases in cooking by themselves, cooking with help, kitchen skill self-efficacy, using technology with help, and goal creation and completion.

GOAL 5: FOOD SAFETY

REE Objective: *Provide science that informs decisions and policies that contribute to a safe food supply and the reduction of foodborne hazards.*

USDA Science Supports Policymaking and Regulatory Activities. U.S. Government regulatory agencies play an important role in ensuring the U.S. food supply is nutritious and safe to eat. REE conducts research, education, and extension activities that help food producers improve agricultural production and support regulatory agencies that make critical decisions and provide guidelines. For example, in 2016, USDA agencies partnered with FDA to conduct a survey of the foodborne pathogen *Listeria monocytogenes* (*Lm*) in ready-to-eat (RTE) foods. Results indicated that the occurrence of *Lm* in RTE foods has decreased over the past decade, coinciding with the implementation of new Federal regulations and new industry guidance to control this pathogen. In another study, USDA researchers sequenced the genomes of seven Shiga toxin producing *E. coli* (STEC) strains—all of which can cause foodborne illness—and found that the STEC strains are distinct, which will help the FDA improve monitoring and regulation. USDA also developed and validated a new method to detect inorganic arsenic in rice; this process costs $40 per sample, which is less expensive than the current FDA method. USDA developed and validated an easy and reliable high-throughput analysis method to detect 192 diverse pesticides and 51 environmental contaminants in cattle, swine, and poultry muscle, which USDA's Food Safety and Inspection Service (FSIS) uses for routine regulatory monitoring of contaminants in meats.

Behavioral scientists and other researchers at ERS determined that reputable suppliers of raw chicken to the National School Lunch Program sold chicken with modestly lower *Salmonella* contamination levels than chicken sold by unknown commercial chicken slaughter establishments, suggesting that reputation creates financial incentives for improving food safety performance. USDA researchers analyzed the records of FDA import refusals from 2005 to 2013 and found the most common products that were refused were seafood, vegetables, and fruit products. The countries with the most food shipments refused were Mexico, India, and China. Because FDA uses a risk-based prediction algorithm to prioritize inspections, the information generated by ERS may be of use to FDA to reduce the likelihood that a contaminated product enters the country.

Microwave pasteurizer - A Washington State University-led research team member works on the prototype microwave assisted pasteurization system (MAPS) unit.

USDA provides grants for food safety education, training, and technical assistance projects to owners of small to mid-sized farms, beginning farmers, socially disadvantaged farmers, small processors, food hubs, farmers' markets, and others. This support helps recipients comply with new food safety guidelines established by FDA under the Food Safety Modernization Act (FSMA). The programs will target a diverse audience of farmers and processors to include organic, sustainable, veteran, urban, African American, Hispanic, Hmong, Amish, Native American, Alaska Native, Native Hawaiian, and Mennonite populations.

USDA-funded research teams led by Washington State University and Michigan State University developed new technologies to control pathogens in foods and standardized validation protocols that can be used by FDA and FSIS to establish guidelines for industrial pasteurization processes. Researchers provided new data that supported commercial development and validation of microwave-assisted thermal sterilization processes for FDA filing. A team led by the University of Nebraska provided data to support the Federal requirement for validated Hazard Analysis and Critical Control Points (HACCP) plans, including validating the current handling and cooking guidelines to control STEC in beef. The efficacy of three FSIS-approved antimicrobial sprays for reducing pathogens on bob veal carcasses were evaluated which will improve the safety of veal. Real-time multiplex PCR assays, including an assay using CRISPR polymorphisms, were developed for detecting STEC in cattle feces, and workshops were held for processors and State regulators on "Managing the Risk of *E. coli* and other STEC in Beef Products." All these achievements will be used to develop, evaluate, or implement regulations that will improve food safety, reduce the incidence of foodborne illness, and save lives.

Norovirus Research. Norovirus is the most common cause of foodborne illness in the United States, *with about 5 million cases per year at a cost of over $2 billion. S*cientists have been trying to culture the virus for almost 50 years but were stymied by the lack of an in vitro cell culture system. USDA-funded researchers at the Baylor College of Medicine in Houston, Texas, made a major breakthrough this year with the successful cultivation of human noroviruses in the laboratory. This research, which was published in the journal *Science*, will allow scientists to identify control strategies, such as effective disinfectants and food processes to prevent transmission, and develop vaccines and therapeutics. All these activities will help reduce infections, hospitalizations, chronic sequelae, and deaths and significantly reduce economic costs associated with norovirus infections.

Antimicrobial Carryover and *Salmonella*. *Salmonella* contamination of raw poultry products can occur during slaughter and processing. USDA demonstrated that poultry pulled from processing facilities for Salmonella testing could have residual sanitizer residues that affect testing results and could lead to underestimates of Salmonella levels. USDA scientists developed a modified protocol, including a collection broth that neutralized a wide range of sanitizers, resulting in more accurate reporting of *Salmonella* contamination of poultry products leaving processing facilities. FSIS subsequently validated, approved, and implemented this modified collection broth for use in regulatory sampling for *Salmonella* testing. Ultimately, this will allow FSIS and poultry processors to recognize potential problems during processing, leading to swift data-based action to protect consumers from contaminated poultry products.

Consumer Response to Food Safety Events. ERS research shows that food recalls influence consumer food purchasing decisions and have a significant economic impact on the meat industry. The biggest economic impact results from consumers who decide not to buy a product following a recall, rather than from the direct cost of removing a recalled product from the supply chain. Other research was conducted on methods to improve estimates of the financial costs and losses associated with recalls, including real-world examples.

Dr. Douglas Fulnechek, U.S. Department of Agriculture (USDA) Food Safety and Inspection Service (FSIS) Inspector-in-Charge/Supervisory Veterinary Medical Officer Public Health Veterinarian (PHV), discusses the different states of a disease process at an off-line carcass disposition correlation station at a poultry slaughtering facility in Springdale, AR.

GOAL 6:
EDUCATION AND SCIENCE LITERACY

REE Objective: *Recruit, cultivate, and develop the next generation of scientists, leaders, and a highly skilled workforce for food, agriculture, natural resources, forestry and environmental systems, and human sciences to promote global prosperity and sustainability.*

USDA Diversity Program Inspires Montana Student To Pursue Agriculture Career.

REE is strongly interested in developing the future agriculture workforce. This starts with promoting student interest in science, technology, engineering, and math (STEM) disciplines that are at the root of all agricultural sciences. A major challenge is that fewer than half of the students who enter college with the intention to complete a STEM program follow through. Attrition from STEM is especially severe among women and underrepresented minorities, who leave STEM fields at higher rates than their White male peers. However, students who engage in hands-on, "experiential learning" programs such as research courses and internships programs are more likely to persist in STEM programs. The Fiscal Year 2015 accomplishments listed here demonstrate how REE cultivates an active and skilled agriculture workforce through programs such as those that feature experiential learning.

ARS Lab Technician Robert Bruton

Robert G. Bruton grew up on the northwestern Montana Flathead Indian Reservation in a family that was challenged by the rising costs of college tuition. He is not a Native American, but he chose to attend Salish Kootenai Tribal College in Pablo, Montana, in part because of its reasonable cost. As a first-year student studying chemistry, Bruton wasn't quite sure what direction his life would take. Considering that fewer than half of undergraduate students with an interest in STEM fields graduate with a STEM degree, Bruton's likelihood for staying in chemistry was uncertain.

One day, Bruton's tutor told him about a USDA program that would pay for his tuition at a 4-year college of his choice. He applied and was accepted into the USDA 1994 Tribal Land-Grant Colleges and Universities Program. The program provides training and internships to students at tribal colleges – Native Americans as well as students from other backgrounds – that equip them to work in fields related to science and technology. Once accepted, students are selected by a host USDA agency. Bruton's host agency was ARS, which covered his tuition and fees when he transferred to Washington State University in Pullman after 2 years at the tribal college. Bruton spent his next three summers completing internships with ARS scientists in Beltsville, Maryland, where he searched for ways to control parasitic diseases in livestock and poultry.

"The program opened up a whole new set of doors in terms of my options for the future," Bruton said. He graduated from Washington State in 2014 and is now a full-time biological sciences laboratory technician at the ARS Chemistry Research Laboratory in Gainesville, Florida, where he is part of a prestigious, one-of-a-kind team searching for ways to control fruit flies and other pests that threaten some of our most important agricultural products. He is developing skills that are likely to be in demand for years to come while he works in a field that will become more important as the climate changes and the world's population continues to grow.

"It's a good field of research, and I do get tremendous satisfaction out of knowing that the work that I'm doing is part of a scientific effort to protect the world's food supply," he says.

Experiential learning programs like USDA's 1994 TLGCU program help retain students in STEM fields, empowering students to meet their goals and cultivating the future workforce of STEM professionals.

USDA Supports Students Through the Hispanic Serving Institutions Education Grant Program. The USDA National Institute for Food and Agriculture's (NIFA) Hispanic Serving Institutions (HSI) Education Grant program supports activities to strengthen institutional educational capacities of HSIs, including experiential learning opportunities such as internships. The program responds to identified educational needs, including the recruitment and retention of undergraduate and graduate students who go on to careers in food, agriculture, natural resources, and human sciences. Through collaboration with ARS, the HSI program supports approximately 125 summer internships every year. Each student intern has the opportunity to work under the supervision of an ARS mentor on a specific, groundbreaking project. In recognition of the benefits of this program, the ARS Beltsville staff who participated in this program were recognized by the Organization of Professional Employees, U.S. Department of Agriculture, with its Unsung Hero Award.

USDA Awards Internships to Underrepresented Students in California. USDA agencies recognize the importance of providing experiential learning opportunities to students who have been historically underrepresented in agriculture as a means of expanding access to quality employment opportunities and bolstering the agriculture workforce. This year, NIFA funded a collaboration project award with the California State University's (CSU) Water Resources and Policy Initiatives program to provide opportunities to students at any of the 23 campuses in the CSU system or the 113 colleges in the Californian Community College (CCC) system. The program aims to increase retention and graduation of underrepresented CSU and CCC students, and it prepares graduates for scientific and professional careers through experiential learning opportunities and mentoring in natural resource and watershed management disciplines. Fifty underrepresented graduate and undergraduate students are placed in paid, relevant, and mentored internships in USDA's Natural Resource Conservation Service (NRCS), ARS, and Forest Service (FS) with the goal of preparing them for careers in these agencies. The project will also support scholarships for 4 underrepresented doctoral students, and it will provide mentorship for up to 10 underrepresented high school students.

The 2016 CONNECT2STEM Innovation Award for Business. Central Arizona College (CAC), with grant funding support from NIFA, developed Project Puente to increase America's agricultural workforce by giving more Hispanic and other college and high school students hands-on exposure to STEM research. This summer, 38 Project Puente students worked side-by-side with research scientists from government, academia, and private industry in an 8-week summer internship program. Students learned first-hand how teams of scientists solve real-world ecological and agricultural problems (i.e. biochemical monitoring of irrigation water; integrated pest management; biofuels development; cultivation of native plants for rubber production; and monitoring a monarch butterfly way station at the Rio Salado). Through this program, students gained a broad perspective of agriculture career opportunities, impacts, and challenges.

GOAL 7:
RURAL PROSPERITY/RURAL-URBAN INTERDEPENDENCE

REE Objective: *To provide effective research, education, and extension that informs public and private decisionmaking in support of rural and community development.*

Confronting Child Poverty in Rural Communities Through Renewal and Growth. Alleviating child poverty in rural America is critically important. The REE mission area promotes renewal and growth through assistance to families and communities so they can regain a self-sustaining way of life. Although most major indicators of economic well-being showed improvement in 2015-16, rural renewal is an irregular, uneven process, which is a reflection of unevenly distributed gains from income and employment growth. In a recent ERS report, researchers investigated the forces behind the rise in rural child poverty since the beginning of the century. They found that rural child poverty increased from 20 percent to nearly 27 percent during 2003-2013 before beginning to decline in 2014. Most of the increase was attributable to rising income inequality in rural areas, rather than falling average family incomes. While demographic change provides part of the explanation for more inequality, the majority of the rise reflected an increase in earnings inequality across all demographic groups.

REE programs are contributing to a set of solutions to these challenges, including enhancing rural entrepreneurship; supporting local and regional food systems; and providing educational programs for communities, children, and families that promote opportunity and reduce poverty in rural America.

Rural entrepreneurship is encouraged through USDA programs. The Small Business Innovation Research Program (SBIR) provides competitive-based awards to small business firms seeking to commercialize technologies. A collaboration between the NIFA SBIR program and ARS promotes SBIR-Technology Transfer, a program soliciting proposals for new science-based technologies that address a variety of topic areas, including Rural and Community Development and Small and Mid-Size Farms. In FY 2016, eight projects selected for NIFA SBIR awards went to small businesses that had established cooperative research and development agreements (CRADAs) with an ARS laboratory. ARS and NIFA worked together to promote and advertise the program, including co-hosting an educational Webinar with the Small Business Administration in March 2016 that was attended by more than 90 participants.

In 2015, as part of its continued support of local and regional food systems, USDA conducted its first Local Food Marketing Practices Survey, which will provide benchmark data on the local food sector in the United States. Results will be a valuable source of data for educators and researchers and will be used to inform programs that support local and regional food systems.

USDA's Food and Nutrition Information Center hosts the Web site Nutrition.gov, which assists families with making critical choices about their food needs and provides information about food assistance programs, family meal planning, and child nutrition from infants to teens. In FY2016, the Web site was visited 2.3 million times and 40 Webpages were translated into Spanish.

Small Business Innovation Research Program Highlight. Stony Creek Colors of Tennessee is developing agronomic procedures for growing indigo plants and chemical processing procedures for extracting the natural indigo dye from these plants. They have a 20,000-square-foot processing facility where the indigo dye is produced and are looking to have 30 farmers growing 180 acres of indigo. They are working with Levi Straus to produce of a line of jeans using the natural dye, and with Sensient Technologies to explore the possibility of using their indigo dye for various food applications. They presented at the Ag Innovation Showcase in 2015 and received the Martha Stewart American Made award.

Photo courtesy of Stony Creek Colors partner Cone Denim

EXCEL: An After-School Program Helping At-Risk Youth. Three quarters of Tennessee's eighth graders are below their grade level in reading, math, and science. Through the NIFA Children, Youth, and Families at-Risk (CYFAR) Program, the University of Tennessee Extension is implementing EXCEL: An after-school program focusing on the needs of at-risk middle school youth and promoting successful leadership and life skills. Compared to non-participating students, students in the program show an average increase of one letter grade in math, science, and reading. Student grade increases are also due to the relationship between the after-school program and the regular day school teachers.

Strengthening Local Food Systems. USDA NIFA's Southern Region Development Center (http://srdc.msstate.edu) focuses on the needs of the rural South. In FY 2016, these efforts aligned new initiatives with existing work on local food systems, strengthening community participation, leadership transition, youth engagement, and advancing the research and Extension working groups emerging from the Turning the Tide on Poverty and Horizons initiatives.

Certified Organic. The 2015 Certified Organic Survey results showed that 12,818 certified organic farms in the United States sold a total of $6.2 billion in organic products in 2015, up 13 percent from $5.5 billion in 2014. The top 10 States in sales accounted for 78 percent of total U.S. certified organic sales in 2014 and in 2015. The industry is also showing potential for production growth by transitioning another 151,000 U.S. acres to organic production.

Farmland Access. The Farmland Access Legal Project is an online legal resource helping farm-seekers, farmers, landowners, and farmer/landowner-advocates understand and navigate various legal issues related to accessing and transferring farmland in New England. The Agricultural Law Information Partnership at USDA's NAL partnered with the Center for Agriculture and Food Systems at Vermont Law School to create the guide. The Farmland Tenure Online Resources Guide is now available and is the first in a series of resources in this Toolkit to assist with information about affordable and equitable land access arrangements.

FARMLAND ACCESS
TOOLKIT

REE Mission Area and FS Research and Development Performance as Measured By Goal Area

REE Goal Measure	Goal 1A	Goal 1B	Goal 1C	Goal 2A	Goal 2B	Goal 3A	Goal 3B	Goal 4	Goal 5	Goal 6	Goal 7
Peer-reviewed Journal articles, publications, and monographs	4,533	5,792	2,673	2,501	940	1,479	3236	2,445	1,226	286	1,262
Non-peer-reviewed publications	1,930	1,540	667	987	274	649	1528	1,302	507	251	1,191
Material transfer agreements	36	131	230	1	17	4	9	4	36		
Number of new Inventions	170	211	174	155	159	153	153	155	165	152	152
Number of patents issued	37	53	40	37	36	37	36	32	38	32	32
New incoming agreements	82	201	123	42	12	50	29	28	29		
New or updated digital data products, online tools and applications	223	294	548	217	108	179	263	138	121	123	136
Information, analysis and research findings provided in form of briefings or reports to decisionmakers and policymakers	39	57	33	44	13	18	32	67	31	1	56
Federal Register Notices or other Government use of research data	4	1		1		1		1	3		12

REE Mission Area and FS Research and Development Performance as Measured By Goal Area *continued*

REE Goal Measure	Goal 1A	Goal 1B	Goal 1C	Goal 2A	Goal 2B	Goal 3A	Goal 3B	Goal 4	Goal 5	Goal 6	Goal 7
Direct contact by extension (# of contacts)	9,780,371	4,599,696	569,450	2,365,940	233,447	1,664,947	3,117,633	11,029,761	915,824	481,262	27,616,076
Number of extramural/ outgoing grants/ agreements awarded	2,109	2,180	2,131	2,058	2,019	2,052	2,044	2,050	2,037	2,014	2,014
Extension professional FTEs from Formula grants	15,47.2	780.1	213.4	449.9	50.6	371.2	512.1	1,746.3	204.3	63.1	3301.5
Scientist years for Formula grant projects	1,114.4	1,297.5	501	486.6	156.9	208.1	702	578.2	202	105	256.8
New plant varieties and germplasm lines	86	25	185	1	N/A	1	16	6	N/A	N/A	N/A
Additional funds leveraged from all grants to other organizations, including Formula grant projects	$516,483,200	$575,253,200	$272,572,200	$185,579,200	$88,572,200	$94,105,200	$311,258,200	$209,128,200	$66,327,200	$51,114,000	$69,400,000

Agency Totals						
REE Goal Measure	ARS	ERS	NASS	NIFA	FS R&D	TOTALS
Peer-reviewed Journal articles, publications, and monographs	3,610	152	5	22,443	540	26,750
Non-peer-reviewed publications	754	118	8	10,045	72	10,997
Material transfer agreements	468	N/A	NA	N/A	N/A	468
Number of new Inventions	127	N/A	NA	152	N/A	279
Number of patents issued	58	N/A	NA	32	N/A	90
New incoming agreements	596	N/A	150	N/A	N/A	746
New or updated digital data products, online tools and applications	477	100	8	696	26	1,307
Information, analysis, research findings provided thru briefings or reports to decisionmakers, policymakers	135	511	20	N/A	N/A	666
Federal Register Notices or other Government use of research data	N/A	46	36	N/A	N/A	82
Direct contact by extension (# of contacts)	N/A	N/A	NA	67,961,434 (31,625,468 Youth)	N/A	67,961,434
Number of extramural/outgoing grants/agreements awarded	554	N/A	NA	2,014 (20,448 Total Active Projects)	N/A	2,568
Extension professional FTEs from Formula grants	N/A	N/A	NA	10,578.2	N/A	10,578.2
Scientist years for Formula grant projects	N/A	N/A	NA	6,131	N/A	6,131
New plant varieties and germplasm lines	100	N/A	NA	222	N/A	322
Funding to external organizations – research	$102,226,000*	N/A	60	$973,421,000	N/A	$1,075,647,000
Funding to minority-serving institutions	$12,477,000*	N/A	14	$108,797,775	N/A	$121,274,775
Survey of customer satisfaction done within the past 3 years	N/A	N/A	73	N/A	(N/A	73
Additional funds leveraged from all grants to other organizations, including Formula grant projects	$20,445,200	N/A	NA	$2,393,620,000	N/A	$2,414,065,200

LINKS TO SUPPLEMENTAL MATERIALS

PREFACE

USDA Annual Report on Technology Transfer FY2015: https://www.ars.usda.gov/ARSUserFiles/ott/FY15-TT_9-30.pdf

SUBGOAL 1A: CROP AND ANIMAL PRODUCTION

National Animal Nutrition Program: https://nanp-nrsp-9.org/

SUBGOAL 1B: CROP AND ANIMAL HEALTH

Wheat blast: https://www.k-state.edu/wheatblast/

https://www.ars.usda.gov/research/publications/publication/?seqNo115=327384

PEDv: https://www.ars.usda.gov/research/publications/publication/?seqNo115=312035

Cattle Tick Fever: https://www.ars.usda.gov/is/pr/2016/160112.htm

SUBGOAL 1C: CROP/ANIMAL GENETICS, GENOMICS, GENETIC RESOURCES, AND BIOTECHNOLOGY

Animal-GRIN (Genetic Resources Information Network) database: http://www.ars-grin.gov

SUBGOAL 1D: CONSUMER AND INDUSTRY OUTREACH, POLICY, MARKETS, AND TRADE

Careeers in Ag: Strategies For Military Veteran Farmers http://blogs.usda.gov/2016/04/12/ars-helps-veterans-weigh-a-career-in-agriculture/

SUBGOAL 2A: RESPONDING TO CLIMATE VARIABILITY

USDA Global Change Task Force (2012) “USDA Climate Change Science Plan”, http://www.usda.gov/oce/climate_change/science_plan2010/USDA_CCSPlan_120810.pdf

The President’s Climate Action Plan, 2013
https://www.whitehouse.gov/sites/default/files/image/president27sclimateactionplan.pdf

USDA Climate Hubs: http://www.climatehubs.oce.usda.gov/

eXtension Climate Learning Network: https://extension.org/category/climate-learning-network/

USDA Northern Plains Climate Hub Multi-State Extension Collaboration : In 2016, the NPRCH initiated three multi-state efforts with six regional extension programs to build capacity for resilience and transfer knowledge to land owners: 1) North Dakota State University (NDSU) Extension will lead an effort titled *Extension Climate Curriculum, A Primer for Weather Extremes in the Northern*

Great Plains with Montana State University (MSU) Extension. 2) The University of Nebraska Lincoln (UNL) Extension will lead an effort titled *Scenario Planning for Resilient Beef Systems* with South Dakota State University (SDSU) Extension. 3) The University of Wyoming (UW) Extension will lead an effort titled *Adapting Agriculture to Weather and Extreme Events by Connecting Agricultural Producers to Early Adopters* with SDSU, Colorado State University Water Institute, and NDSU.

USDA California Climate Hub drought information for California (http://www.climatehubs.oce.usda.gov/california/california-regional-assessments).

National Agroforestry Center research: Possu, W.B., Brandle, J.R., Domke, G.M. et al. Agroforest Syst (2016) 90: 889. doi:10.1007/s10457-016-9896-0

Assessing California Drought Impact on Agriculture from the Ground to Space: Federal Agencies Release Data Showing California Central Valley Idle Farmland Doubling During Drought (https://www.nasa.gov/feature/ames/federal-agencies-release-data-showing-california-central-valley-idle-farmland-doubling).

SUBGOAL 2B: BIOENERGY/BIOFUELS AND BIOBASED PRODUCTS

Biochar spreader: (http://www.fs.fed.us/rmrs/science-spotlights/development-forest-biochar-spreader)

Orange Peel to Nylon: Lee, C.C., Kibblewhite, R.E., Paavola, C.D., Orts, W.J., Wagschal, K. Production of Glucaric Acid from Hemicellulose Substrate by Rosettasome Enzyme Assemblies (2016) Molecular Biotechnology, 58 (7), pp. 489-496.

SUBGOAL 3A: WATER AVAILABILITY: QUALITY AND QUANTITY

Science-based Trials of Row Crops Integrated with Prairie Strips- https://www.nrem.iastate.edu/research/STRIPs/

Water and Agriculture Information Center - https://www.nal.usda.gov/waic

Long-Term Agroecosystem Research Common Meteorology Data - https://ltar.nal.usda.gov/ltar/met/index

Ag Data Commons (beta) Water Datasets - https://data.nal.usda.gov/dataset?query=water

Marshall E., M. Aillery, S. Malcolm, and R. Williams. 2015. Climate Change, Water Scarcity, and Adaptation in the U.S. Fieldcrop Sector, Economic Research Report No. (ERR-201), Economic Research Service, USDA (November), at: http://www.ers.usda.gov/publications/err-economic-research-report/err201.aspx .

Schaible, G.D. and M.P. Aillery. 2016. *Challenges for U.S. Irrigated Agriculture in the Face of Emerging Demands and Climate Change,* in Competition for Water Resources: Experiences and Management Approaches in the US and Europe, J. Ziolkowska and J. Peterson eds., Elsevier Publishing (September 30), at: http://store.elsevier.com/Competition-for-Water-Resources/isbn-9780128032374/ .

SUBGOAL 3B: LANDSCAPE-SCALE CONSERVATION, MANAGEMENT, AND RESILIENCY

NASS Honey Bee Colonies report for case/feature story

GMO/non-GMO story: http://www.ers.usda.gov/publications/pub-details/?pubid=44044

Biological weed control URL: http://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=19849

Windbreaks: http://nac.unl.edu/practices/windbreaks.htm

Estimating carbon storage in windbreak trees on U.S. agricultural lands, Possu, William Ballesteros; Brandle, James R.; Domke, Grant M.; Schoeneberger, Michele; Blankenship, Erin. http://www.treesearch.fs.fed.us/pubs/52572

Windbreak image https://www.flickr.com/photos/139938511@N02/26583241660/in/album-72157666621959212/

Rotational Grazing: https://www.youtube.com/watch?v=daCkJNT7y38

GOAL 4: NUTRITION & CHILDHOOD OBESITY

Economic Research Service (ERS), U.S. Department of Agriculture (USDA), Food Expenditures. http://www.ers.usda.gov/data-products/food-expenditures.aspx.

Diep, Cassandra S., Beltran Alicia, Chen, Tzu-An, Thompson Debbe, O'Connor Teresia, Hughes, Sheryl, Baranowski, Janice, Baranowski Tom. 2015. Predicting use of effective vegetable parenting practices with the Model of Goal Directed Behavior. Public Health Nutr 18(8):1389-1396.

Hughes, Sheryl O., Power, Thomas G., O'Conner, Teresia, M., Fisher, Jennifer Orlet, Chen, Tzu-An. 2016. Maternal feeding styles and food parenting practices as predictors of longitudinal changes in weight status in Hispanic preschoolers from low-income families. J Obes 2016:7201082.

Grimes, C.A., Szymlek-Gay, E.A., Campbell, K.J., Nicklas, T.A. 2015. Food sources of total energy and nutrients among U.S. infants and toddlers: National Health and Nutrition Examination Survey 2005-2012. Nutrients 7(8):6797-6836.

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GOAL 5: FOOD SAFETY

Ettayebi, Khalil., Sue E. Crawford, Kosuke Murakami, James R. Broughman, Umesh Karandikar, Victoria R. Tenge, Frederick H. Neill, Sarah E. Blutt, Xi-Lei Zeng, Lin Qu, Baijun Kou, Antone R. Opekun, Douglas Burrin, David Y. Graham, Sasirekha Ramani, Robert L. Atmar, Mary K. Estes. 2016. Replication of human noroviruses in stem cell–derived human enteroids. *Science* 353: 1387-1393. http://science.sciencemag.org/content/353/6306/1387

Sevart, N. J., N. Baumann, H. Thippareddi, T. A. House, J. B. Luchansky, A. C. S. Porto-Fett, D.

B. Marx, G. R. Acuff, and R. K. Phebus. 2016. Evaluating the efficacy of three U.S. Department of Agriculture-approved antimicrobial sprays for reducing Shiga toxin-producing *Escherichia coli* surrogate populations on bob veal carcasses. *Journal of Food Protection* 79:956-962.

Shridhar, P. B., L. Noll, X. Shi, B. An, N. Cernicchiaro, D. G. Renter, T. G. Nagaraja, and J. Bai. 2016. Multiplex quantitative PCR assays for the detection and quantification of the six major non-O157 *Escherichia coli* serogroups in cattle feces. *Journal of Food Protection* 79:66-74.

Ziara, RMM, S. Li, B. I. Dvorak, J. Subbiah. 2016. Water And Energy Use Of Antimicrobial Interventions In A Mid-Size Beef Packing Plant. *Applied Engineering in Agriculture* 32(6): 873-879. DOI 10.13031/aea.32.11615

Taylor, Mykel, H. Allen Klaiber, and Fred Kuchler. Changes in U.S. Consumer Response to Food Safety Recalls in the Shadow of a BSE Scare. *Food Policy* 62(July 2016):56-64. http://www.sciencedirect.com/science/article/pii/S0306919216300239

GOAL 6: EDUCATION AND SCIENCE LITERACY

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GOAL 7: RURAL PROSPERITY/RURAL-URBAN INTERDEPENDENCE

Small Business Administration
Web site: http://www.nifa.usda.gov/program/small-business-innovation-research-program

2015 Local Food Marketing Practices Survey
Web site: https://www.agcensus.usda.gov/publications/local_food

USDA's Food and Nutrition Information Center
Web site: http://www.nutrition.gov

Strengthening local food systemsWeb site: http://srdc.msstate.edu

Certified Organic Web site: https://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Organic_Production/index.php

https://www.nass.usda.gov/Newsroom/Executive_Briefings/2016/09_15_2016.pdf

Farmland Access Web site: https://www.nal.usda.gov/aglaw/farmland-tenure

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