United States Department of Agriculture

Agricultural Research Service

Annual Performance Report for FY 2015 and Performance Plan for FY 2016 - 2018

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ARS Annual Performance Report for FY 2015 and Performance Plan for FY 2016 - 2018

Introduction

Mission Statement

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

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

Vision Statement

The ARS vision is to lead America towards a better future though agricultural research and information.

Core Values

Our success depends on:

- **Inclusion** — Providing opportunities for ARS constituents to shape and improve those services provided by the Agency.
- **Collaboration** — Working cooperatively at all governmental levels domestically and internationally on policy matters affecting a broad audience.
- **Accountability** — Ensuring that the performance of all employees is measured against the achievement of the Agency's strategic goals.
- **Customer Focus** — Serving ARS' constituents by delivering programs that address their diverse needs.
- **Professionalism** — Building and maintaining a highly skilled, diverse, and compassionate workforce.
- **Results Orientation** — Measuring performance and making management decisions to direct resources to where they are used most effectively.

Strategic Plan Framework

Formed in 1953 as USDA's chief scientific research agency, ARS is one of the four component agencies of the Research, Education, and Economics (REE) mission area. The Agency's mission centers around conducting the basic and applied research needed to solve problems of national importance for American agricultural producers, Government action agencies, and the general public and, increasingly, for producers and consumers worldwide. This work covers a wide range of needs, ranging from animal and crop protection and production to human nutrition, food safety, and natural resources conservation. Today, with a staff of over 8,000 employees, ARS carries out research at over 90 laboratories throughout the Nation and in several foreign countries. These laboratories are led by Research Leaders – scientists that are critical to the research mission and operation of the agency.

Outlining the major needs and corresponding goals for the five years ending in 2017, the ARS Strategic Plan helps guide the Agency's scientific activities and the accompanying transfer of ARS research products to producers, consumers, action and regulatory agencies, the private sector, and other customers and stakeholders.

Goal Areas

Echoing ARS' National Program structure, the Plan is organized into four main Goal Areas: Nutrition, Food Safety, and Quality, Natural Resources and Sustainable Agricultural Systems, Crop Production and Protection, and Animal Production and Protection. These Goal Areas—and the goals, performance measures, and actionable strategies identified within them—align with the components of the REE Action Plan and the USDA Strategic Plan Goals as follows:

ARS Goal Area	ARS Strategic Goal	REE Action Plan Goal	USDA Strategic Goal Objective(s)
1: Nutrition, Food Safety and Quality	1.1 Human Nutrition	4	4.2
	1.2 Food Safety	5	4.3
	1.3 Quality and Utilization of Agricultural Products	2B, 7	1.3
2: Natural Resources and Sustainable Ag Systems	2.1 Water Availability and Watershed Management	3A	2.2, 2.3
	2.2 Climate Change, Soils, and Emissions Research	2A, 3B	2.1, 2.2, 2.3
	2.3 Biorefining	2B	1.1
	2.4 Agricultural & Industrial Byproducts	3B	1.3, 2.1, 4.3
	2.5 Rangeland, Pasture and Forages	3B	2.1
	2.6 Agricultural Competitiveness and Sustainability	2A, 2B, 3B	1.3, 2.1, 2.2, 2.3
3: Crop Production and Protection	3.1 Plant Genetic Resources, Genomics, Genetic Improvement, and Crop Production	1A, 1C	1.3, 3.1, 4.4
	3.2 Plant Diseases, Crop Protection and Quarantine, and Methyl Bromide Alternatives	1B, 1C	3.1, 4.4
4: Animal Production and Protection	4.1 Animal Production	1A, 1B, 1C	1.3, 3.1
	4.2 Prevention and Control of Pests and Animal Disease that Threaten Agriculture	1B, 1C	3.1, 4.4

Goals

Each Goal Area includes specific goals that are aligned groupings of ARS' 17 National Programs, derived from the Agency's specific mission, as outlined in each 5-year National Program Action Plan. In developing their individual Project Plans, each ARS scientist will, in turn, align his or her research objectives with the overarching goals identified in this portion of the ARS Strategic Plan, thereby ensuring continuity with the USDA, REE, and ARS vision for agricultural research.

Performance Measures – Explaining the Numbering System

The performance measures describe specific measurable achievements, which indicate progress toward reaching the broader objectives and goals. The first digit of the performance measure ties it to the primary USDA Strategic Goal that is being addressed, the next digit represents the ARS goal area, while the 3rd digit together with the ARS goal area, represents the specific ARS goal.

Performance Targets

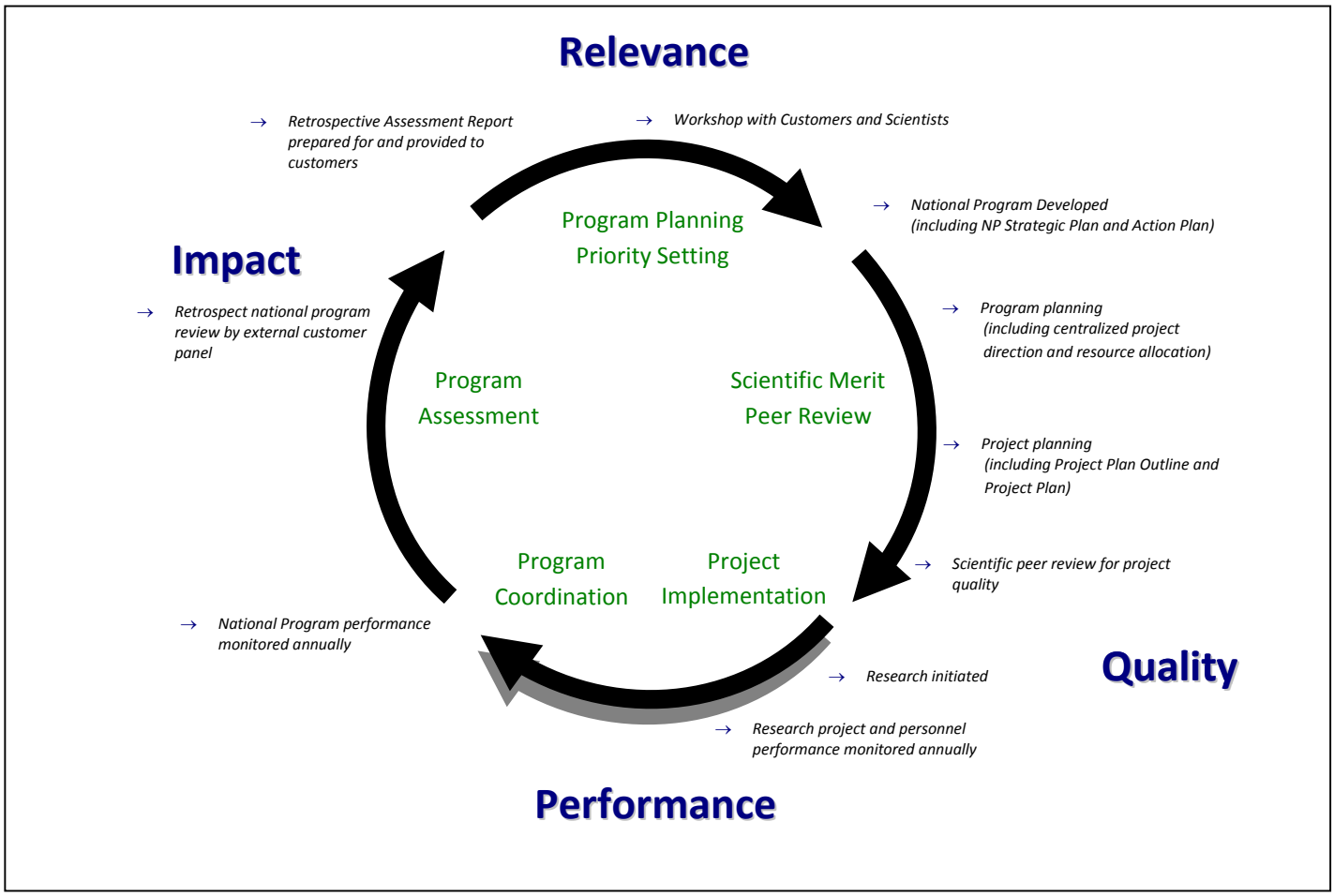
There are a number of performance targets that will be used to achieve each performance measure. These are research components broken down to more clearly align research products and accomplishments with the appropriate performance measure, with a baseline and target to be reached by 2017.

Strategies and Means

These include some of the specific research activities that ARS anticipates conducting during the next five years to address each Performance Measure.

National Research Program Management in ARS

Approximately 750 research projects from around the country are aligned into 17 National Programs that encompass all the research of the Agency. The National Programs are grouped into four program areas: Animal Production and Protection; Crop Production and Protection; Natural Resources and Sustainable Agricultural Systems; and Nutrition, Food Safety, and Quality. Each of the four program areas is managed by a Deputy Administrator and each program is led by a team of National Program Leaders (NPLs). Some 25 NPLs are responsible for planning and developing research strategies to address critical issues affecting American agriculture. Nearly 200 Research Leaders work with five geographically-based Area Directors to implement the coordinated research objectives issued by the NPLs.



Implementation of the 5-Year National Program Cycle

The overarching objectives of the National Programs are ***relevance, quality,*** and ***impact*** of ARS research, all important elements of improved accountability. Research must be ***relevant*** to the highest priority problems, the goals and outcomes of the research should significantly ***impact*** the problems, and the science must meet the highest standards of ***quality.*** To ensure that these objectives could be achieved, ARS implemented the National Program Cycle, a cycle of phases embodying a series of recurring activities.

The 5-year program management cycle illustrates the activities by which ARS conducts its research: program planning and priority setting, peer review, project implementation, program coordination, and assessment. The cycle ties these activities together in a recurring five-year sequence to ensure effective and efficient program and project management within ARS.

Ongoing monitoring of project quality and performance takes place throughout the program cycle, and adjustments are made when necessary to improve performance or meet emerging challenges. At the end of the program's 5-year cycle, a rigorous National Program Retrospective Review is convened. The purpose is two-fold: to ensure, based on feedback from an outside group of experts (made up of academics, stakeholders, and government) that the research is being conducted as indicated in the Action Plan; and to gain advice and insight from these same experts as to the future direction of the research.

Relevance, Quality (Prospective and Retrospective), and Performance—these objectives are what a research organization must promote to be successful. Program Planning and Priority Setting, Scientific Merit Peer Review, Project Implementation and Coordination, and Program Assessment —prescribe the actions that the Agency undertakes carefully, thoroughly, and with outside review to demonstrate that our research is of the highest quality.

Increasing Communication within and outside ARS

By definition, the planning and implementation of National Program research is designed to be a participatory process requiring significant input from the broad sources of expertise and experience within and outside the Agency. Through coordinated efforts that emphasize communication with valued partners and scientists, ARS can ensure that public resources are expended in a targeted and synchronized fashion on scientifically and programmatically relevant problems.

Further, by gathering input from outside users of ARS research, the Agency meets the ever-increasing demand for public accountability. ARS solicits input from the Administration, regulatory and action agencies, producers and producer groups, university communities, and non-governmental organizations, often through face-to-face exchanges. By accounting for the needs and priority issues of these customers, stakeholders, and partners, ARS develops responsive research that emphasizes meeting short-term emergencies or requirements as well as long-term sustained research to address problems of regional, national, and international scope and importance.

Emphasis on communication and coordination ultimately ensures that the physical, financial, and human resources of ARS are deployed appropriately to address high-priority agricultural, food, and environmental research needs of the Nation.

Because agricultural research is not the exclusive domain of any public or private entity, the very specific and the wide variety of needs that farmers, producers, ranchers, and industry stakeholders have must be met in a broad collaborative and cooperative effort. ARS has developed and continues to utilize an extensive network of research relationships among researchers with universities, industry, and other Federal government agencies to meet the research needs of U.S. agriculture. First among those Federal relationships is the USDA National Institute for Food and Agriculture (NIFA), USDA's extramural research agency. ARS and NIFA national program leaders work closely together to ensure that research funded by each agency is complimentary, and not duplicative. For example, ARS and NIFA national program leaders have collaborated on utilizing intramural and extramural research to develop joint action strategies for research on plant diseases and pests (i.e., citrus greening), animal diseases, and water and soil conservation.

National Programs

ARS organizes its research activities under 17 National Programs under four broad categories: Nutrition, Food Safety and Quality; Natural Resources and Sustainable Agricultural Systems; Crop Production and Protection; and Animal Production and Protection. To best address issues of agricultural importance, ARS makes regular adjustments to this program structure. The current structure appears below.

Nutrition, Food Safety, and Quality

- Human Nutrition
- Food Safety (Animal and Plant Products)
- Quality and Utilization of Agricultural Products

Natural Resources and Sustainable Agricultural Systems

- Water Availability and Watershed Management
- Climate Change, Soils, and Emissions
- Biorefining
- Agricultural and Industrial Byproducts
- Pasture, Forage, and Rangeland Systems
- Agricultural System Competitiveness and Sustainability

Crop Production and Protection

- Plant Genetic Resources, Genomics, and Genetic Improvement
- Plant Diseases
- Crop Protection and Quarantine
- Crop Production

Animal Production and Protection

- Food Animal Production
- Animal Health
- Veterinary, Medical , and Urban Entomology
- Aquaculture

General Comments: In January 1998, ARS requested a waiver from the Office of Management and Budget's (OMB) requirement "to describe specific and tangible products, steps, intermediate goals, and/or accomplishments that will demonstrate that the Agency has successfully met each Performance Measure/Goal in a given fiscal year." With OMB's concurrence, ARS is able to use narrative descriptions of intermediate outcomes and indicators of progress instead of numerical metrics as specified in GPRA. The research and technology transfer activities listed in this report are not all inclusive of the Agency's work. The reported accomplishments reflect, but do not adequately capture, the broad range of basic applied and developmental research that underpins the Agency's work.

Only Federal employees were involved in the preparation of this report.

Strategic Goal Area 1:
Nutrition, Food Safety, and Quality

The Nutrition, Food Safety, and Quality research and information area exists to lead and coordinate ARS research and information dissemination to define the role of food and its components in optimizing health for all Americans; develop tests and processes that keep the food supply safe; reduce and control pathogens and toxins in agricultural products; and improve the economic viability and competitiveness of American agriculture by enhancing the quality and utilization of agricultural products for the benefit of producers and consumers.

GOAL 1.1 – ENABLE AMERICANS TO MAKE HEALTH-PROMOTING, SCIENCE-BASED DIETARY CHOICES.

NATIONAL PROGRAM 107 - HUMAN NUTRITION

To improve the nutrition and health of the American people, ARS conducts research on the quality of the American diet and on related health behaviors. Distinctive aspects of this research include an emphasis on a food-based approach to improving health; the core capability to sustain long-term research in areas deemed of high priority for the Nation's health; the availability of state-of-the-science equipment and facilities for human research across the lifecycle; and the conduct of multidisciplinary research to improve the nutritional value of the American diet and food supply. The mission of the Human Nutrition Program is to define the role of food and its components in optimizing health throughout the life cycle for all Americans by conducting high national priority research. This research emphasizes study of essential nutrients and nonessential, health-promoting components in foods; evaluating the nutritional value of diets eaten by people in America; determining how consumption of specific foods or food components can enhance health; and developing strategies to improve food choices and lifestyle factors. Increasingly, research focuses on addressing over-consumption and caloric imbalance with incorporation of cutting-edge genomic and metabolomic technologies to carry out research. Research addresses four overarching components: nutrition monitoring, the scientific basis for dietary recommendations, obesity prevention, and life stage nutrition and metabolism. Information dissemination programs operated by the National Agricultural Library address general and specific human nutrition issues and audiences and include general Web portals such as www.nutrition.gov as well as the targeted Web sites of the Food and Nutrition Information Center.

Performance Measure

4.1.1 Monitor nutrient composition of food supply and consumption by Americans while conducting research on life stage nutrition and metabolism. Strengthen the scientific basis for dietary guidance for health promotion and disease prevention and develop strategies for prevention of obesity and related diseases.

Indicator 1: ***During 2015, ARS will survey, release data on, and analyze national food consumption patterns of Americans.***

FY 2015 Accomplishments:

1. ARS-funded researchers in Boston, MA, examined the variability of portion sizes in popular food items in three U.S. fast-food restaurants over the past 18 years and found that most items decreased

in energy content, but many increased. Sodium showed a similar pattern but absolute differences were modest. In 2013, the energy content of a large-sized "meal" (cheeseburger, French fries, and regular cola) represented 65 to 80 percent of a 2,000-calorie-per-day diet, as well as a significant portion of recommended sodium intake.

***Impact*:** These findings suggest that efforts to promote reductions in energy, sodium, saturated fat, and trans fat intakes need to be shifted from emphasizing portion size to emphasizing additional factors such as total calories, frequency of eating, number of items ordered, menu choices, and energy-containing beverages.

2. ARS-funded researchers in Houston, TX, reported that data collected by the National Health and Nutrition Examination Survey showed that rice consumption is associated with better adult nutrient intake and diet quality. Rice consumption was associated with consistently better diet quality and nutrient intake, including better intakes of dietary fiber, folate, magnesium, iron and potassium, and greater consumption of fruit, dark green/orange vegetables, grains, meat/beans, and oils.

   ***Impact*:** Rice consumption has doubled in the United States over the last 20 years and enriched, fortified white rice makes up more than 70 percent of that increase, and these results show that including rice in the diet complements a pattern of healthy eating.

3. The most recent Dietary Guidelines for Americans emphasizes the importance of dietary patterns rather than single nutrients or foods. ARS scientists at Beltsville, MD, released national estimates of daily intakes of Food Pattern components based on What We Eat in America, the National Health and Nutrition Examination Survey. Foods and beverages were disaggregated into 37 Food Pattern components in order to report on amounts consumed of those components.

   ***Impact*:** These estimates provide unique data to evaluate food and beverage intakes of Americans compared to recommendations of the 2015 Dietary Guidelines for Americans.

Indicator 2: ***During 2015, ARS will develop new methods, conduct food composition analyses, and compile databases for known, emerging, and new classes of nutrients.***

FY 2015 Accomplishments*:*

1. ARS scientists in Beltsville, MD, compiled and released the USDA National Nutrient Database for Standard Reference, Release 28.

   ***Impact*:** This database is the gold standard used by all commercial suppliers of nutrient data and many other countries. It is used by the public, researchers, clinicians, and other Federal agencies, including NIH, CDC, FDA, and USDA/FNS and CNPP, EPA, and the Department of Defense.

2. ARS scientists in Beltsville, MD, reported that baking results in differences in the levels of phytochemicals such as phenolic acids, carotenoids, and tocopherols, in whole and refined flours from two wheat varieties. Levels of phenolic acids, carotenoids, and tocopherols were significantly higher in all fractions made from whole wheat flour. Baking was observed to reduce the concentrations of carotenoids and tocopherols but did not significantly change the concentration of phenolic acids.

   ***Impact*:** These data give researchers a more comprehensive understanding of the components that play a role in potential health benefits of whole grain flour.

Indicator 3: ***During 2015, ARS will identify dietary and lifestyle intervention strategies to prevent obesity and promote healthy food choices and eating behaviors.***

FY 2015 Accomplishments*:*

1. ARS researchers in Davis, CA, found that when women with self-reported elevated chronic stress levels view pictures of high-calorie foods they have exaggerated activity in brain regions linked to reward and emotionally-based food intake, and reduced activity in regions that mediate self-control and decision making. Study participants also selected more high-fat/sweet foods from a voluntary snack food buffet.

   ***Impact*:** This neurophysiological and behavioral evidence supports a biological basis for poor food choice, dysfunctional eating habits, and obesity risk in persons experiencing chronic stress. These findings can encourage healthcare practitioners to incorporate stress-reduction techniques in the development of more effective weight-control strategies for people who experience elevated chronic stress levels.

2. ARS-supported scientists in Houston, TX surveyed mothers of pre-school children about their attitudes, habits, and emotions regarding nutrition and vegetable consumption and determined that half the variation in children's vegetable consumption could be explained by three factors: (1) actively involving the child in choosing vegetables in the store, (2) praising the child for eating vegetables, and (3) automatically including vegetables on the plate.

   ***Impact*:** This study tested a behavioral model to predict effective parenting practices that increase vegetable consumption and it should lead to designing successful interventions.

3. ARS-supported researchers in Houston, TX, reported that some children are at increased risk of weight gain during the summer. When the weight changes in over 7,500 ethnically diverse children in elementary school were tracked, they found that Hispanic children and children who were overweight or obese gained more weight during the summer than during the school year. This pattern was not found in children of other ethnicities or children with healthy body weights.

   ***Impact*:** These findings indicate that strategies are needed outside of the school year to help children maintain healthy growth.

Indicator 4: ***During 2015, ARS will determine the functions, bioavailability, interactions, and requirements for known, emerging, and new classes of nutrients across the lifecycle.***

FY 2015 Accomplishments*:*

1. ARS scientists in Davis, CA, in collaboration with other researchers have developed and applied a new marker for vitamin B-12 status. Vitamin B12 deficiency is a serious problem in many areas of the world and the newly developed more accurately identifies individuals or populations with vitamin B12 deficiencies.

   ***Impact*:** This new marker of vitamin B12 status is likely to be used widely in clinical practice, epidemiological investigations, and nutrition research to help identify and mitigate health issues associated with Vitamin B12 deficiencies.

2. ARS-funded researchers in Boston, MA, discovered that meal composition affects vitamin D absorption in older adults. Absorption of vitamin D from a supplement was over 30 percent greater when the supplement was taken with a meal containing fat (in an amount commonly consumed) than with a fat-free meal.

   ***Impact*:** This research may lead to more effective strategies for older adults to achieve and maintain healthy vitamin D levels that protect bone and cognitive health.

Indicator 5: ***During 2015, ARS will publish new findings on metabolic processes that are affected by nutrient intake.***

FY 2015 Accomplishments*:*

1. ARS-funded researchers in Boston, MA, have discovered biological pathways that are important for preventing cataracts. The human eye lens requires soluble proteins to establish and maintain a clear lens, and cataracts develop as the eye lens loses its ability to eliminate insoluble proteins that develop from stresses and aging. Researchers discovered pathways by which lens proteins are kept soluble and/or are recognized for degradation and elimination.

   ***Impact*:** The findings are essential for understanding how nutritional interventions that impact natural systems have the potential for helping preserve vision and diminishing the burden from cataract, which afflicts 17,000,000 people worldwide.

2. ARS scientists in Grand Forks, ND, have shown that consumption of honey and high fructose corn syrup cause similar blood sugar responses. Some claim that consuming honey results in a different blood glucose response than high-fructose sugars in corn syrup and other sources, however, a human clinical trial found that consuming either honey, sucrose, or high-fructose syrup every day for 2 weeks resulted in identical glycemic and insulin responses.

   ***Impact*:** These results add important knowledge regarding sugar metabolism from different sources and may be helpful in devising dietary guidance regarding sugar intake.

Indicator 6: ***During 2015, ARS will discover genetic or epigenetic factors that influence physiologic responses to diet or changes in gene expression in response to dietary intake.***

FY 2015 Accomplishments*:*

1. ARS investigators in Little Rock, AR, discovered that infants born to obese mothers had changes in methylation marks (epigenetic marks) around genes involved in neurological development.

   ***Impact*:** In light of infant brain scans that show lesser "white matter" in children born to obese mothers, the findings strongly suggest that exposure to maternal obesity in the womb may detrimentally alter brain development.

2. ARS funded researchers in Boston, MA, examined epigenetic profiles in immune cells from North American subjects with a range of sunlight exposure and reported that sunlight exposure results in epigenetic changes that affect the expression of genes involved in regulating cell proliferation and differentiation. The same changes were not seen in a Mediterranean population and understanding the functional effects will require future studies.

***Impact*:** These results support the role of sunlight exposure in epigenetic processes, and lay the groundwork for future studies of the molecular link between sunlight and physiologic processes such as cancers and altered metabolism.

Indicator 7: ***During 2015, ARS will identify processes and methods whereby agriculture production influences the nutritional value of the food supply.***

FY 2015 Accomplishments*:*

1. ARS researchers in Houston, TX, have reported ways to enhance nutrient density in legume seeds as a strategy to improve the nutritional quality of the food supply. Using a model legume, *Medicago truncatula*, they found that different genotypes resulted in different patterns of mineral accumulation within different tissues

   ***Impact*:** This information will be critical in designing breeding strategies to optimize the nutritional content of edible beans.

2. ARS scientists at Davis, CA, reported that how farmed salmon are raised affects their healthfulness as a human food. When the oil in the fish feed was switched from fish oil, high in omega-3 fatty acids, to soybean oil, high in omega-6 fatty acids, mice fed the salmon flesh had more pro-inflammatory molecules in the liver, and this was associated with increased insulin resistance and accumulation of liver fat.

   ***Impact*:** These findings underpin the need for carefully considering the type of oil used for feed in salmon farming, and indicate that the use of omega-3 rich vegetable oils such as rapeseed oil may result in a healthier salmon product.

Performance Targets

1.1.A Link Agricultural Practices and Beneficial Health Outcomes

Baseline 2012	Target 2017
Two discoveries documented and published in peer-reviewed journals that demonstrate how agronomic practices may benefit public health by improving important nutritional components of the food supply	Cumulatively, six discoveries communicated to ARS stakeholders through peer-reviewed scientific papers

1.1.B Monitor Nutrient Composition of the Food Supply and Consumption by Americans

Baseline 2012	Target 2017
Three datasets on food composition and dietary intake were released by ARS and used by customers to establish Federal dietary policy guidelines, food assistance and feeding programs, and food labeling to safeguard the health of the American people	**Cumulatively, six discoveries communicated to ARS stakeholders through peer-reviewed scientific papers**

1.1.C Strengthen the Scientific Basis for Dietary Guidance for Health Promotion and Disease Prevention

Baseline 2012	Target 2017
Four research studies on health effects of foods or nutrients published in peer-reviewed scientific journals that contribute evidence used in Dietary Reference Intake reports or the Dietary Guidelines for Americans	Cumulatively, 20 studies published and released to ARS customers

1.1.D Develop Strategies for Prevention of Obesity and Related Diseases

Baseline 2012	Target 2017
Five papers in peer-reviewed scientific journals that test innovative approaches to preventing obesity or related conditions	Cumulatively, 25 papers documenting these discoveries added to the scientific literature on this topic

1.1.E Conduct Research on Life Stage Nutrition and Metabolism

Baseline 2012	Target 2017
Five studies published in peer-reviewed journals that increase knowledge of nutrient requirements in the youngest and oldest Americans, how nutritional status relates to health, and how genes and epigenetic mechanisms contribute to this interplay	Cumulatively, 25 scientific discoveries will be documented in scientific publications

Measure 4.1.1 Summary of the Major Technologies Developed, Transferred, and Used in FY 2015:

During FY 2015, ARS reported on three new technologies adopted for uses that provide data on nutrient content of foods consumed by Americans that enable regulatory agencies to monitor accuracy, allows the food industry to formulate labels without conducting their own expensive analyses, and helps health professionals, researchers, and consumers know the nutrient content of individual foods and dietary patterns.

Describe the Technology	Describe the Transfer	Identify the Customer	Impact
USDA National Nutrient Database for Standard Reference, Release 28	Nutrient content of more than 8,600 foods freely available on the ARS website	FDA, FSIS, FNS, CNPP, EPA, food industry, academic researchers, consumers	Provides information that enables USDA feeding programs to meet nutrient requirements
USDA Database for the Flavonoid Content of Selected Foods, Release 3.2	Values for five subclasses of flavonoids in 506 food items freely available on the ARS website	CDC, FDA, NIH, food industry, academic researchers, consumers	Allows researchers to link health outcomes with consumption of different forms of flavonoids

Dietary Supplements Ingredient Database-3	Analytically-derived national estimates of ingredient levels in 4 categories of dietary supplements available on ARS website	USDA/FNS, CDC, FDA, NIH, food industry, academic researchers	Gives users reliable estimates of ingredients in dietary supplements and supports assessment of total dietary intake

Measure 4.1.1: ***Monitor nutrient composition of food supply and consumption by Americans while conducting research on life stage nutrition and metabolism. Strengthen the scientific basis for dietary guidance for health promotion and disease prevention and develop strategies for prevention of obesity and related diseases.***

During FY 2016, ARS will:

Survey, release data on, and analyze national food consumption patterns of Americans.

Develop new methods, conduct food composition analyses, and compile databases for known, emerging, and new classes of nutrients and for branded food items.

Identify dietary and lifestyle intervention strategies to prevent obesity and promote healthy food choices and eating behaviors.

Determine the functions, bioavailability, interactions, and requirements for known, emerging, and new classes of nutrients across the lifecycle.

Publish new findings on metabolic processes that are affected by nutrient intake.

Discover genetic or epigenetic factors that influence physiologic responses to diet or changes in gene expression in response to dietary intake.

Identify processes and methods whereby agriculture production influences the nutritional value of the food supply.

During FY 2017, ARS will:

Survey, release data on, and analyze national food consumption patterns of Americans.

Develop new methods, conduct food composition analyses, and compile databases for known, emerging, and new classes of nutrients and for branded food items.

Identify dietary and lifestyle intervention strategies to prevent obesity and promote healthy food choices and eating behaviors.

Determine the functions, bioavailability, interactions, and requirements for known, emerging, and new classes of nutrients across the lifecycle.

Publish new findings on metabolic processes that are affected by nutrient intake.

Discover genetic or epigenetic factors that influence physiologic responses to diet or changes in gene expression in response to dietary intake.

Identify processes and methods whereby agriculture production influences the nutritional value of the food supply.

During FY 2018, ARS will:

Survey, release data on, and analyze national food consumption patterns of Americans.

Develop new methods, conduct food composition analyses, and compile databases for known, emerging, and new classes of nutrients and for branded food items.

Identify dietary and lifestyle intervention strategies to prevent obesity and promote healthy food choices and eating behaviors.

Determine the functions, bioavailability, interactions, and requirements for known, emerging, and new classes of nutrients across the lifecycle.

Publish new findings on metabolic processes that are affected by nutrient intake.

Discover genetic or epigenetic factors that influence physiologic responses to diet or changes in gene expression in response to dietary intake.

Identify processes and methods whereby agriculture production influences the nutritional value of the food supply.

GOAL 1.2 – PROTECT FOOD FROM PATHOGENS, TOXINS, AND CHEMICAL CONTAMINATION DURING PRODUCTION, PROCESSING, AND PREPARATION.

NATIONAL PROGRAM 108 - FOOD SAFETY

The safety of the food supply continues to be a highly visible public health issue and a national priority for the Federal government. The continued priority is partly due to the diverse and complex system of production, processing, and distribution of food in the U.S. and the increasing global distribution. Outbreaks of foodborne illness are seen as a major cause of morbidity and mortality, and economic costs, both nationally and internationally. The full extent of the disease burden is still unknown, even with recent CDC estimates. Foodborne illnesses can be caused by microbial pathogens, parasites, viruses and an array of foodborne contaminants such as chemicals or toxins. The cause of every outbreak is still unknown, but persistent outbreaks of major commodity-specific foods that may directly affect public health, regulations, industry, and trade, require our immediate attention.

ARS has developed an integrated approach to food safety, that is, food production is seen as a continuous process from production, through harvesting and processing, to retail and the consumer. Pre- and post-harvest are not separated but considered an integrated production system of safe and quality food. Interventions and controls that are applied to one phase will ultimately affect the other segments of food production and processing. Food safety research has also changed during the past decade, having moved past simple, surveillance/prevalence studies to asking more complex questions. Consequently, researchers are required to think creatively to solve problems, which means considering alternate perspectives, exploiting new opportunities and technologies, and crossing conventional boundaries. Multidisciplinary collaborations, especially between Centers/Institutes, nationally and internationally are an absolute necessity.

ARS provides the intramural infrastructure and expertise to address short and long-term needs in food safety. Because of the infrastructure, ARS is uniquely poised to respond quickly to emerging and critical food safety issues. ARS also collaborates closely with Federal regulatory agencies as well as industry, professional, and international stakeholders to assist in addressing their specific food safety needs.

Performance Measure

4.1.2 Develop new technologies that assist ARS customers in detecting, identifying and controlling foodborne diseases associated with the consumption of animal products that affect human health.

Indicator 1: ***During 2015, ARS will determine how population systems in animals, plants, or the environment, or any combination of these influence the safety of food. Determine the conditions under which microorganisms exist. Determine how microorganisms may in turn influence the conditions prevailing in the environment. Ensure that these technologies can be utilized by regulatory agencies, producers and/or processors to help assure safe food products.***

FY 2015 Accomplishments*:*

1. Lettuce is one of the main crops implicated in produce-linked outbreaks of *Escherichia coli* O157:H7 infections. In the Salinas Valley of California, one of most important lettuce growing regions in the United States, lettuce is also frequently infected with the downy mildew pathogen (a fungus-like water mold). ARS scientists in Albany and Salinas, CA, determined that *E. coli* O157:H7 multiplied 1,000-fold more in downy mildew lesions than on healthy lettuce leaf tissue under warm temperature and on wet leaves. On dry lettuce leaves, the pathogen persisted in greater numbers when downy mildew disease was present. A lettuce line that is more resistant to the downy mildew pathogen supported less *E. coli* O157:H7 multiplication than those of a line that was highly susceptible to the pathogen.

***Impact*:** This and related findings indicated that breeding lettuce against downy mildew, which is one of the biggest problems that lettuce growers must manage, may also serendipitously be effective as a defensive line against *E. coli* O157:H7 colonization.

2. *Salmonella* is the most commonly identified foodborne pathogen in produce, meat, and poultry. Cattle are known reservoirs of *Salmonella,* and when the pathogen is excreted in feces, it ends up in manure flush lagoons. ARS researchers in Albany, CA, demonstrated that populations of *Salmonella* species declined rapidly with reduction times of less than 2 days in aerated wastewater prepared from lagoons equipped with circulating aerators when compared with non-aerated waters, and with greater reductions in summer than winter.

***Impact*:** The results indicated that holding wastewater for sufficient time in lagoons with aerators yields pathogen-free, nutrient-rich water, which is important because some growers use dairy lagoon water to irrigate fodder plants and crops and as water for dairy cows, and as fertilizer.

3. *Toxoplasma gondii* is a protozoan parasite that is responsible for approximately 24 percent of all estimated deaths attributed to foodborne pathogens in the United States. Human infection results from accidental ingestion of oocysts either through water or through insufficiently washed produce, or via consumption of raw or undercooked meat products that contain *T. gondii* tissue cysts. ARS scientists in Beltsville, MD, working with researchers at the CDC reviewed studies of *T. gondii* infection in meat because substantial proportions of human *T. gondii* infection are acquired through consumption of raw or undercooked meat.

***Impact*:** The results showed that prevalence of *T. gondii* is higher in conventionally reared pigs, sheep, and poultry than it is in cattle. Prevalence of *T. gondii* is greater in meat products from organic compared with conventionally reared meat animals because access to the outdoors poses substantially greater opportunities for animal exposure to infected rodents, wildlife, and oocyst-contaminated feed, water, and environmental surfaces. Risk factors related to *T. gondii* exposure for livestock include farm type, feed source, presence of cats, methods of rodent and bird control, carcasses handling, and water quality. This work serves as a useful resource and information repository for informing quantitative risk assessment studies for *T. gondii* infection in humans through meat consumption.

4. Identifying molecular markers are necessary in order to monitor atoxigenic *Aspergillus flavus* competitive exclusion strains. ARS scientists in Tuscon, AZ, with the International Institute of Tropical Agriculture (IITA), developed the biocontrol, Aflasafe NG01, for aflatoxin management in Nigeria. NG01 has four atoxigenic strains of *A. flavus* as active ingredients. To identify markers useful in long-term monitoring of the NGO1 atoxigenics, whole genome comparisons with Illumina Next Generation Sequencing was conducted. Sequences with at least 50 times coverage were mapped to the *Aspergillus oryzae* RIB40 genome to identify variation useful in distinguishing the fungi from other *A. flavus* native to West Africa.

   ***Impact*:** The studies identified several useful genomic variations which will be used in assays directed at quantifying displacement of aflatoxin producers. This work demonstrates the utility of whole genome sequencing in developing assays to monitor (plant associated) microbial populations in the field.

5. *Salmonella Enteritidis* is one of the most commonly reported causes of human salmonellosis. Its low genetic diversity, measured by fingerprinting methods, has made subtyping a challenge. Whole-genome sequencing was used to characterize *S. Enteritidis* and a variant of *S. Enteritidis, Salmonella Nitra.* The whole-genome single-nucleotide polymorphism typing approach was robust for *S. Enteritidis* subtyping with combined data for different strains from two different sequencing platforms.

   ***Impact*:** From the research, five major *S. Enteritidis* genetic lineages were recognized, which revealed possible patterns of geographic and epidemiologic distribution. Analyses on the population dynamics and evolutionary history estimated that major lineages emerged during the 17th-18th centuries and diversified during the 1920s and 1950s. Identification of evolutionary history of *Salmonella Enteritidis*, and the methods developed by ARS in this study are useful for epidemiologic surveillance and outbreak investigations involving this critically important bacterial pathogen.

Indicator 2: ***During 2015, ARS will develop an understanding of bacterial, viral, and fungal pathogenicity through a systems biology approach. Utilize this data for pathogen intervention and control, modeling, and providing data for the development of risk assessments by regulatory agencies. Ensure that these technologies can be utilized by regulatory agencies, producers and/or processor to help assure safe food products.***

FY 2015 Accomplishments*:*

1. Vertical transmission (mother to offspring) of *Salmonella* contributes to persistent, carrier-type infections in cattle. *Salmonella* is an important foodborne and animal pathogen that can reside within the gastrointestinal tract and more importantly, within the lymph tissue of food-producing animals. ARS researchers in College Station, TX, working in cooperation with researchers at Texas

Tech University, demonstrated vertical transmission of *Salmonella* from pregnant cows to their neonatal offspring.

***Impact*:** The results demonstrated that Holstein dairy calves can be born with *Salmonella* in multiple tissues (gastrointestinal, lymph nodes, organs). These findings challenge the traditional view that *Salmonella* infection occurs exclusively via the fecal-oral route of transmission. They also provide an explanation for depressed immune-recognition of *Salmonella* in persistently infected cattle. This research provides critical new information on transmission dynamics of *Salmonella* that can lead to the development of new pathogen intervention strategies to help producers continue to produce *Salmonella*-free meats.

2. Some *Listeria* species are known human pathogens that cause foodborne illness and potentially severe sequelae. There is considerable known diversity within serotypes (strains) of *Listeria monocytogenes*, and their potential to cause disease in humans is also variable. To better understand the relationship between strains found on dairy farms and those involved in human illness, ARS researchers in Beltsville, MD, examined the diversity of *L. monocytogenes* isolates collected over a 6-year study from the feces of dairy cattle on a single dairy farm. Differences were assessed using a multi-virulence locus sequence typing assay. The results were compared with those from other strains isolated globally from human clinical cases, foods, and the environment.

   ***Impact*:** The research demonstrated that multiple, distantly related *L. monocytogenes* strains persisted among members of the herd over the course of the study, whereas other strains were present for short time periods only. Some strains isolated were identified as new sub-lineages in the *L. monocytogenes* global phylogeny, whereas others were closely related to epidemic clones that had been previously isolated from human clinical cases. The importance of this work is that it demonstrated to dairy producers, processors, and regulatory agencies that dairy cows can be reservoirs of a diverse population of human pathogenic *L. monocytogenes*, which can be a potential risk to consumers of milk, dairy products, and meat.

3. The *Campylobacter concisus* group consists of several closely-related *Campylobacter* species commonly associated with humans, although some members of this group have also been identified in livestock. Historically, these species have been thought of as human-associated but of low clinical importance, occasionally causing gastroenteritis or periodontal disease; however, in the last 5 years an increasing number of reports have been published associating *C. concisus* group species, especially *C. concisus* and *Campylobacter showae,* with serious and severe human illness, including inflammatory bowel disease (Ulcerative Colitis and Crohn's Disease) and gastrointestinal cancer. Major knowledge gaps still remain within the *C. concisus* group, such as: the cause of the sudden surge of *C. concisus* group-related illness (acquisition of virulence genes from other microorganisms or simply improved detection methods); the mode of transmission of these organisms; and what genetic factors are responsible for causing severe illness. To address some of these issues, in collaboration with scientists at U.S. Meat Animal Research Center (MARC) in Clay Center, NE, and the Institute of Environmental Science and Research in New Zealand, ARS sequenced 30 *C. concisus* group genomes (12 to completion and 18 to draft), representing all species within the group and including at least 5 putative new species.

   ***Impact*:** The comparative genomics of these strains indicates that these organisms are genetically-distinct but also share a large core gene set. Identification of pathogenicity/toxin genes from multiple members of the *C. concisus* group, including a new species isolated from food animals (pigs, cattle), suggests that the virulence potential of this group may be vastly underestimated;

additionally, further characterization would lead to much-needed improvements in detection technologies to identify these pathogens in the food supply.

4. Most human illnesses caused by *Salmonella Enteritidis* are attributed to contaminated eggs produced by infected hens. The recent growth of interest in alternative production housing systems for commercial laying flocks (including various types of cage-based and cage-free options) has raised many questions about the influence of poultry housing on flock infections and egg contamination. ARS researchers at Athens, GA, examined the persistence of fecal shedding of *S. Enteritidis* by experimentally infected laying hens housed in conventional or enriched colony cages with perches, enclosed nesting areas, and greater floor space per bird were evaluated for their effects on the length of time that experimentally infected hens would continue to shed *S. Enteritidis* into their environment via feces. Laying hens housed in each cage system were orally infected with *S. Enteritidis,* and fecal samples collected from each group at weekly intervals for 3 months were tested to detect the pathogen.

   ***Impact*:** The results indicated that housing experimentally infected hens in 2 different types of cage systems (conventional and enriched colony cages) significantly affected the frequency of *S. Enteritidis* isolation from voided feces during the first month after infection, but not the eventual duration of fecal shedding. Voided feces was significantly higher among birds in conventional cages than from those in enriched cages during the first 4 weeks after inoculation, but neither group continued shedding for more than 10 weeks. These results demonstrate that differences in housing systems for egg-laying flocks can sometimes affect the susceptibility of hens to the establishment of intestinal colonization by *S. Enteritidis.*

5. Shiga-toxigenic *Escherichia coli* (STECs) belonging to serogroup O104 caused a large outbreak in Europe in 2011 associated with sprouts, affecting over 4,000 people. One of the first STEC outbreaks in the U.S. was caused by STEC O104 associated with milk. ARS researchers at Wyndmoor, PA, undertook sequence analysis of the O104 genome to determine how this dangerous pathogen emerged, since it is a combination of distantly related *E. coli*. Pathogens can emerge and virulence can be increased by acquiring genes from other bacteria that encodes for proteins that are involved in the disease process. Two O104 strains (O104:H7 isolated from cattle and the O104:H21 milk outbreak strain) that produce harmful Shiga toxins, were sequenced and the genomes compared to publicly available genome sequences of *E. coli* O104:H4 and to other strains that produce Shiga toxins.

   ***Impact*:** Studies revealed both genetic similarities and differences among the different bacterial strains; however, one major conclusion that was drawn from this work was that *E. coli* O104 strains may become more pathogenic to humans through the acquisition of genes from other bacteria that are carried on mobile genetic elements. This research enhanced our understanding of the evolution and virulence of this important group of emerging pathogens and will help in the design of improved methods for detection; in determining their associated risk in foods; in developing predictive models, and in developing appropriate interventions.

Indicator 3: ***During 2015, ARS will develop innovative methods and advanced technology systems that rapidly and accurately detect, identify, and differentiate the most critical and economically important foodborne bacterial, viral, and protozoan pathogens. Ensure that these technologies can be utilized by regulatory agencies and/or producers to help assure safe food products.***

FY 2015 Accomplishments*:*

1. Ensuring that surfaces are effectively cleaned and sanitized is critically important for the food industry. Because cross-contamination from surfaces by pathogenic bacteria can lead to foodborne illnesses, handheld imaging devices are needed as aids to detect food residues on processing surfaces. A handheld fluorescence imaging device developed by ARS scientists in Beltsville, MD, was validated for its ability to detect food residues on spinach leaf, milk, and bovine red meat, three foods that have been associated with foodborne illness outbreaks. Two common processing surfaces (high-density polyethylene and food-grade stainless steel) were evaluated. Interchangeable optical filters were selected to optimize the contrast between food residues and processing surfaces as they were detected using hyperspectral fluorescence imaging.

   ***Impact*:** This technology now patented uses fluorescence imaging and analysis helped to clearly differentiate food residues from the processing surfaces than did human visual inspection in ambient lighting. This cost-effective optical sensing device can be used over relatively large or complex surfaces of processing equipment to detect food residues and has strong potential for use in the food industry, and by regulatory and defense agencies as an aid for detecting specific (targeted) residues. Interest has been shown both nationally and internationally for this technology development.

2. Determining *Salmonella* serotypes can be an expensive and time-consuming effort; however, serotyping is a fundamental method that identifies those strains with most risk to the food supply. More than 2,600 serotypes of *Salmonella* have been identified but only 30 are considered to be recurring causes of foodborne illness. Although DNA-based serotyping has been used by research laboratories for some time, no one technique has made it to the point at which a producer could have access at an affordable cost. ARS scientists in Athens, GA developed and validated a democratized bacteriological serotyping assay for *Salmonella.*

   ***Impact*:** ARS obtained approval to release a DNA database for assigning a serotype to *S. enterica* in the USDA Open Data Catalog. To facilitate open use by industry, regulatory agencies, and food safety monitoring services, ARS provided 96 key isolates to Neogen Corporation for development of a streamlined service for serotyping (www.neogen.com/Corporate/PR2015/2015-07-27.html). This low cost and widely available technology will have a major effect on improving public health.

3. *Salmonella* contamination of foods regulated by the FDA is a critical concern to ARS. The innovation challenge presented by FDA was to encourage development of technologies for detecting *Salmonella* in minimally processed fresh produce. A bio-separation technology funded by ARS was developed by collaborators at Purdue University. This physical method for concentrates *Salmonella* to detectable levels using a combination of enzyme treatment and pre-filtration followed by automated microfiltration. The sample preparation is completed within 4 hours, leaving another 4 hours to accomplish specific pathogen detection within a work shift (8 hours).

   ***Impact*:** This technology developed by ARS-funded scientists at the Center for Food Safety Engineering at Purdue University will speed up and enhance the recovery and detection of *Salmonella* by FDA laboratories from foods regulated by this agency. The technology was also the recipient of the FDA 2015 Food Safety Challenge.

4. Shiga-toxigenic *Escherichia coli* (STECs), in particular subtype 2 strains, are a major cause of foodborne illness and responsible for many deaths worldwide. To reduce the sources and incidence of foodborne illness caused by STEC, a need existed to develop field-deployable sensitive devices to detect active Stx2. ARS scientists in Albany, CA, collaborated with FDA scientists to develop a low-cost, simple, portable, optical sensor detection system to measure Stx2. The sensor measures a

fluorescent signal produced in the presence of toxin. The system was evaluated side-by-side with a commercial laboratory instrument and it performed better.

***Impact*:** The technology developed could detect active toxin as low as 0.1 pg/ml and will fulfill the need for portable onsite tests for Shiga toxins. More critical is that the sensor system can be purchased with off-the-shelf components for $300 compared with a current fluorometer costing $35,000. The camera sensor system can be easily adapted to detect other foodborne toxins that may have long-term diagnostic role for developing countries.

5. Aflatoxin B_1 produced by the fungus *Aspergillus* is a highly carcinogenic mycotoxin that affects humans, and it is also commonly found in feed used for dairy cattle/milk production. Instead of being excreted, B_1 can, unfortunately, be metabolized by dairy cattle into another carcinogen, aflatoxin M_1 (AFM1), which is excreted in their milk. Detecting aflatoxins in milk is a critical issue for the dairy and related food industries and for the FDA, which regulates milk production. To test milk samples, ARS scientists in Peoria, IL, developed a novel technique that combines mass spectrometry with an ambient ionization method.

   ***Impact*:** The technology developed, known as direct analysis in real time-mass spectrometry (DART-MS), allows rapid and sensitive testing of milk samples without extensive sample preparation or time-consuming chromatographic separation. This is a new rapid, sensitive, and convenient analytical tool for industry and the FDA to assure the safety of milk-based food products.

Indicator 4: ***During 2015, ARS will develop intervention and control strategies that will help to significantly decrease or eliminate pathogens in food animals and their derived products (eggs/milk), seafood, and plant crops (produce/grains/tree nuts) during critical periods of production and processing. Develop and subsequently combine new/innovative processing technologies using the intelligent hurdle concept. Ensure that these technologies can be utilized by producers and/or processors to help assure safe food products.***

FY 2015 Accomplishments*:*

1. The poultry and animal industries continue to combat the spread of foodborne pathogens in food products and have spent millions of dollars attempting to control *Salmonella* and *Campylobacter* with minimal results. Poultry companies have ruled out many intervention strategies because of costs. New interventions must be cost-effective and easily integrated into normal production practices. ARS researchers in College Station, TX, demonstrated that a normal Marek's disease vaccine can increase the *Salmonella* load in birds if given incorrectly.

   ***Impact*:** Early vaccination of the chick while still in the embryo instead of at the day of hatch, can reduce by 10-fold the number of *Salmonella* in the growing chick. This significant reduction in *Salmonella* contamination will impact poultry producers, by providing a safer product for consumers. The results will also impact how vaccine manufacturers and producers interact to provide a safer product.

2. Although numerous interventions targeting *Escherichia coli* O157:H7 have been developed and implemented to decontaminate meat and meat products during the harvesting process, the beef industry still seeks novel compounds that effectively reduce or eliminate non-O157 Shiga toxin-producing *E. coli* (non-O157 STEC) and *Salmonella*. ARS scientists in Clay Center, NE, worked with antimicrobial compound suppliers and beef industry partners to evaluate four compounds:

hypobromous acid, neutralized acidified sodium chlorite, Citrilow, and FreshFx, all of which are approved by the FDA.

***Impact*:** The results indicated that these commercially available compounds effectively reduced up to 99 percent of *E. coli* O157:H7 and *Salmonella*, and were effective against the non-O157 STEC. These compounds can be used alone or integrated into multi-hurdle systems by industry to enhance the safety and wholesomeness of fresh beef.

3. Reducing pathogens on produce is a critical issue because produce accounts for nearly 50 percent of foodborne illness outbreaks. Chlorine dioxide (ClO_2) gas can be used as a chemical intervention to significantly reduce pathogenic and rot organisms on produce. However, its regulatory approval by Federal agencies has been precluded by the absence of conclusive residue data. ARS researchers in Fargo, ND, used labeled ClO_2 gas to provide definitive studies of ClO_2 residue fate and distribution on tomatoes and melons.

   ***Impact*:** The studies showed that the major residue remaining on plant tissues is chloride, a nutrient present in all foods. Researchers also provided data demonstrating how the formation of unwanted residues (perchlorate, for example) may be prevented. The data have been submitted to the EPA for review. If approved, ClO_2 sanitation of vegetables, melons, and other fresh produce could be implemented and play a significant role in ensuring that fresh produce is free of pathogens.

4. The contamination of ready-to-eat meat products by foodborne pathogens is a concern for the meat industry. One of the potential solutions to prevent these pathogens is to wrap meats in films composed of natural biopolymers combined with nanotechnology. ARS researchers in Wyndmoor, PA, developed edible antimicrobial composite films from microemulsions containing all-natural compounds using high-pressure homogenization (HPH) technology.

   ***Impact*:** The HPH treatment significantly reduced polymer particle sizes in the emulsion to about 1 mm. The films from the coating solution were softer, less rigid, and more stretchable than those without HPH treatments. When the composite films were used in studies that mimicked industry food processing conditions, *Listeria* on the surface of ready-to-eat meat samples was inactivated by 99.99 percent after 35 days at 10°C. These new edible antimicrobial films and coatings could be used by industry as an intervention to enhance the safety of ready-to-eat foods.

5. Monitoring the effectiveness of a sanitizer during food processing is a critical component of a Hazard Analysis Critical Control Point plan. ARS scientists in Beltsville, MD, developed, fabricated, and validated a novel microfluidic mixer to accurately determine time-dose responses of pathogen inactivation with chlorine solutions from 0.1 second to 5 minutes.

   ***Impact*:** The technology provided a valuable tool for industry and public health agencies to determine pathogen inactivation kinetics in the sub-second time scale, filling a void in laboratory equipment that had been needed to study pathogen inactivation kinetics in fractions of a second. The technology was transferred to the CDC and is currently in use by that agency.

Indicator 5: ***During 2015, ARS will develop bioinformatic databases and tools, and predictive user-friendly models to understand pathogen behavior and acquisition of virulence characteristics under various stress conditions. Determine the key risk factors of human pathogens in foods, and evaluate systems interventions for their impact, which will enable regulatory/action agencies to make critical food safety decisions that impact public health.***

FY 2015 Accomplishments*:*

1. The bacterium *Clostridium perfringens* is a major foodborne pathogen of concern because it produces an enterotoxin with superantigenic activity that causes extreme foodborne illness and subsequent sequelae. A particular issue that concerns FSIS is that *C. perfringens* has an extremely fast growth rate, with a generation time of less than 10 minutes. After meat products have been cooked to achieve desired lethality for vegetative foodborne pathogens, without adequate and rapid cooling of the product, any heat-resistant spores of *C. perfringens* can germinate and grow in a nutrient-rich environment without bacterial competition. ARS researchers in Wyndmoor, PA, compared and evaluated several well-known models regularly used by regulatory agencies and industry.

   ***Impact*:** This work found that three models could be considered useful and reliable tools for food processors and regulatory agencies for evaluating the safety of cooked/heat-treated, uncured meat and poultry products involved in cooling deviations or developing customized cooling schedules industry. This was critical since FSIS regulations require food establishments to use models that predict *C. perfringens* growth to document process compliance.

2. In 2010, the FDA proposed guidance for the food industry stipulating that spores of *Bacillus* species needed to be killed by heat processing for the production of acidified vegetable products. Implementing the guidance would have been a significant burden to industry because the times and temperatures needed to thermally process these products would negatively affect product texture and quality. ARS scientists in Raleigh, NC, undertook research to show how the different acids present in tomato vs. acidified vegetables (such as cucumber pickles, and peppers) affect the spoilage process.

   ***Impact*:** The studies showed that acids added to preserve acidified vegetables (primarily vinegar) are sufficient to prevent *Bacillus* spoilage. Malic acid naturally present in tomato products was not necessarily sufficient to prevent spoilage. These data and various models developed were made available to the FDA and industry representatives for the development and implementation of science-based regulations and production practices.

3. Modeling of microbial water quality is dependent on estimates of microorganism survival after deposition on land in manure or animal wastes. ARS scientists from Beltsville, MD, completed the development of a sub-model to simulate fate and transport of microorganisms from land-applied manures and animal wastes. The sub-model was developed to be used with the existing watershed scale and farm-scale water quality models and includes state-of-the-art information about bacterial survival kinetics. It comes with the databases on survival of indicator microorganisms in surface waters, soils, land deposited manure, animal wastes, and bottom sediments. Different types of waters, soils, animal sources, application methods, and experimental conditions were represented.

   ***Impact*:** The database was pre-analyzed using predictive microbiology to provide default parameters for site-specific simulations. These results will lead to substantial improvements in accuracy of microbial water quality models used for assessment and predictions for safety of recreational and irrigation water sources. These models have a direct input into the FDA-Produce Rule under the new Food Safety Modernization Act.

4. ARS researchers at Albany, CA, undertook an analysis of the complete DNA sequences of six *Campylobacter jejuni* strains associated with poultry and cases of human illness. The genome sequences of several *Campylobacter* strains have been recorded in genetic databases; however,

there is a shortage of complete DNA sequence information on *C. jejuni* strains isolated directly from human disease outbreaks or contaminated poultry. Six *C. jejuni* strains, three isolated directly from human disease cases and three isolated from chickens, and complete genome sequences for all six strains were determined and recorded.

***Impact*:** The comparative sequence analyses of these strains revealed differences that may explain why some *C. jejuni* strains may be able to survive in greater numbers than other *C. jejuni* strains when subject to high levels of pressure applied by an intervention technology designed to reduce bacterial numbers in some food products. This research will help in the design of improved interventions to control *Campylobacter* in foods.

5. Shiga toxin-producing *Escherichia coli* (STECs) are common contaminants in ground beef and are known to have caused numerous foodborne illness outbreaks. ARS researchers at Wyndmoor, PA, determined the High Pressure Processing (HPP) D10 value, the dose needed to kill 90 percent of a microorganism, for 40 STEC isolates which carried various combinations of genes necessary to cause illness in humans. The presence or absence of virulence factors (STx1 or 2, intimin, or enterohemolysin) had no effect on the STEC D-10.

   ***Impact*:** The D10 of the STEC ranged from 0.89 to 25.7 min at a pressure of 350 MPa. A High Pressure Processing (HPP) database for inactivation of Shiga toxin-producing *E. coli* in ground beef was developed. The database will allow regulatory agencies and the food processing industry to conduct risk analysis, and model systems, thus providing safer meat to consumers. Consumers, especially those who are immuno-compromised (cancer patients, diabetics, and the HIV/AIDS population) will benefit from having more information about foods treated with alternative (GRAS) processes which kill pathogenic bacteria.

Indicator 6: ***During 2015, ARS will develop innovative methods and advanced technology systems that rapidly and accurately detect and identify veterinary drugs, chemical residues, heavy metals, persistent organic pollutants, and biological toxins derived from bacteria, fungi and plants. Evaluate contaminant toxicity, and mechanism of action. Provide data which will enable regulatory/action agencies to make critical food safety decisions that impact public health.***

FY 2015 Accomplishments*:*

1. The use of biopesticide strains that do not produce toxin**s** (atoxigenic) to prevent aflatoxin contamination (competitive exclusion intervention) has expanded in the United States to include commodities such as cotton, corn, peanut, fig, and pistachio. This expansion has resulted in the need for additional capacity to produce these biological control agents. To meet the demand, ARS researchers in Tucson, AZ, developed novel biocontrol formulations that permit high production while reducing capital input, lowering energy costs, and using less expensive materials. With the Arizona Cotton Research and Protection Council (ACRPC) and the IR-4 project, ARS submitted multiyear field efficacy, safety, stability, quality, and manufacturing performance data to Environmental Protection Agency (EPA) as part of a request for registration for a biopesticide identified by ACRPC and named *Aspergillus flavus* AF36 Prevail.

   ***Impact*:** Based on that data ARS and its collaborators generated the EPA granted an unconditional registration for the new biopesticide in June 2015. This unconditional approval will allow cost-effective increases in the use of atoxigenic strain-based biopesticides to reduce aflatoxin contamination in the United States. This technology will also find efficacy of use for production of biopesticides internationally.

2. Lead and arsenic are two heavy metals of significant concern to the food industry, in particular for baby food producers, and public health regulatory agencies. Lead-arsenate was used as a pesticide in apple orchards from the 1900s to 1960s, and residual lead and arsenic may remain in those soils. Some of the lands are now being converted to vegetable crop production, and because of food safety concerns about lead in carrots, the FDA asked ARS to investigate the nature of the lead. ARS scientists in Beltsville, MD, grew three cultivars of carrots on four lead-arsenate-contaminated soils to determine lead and arsenic uptake. Studies showed that lead was significantly higher in peeled carrots compared with the peel, whereas arsenic was highest in carrot peel than in peeled carrots.

   ***Impact*:** These findings relayed to the FDA and farmers provided valuable information on the safety of alternative use of old orchard soils. Lead contamination of food and water is a critical focus for infants and children at the moment, where contamination can lead to various developmental challenges.

3. Chemical residues in foods for human consumption are a critical food safety issues for USDA-FSIS. Unfortunately, dairy cattle contribute significantly to the total burden of drug residue violations in the United States. ARS scientists in Fargo, ND, undertook a study to determine whether drug residues were related to the route of drug administration or the presence of inflammation (to mimic infection).

   ***Impact*:** The study showed that composition of metabolites in liver and urine were correlated with residue concentrations in liver, but only in cows undergoing an inflammatory response. This work provides a rationale for why dairy cattle have a relatively high incidence of unsafe levels of residues suggests to the dairy industry that drug clearance could be altered in dairy cattle being treated for inflammatory conditions through better, more effective production management.

4. Fumonisin-producing molds such as *Fusarium* species are commonly found in corn, and consumption of contaminated corn by farm animals has been shown to be the cause of disease. Fumonisin intoxication has also been hypothesized to be an environmental risk factor for diseases in human populations where corn is a dietary staple and infection with the mold is likely. To determine whether fumonisin contributes to disease in humans, ARS scientists in Athens, GA, in collaboration with researchers at Centro de Investigaciones en Nutrición y Salud in Guatemala, Creighton University, and Duke University developed methods to measure changes in the urine and blood levels of chemicals that are indicators of changes indicative of pre-disease states.

   ***Impact*:** Human studies conducted in Guatemala where corn is a dietary staple, showed that fumonisin intake and changes in a unique class of fats (sphingoid base 1-phosphates) in the blood are correlated in a manner that mimics the effects of fumonisin in laboratory animal findings. The findings are consistent with the hypothesis that fumonisin inhibits the same enzyme in humans as it does in farm and laboratory animals that consume diets high in fumonisin. These studies are critically important for medicine because they are the basis for development of biomarker-based studies designed to identify possible human diseases where fumonisin could be a contributing factor. Furthermore, the data will provide an incentive to reduce fumonisin exposure in developing countries where corn is a dietary staple.

5. Simple, fast, and inexpensive sample preparation techniques are critical for the analysis of chemical contaminants in food and environmental samples. Analysis of polybrominated diphenyl ethers (PBDE) flame retardants and dichlorodiphenyltrichloroethane (DDT) pesticides in fish ensures product food safety and ecosystem health. ARS researchers at Wyndmoor, PA, compared a pair of analytical methods for detecting persistent organic pollutants in fish. One method for analysis used

low-pressure gas chromatography tandem mass spectrometry (LPGC-MS/MS) and the other method used commercial enzyme-linked immunosorbent assay (ELISA) kits. Incurred PBDEs and DDTs were analyzed in three types of fish with 3-10 percent lipid content: Pacific croaker, salmon, and Standard Reference Material 1947 (Lake Michigan fish tissue).

***Impact*:** The results for both methods (LPGC-MS/MS and ELISA) were in good agreement, and similar detection limits were achieved for both techniques. Matrix effects were significant for measurement of brominated flame retardants in ELISA, but not a factor in the case of organochlorinated pesticides. This study demonstrated that ELISA is an excellent alternative chemical mechanism to confirm LPGC-MS/MS findings and that this method can be adopted for fast and inexpensive analysis in any typical laboratory and possibly in the field.

Indicator 7: ***During 2015, ARS will develop approaches to understand the development, persistence, and transmission of antimicrobial resistant (AMR) genetic elements that result in antimicrobial resistant foodborne pathogens. Develop and validate assays to rapidly detect and assess AMR pathogens. Develop and evaluate alternatives to antibiotics to reduce the development of AMR in foodborne pathogens.***

FY 2015 Accomplishments*:*

1. Concerns have been raised that antimicrobial resistant (AMR) *Escherichia coli* and AMR *Salmonella* species may be present in cattle feedlots, persist through beef processing, and contaminate final products. In addition, it has been theorized that meat products, including beef products, are a source of extra-intestinal pathogenic *E. coli* (ExPEC) that cause human urinary tract infections. ARS scientists in Clay Center, NE, tracked the occurrences of AMR *E. coli*, AMR *Salmonella*, and ExPEC in cattle from feedlots through processing. AMR *E. coli* were present on 100 percent of hides at feedlots, on 100 percent of hides when cattle began processing, on 1 percent of final carcasses, and on 0 percent of final products. AMR *Salmonella* species were identified on 11 percent of hides at feedlots and on 8 percent of hides when cattle began processing but not on carcasses or final products. ExPEC were rarely detected (0.4 percent) in feedlot and pre-intervention processing, and ExPEC were never detected from post-intervention processing and final products.

   ***Impact*:** These results, conveyed to both industry and various regulatory agencies, indicated that sanitizing interventions currently employed at beef processing plants effectively eliminates AMR bacteria and ExPEC from final finished products. This is positive news for industry since it means they do not have to implement additional intervention strategies for these pathogens.

2. Very little is known about the occurrence of *Salmonella* in sheep, how often the organism is associated with disease in sheep, and whether antimicrobial resistance genes flow through this population. ARS scientists in Athens, GA, collaborated with APHIS to determine how often sheep are infected with *Salmonella*, characterize the salmonellae that were found for their type, and determine whether they were resistant to antimicrobial treatment. *Salmonella* collected from sheep nationwide were evaluated. Approximately 4,000 fecal samples were collected from 247 farms in 22 States. Seventy-two percent of the farms had at least one sample positive for *Salmonella* and 27 percent of all the samples were positive. Ewes that were nursing lambs were most likely to be infected with *Salmonella*. Antimicrobial resistance was rare among the observed isolates. The vast majority (95 percent) of the *Salmonella* that were isolated were of the type known as *S. enterica* subspecies diarizonae, a rare type outside of sheep populations.

***Impact*:** The results of this survey indicated that *Salmonella* species typically found in sheep are not likely to be associated with foodborne disease in the United States.

3. Agricultural antibiotics trigger multidrug-resistant Salmonella to transfer genes. Antibiotics are used in food animal production for the prevention and treatment of bacterial diseases, but antibiotic usage can have unintended effects. ARS researchers in Ames, IA, reported that the agriculturally-used antibiotics carbadox, enrofloxacin and danofloxacin caused specific multidrug-resistant (MDR) *Salmonella* isolates to lyse and release bacterial viruses (called bacteriophage or phage). The released phage contained a kanamycin (an antibiotic) resistance gene from the MDR *Salmonella* that infected a kanamycin-sensitive *Salmonella* strain, resulting in horizontal gene transfer of the antibiotic resistance.

   ***Impact*:** This research demonstrated that these agriculturally-used antibiotics can cause dissemination of antibiotic resistance genes from MDR *Salmonella* to naïve bacteria. Antibiotic-induced, phage-mediated gene transfer highlights an unintentional outcome of antibiotic usage that should be considered by veterinarians and producers when selecting an antibiotic for bacterial disease treatment.

4. Research on the production environment can directly contribute to a better understanding of the larger problem of emerging antibiotic resistance. ARS scientists in Athens, GA, characterized antibiotic resistance profiles of bacteria causing foodborne illness as isolated from all-natural, antibiotic-free broilers. Isolates examined were *Campylobacter, Listeria,* and *Escherichia coli* and included 15 flocks raised on pasture from 6 different farms throughout the 2014 growing season. Isolates from a variety of environmental samples (feces, soil, carcass rinses, and ceca) were collected.

   ***Impact*:** The antibiotic resistance patterns were found to be diverse among the different isolates, with resistance profiles being farm-specific under certain circumstances (e.g. *Salmonella)*. These data highlight the importance of including background antibiotic resistance profiling in future studies because higher levels of resistance, and also multi-drug resistance, can be found on farms that have never used antibiotics during production.

5. Antibiotic resistance in foodborne pathogens poses serious public health concerns and can be a confounding factor in the treatment of foodborne illnesses. Antibiotic resistance genes can reside on the bacterial chromosome or on small self-replicating plasmids antibiotic resistance can spread by movement of these antibiotic resistance-encoding plasmids between bacteria. ARS researchers at Wyndmoor, Pennsylvania, demonstrated that some large plasmids that carry resistance to several antibiotics can assist in the movement of some small plasmids between bacteria. The smaller plasmids typically carry resistance to only one or two antibiotics but cannot move on their own.

   ***Impact*:** These studies demonstrated a mechanism for the movement of small plasmids between bacteria and for the spread of antibiotic resistance. Understanding the mechanisms and preferences by which the antibiotic resistance plasmids are transferred enhances our knowledge on the spread and transmission of antibiotic resistance genes and may help devise intervention technologies to interfere with or prevent the spread.

Performance Targets

1.2.A Develop detection methodologies for food-borne pathogens and technologies for the rapid and sensitive detection of toxins, chemicals, and biologics that can be implemented for improved food safety and food defense.

Baseline 2012	Target 2017
Develop and transfer one new technology to ARS customers to detect, identify, and control foodborne pathogens and contaminants along the food production continuum	Cumulatively, five new technologies will be developed and transferred

1.2.B Conduct and evaluate research that will lead to effective control and intervention strategies for the reduction of microbial, chemical, and other contaminants of the food supply, as well as elucidation of the molecular and physiological mechanisms that allow for persistence, survival, and transmission of foodborne pathogens in the populations and environment.

Baseline 2012	Target 2017
Identify and evaluate potential control and intervention strategies for the reduction and control of foodborne pathogens and contaminants along the food production continuum	Identify and evaluate potential control and intervention strategies for the reduction and control of foodborne pathogens and contaminants along the food production continuum

Measure 4.1.2 Summary of the Major Technologies Developed, Transferred, and Used in FY 2015:

During FY 2015, ARS reported on seven new technologies adopted for uses that provide technologies that detect, identify, and control the most critically and economically important foodborne contaminants causing illness, death, or chronic disease that impact public health and industry, as determined by FSIS, APHIS, ERS, CDC, FDA, DHS, DoD, FBI, CIA, Risk Assessment Consortium Codex Alimentarius Commission, academia, and consumer and commodity organizations.

Describe the Technology	Describe the Transfer	Identify the Customer	Impact
Bioseparation technology for pathogens from complex matrices	Developed and validated a new method for concentrating, and isolating pathogens to detectable levels in less than 4 hours	FDA, FSIS, CDC, industry, testing laboratories	Awarded winner of FDA Food Safety Challenge Prize: Immediately incorporated into FDA laboratories
Production technology for biocontrol agents	Developed and validated novel formulations that permit high throughput production of biocontrol agents while requiring reduced capital input, lower energy costs, and less expensive substrates	EPA, public sector partners IR-4, Arizona Cotton Research Protection Council	Allows industry to produce biocontrol agents of aflatoxin in field crops at reduced cost and with higher efficiency thus reducing the level of cancer forming agents in staple foods

Controlling Marek's Disease in poultry	Demonstrated that changing vaccination regime for Marek's from day 1 to day 18 increased the effectiveness of vaccine by reducing Salmonella load by 10-fold	U.S. vaccine companies, poultry industry, FSIS, APHIS	Innovative approach to control a critical disease in poultry will impact food safety and animal health and may also find efficacy for infectious bronchitis vaccine
Aflatoxin detection in milk	Developed and validated combining mass spectrometry with ambient ionization to detect Aflatoxin B1 and its derivatives in milk	FDA, Dairy processors	A new, rapid, sensitive and convenient analytical technology to assure the safety of milk-based food products
Optical sensing device for detecting surface contamination	Developed, validated, patented, and licensed a battery operated, hand held sensor that effectively detects contaminants	FDA, FSIS, EPA, DHS, Military, UK Food Standards Agency, European Food Standards Agency, Industry, State and Local Food Inspectors	Innovative technology with immediate application in food safety, defense, biosecurity
Optical sensing device for Shiga-toxin2	Developed and validated a rapid, sensitive, low cost, portable, field-deployable optical sensing system for Shiga-toxin 2	FDA, FSIS, CDC, UK Food Standards Agency, European Food Standards Agency, Industry	Innovative sensing system that can detect active toxin and can be reformatted for other biological toxins
Serotyping technology for *Salmonella*	Developed and validated a rapid, cost effective DNA-based serotyping assay for 30 of the most critical *Salmonella* pathogens	FSIS, FDA, industry, microbiology testing laboratories	Innovative technology for serotyping *Salmonella* resulting in a license and industry partner for tests kits

Measure 4.1.2: Develop new technologies that assist ARS customers in detecting, identifying and controlling foodborne diseases associated with the consumption of animal products that affect human health.

During FY 2016, ARS will:

Determine how population systems in animals, plants, or the environment, or any combination of these influence the safety of food. Determine the conditions under which microorganisms exist. Determine how microorganisms may in turn influence the conditions prevailing in the environment. Ensure that these technologies can be utilized by regulatory agencies, producers and/or processors to help assure safe food products.

Develop an understanding of bacterial, viral, and fungal pathogenicity through a systems biology approach. Utilize this data for pathogen intervention and control, modeling, and providing data for the development of risk assessments by regulatory agencies. Ensure that these technologies can be utilized by regulatory agencies, producers and/or processor to help assure safe food products.

Develop innovative methods and advanced technology systems that rapidly and accurately detect, identify, and differentiate the most critical and economically important foodborne bacterial, viral, and protozoan pathogens. Ensure that these technologies can be utilized by regulatory agencies and/or producers to help assure safe food products.

Develop intervention and control strategies that will help to significantly decrease or eliminate pathogens in food animals and their derived products (eggs/milk), seafood and plant crops (produce/grains/ tree nuts) during critical periods of production and processing. Develop and subsequently combine new/innovative processing technologies using the intelligent hurdle concept. Ensure that these technologies can be utilized by producers and/or processors to help assure safe food products.

Develop bioinformatic databases and tools, and predictive user-friendly models to understand pathogen behavior and acquisition of virulence characteristics under various stress conditions. Determine the key risk factors of human pathogens in foods, and evaluate systems interventions for their impact, which will enable regulatory/action agencies to make critical food safety decisions that impact public health.

Develop innovative methods and advanced technology systems that rapidly and accurately detect and identify veterinary drugs, chemical residues, heavy metals, persistent organic pollutants, and biological toxins derived from bacteria, fungi and plants. Evaluate contaminant toxicity, and mechanism of action. Provide data which will enable regulatory/action agencies to make critical food safety decisions that impact public health.

Develop approaches to understand the development, persistence, and transmission of antimicrobial resistant (AMR) genetic elements that result in antimicrobial resistant foodborne pathogens. Develop and validate assays to rapidly detect and assess AMR pathogens. Develop and evaluate alternatives to antibiotics to reduce the development of AMR in foodborne pathogens.

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GOAL 1.3 – ENHANCE THE ECONOMIC VIABILITY AND COMPETITIVENESS OF U.S. AGRICULTURE BY MAINTAINING THE QUALITY OF HARVESTED AGRICULTURAL COMMODITIES OR OTHERWISE ENHANCING THEIR MARKETABILITY, MEETING CONSUMER NEEDS, DEVELOPING ENVIRONMENTALLY FRIENDLY AND EFFICIENT PROCESSING CONCEPTS, AND EXPANDING DOMESTIC AND GLOBAL MARKET OPPORTUNITIES THROUGH THE DEVELOPMENT OF VALUE-ADDED FOOD AND NONFOOD TECHNOLOGIES AND PRODUCTS, EXCEPT ENERGY AND FUELS.

NATIONAL PROGRAM 306 - QUALITY AND UTILIZATION OF AGRICULTURAL PRODUCTS

This research will increase our knowledge and develop technologies to better measure or enhance the quality of crop and animal products after harvest. Similarly, the marketability and value of commodities can be increased by ensuring that value-added food products (such as fresh-cut or minimally processed produce) retain sensory quality, nutritional value, and are free from food safety hazards. The research in this National Program will also generate new information on health promoting components of foods and assess their effects on important human diseases and obesity, in cooperation with the Human Nutrition National Program (NP 107) and other partners. In addition to food quality and safety, consumers have expressed concern over rising food prices which can be attributed to multiple factors. A significant factor in the cost of food production can be attributed to food waste or rot. Estimates indicate that approximately 27 percent of food produced in the U.S. is lost as waste among retailers, food service businesses, and consumers. Additional losses occur during food harvesting, storage, and distribution. The magnitude of the loss is even greater when resources spent on growing food such as fuel, water, fertilizer, chemicals, land-use and human resources are considered. NP 306 research will develop technologies that improve quality, extend product shelf life, reduce waste, and decrease costs.

Research is being conducted on the development of nonfood, nonfuel biobased products from agricultural commodities and byproducts. Interest in biobased products has increased as consumers and governments have sought more environmentally friendly products that provide alternatives to petroleum and which do not contribute to greenhouse gases. Thus, biobased products can reduce our dependency on petroleum and provide a more sustainable technology for the future. Biobased products that were once too expensive to commercialize may now be affordable. There is some public concern that biobased products could contribute to the rising cost of food in the U.S. This program seeks opportunities to develop biobased products from agricultural feedstocks that do not compete with food, in cooperation with other ARS national programs and partners. ARS also supports quality and processing research on crop fiber, such as cotton, and animal hides, leather and wool. Stakeholders who produce fibers and hides constitute an important segment of our rural economy. These industries are severely impacted by energy and production costs and have lost market share to foreign competition. Technologies that improve fiber quality, reduce the energy consumption of processing equipment, and develop new products are needed to help the fiber industry to compete in a global market.

Performance Measure

1.1.3 Develop methods and technologies to better define, measure, preserve or enhance quality and improve utilization of food crops, animals and agricultural fibers, as well as non-food, non-fuel biobased products and sustainable technologies/processes.

Indicator 1: ***During 2015, ARS will develop technologies leading to new or improved products from bio-based (agricultural) renewable resources, residues, and wastes.***

FY 2015 Accomplishments*:*

1. To establish a bio-economy that can displace petroleum-based products, new processes and materials must be developed to convert sustainable, agricultural commodities to new, higher-value materials with useful properties. ARS scientists in Peoria, IL, developed an enzymatic method to efficiently convert soybean oil into a high-value skin care active ingredient with antioxidant and broad ultra violet absorbing properties. The new ingredient is available in several retail skin care formulations and is one of several higher-value, vegetable oil-based cosmeceutical ingredients in development.

   Impact**:** The technology has been transferred to a commercial partner who has constructed a metric ton per year biorefinery to manufacture the vegetable oil-based skin care ingredient.

2. Many food products require structured fats, such as those provided by either trans or saturated fats, for desired melting profiles, texture, stability, and sensory properties. ARS scientists in Peoria, IL, developed organogels with small quantities of inexpensive waxes to structure vegetable oils without adding trans or saturated fats. Organogels required over 75 percent less structurant to achieve firmness compared to partially hydrogenated soybean oil. Margarines with similar firmness to commercial spreads were made, representing the first successful formulation of margarines from organogels. This technology may be used to replace imported palm oil with soybean and other U.S. commodity oils, benefiting U.S. farmers and oil processing industries. Companies that make margarines and shortenings are very interested in these technologies in order to eliminate hydrogenated oils and limit imported saturated oils such as palm oil.

   Impact**:** This technology has been transferred to industry to be used to replace imported palm oil with soybean and other U.S. commodity oils, benefiting U.S. farmers and oil processing industries.

3. A novel co-formulation of non-ionic surfactants and added electrolytes reduced the depletion of quaternary ammonium compounds with cotton fabrics. The optimized formulation with a 100 percent raw cotton wipe was subjected to Good Laboratory Practice (GLP) efficacy testing at the level of EPA registration. The wipe successfully passed using the microorganisms *Staphylococcus aureus* and *Pseudomonas aeruginosa*, which are the representative microorganisms for registration of hospital-grade disinfectants. Currently, chemical characterization testing, stability testing, and further GLP efficacy testing are being conducted that includes the clinically important microorganisms methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococci (VRE).

   Impact**:** This technology has been transferred to the cotton industry.

Indicator 2: ***During 2015, ARS will develop new or improved methods to measure or predict marketable and or nutritional quality, or to sort by quality.***

FY 2015 Accomplishments*:*

1. ARS in Albany, CA, developed a low-calorie, fruit-based bar fortified with micronutrients, fiber, and other dietary components that are deficient in a typical Western diet. Twice daily consumption of the bar for 8 weeks, without any other dietary/lifestyle requirements resulted in favorable shifts in measures for cardiovascular health, insulin resistance, inflammation, and obesity in adults. A patent has been applied for and companies are pursuing licensing and commercializing the technology to improve the health of consumers worldwide.

***Impact*:** A patent has been applied for and companies are pursuing licensing and commercializing the technology to improve the health of consumers worldwide**.**

1. The selection of wheat genetic lines resistant to *Fusarium* and deoxynivalenol (DON) is hampered by the inability to select seeds free of fungi and toxins. An automated single kernel near-infrared spectroscopic method was developed by ARS in Manhattan, KS, and evaluated for identification of wheat kernels damaged by *Fusarium* fungi and for estimating DON levels. Because the method is non-destructive, seeds may be saved for generation advancement. The automated method is rapid, and the sorting of grains into several fractions depending on DON levels provides breeders with valuable information for evaluating resistant lines.

   ***Impact*:** This technology has been transferred to breeders throughout the U.S. and are using this technology to study fungal infections, to objectively score breeding lines, and to select resistant seed to speed development of lines resistant to *Fusarium* head blight as part of the U.S.

2. Chilling injury occurs when tomatoes are stored at temperatures below 10-13 °C, and aroma loss usually takes place before visual symptoms of chilling injury. ARS at Fort Pierce, FL, found that chilling such as 5 °C during 4-5 days extended shelf-life, did not induce visual defects but decreased aroma production including important aroma contributors in comparison with non-chilled tomatoes. Pre-chilling treatments with hot water dip or methyl salicylate fumigation substantially alleviated chilling-induced aroma loss. Application of heat treatments prior to low temperature storage is proposed to be an effective postharvest handling method to alleviate tomato chilling injury, hence offering the consumer tomatoes with better shelf-life and eating quality.

   ***Impact*:** This technology has been transferred to produce processing industry throughout the U.S.

Performance Targets

1.3.A Develop Methods and Technologies to Better Define, Measure, Preserve, or Enhance Quality and Improve Utilization of Food Crops and Animals

1.3.B Develop Methods and Technologies to Better Define, Measure, Preserve, or Enhance Quality and Improve Utilization of Agricultural Fibers

1.3.C Develop Non-Food, Non-Fuel Biobased Products and Sustainable Technologies/Processes

The following baselines and targets apply to all three performance targets listed above.

Non-food, non-fuel biobased products derived from renewable agricultural resources represent a small fraction of the market for petroleum-based industrial products and some are not yet economically competitive. Also, many agricultural products are marketed as low-value commodities, with postharvest spoilage decreasing return to producers. Healthy foods are often not convenient or readily accepted by significant numbers of consumers. Quality of agricultural fibers needs to be assured in an increasingly competitive global market.

Baseline 2012	Target 2017
Four new biobased or fiber products and food items with improved quality, nutritional or functional characteristics were developed by ARS and used by customers, both domestic and foreign	Cumulatively, 20 new technologies developed by ARS and adopted for uses that provide food crops and products with higher quality and extended shelf life; convenient and acceptable healthy foods; non-food, non-fuel biobased products with cost and performance features comparable or superior to petroleum-based products; high quality agricultural fibers; and valuable co-products from agricultural residues and processing wastes

Measure 1.1.3 Summary of the Major Technologies Developed, Transferred, and Used in FY 2015:

During FY 2015, ARS reported on five new technologies adopted for uses that provide for enhancing the economic viability and competitiveness of U.S. agriculture by maintaining the quality of harvested agricultural commodities or otherwise enhancing their marketability, meeting consumer needs, developing environmentally friendly and efficient processing concepts, and expanding domestic and global market opportunities through the development of value-added food and nonfood technologies and products, except energy and fuels.

Describe the Technology	Describe the Transfer	Identify the Customer	Impact
Development of an online database management software for egg graders	Software system demonstrated to AMS graders and administrators	USDA Agricultural Marketing Service	Automatic management and real-time monitoring of egg grading information
Portable and stationary candling lights for grading table eggs	Material Transfer Agreement signed with a commercial company	Agricultural Marketing Service and the National Egg Quality School	High intensity LED candling lights to replace obsolete incandescent lights
Successful efficacy testing of optimized quaternary ammonium compound solutions with cotton wipes	Technology transfer to CRADA partner	US Cotton Incorporated	Cotton wipes with quaternary ammonium-based disinfecting solutions
Automated detection of fungi and toxins in wheat kernels	Technology transferred to wheat breeders	Wheat breeders throughout the U.S	Speed development of lines resistant to Fusarium head blight as part of the U.S. Wheat and Barley Scab Initiative
A method to alleviate symptoms of internal chilling injury in tomatoes	Technology transferred to the Florida tomato industry	Tomato Fresh Pak industry	Alleviate symptoms of internal chilling injury in tomatoes

Measure 1.1.3 : Develop methods and technologies to better define, measure, preserve or enhance quality and improve utilization of food crops, animals and agricultural fibers, as well as non-food, non-fuel biobased products and sustainable technologies/processes.

During FY 2016, ARS will:

Enable commercially-viable post-harvest technologies for non-food biobased products and for value-added non-food processing.

Develop new or improved methods to measure, predict, enhance or reduce impacts to food marketability, nutritional quality, new bioactives and functional foods, and/or food processing technologies.

During FY 2017, ARS will:

Enable commercially-viable post-harvest technologies for non-food biobased products and for value-added non-food processing.

Develop new or improved methods to measure, predict, enhance or reduce impacts to food marketability, nutritional quality, new bioactives and functional foods, and/or food processing technologies.

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Enable commercially-viable post-harvest technologies for non-food biobased products and for value-added non-food processing.

Develop new or improved methods to measure, predict, enhance or reduce impacts to food marketability, nutritional quality, new bioactives and functional foods, and/or food processing technologies.

Strategic Goal Area 2: Natural Resources and Sustainable Agricultural Systems

We conduct research that *explains* the nature and function of agricultural systems and their physical, chemical, and biological components. With that explanatory power, we develop abilities to *predict* how agricultural systems may respond to different environments or management scenarios. Once we can make predictions with confidence, we turn that knowledge into *decision support* tools and methods for:

- Improving the efficiency and effectiveness of management practices for agricultural systems and working lands to enhance ecosystem goods and services, including the sustainable production of agricultural commodities;
- Managing soil, water, air, and biological resources for society's benefits, including reductions in environmental impact, under different climatic regimes and environmental conditions;
- Providing agricultural products and co-products as renewable, bio-based alternatives to petroleum as inputs to manufacturing and generating energy;
- Developing new, valuable, environmentally sound uses for agricultural and industrial byproducts.

Major priorities for ARS research on interactions among land, water, atmosphere, and diverse biological communities include remediation and use of degraded water for production of a wide range of crops; protection and enhancement of ecosystem goods and services arising from our natural resources; adaptation of agricultural production systems to climate change, and mitigation of agricultural greenhouse gas emissions; development of diverse energy crops and agronomic practices for efficient and sustainable production, optimized for different geographic regions and climatic conditions throughout the U.S.; identification of safe uses of agricultural wastes and byproducts in generating energy/fuel and value-added biochemical products and fertilizers; creation and evaluation of conservation practices and land management decision-support tools arising from ARS' long-term agricultural research conducted in the agency's unique, critical infrastructure of instrumented watersheds and rangelands; development of widely accessible databases to support analyses of agriculture, land management, and the environment; and creation of a broad-based data and information access portal at the National Agricultural Library to enable life-cycle analyses and development/validation of sustainability indices for agricultural production and delivery systems.

GOAL 2.1 – INTEGRATED, EFFECTIVE, AND SAFE WATER RESOURCE MANAGEMENT.

NATIONAL PROGRAM 211 - WATER AVAILABILITY AND WATERSHED MANAGEMENT

Fresh water is essential to maintaining both agricultural and industrial production, ecosystem integrity, and human health. As the nation was established and expanded, it flourished in part because of its abundant and readily available water and other natural resources. As the 21st century unfolds, agriculture faces new and intensifying water challenges—increasing demands for water from our cities, farms, and aquatic ecosystems; increasing reliance on irrigated agriculture for stable crop and animal production and farm income; and changing water supplies due to groundwater depletion in some areas, climate variability and change, and the need to tap alternative water sources. These challenges are not insurmountable, and agricultural lands can play an important role in meeting them. Advances in agricultural water management can provide important and unique contributions to the complex problem of water management at regional and national scales. As new and

emerging technologies widen the range of options for future water management, science can develop and provide the tools needed by managers and planners to accurately predict the outcomes of proposed water management decisions at farm to national scales. The factual basis for decision-making includes an understanding of these new technologies, their effectiveness as well as potential unintended consequences, and a strategy for getting water users and agencies to adopt the technologies determined to be most effective. Thus the Nation has the opportunity to apply and use science and technology to protect, sustain, enhance, and manage our water resources, improving human and ecological health while continuing to build a strong and growing economy.

Performance Measure

2.2.1 Develop technology and practices to promote improvement of integrated, effective and safe water resource management.

Indicator 1: ***During 2015, ARS will develop new or improved guidelines, technologies, and/or knowledge to increase the effectiveness of agricultural water management.***

FY 2015 Accomplishments*:*

1. California is currently in a state of severe drought and the supply of water available to support California's critically important agricultural industry, as well as for urban and other uses, requires the effective management of water resources derived from Sierra Nevada snowmelt. Standard methods of estimating water supply from the snow pack are not suited to these unusual conditions and cannot be updated to provide critical management information. Using the ARS-developed iSnobal model, ARS scientists in Boise, ID worked with the National Aeronautics and Space Administration/Jet Propulsion Laboratory (NASA/JPL) to implement an entirely new technology for forecasting water supply derived from melting snow. NASA/JPL and the Airborne Snow Observatory (ASO) program used remote sensing to provide periodic measurements of snow cover distribution across the Sierra Nevada Mountains while ARS scientists used the iSnobal model to generate sophisticated estimates of snow density over the same region. The combination of highly accurate measurements/estimates of snow cover and density respectively, enable highly accurate estimates of the water content of the snow pack, significantly improving management of this critical water source.

   ***Impact*:** The work directly impacts farmers, residents, public utilities, and other potential water users in California's Central Valley by providing projections of available water supply from snowmelt that can be used to plan water use and allocations.

2. Satellite imagery holds promise for remotely sensing crop water-use, but further technological development is needed to deliver tractable tools to accomplish this objective. ARS researchers in Fort Collins, CO, and Parlier, CA, worked collaboratively with NASA to develop basic algorithms that allow satellite imagery (vegetation indices) to predict crop water requirements for individual fields and crops. These algorithms were combined with ground-based weather station data to predict water use on a daily basis for irrigated crops in California.

   ***Impact*:** NASA has used these technologies to develop the Satellite Irrigation Management Support (SIMS) Decision Support System (DSS) for more than 10 million irrigated acres in California.

Indicator 2: ***During 2015, ARS will develop new or improved guidelines, technologies, and/or knowledge to reduce erosion and sedimentation from agricultural lands and/or improve water quality.***

FY 2015 Accomplishments*:*

1. While current weather patterns and rapidly accelerating changes in technology often focus attention on short-term trends in agriculture, the fundamental demands on agriculture to meet society's food, feed, fuel, and fiber production needs, while also providing the foundation for a healthy environment, require a long-term perspective. The Long-Term Agroecosystem Research (LTAR) network was established in 2012 to ensure sustained crop and livestock production and ecosystem services from agriculture, as well as to forecast and verify the effects of environmental trends, public policies, and emerging technologies. In 2014, the network was expanded from 10 to 18 locations, representing key farm resource regions, as well as hydrologic basins and eco-climatic zones, across the U.S. The expansion necessitated revising the Shared Research Strategy, initially created in FY13, to reflect changes in network composition and foundation science. The revised SRS includes information about the 8 new sites that complements similar information about the 10 original sites. It also specifies a series of common measurements and shared protocols for the collection, verification, organization, archiving, access, and distribution of LTAR data for these 18 sites, including a new data portal sponsored by the National Agricultural Library. As outlined in the SRS, each LTAR site is now engaged in a local adaptation of a "common experiment" that contrasts conventional production systems with innovative systems that strive to optimize productivity, profitability, and ecosystem services in agroecosystems and agricultural landscapes in the U.S.

   ***Impact*:** Findings that flow from the LTAR network will advance four areas of foundational science: (1) agroecosystem productivity; (2) climate variability and change; (3) conservation and environmental quality; and (4) socio-economic viability and opportunities, improving agricultural applications, predictive capabilities, linkages to other scientific networks, and enhancing educational outreach.

2. If landowners could readily identify a set of viable choices for intercepting and treating water flows with conservation practices, conservation planning could more consistently lead to better water quality. ARS scientists in Ames, IA, have developed the Agricultural Conservation Planning Framework (ACPF) toolset which uses soil, land use, and topographic data to identify multiple locations suitable for a variety of conservation practices across a watershed. The toolset can suggest where runoff and subsurface tile flows can be intercepted by different practices and produce maps showing how riparian buffer vegetation and widths can be varied to match streamside settings. Results provide an inventory of opportunities to improve water quality across a watershed, which can enable local landowners and farmers to identify preferred practices and locations, and to better participate in watershed planning. As the detailed input data necessary to drive this toolset become more broadly available, this new watershed planning technology could help agriculture more effectively address national-scale water quality concerns by leveraging local opportunities and preferences.

   ***Impact*:** The ACPF is currently being evaluated in four states, including several projects with long-term monitoring, to document eventual water quality benefits at the watershed scale.

Indicator 3: ***During 2015, ARS will develop new or improved knowledge, tools, technologies, guidelines, and/or conservation practices to better protect water resources, improve the overall effectiveness of USDA conservation programs, and/or improve watershed management and ecosystem services in agricultural landscapes.***

FY 2015 Accomplishments*:*

1. On January 31, 2015, the National Aeronautics and Space Administration (NASA) Soil Moisture Active/Passive (SMAP) mission was successfully launched and deployed into Earth orbit. Due to its particular combination of resolution, accuracy, global coverage, and repeat time characteristics, SMAP is the best satellite soil moisture sensor ever deployed. A large portion of the scientific and technical basis for the mission was based on over 30 years of microwave remote sensing research by ARS researchers in Beltsville, MD, and Tucson, AZ. Prior to the launch of the mission, these ARS scientists also led efforts to engage potential SMAP data users. The result has been an unprecedented pre-launch preparation for SMAP applications and critical feedback to improve the mission, providing direction for all upcoming NASA Earth observation missions and setting the context for the future of Earth observation. SMAP will provide global measurements of soil moisture for weather prediction, drought and flood forecasting, agricultural management, and national security.

   ***Impact*:** The potential value of these measurements for agricultural applications is underscored by a recent 5-year NASA/USDA agreement signed by the USDA's Deputy Secretary and NASA's Deputy Administrator "to improve agricultural and Earth science research, technology, agricultural management, and the application of science data, models, and technology in agricultural decision-making."

2. The Soil Water Assessment Tool (SWAT) is the world's leading simulation model for assessing the watershed-scale environmental effects of crop, forest, and rangeland management. Developed by ARS scientists in Temple, TX, SWAT is a critical component of the Conservation Effects Assessment Project (CEAP), through which Congress and the Office of Management and Budget mandated that USDA evaluate the regional and national effects of conservation practices. In collaboration with NRCS scientists, ARS scientists at Temple, TX, have improved SWAT by: 1) modernizing its data structures and modules; 2) developing a web-based interface with an output analyzer and scenario analysis tools; 3) improving floodplain, riparian zone, and gully erosion routines; and 4) improving representation of critical agricultural production regions. These enhancements maintain SWAT as the state-of-the art scientific tool relied upon by Congress, USDA, and international decision-makers to support natural resource management and conservation decisions.

   ***Impact*:** Because of these enhancements to SWAT, the NRCS/ARS national CEAP modeling team can better address Cabinet-level and Congressional requests by providing scientifically-sound information on regional and national conservation effects, including identification of conservation successes and remaining concerns. In addition, analyses with SWAT and field-scale models developed by ARS in Temple support agricultural policy formulation and implementation through the Farm Bill and other regional and national programs.

Performance Targets

2.1.A Develop Tools and Technologies to Improve the Effectiveness of Agricultural Water Management.

Baseline 2010	Target 2017
ARS released new FAO water quality guidelines for irrigation with marginal waters and treated wastewaters.	Cumulatively, 17 models, tools, databases, sets of guidelines, or design criteria developed and released to ARS customers

2.1.B Improve the Scientific Understanding of Erosion, Sedimentation, and Contaminant Transport Processes from Agricultural Fields and Landscapes to Facilitate the Development of Tools and Technologies to Better Protect the Agricultural Water Quality.

Baseline 2010	Target 2017
ARS released version 2010.1 of the Water Erosion Prediction Project (WEPP) model, to users in the US and throughout the world. Customers include land managers and conservationists charged with predicting runoff, soil loss, and sediment yield from hill slopes and small watersheds. The new version gives improved performance especially in areas experiencing substantial erosion from snowmelt on thawing soils.	Cumulatively, 16 technologies, databases, tools, models, or sensor-based monitoring systems developed and released to ARS customers

2.1.C Develop Strategies to Improve the Effectiveness of Agricultural Conservation Efforts by Developing New or Improved Conservation Practices, Improving Practice Placement to Maximize Effectiveness and Minimize Cost, and Developing a Better Understanding of the Effects of Agricultural Conservation at the Landscape Scale.

Baseline 2010	Target 2017
Three tools to enhance conservation effectiveness released by ARS and used by customers to improve conservation management	Cumulatively, 10 tools, technologies, models, databases, or improved conservation practices developed and released to ARS customers

2.1.D Conduct Research to Improve Watershed Management and Ecosystem Services in Agricultural Landscapes.

Baseline 2010	Target 2017
Two tools to enhance watershed management and ecosystem services in agricultural landscapes released by ARS and used by customers to improve flash flood forecasting and set design standards for flood and transport infrastructure, erosion estimates, storm characteristics, and other watershed processes	Cumulatively, 10 tools, models, databases, or technologies developed and released to ARS customers

Measure 2.2.1 Summary of the Major Technologies Developed, Transferred, and Used in FY 2015:

During FY 2015, ARS reported on four new technologies that enhance conservation effectiveness, watershed management and ecosystem services in agricultural landscapes.

Describe the Technology	Describe the Transfer	Identify the Customer	Impact
An improved global root-zone soil moisture data product	Operational delivery to FAS	FAS	Under evaluation by FAS for integration into their operational system for global crop condition

			and yield forecasts
Object Modeling System (OMS) Version 3.3 released as an open-source software framework for object-based environmental modeling	OMS source code, component repository, technical documentation, user manual, and training material	Scientists, consultants, government agencies	Potentially significant cost reductions for model development, deployment, maintenance, and ongoing application
Jet test soil erodibility testing technology	Jet tester was transferred to study formation of gullies	University of Minnesota	Key data for the understanding of the formation and growth of the ravines
A mobile treatment system to remove phosphorus from liquid manures and other high phosphorus-containing fluids	Contacting companies to purchase the license	Companies that manufacture and supply manure handling equipment, large farms, or a consortium of small farms	Reduces the environmental impact farms have on eutrophication of streams and other receiving water bodies while allowing the farmer to retain the benefit of the nitrogen content of animal manures

Measure 2.2.1: Develop technology and practices to promote improvement of integrated, effective and safe water resource management.

During FY 2016, ARS will:

Develop new or improved guidelines, technologies, and/or knowledge to increase the effectiveness of agricultural water management.

Develop new or improved guidelines, technologies, and/or knowledge to reduce erosion and sedimentation from agricultural lands and/or improve water quality.

Develop new or improved knowledge, tools, technologies, guidelines, and/or conservation practices to better protect water resources, improve the overall effectiveness of USDA conservation programs, and/or improve watershed management and ecosystem services in agricultural landscapes.

During FY 2017, ARS will:

Develop new or improved guidelines, technologies, and/or knowledge to increase the effectiveness of agricultural water management.

Develop new or improved guidelines, technologies, and/or knowledge to reduce erosion and sedimentation from agricultural lands and/or improve water quality.

Develop new or improved knowledge, tools, technologies, guidelines, and/or conservation practices to better protect water resources, improve the overall effectiveness of USDA conservation programs, and/or improve watershed management and ecosystem services in agricultural landscapes.

During FY 2018, ARS will:

Develop new or improved guidelines, technologies, and/or knowledge to increase the effectiveness of agricultural water management.

Develop new or improved guidelines, technologies, and/or knowledge to reduce erosion and sedimentation from agricultural lands and/or improve water quality.

Develop new or improved knowledge, tools, technologies, guidelines, and/or conservation practices to better protect water resources, improve the overall effectiveness of USDA conservation programs, and/or improve watershed management and ecosystem services in agricultural landscapes.

GOAL 2.2 – IMPROVE QUALITY OF ATMOSPHERE AND SOIL RESOURCES, UNDERSTAND EFFECTS OF CLIMATE CHANGE

NATIONAL PROGRAM 212 - CLIMATE CHANGE, SOILS AND EMISSIONS RESEARCH

Agricultural systems function within the soil-atmosphere continuum. Mass and energy exchange processes occur within this continuum and agriculture can significantly affect the processes. Emissions from agriculture to the atmosphere affect air quality and increase atmospheric greenhouse gas (GHG) concentrations. While GHG emissions are largely a result of the natural cycling of carbon (C) and nitrogen (N), these emissions also contribute to climate change.

A changing climate impacts agriculture, range and pasture systems, and soils through alterations of precipitation and temperature patterns. Increased atmospheric carbon dioxide (CO2) concentration has an enhanced fertilization effect on plants, particularly weeds. Combining these impacts of changing climate can alter habitats, thus changing the distribution of pathogens, weeds, and invasive species, resulting in increased threats to agricultural production and increasing the cost of production. The impacts of climate change clearly create challenges to agriculture and soil, water and air resources, and yet may also offer new opportunities for agricultural production and enhancement of soil quality.

Soils are a crucial boundary resource between agriculture and the atmosphere. Soils in agricultural systems must be managed to meet rising global demands for food, feed, fiber, fuel and ecosystem services while maintaining soil productivity and limiting undesirable interactions between soils and the atmosphere. Enhancement of soil productivity is a focus of ARS research and together with crop improvement research, offers promise for meeting future global agricultural demands.

The variability of the atmosphere, soils, and plants, and the complexity of interactions among these systems require collaborations by ARS scientists conducting NP212 research. Formal and informal Cross Location Research (CLR) projects including the Greenhouse gas Reduction through Agricultural Carbon Enhancement network (GRACEnet), the Resilient Economical Agricultural Practices project (REAP; formerly called the Renewable Energy Assessment Project), the Long-Term Agroecosystem Research (LTAR) Network and field campaigns focused on air quality are successful examples. Synthesis and integration of information, including sources outside NP212 research projects, increases the utility and impact of ARS research for producers, land managers and policy-makers. Efficient assimilation of data from NP212 projects into existing and future collaborative data bases enhances synthesis and integration analyses and expands research opportunities.

Performance Measure

2.2.2 Improve quality of atmosphere and soil resources; understand effects of climate change through development of knowledge and technologies.

Indicator 1: ***During 2015, ARS will assess the potential risks and benefits to agricultural systems from climate change, and develop agricultural management practices and decision support strategies that enable producers to take advantage of the beneficial effects, and adapt to the adverse effects of climate change.***

FY 2015 Accomplishments*:*

1. A secure, resilient, and sustainable food supply requires continued progress toward ending soil erosion. The most common wheat production method in low-rainfall areas of the Pacific Northwest relies upon intensive tillage that leaves the soil susceptible to wind erosion. ARS scientists at Pendleton, OR, measured the effects of surface residue and soil tillage on the amount of soil moisture available for crop growth. It was found that, with careful timing, reductions in tillage and an increase in surface residue often increase water available to the crop. The result is equal or better wheat yields with greater weather resilience and much less exposure to wind and water erosion. Additionally, an average reduction of two tillage passes on 4 million acres of low-precipitation-zone wheat can save 1.75 million gallons of diesel fuel per year.

   ***Impact*:** Farmers are using this knowledge to reduce the number of tillage passes used in the crop cycle while maintaining yields, reducing vulnerability to soil erosion, increasing climate resilience, decreasing fuel costs, and reducing GHG emissions. This has the potential to improve the producer's bottom line while enhancing production, reducing inputs, improving soil health and providing additional environmental services.

2. The impact of climate change on semi-arid rangelands, which provide forage for the majority of the world's livestock, is likely to strongly influence human well-being. Research by scientists from ARS in Fort Collins, CO, Cheyenne, WY, and the University of Wyoming, suggests that elevated carbon dioxide (CO_2) may have positive effects on the stability of forage production. A unique climate change experiment undertaken in native, semiarid rangeland at the High Plains Grasslands Research Station near Cheyenne, WY revealed that increasing the ambient CO_2 concentration from the present-day level of 400 parts per million (ppm) to 600 ppm, decreased year-to-year variation in plant production, in part by increasing the abundance of less common plant species. Even with elevated CO_2, however, productivity was much lower in dry years, suggesting that if precipitation becomes more variable in the future, as predicted, it will still lead to wide swings in forage production.

   ***Impact*:** These results will be critical in helping agricultural scientists adapt management and genetic strategies for a changing climate. The results are also being used to improve and refine models and decision support tools. Better modeling capabilities facilitate the improvement of decision support tools used by producers to evaluate management options and outcomes.

Indicator 2: ***During 2015, ARS will develop management practices and decision tools to improve soil quality, protect the environment, and contribute to the sustainability of agricultural systems*.**

FY 2015 Accomplishments*:*

1. ARS scientists successfully obtained registration for a bacterial bioherbicide for the treatment of persistent annual grass weed species. This represents the first bacterial bioherbicide to be registered by the Environmental Protection Agency (EPA). Downy brome (cheatgrass), medusahead rye, and jointed goatgrass are invasive annual grass species that cause an increase in the number and intensity of wildfires; reduce cereal yields; compete with native plant species; and reduce the quality of habitat for wildlife. Naturally occurring soil bacteria inhibit these annual grass weeds, but do not harm crops or natives. ARS scientists at Pullman, WA, have isolated bacteria that reduce these three grass weeds to near zero within 5 years and reduce the weed seed bank, when used in an integrated program. The EPA has registered one of the bacteria as an herbicide and is considering a second.

   ***Impact*:** This bioherbicide provides an additional tool to private, state and federal land managers to fight these invasive grass weeds, while limiting the need for tillage and herbicide use, thus reducing environmental concerns. Limiting the growth and spread of these annual grass weeds helps reduce risk of wildfire and maintain critical wildlife habitat. This research development has already had considerable impact, gaining a lot of press attention and the attention of federal land management agencies.

2. Soil carbon plays a critical role in soil fertility and farm productivity, and is important for water/nutrient retention, good soil structure, and maintenance of clean water through erosion prevention. Further, carbon capture from the atmosphere by plant growth helps mitigate global climate through soil carbon storage. Measurement of soil carbon remains a time-consuming and laborious practice. ARS scientists in Auburn, AL developed a new in situ rapid, non-destructive method of measuring soil carbon (mobile inelastic neutron scattering, MINS) MINS has been tested and compared to the standard dry combustion method. Soil carbon assessments by dry combustions and MINS demonstrated a linear correlation in the 0-30 cm soil layer, indicating that MINS produces reliable soil carbon measurements.

   ***Impact*:** This rapid measurement tool allows soil scientists to quickly quantify carbon storage in agricultural soils, helping land managers evaluate best management practices, improve soil health, increase resilience to weather events and mitigate climate change. The tool could also help producers assess opportunities to engage in markets for environmental services.

Indicator 3: ***During 2015, ARS will assess the greenhouse gas emissions from agricultural systems and develop methods for reducing the emissions.***

FY 2015 Accomplishments*:*

1. Nitrogen use in agricultural systems can result in emissions of nitrous oxide (N_2O), a greenhouse gas, and in nitrate (NO_3) contamination of ground and surface waters. ARS scientists in Ames, IA studied the use of perennial vegetation filter strips in the toe-slope of annual cropland watersheds and found that these can be used to decrease NO_3 losses to ground and surface waters via plant uptake, immobilization into soil organic matter, and microbial denitrification. This work showed that denitrification was the predominant NO_3 sink, accounting for approximately 70 percent of NO_3. Also, despite the fact that denitrification was stimulated; less N_2O was emitted than from upland cropland. These results suggest that the greater potentially mineralizable carbon (C) in filter strips support more complete denitrification of NO_3 to nitrogen (N_2) gas. In a separate chronosequence study investigating inter-seeded alfalfa and fluxes of N_2O and methane (CH_4), ARS scientists found that while alfalfa can increase soil N and improve productivity, trace gas emissions were not increased relative to native grasslands.

***Impact*:** This research helps land managers keep and utilize nutrients on their properties, increasing production and potentially reducing the need for costly nutrient inputs. Improving the uptake of nutrients and reducing the off-site losses reduces GHG emissions and results in improved water quality.

2. Amending soils with biochar, a byproduct of bio-oil production, could remove excess atmospheric carbon dioxide, while improving soil quality. ARS researchers at Kimberly, ID, and St. Paul, MN, measured plant-available nitrogen and greenhouse gas emissions from plots treated with biochar and/or manure. Although biochar decreased carbon dioxide emissions from soil, it also decreased corn yields under particular soil conditions. Combining biochar with manure eliminated potential yield reductions from biochar while increasing nitrogen availability from manure.

   ***Impact*:** This improved method for the utilization of biochar provides important information to producers who wish to use biochar to improve soil quality and meet other environmental services goals while maintaining or increasing their yields.

Performance Targets

2.2.A Enable Improvements of Air Quality via Management and Mitigation of Emissions from Agricultural Operations.

Baseline 2010	Target 2017
Integrated Farm Systems Model (IFSM) and Dairy Greenhouse Gas Emissions Model (DairyGEM) developed with focus on NE US agricultural systems, as a prototype for on-farm decision support technology.	Protocols implemented for standardized air quality research data collection and storage with transport parameters and emission rates for emission and transport model improvement, evaluation, and validation. IFSM and DairyGEM calibrated and tested for other regions of US.

2.2.B Develop Knowledge and Technologies for Reducing Atmospheric Greenhouse Gas Concentrations Through Management of Agricultural Emissions and Carbon Sequestration.

Baseline 2010	Target 2017
Cumulative GRACEnet project production of 208 scientific publications on GHG emissions and carbon sequestration in US croplands and rangelands.	Agriculture product/production system/-specific decision support tools and management strategies for balancing production goals, environmental stewardship objectives, GHG emission reductions, and C sequestration.

2.2.C Enable Agriculture to Adapt to Climate Change.

Baseline 2010	Target 2017
Data revealing anticipated impacts of climate change on crop production, weeds, pathogens, food and forage quality.	Prototype decision support tools that enable sustainable agriculture under conditions of changing climate

2.2.D Develop Technologies for Maintaining and Enhancing Soil Resources.

Baseline 2010	Target 2017
Data on effects of biochar amendments and crop rotations on soil biomass, carbon cycling and enzymes.	Develop guidelines and practices to lower production costs, improve soil quality and health, and reduce use of energy and petroleum-based products.

Measure 2.2.1 Summary of the Major Technologies Developed, Transferred, and Used in FY 2015:

During FY 2015, ARS reported on four new technologies adopted for uses that provide on-farm decision support, management strategies, and tools that enable sustainable agriculture.

Describe the Technology	Describe the Transfer	Identify the Customer	Impact
Decision Support System for Agrotechnology Transfer (DSSAT) version 4.5 and 4.6	Software made available to users via workshops and Internet download (www.DSSAT.net)	Students, researchers and private sector (e.g., seed companies and crop forecasting enterprises) and International	Over 1000 downloads of the tool from the US and approximately 100 countries enabling users to more accurately simulate potential effects of climate, soils, management and other factors
A new Standard Method (ASTM E2945–14) to accurately measure and test the permeability of agricultural films to fumigant gases	Publication of an ASTM Standard Method (ASTM E2945–14)	Federal and State regulators, film manufacturers, chemical companies, farm consultants, contract laboratories and researchers	Over 130 downloads of the Film Permeability Calculator (FilmPC) programs and adoption by U.S. EPA and CA Department of Pesticide Regulation.
Enhanced two programs, Management Zone Analyst (MZA) and Yield Editor, for efficiently processing precision agriculture data	Both programs are available for free web download	Scientists, crop advisors, agribusiness, producers	300 downloads of MZA and 1200 downloads of Yield Editor this year, providing users with efficient methods for analyzing precision agriculture datasets and developing improved management recommendations

A bacterial bioherbicide to control growth of annual bluegrass	Patent application filed 02/02/2015	Home owners, golf course superintendents, federal and state Departments of Transportation, land managers, BLM, and agribusiness personnel	Can be used in management of the invasive annual bluegrass in rangeland, cropland, pasture, turf, sod production, golf courses, road sides and road cuts, construction sites, and right-of-ways

Measure 2.2.2: Improve quality of atmosphere and soil resources; understand effects of climate change through development of knowledge and technologies.

During FY 2016, ARS will:

Assess the potential risks and benefits to agricultural systems from climate change, and develop agricultural management practices and decision support strategies that enable producers to take advantage of the beneficial effects, and adapt to the adverse effects of climate change.

Develop management practices and decision tools to improve soil quality, protect the environment, and contribute to the sustainability of agricultural systems.

Assess the greenhouse gas emissions from agricultural systems and develop methods for reducing the emissions.

During FY 2017, ARS will:

Assess the potential risks and benefits to agricultural systems from climate change, and develop agricultural management practices and decision support strategies that enable producers to take advantage of the beneficial effects, and adapt to the adverse effects of climate change.

Develop management practices and decision tools to improve soil quality, protect the environment, and contribute to the sustainability of agricultural systems.

Assess the greenhouse gas emissions from agricultural systems and develop methods for reducing the emissions.

During FY 2018, ARS will:

Assess the potential risks and benefits to agricultural systems from climate change, and develop agricultural management practices and decision support strategies that enable producers to take advantage of the beneficial effects, and adapt to the adverse effects of climate change.

Develop management practices and decision tools to improve soil quality, protect the environment, and contribute to the sustainability of agricultural systems.

Assess the greenhouse gas emissions from agricultural systems and develop methods for reducing the emissions.

GOAL 2.3 – ENABLE NEW BIOREFINING TECHNOLOGIES TO SUPPORT AN ECONOMICALLY ROBUST BIOREFINING INDUSTRY.

NATIONAL PROGRAM 213 - BIOREFINING

The ARS Bioenergy program develops technologies to enable sustainable commercial production of biofuels by the agricultural sector in ways that enhance our natural resources without disrupting existing food, feed, and fiber markets. Research will optimize both the production of plant feedstocks and the biorefining of agricultural materials to bioenergy and value-added coproducts. This research will strengthen rural economies, provide increased supplies of renewable transportation fuel, enhance energy security, and improve the U.S. balance of trade, while diversifying rural economies and employment through new biobased technologies and commercial coproducts.

The growth and long-term viability of bioenergy production in the Nation is impeded by a number of technical and commercial barriers. ARS leverages its unique strengths and capabilities to pursue technical barriers that can be overcome by ARS resources.

In addition to tackling specific technical barriers and leveraging ARS core competencies, ARS bioenergy research is consistent with relevant non-technical considerations associated with public policy, general resource constraints, and overall practices/trends within the bioenergy industry.

Performance Measure

1.2.3 Enable new commercially-viable technologies to (1) convert agricultural materials and byproducts into fuels and other marketable products, and (2) reduce risks and increase profitability in existing industrial biorefineries.

Indicator 1: ***During 2015, ARS will enable technologies that can reduce business risks, increase the value of co-products, and/or expand the number of revenue streams for existing biorefineries.***

FY 2015 Accomplishments*:*

1. Through genomic mining of bacterial strains, ARS scientists in Albany, CA, identified a highly active enzyme called exo-polygalacturonase from *Thermotoga* sp., a non-pathogenic compost microbe. Exo-polygalacturonase converts peel waste into acid that can be used for the development of fine chemicals, such as adipic acid, which is used to make nylon, the base material for the multi-billion dollar sanitary wipe industry.

   ***Impact*:** With this enzyme process, the production of nylon is cleaner, faster, and well-suited for the use of non-fossil fuels for a greener footprint. Additionally, the process can easily substitute for the current highly corrosive chemical production process.

2. A novel heat treatment was developed, when compared with the industry standard biocides applied during the clarification process of sugarcane juice, eliminated microbial contamination. This heat treatment technology has been adopted by numerous U.S. sugar factories to replace costly commercial biocide antimicrobial treatments.

   ***Impact*:** A current estimate is that each factory has saved approximately $47,000 per year on average, or about $515,000 per year for the industry in Louisiana alone while using a technology less prone to antimicrobial resistance.

Indicator 2: ***During 2015, ARS will enable technologies for the production of new biofuels which are compatible with the Nation's existing fuel distribution infrastructure.***

FY 2015 Accomplishments:

1. ARS scientists in Peoria, IL, and Tifton, GA, converted Napier grass into ethanol with an estimated yield of 10,300 liters per hectare. By comparison, a corn field that typically yields 444 bushels a hectare could produce only 4,640 liters per hectare.

   ***Impact*:** This research demonstrates that bioenergy crops, specifically Napier grass, are a feasible, economically viable feedstock for production of liquid biofuels in the southeastern United States.

2. Guayule, a woody desert shrub cultivated in the southwestern United States, will soon be commercialized as a source of natural rubber, organic resins, and possibly a high energy biofuel feedstock.

   ***Impact*:** Guayule bagasse, the by-product following natural rubber extraction, in a pyrolysis process that employs a reactive gas environment to formulate a special intermediate bio-oil product, is a readily usable, renewable, sustainable waste product that can be used as a hydrocarbon (drop-in) fuel.

Performance Targets

2.3.A Enable New Technologies that Benefit Biorefiners which Utilize Biochemical Processes to Convert Carbohydrate-Based Feedstocks.

Baseline 2012	Target 2017
ARS characterized two important feedstock traits, make progress on one enhanced germplasm pool, and establish one significant public-private partnership for advancing feedstock variety improvement.	By 2017, ARS will characterize 10 important feedstock traits, create three enhanced germplasm pools, and establish five significant public-private partnerships for advancing feedstock variety improvement.

2.3.B Enable New Technologies that Benefit Biorefiners which Convert Lipid-Based Feedstocks.

Baseline 2012	Target 2017
ARS incorporated at least one new technology that enables production of biomass and will contribute to the introduction of a new region-based system.	By 2017, ARS will incorporate six new technologies and introduce three new region-based systems that enable the production of biomass feedstocks to help achieve U.S. goals for meeting legislated mandates for blending biofuels. We will provide 10 science-based practices suitable for developing NRCS conservation plans.

2.3.C Enable New Technologies that Benefit Biorefiners which Utilize Pyrolysis to Convert Feedstocks.

Baseline 2012	Target 2017
ARS commercialized one biorefining and /or co-products technology which was enabled by ARS research.	By 2017, industry will commercialize five biorefining and/or co-products technologies which were enabled by ARS research.

Measure 1.2.3 Summary of the Major Technologies Developed, Transferred, and Used in FY 2015:

During FY 2015, ARS developed one new method to measure enzyme deterioration of sugar beet, sugarcane, and sweet sorghum, and to predict/control processing problems at the processing plant.

Describe the Technology	Describe the Transfer	Identify the Customer	Impact
Replace commercial biocides with heat to eliminate microbial contamination of sugarcane juice	Numerous U.S. sugar factories to replace costly commercial biocide treatments with heat	Sugarcane industry	LA sugarcane factories saved an estimated $515,000 per year

Measure 1.2.3: Develop technologies to enable sustainable commercial production of bioenergy feedstocks and other biofuels.

During FY 2016, ARS will:

Enable technologies that can reduce business risks, increase the value of co-products, and/or expand the number of revenue streams for existing biorefineries.

Enable technologies for the production of new biofuels which are compatible with the Nation's existing fuel distribution infrastructure.

During FY 2017, ARS will:

Enable technologies that can reduce business risks, increase the value of co-products, and/or expand the number of revenue streams for existing biorefineries.

Enable technologies for the production of new biofuels which are compatible with the Nation's existing fuel distribution infrastructure.

During FY 2018, ARS will:

Enable technologies that can reduce business risks, increase the value of co-products, and/or expand the number of revenue streams for existing biorefineries.

Enable technologies for the production of new biofuels which are compatible with the Nation's existing fuel distribution infrastructure.

GOAL 2.4 – EFFECTIVELY AND SAFELY MANAGE AND USE MANURE AND OTHER AGRICULTURAL AND INDUSTRIAL BYPRODUCTS IN WAYS THAT MAXIMIZE THEIR POTENTIAL BENEFITS WHILE PROTECTING THE ENVIRONMENT AND HUMAN AND ANIMAL HEALTH.

NATIONAL PROGRAM 214 - AGRICULTURAL AND INDUSTRIAL BYPRODUCTS

Improvements are needed in animal feeding and management regimens in order to increase the proportion of dietary nutrients retained in the animal or animal products while decreasing the quantity of dietary nutrients excreted and lost to the environment. Basic research is needed to evaluate the fate and transport of manure nutrients in the major soil-crop systems common to animal agriculture. This is the foundation for developing Best Management Practices (BMP). Application methods are needed that can improve nutrient use efficiency and incorporate manure to conserve N while maintaining adequate crop residue to protect the soil from erosion and runoff. These practices, and their associated nutrient management plans, must be based on sound understanding of the fate and transport of specific nutrients for major soils, hydrologic conditions, and cropping systems. Information is needed on pathogen inactivation and die-off as well as their potential for regrowth as functions of environmental conditions (e.g., temperature, moisture, etc.) during all stages of waste management. Technologically sound methods are needed for utilizing byproducts that will be characterized as beneficial and can result in products that are commercially sustainable. This includes blending, composting, and amending byproducts as well as developing land application and management techniques that will improve soil, water, and air quality in addition to improved plant growth. In addition, improved formulations of agriculture byproducts feed stock for use in industrial as well as agricultural applications are needed.

Performance Measure

2.2.4 Effectively and safely manage and use manure and other agricultural and industrial byproducts in ways that maximize their potential benefits while protecting the environment and human and animal health.

Indicator 1: ***During 2015, ARS will increase utilization of manure nutrients and resources.***

FY 2015 Accomplishments*:*

1. Broiler litter application to land can cause excess phosphorous to accumulate in soils. One alternative to land application of broiler litter to soils is the burning of broiler litter to generate electricity. The resulting ash is high in macro and micro nutrients that release at a slower rate into the soil compared to the raw poultry litter. Field and greenhouse experiments conducted by ARS scientists in Beltsville, MD demonstrated that broiler litter ash is a very effective fertilizer for crops grown on disturbed soils.

   ***Impact*:** Utilizing broiler litter in this way reduces the waste stream from broiler production, provides a fuel source for renewable energy production, helps protect water quality within the watershed, and creates a valuable soil amendment. The soil amendment helps enable remediation of disturbed soils while allowing farmers to achieve nutrient management goals for reducing phosphorus run off from their agricultural land.

2. Ammonia emissions from animal husbandry operations in the USA were estimated at 2.4 million tons/year in 2010, and the costs of fertilizers have rapidly increased in recent years, especially nitrogen fertilizer such as anhydrous ammonia which is made from natural gas. ARS researchers at Florence, SC have developed a new technology to recover concentrated ammonia from liquid manures, reducing ammonia emissions and providing a source of crop fertilizer. A U.S. patent was awarded in 2015 (US 9,005,333 B1). The new technology worked well to recover ammonium from

liquid manure. Ammonium concentration in raw swine manure declined from 2270 milligram ammonium-N per liter pre-treatment to 20 milligram ammonium-N per liter post-treatment, demonstrating an overall capture of 98 percent of the ammonia in the manure. Because the system does not rely on chemicals, the operational cost of ammonia recovery was further reduced by 57 percent.

***Impact*:** This new system provides livestock producers a cost effective way to reduce ammonia emissions from manure. It also provides a renewable source of nitrogen fertilizer that may be useful to the producer or marketable to nearby producers.

Indicator 2: ***During 2015, ARS will reduce manure pathogens and Pharmaceutically Active Compounds (PACs).***

FY 2015 Accomplishments*:*

1. Salmonella often live in the intestinal tract of food-producing animals and are a leading cause of bacterial foodborne disease and food-related deaths in the U.S. The development of antibiotic resistance in Salmonella is considered a serious concern by the U.S. Centers for Disease Control and Prevention. Bacterial viruses (prophage) are frequently found in the chromosome of Salmonella and, when activated, can transfer genetic material from the original strain to another Salmonella recipient. ARS researchers in Ames, IA, demonstrated in laboratory experiments that multidrug-resistant Salmonella exposed to fluoroquinolone antibiotics, which are used in both human and veterinary medicine, can stimulate prophage to transfer genetic material including antibiotic resistance genes to another Salmonella strain. The fluoroquinolones are an important group of antibiotics used to treat a broad range of bacterial illnesses. Although antibiotics are beneficial for treating bacterial disease in both people and animals, this accomplishment highlights the need to use antibiotics judiciously.

   ***Impact*:** This research provides physicians, veterinarians, animal producers, and the public with scientific information on the transfer of antibiotic resistance genes. This information supports efforts to promote and encourage the cautious use of antimicrobials in order to prevent the transfer of antibiotic resistance genes that reduce the effectiveness of certain antibiotics used to treat bacterial diseases in the future.

2. Unintended discharge from feedlot runoff holding ponds can contaminate soil and groundwater. A collaborative effort with the Nebraska Cattlemen's Association, Nebraska Department of Environmental Quality, AgraTek LLC, and ARS scientists at Clay Center, NE, has developed linear resistivity array systems to function as an early-warning system. The technology was shown to effectively respond to unintended subsurface discharge in both the saturated and non-saturated zones. The technology improves monitoring over conventional methods by sampling more frequently, sampling a greater area for leakage and can be automated to alert managers when pre-set threshold changes are met.

   ***Impact*:** Improved ability to monitor unintended discharges from feedlot runoff holding ponds can help protect surrounding soils and waters from contamination. This provide a tool that improves our ability to manage for the potential movement of contaminants including manure pathogens.

Indicator 3: ***During 2015, ARS will reduce atmospheric emissions from animal production facilities.***

FY 2015 Accomplishments*:*

1. The economics of dairy manure-based digesters are not always favorable due to the relatively low biogas yield of dairy manure compared to other organic wastes. However, co-digesting dairy manure with other substrates have been shown to increase biogas production up to 5-fold compared to digestion of manure without amendment. As part of a larger effort to evaluate the environmental benefits of the cover crop winter radish, ARS scientists in Beltsville, MD, sought to determine optimal mixtures of dairy manure and chopped forage radish for anaerobic digestion. Results showed that methane production increased as the radish content increased. Results also showed that forage radish harvest date did not affect methane production during co-digestion with dairy manure.

   ***Impact*:** These results will be useful for those interested in additional benefits of cover crops and dairy farmers interested in increasing methane production in digesters during the winter months when the demand for supplemental heating is the greatest. Increased use of cover crops results in enhanced soil carbon, increased soil health and resilience to weather extremes, and reduces runoff and wind erosion. The winter radish harvested from the cover crop enhances the productivity and function of the anaerobic digester resulting in increased production of renewable energy and improved operating efficiencies.

2. Anaerobic digesters are used on about 300 U.S. dairies for treatment of manure prior to storage and land application. But roughly 90 percent of U.S. dairies have less than 200 cows, making large commercial digesters impractical. In a cooperative project between ARS in Beltsville, MD, and the University of Maryland, researchers designed and constructed six pilot-scale plug flow digesters, using simple, successful designs used in developing countries modified to function in the temperate climate of the U.S. Results showed that biogas production and solids removal values of the simple unmixed pilot-scale digesters were comparable to values from a traditional farm-scale vertical tank digester.

   ***Impact*:** Results from this study will be important across the U.S. dairy and livestock industries, especially to small operations, as they work to reduce their fossil fuel use and greenhouse gas emissions. Anaerobic digester technology has been viewed as only economically feasible on large dairies, but this effort provides a means for smaller operators to implement the technology in a cost effective manner, reducing emissions of the greenhouse gas methane.

Indicator 4: ***During 2015, ARS will develop beneficial uses of agricultural, industrial, and municipal byproducts.***

FY 2015 Accomplishments*:*

1. Heavy metal contamination poses a serious threat to both environment and human health. Thus, development of remediation strategies for heavy metals polluted soils is important for ecological conservation and health risk. A number of micro-organisms inhabiting soil and water can transform these toxic metals into a nontoxic form (biotransformation), which could reduce these toxic metals in the food chain. Researchers from ARS in Bowling Green, KY, along with scientists from the Chonbuk University in South Korea, isolated and identified microorganisms that were able to transform lead heavy metal from toxic to non-toxic form. Application of sesame oil cake extract enhanced the bacterial activity in mine drainage soils. Total lead (about 39 percent) was successfully transformed in mine drainage soils with sesame oil cake extract amendment. The utilization of oil cake extract not only increased the transformation rate but also improved soil quality.

   ***Impact*:** The present study provides a potential eco-friendly and sustained way for reducing the toxicity of lead and other heavy metal contaminants from mine drainage soils and as well as from

contaminated agricultural lands. These findings can reduce risks to human health and enhance soil and water quality.

2. To reduce the amount of municipal solid waste being landfilled, a new garbage processing technology has been developed. This technology sterilizes and separates the municipal solid waste into recyclables (metals and plastics) and an organic material called Fluff®. The Fluff material can be land applied to improve soil conditions. The U.S. Army often has large areas that have been damaged due to extensive army training and lack sufficient topsoil, organic matter, and nutrients necessary for successful revegetation. The potential of using Fluff as a soil amendment on these damaged training grounds was evaluated. Studies conducted at Fort Campbell, KY, and Fort Benning, GA, showed that native grass establishment was successful with the use of Fluff, with soil benefits observed five years after Fluff application. Fluff addition to soil decreased compaction of the soil and increased soil carbon and nitrogen concentrations.

   ***Impact*:** This study demonstrates that recycling municipal solid waste into Fluff can be an efficient and effective alternative for reclamation of degraded lands. The Fluff addition improves soil health and improves efforts to establish native grasses, thereby reducing erosion and also helping to protect water quality in the surrounding watershed.

Performance Targets

2.4.A Increase Utilization of Manure Nutrients and Resources.

Baseline 2012	Target 2017
Data of the effectiveness of current practices.	Develop manure treatment/handling systems and management strategies for maximizing effective nutrient utilization and environmental stewardship objectives.

2.4.B Reduce Manure Pathogens and Pharmaceutically Active Compounds (PACs).

Baseline 2012	Target 2017
Data on environmental fate and transport of pathogens and PACs.	Develop animal production strategies for reducing excretion of pathogens and PACS. Develop manure treatment/utilization systems minimizing introduction of pathogens and PACs into the environment.

2.4.C Reduce Atmospheric Emissions from Animal Production Facilities.

Baseline 2012	Target 2017
Initial datasets of emissions from animal production operations and facilities.	Develop manure treatment/handling systems and animal production/management strategies for minimizing emissions.

2.4.D Develop Beneficial Uses of Agricultural, Industrial, and Municipal Byproducts.

Baseline 2012	Target 2017
Reuse of some materials and disposal of the majority.	Ten new economical and environmentally beneficial products created from materials previously considered to be wastes. Examples include new fuels, structural materials, and soil amendments.

Measure 2.2.4 Summary of the Major Technologies Developed, Transferred, and Used in FY 2015:

During FY 2015, ARS reported on three new technologies adopted that decrease the use of manure nutrients and resources, reduce risk of pathogen and PACs transport, and protect the environment.

Describe the Technology	Describe the Transfer	Identify the Customer	Impact
Application of gypsum to fields receiving animal manures to reduce soluble phosphorus (P) losses to the environment	Adoption into NRCS National Standard Code 333, Amending Soil Properties with Gypsum Products	Farmers	Better phosphorus management and improved water quality
A technology that makes the use of ammonia scrubbers a cost-effective best management practice to capture ammonia exhausted from poultry and swine houses	A patent application has been filed	Poultry producers, air and water regulatory agencies	Cost-effective reduction in ammonia emissions from poultry and swine houses, and notable improvement in air and water quality in the surrounding agroecosystem
A new bio-refinery concept that produces value-added chemicals and materials from manure: phosphorus, amino acids, and a sanitized leftover solids biomass rich in carbon	Commercial license to industry	Entrepreneurs, livestock producers, industrialists, extension practitioners, other scientists	Recovery from manure solids produced by a typical 6,000-head finishing swine farm resulting in about 60.3 tons protein/year and 9.1 tons of P/year valued at $81,570/year

Measure 2.2.4: Effectively and safely manage and use manure and other agricultural and industrial byproducts in ways that maximize their potential benefits while protecting the environment and human and animal health.

During FY 2016, ARS will:

Increase utilization of manure nutrients and resources.

Reduce manure pathogens and Pharmaceutically Active Compounds (PACs).

Reduce atmospheric emissions from animal production facilities.

Develop beneficial uses of agricultural, industrial, and municipal byproducts.

During FY 2017, ARS will:

Increase utilization of manure nutrients and resources.

Reduce manure pathogens and Pharmaceutically Active Compounds (PACs).

Reduce atmospheric emissions from animal production facilities.

Develop beneficial uses of agricultural, industrial, and municipal byproducts.

During FY 2018, ARS will:

Increase utilization of manure nutrients and resources.

Reduce manure pathogens and Pharmaceutically Active Compounds (PACs).

Reduce atmospheric emissions from animal production facilities.

Develop beneficial uses of agricultural, industrial, and municipal byproducts.

GOAL 2.5 - DEVELOP AND TRANSFER ECONOMICALLY VIABLE AND ENVIRONMENTALLY SUSTAINABLE PRODUCTION AND CONSERVATION PRACTICES, TECHNOLOGIES, PLANT MATERIALS AND INTEGRATED MANAGEMENT STRATEGIES, BASED ON FUNDAMENTAL KNOWLEDGE OF ECOLOGICAL PROCESSES, THAT CONSERVE AND ENHANCE THE NATION'S DIVERSE NATURAL RESOURCES FOUND ON ITS RANGE, PASTURE, HAY, AND TURF LANDS.

NATIONAL PROGRAM 215 - RANGELAND, PASTURE & FORAGES

This program develops and integrates improved management practices, germplasm, and land-use strategies to optimize productivity, economic viability and environmental enhancement in managing vegetation, livestock and natural resources on private and public grass and forage lands. Research activities include: enhancing conservation and restoration of ecosystems and agro ecosystems through improvements based on the application of ecological principles; improving management of fire, invasive weeds, grazing, climate change and other agents of change; developing grazing-based livestock systems that reduce risk and increase profitability in existing and emerging markets; developing improved grass and forage legume germplasm for livestock, conservation, turf and bioenergy and bioproduct systems; improving the sustainability of turf management; and improving decision-support systems including improving inventory, monitoring, and assessment tools.

Performance Measure

2.2.5 Develop and transfer economically viable and environmentally sustainable production and conservation practices, technologies, plant materials and integrated management strategies, based on fundamental knowledge of ecological processes, that conserve and enhance the Nation's diverse natural resources found on its range, pasture, hay and turf lands.

Indicator 1: ***During 2015, ARS will provide improved germplasm and cultivars that can be released for pasture, harvested forages, turf, biofuels, rangeland restoration, and conservation.***

FY 2015 Accomplishments:

1. While there is increasing interest in utilizing less productive agricultural lands (i.e., associated with increased drought, soil salinity, and low fertility) for grazing in the western U.S., it is difficult to establish grasses in these harsh environments. Thus, there is a critical need for winter hardy, early maturing grasses that establish rapidly and provide highly nutritional forage on western U.S. semiarid rangelands and non-irrigated pastures. ARS researchers at Logan, UT, released a drought tolerant, winter hardy meadow bromegrass cultivar "Arsenal". On arid and semi-arid rangelands, Arsenal had 32 percent more seedlings establish than meadow bromegrass cultivars currently in use. Under similar conditions, Arsenal averaged 14, 66, and 5 percent increase in forage production over cultivars Cache, Regar, and MacBeth. Spring forage crude protein and digestibility were 17 and 12 percent greater than Cache and fiber 6 percent lower. Use of Arsenal is already expanding as ARS researchers in El Reno, OK have obtained plant variety protection and a license for the commercialization and marketing of the cultivar for Southern Plains rangelands.

   ***Impact*:** Arsenal (Plant Variety Protection No. 201500355) expands the use of meadow bromegrass from irrigated pastures to nonirrigated pastures and rangelands with =250 mm annual precipitation, providing livestock producers with high-yielding nutritious forage where less nutritious and lower yielding grasses were typically used.

2. Grasses frequently have a lower digestibility compared to other forages such as alfalfa due to a strong cross-linked structure in grass cell walls. A major component of the cross-linking in grass cell walls is a phenolic compound called ferulic acid which produces ferulates. Ferulates in the cell wall become attached to lignin, creating a cross-linked network that reduces grass digestibility in dairy cows and other ruminants. ARS scientists in Madison, WI found a way to change the composition of the cell wall components in grasses, resulting in decreased ferulate attachments, fewer cross-linkages, and improved digestibility. Using modern genetic engineering tools, forage grasses can be modified to increase digestibility without inhibiting yield.

   ***Impact*:** Increasing digestibility in this way has both economic and environmental benefits to U.S. dairy producers with the potential to save $350 million in feed costs and reduce the amount of manure produced by 2.8 million tons.

Indicator 2: ***During 2015, ARS will provide forage, pasture, and rangeland management technologies and strategies that reduce inputs while improving livestock performance and sustaining the environment.***

FY 2015 Accomplishments:

1. Scientists across New Mexico, Arizona, Hawaii, Nevada, California, and Utah established a partnership to develop climate-smart decision-making tools in support of the USDA South West Regional Climate Hub. ARS scientists in Las Cruces and Cooperative Extension Agents in all six states worked together to translate scientific information into management resources and tools that are readily available to farmers, ranchers, foresters, and other stakeholders. Team members also met with counterparts in the U.S. Affiliated Islands of Guam and American Samoa that fostered closer ties to the S.W. Regional Climate Hub.

   ***Impact*:** This tools and resources resulting from this collaborative effort provide critical content to the S.W. Climate Hub in their efforts to equip land managers with tools for adapting to changing climate. Improved and adaptive management can result in sustained production, and reduced soil erosion. It can also help to maintain wildlife habitat and protect water quality.

2. Degraded big sagebrush/bunchgrass communities in the Great Basin provide very poor habitat and grazing resources for cattle and wildlife, including the sage grouse. ARS scientists mechanically treated old, degraded big sagebrush habitats in north-central Nevada using a Lawson Aerator. Pulled by a tractor, the Lawson Aerator consists of a heavy drum with blades that crush large, woody vegetation (such as declining sage brush and invading juniper), reduce soil compaction, and aerate the soil. When an area composed of 40 percent declining big sagebrush cover and desirable herbaceous vegetation at 1.3 plants per square meter was treated in the spring, it was converted to a habitat with 8.7 perennial grasses and 3.4 perennial forbs per square meter. In the first year post-treatment of this area, big sagebrush cover had already increased to 5 percent.

   ***Impact*:** This innovative treatment provides land managers with a tool for improving the condition of degraded rangelands, enhancing wildlife habitat and grazing values.

Performance Targets

2.5.A Develop Practices and Technologies to Improve Rangeland Productivity and Ecological Services.

Baseline 2012	Target 2017
Three practices and technologies that improve livestock production and the effectiveness of conservation and restoration including reducing the risk of wildfires, invasive weeds and climatic uncertainty to improve profitability and enhance ecological services	Cumulatively, 15 rangeland practices and technologies developed and released to ARS customers

2.5.B Develop Practices and Technologies to Improve Pasture Productivity and Ecological Services.

Baseline 2012	Target 2017
Three practices and technologies that improve livestock production and the effectiveness of conservation on pasture lands including reducing the risk of climatic uncertainty and enhancing water resources and other ecosystems services	Cumulatively, 10 pasture practices and technologies developed and released to ARS customers

2.5.C Developed Sustainable Harvested Forage Systems for Livestock, Bioenergy and Bioproducts.

Baseline 2012	Target 2017
Two practices and technologies that improve harvested forage production for livestock and bioenergy while reducing the risk of climatic uncertainty and enhancing water resources and other ecosystems services	Cumulatively, 10 forage practices and technologies developed and released to ARS customers

2.5.D Develop Improved Germplasm and Management Practices for Sustainable Turf Systems.

Baseline 2012	Target 2017
One improved germplasm that enhances turf management including improving the environment and reducing the risk of climatic uncertainty	Cumulatively, five improved germplasm releases or improved management practices developed and released to ARS customers

Measure 2.2.5 Summary of the Major Technologies Developed, Transferred, and Used in FY 2015:

During FY 2015, ARS reported on four new technologies adopted for uses that provide improved germplasm for climatic variability, and more effective conservation and restoration practices.

Describe the Technology	Describe the Transfer	Identify the Customer	Impact
Columbia bluebunch wheatgrass, a drought tolerant native of the Columbia Basin which produces comparatively large quantities of seed, for Columbia Basin rangeland restoration efforts	Public germplasm release to the seed industry	Seed companies producing seed for rangeland restoration, land managers and federal agencies interested in rangeland improvement	An improved bluebunch germplasm that outperforms existing varieties for yield and persistence
Ecological site descriptions about ecosystem services provided by ecological sites and their ecological dynamics, indicators of ecosystem change, and best management practices via state-and-transition models	Used to stratify the landscape and organize ecological information for purposes of monitoring, assessment, and management	State and federal government agencies (NRCS, BLM, US Forest Service), land and environment NGO's such as The Nature Conservancy, and others interested in monitoring or assessing rangeland health	Improved assessment and monitoring of rangeland health and condition, resulting in opportunities for improved rangeland management
The Northeast Grazing Guide (http://grazingguide.net/), an outreach tool for the Northeast Pasture Consortium providing detailed information for forage-livestock systems in the northeastern U.S.	Website	Forage-livestock managers, agribusiness, and public agencies	More than 10,000 page views last year from users nationally and internationally
JournalMap, an ecological literature search engine that directly links published research to a geographic location and biophysical variables of the area where that research was conducted	Web-based search engine	Scientists, agencies, university students and general public	Geotagged journal articles

Measure 2.2.5: Develop and transfer economically viable and environmentally sustainable production and conservation practices, technologies, plant materials and integrated management strategies, based on fundamental knowledge of ecological processes, that conserve and enhance the Nation's diverse natural resources found on its range, pasture, hay and turf lands.

During FY 2016, ARS will:

Provide improved germplasm and cultivars that can be released for pasture, harvested forages, turf, biofuels, rangeland restoration, and conservation.

Provide forage, pasture, and rangeland management technologies and strategies that reduce inputs while improving livestock performance and sustaining the environment.

During FY 2017, ARS will:

Provide improved germplasm and cultivars that can be released for pasture, harvested forages, turf, biofuels, rangeland restoration, and conservation.

Provide forage, pasture, and rangeland management technologies and strategies that reduce inputs while improving livestock performance and sustaining the environment.

During FY 2018, ARS will:

Provide improved germplasm and cultivars that can be released for pasture, harvested forages, turf, biofuels, rangeland restoration, and conservation.

Provide forage, pasture, and rangeland management technologies and strategies that reduce inputs while improving livestock performance and sustaining the environment.

GOAL 2.6 – DEVELOP INTEGRATED SOLUTIONS TO SOLVE CHALLENGES RELATED TO AGRICULTURAL SYSTEM PRODUCTIVITY, PROFITABILITY, ENERGY EFFICIENCY, AND NATURAL RESOURCE STEWARDSHIP.

NATIONAL PROGRAM 216 - AGRICULTURAL COMPETITIVENESS & SUSTAINABILITY

Profitable farms are the basis of vibrant rural economies. Consumers benefit from agricultural production that provides abundant choices of products at relatively low costs. Even though commodity prices are now high, many farms still have difficulty responding to changing market conditions, and the high costs of fuel and other purchased inputs. In addition, there is increasing competition from overseas markets where production costs are comparatively low. At the same time, continued advancement of conservation goals is needed to enhance the natural resource base upon which the nation not only depends for food, feed, fiber, and renewable energy, but also for supplies of fresh water, clean air, and healthy ecosystems. The challenges producers face regarding productivity, profitability, and natural resource stewardship are complex, so the solutions to these challenges will not be simple.

Producers and natural resource managers need holistic solutions to the complex problems they face. Not only do they need to decide what the best production methods, improved varieties, and advanced technologies to use, they want to know how these innovations can be best incorporated into their operations and whether their investment will increase their ability to compete in the market. Though many of the problems producers face are

the same across the country, it is accepted that each region and every farm is different, so there are no "one-size-fits-all" solutions.

These challenges are not unique to the United States. The United Nations Food and Agriculture Organization (GAO) addressed similar issues in their Strategic Framework 2010-2019. Strategic Objective A – Sustainable Intensification of Crop Production – seeks to increase production per unit land area to meet world food needs and "requires the integration and harmonization of all appropriate crop production policies and practices aimed at increasing crop productivity in a sustainable manner, thereby meeting key millennium development goals aimed at reducing hunger and preserving the natural resources and environment for future use."

Interdisciplinary systems research provides an approach to understand how different kinds of farm enterprises function, and how changing or introducing new technology will affect their productivity, profitability, energy efficiency, and natural resource stewardship. Finding the best combinations of practices will help producers achieve their production goals, while enhancing the environmental goods and services derived from agricultural lands. Diverse and dynamic agricultural systems are needed that can adjust to changing environmental and market conditions to increase the long-term financial viability and competitiveness of farms, enhance natural resource quality, contribute to the vibrancy of rural communities, and increase the food, fiber, and energy security for the Nation and the world. This research will contribute to making sustainable intensification of agriculture a reality.

Performance Measure

1.2.6 Develop integrated solutions to solve challenges related to agricultural system productivity, profitability, energy efficiency, and natural resource stewardship.

Indicator 1: ***During 2015, ARS will develop integrated solutions to solve challenges related to agricultural system productivity, profitability, energy efficiency, and natural resource stewardship.***

FY 2015 Accomplishments:

1. Producers grow cover crops to improve soil health and soil nutrient management, and to control soil erosion. However, there are many cover crop options to choose from, which makes selecting a cover crop to meet specific producer needs challenging. ARS researchers in Mandan, ND developed an updated Cover Crop Chart (CCC) to help producers select cover crops that will meet specific production and natural resource goals. The chart categorizes 57 cover crops based on plant type and general growth characteristics, and provides basic descriptive information. The CCC is internet-accessible and is being used by producers and conservation agencies to help assess and select cover crops that will meet producer needs.

   ***Impact*:** Because the CCC simplifies decision-making about cover crops, it is expected to increase the use of cover crops and increase benefits of soil management, which will help producers meet their goals for protecting and improving soil quality and controlling soil erosion.

2. Above ground biomass is an important parameter used to estimate crop yields from remote sensing data, but the reflectance from bright yellow canola flowers creates errors when estimating canola biomass. ARS scientists in Pendleton, OR, have developed a novel spectral index that corrects for the effects of yellow flower reflectance and that generates reliable estimates of canola plant biomass and yield. The new spectral index also performed well as an estimator of oilseed yield based on the premise that yield is directly proportional to flower and seed pod numbers.

***Impact*:** The index provides a means for private firms and government agencies to monitor crop conditions and estimate crop yields at county and State levels. Crushing plants could also use the method to more efficiently find and procure oilseed, minimizing storage and transportation costs.

3. Alabama wheat farmers are changing to no-tillage and non-inversion tillage (where the plough does not completely invert the soil) conservation systems, and are increasing N fertilizer rates to maximize yields. ARS scientists in Auburn, AL and Auburn University collaborators conducted experiments to test these practices across different regions of Alabama. The results showed that non-inversion tillage on the sandy loam soils of central and south Alabama produced approximately 13 percent greater yields, while no-tillage on the silt loam soils in north Alabama produced equivalent yields to conventional tillage operations requiring multiple passes. Fall N application was imperative for successful wheat production on central and south Alabama soils, while north Alabama soils were less responsive to applied N.

   ***Impact*:** At some locations, producers who use conservation tillage techniques can obtain yields that meet or exceed yields from conventional tillage; save time, fuel, and labor; promote soil health; and keep N usage within current recommended levels.

4. Legume cover crops in rotation with cash crops are used for nitrogen fixation, weed suppression, and improved soil quality, but there has been little effort to improve the cover crop varieties available to U.S. farmers. The genome of hairy vetch (*Vicia villosa*) cultivar Purple Prosperity® was sequenced by ARS scientists in Beltsville, MD, and the draft sequence was deposited on the iPlant Collaborative cloud platform for access by cover crop developers and breeders.

   ***Impact*:** This is a major step towards enabling plant breeders to quickly identify the underlying genetics controlling desirable hairy vetch traits that help reduce the environmental impact of agricultural systems. New cover crop cultivars will be developed because this information is available.

5. The runoff curve number (CN) is a widely used, efficient method for estimating runoff for water quantity and quality model projections. The CN method was empirically developed using runoff data collected from small catchments and hillslope plots prior to the advent and widespread adoption of no-tillage (NT) systems. Unfortunately, little work has gone into validating CNs for NT cropping. Using 1972 to 2010 rainfall-runoff data from a watershed near Athens, GA, ARS scientists derived CNs when conventional tillage (CT) and NT management were used. Results showed that CNs for NT cropping systems are smaller than CNs currently used for comparable tilled watersheds in the southeastern United States. The NT CNs provide more realistic representations of landscape characteristics for hydrologic modeling of water quantity and quality, where the use of the CN method is widespread.

   ***Impact*:** Users of CNs such as NRCS, EPA, and state and local agencies are now able to more accurately evaluate how land management could potentially affect water quantity and quality, which will support efforts to implement and assess practices that reduce the effects of agriculture on the environment.

Performance Targets

2.6.A Develop new strategies and technologies to reduce production costs and risks of economic losses for agronomic and bioenergy crop production systems.

Baseline 2012	Target 2017
Description of baseline systems for regional agronomic crop production systems	Identify five new region-specific agronomic crop production system configurations that utilize on-farm resources and natural ecosystem processes to reduce the need for purchased inputs and reduce whole-system costs and risks

2.6.B Develop new specialty crop management strategies to reduce production costs but have neutral or positive impacts on yield, product quality, and risk of economic loss.

Baseline 2012	Target 2017
Description of baseline condition for region-specific specialty crop production systems	Identify four new region-specific production system configurations for new crops that utilize on-farm resources and natural ecosystem processes to reduce the need for purchased inputs and reduce whole-system costs and risks

2.6.C Develop new strategies that integrate crop and livestock production elements to reduce risks of economic loss, diversify income, and enhance environmental benefits.

Baseline 2012	Target 2017
Description of baseline conditions for integrated crop-livestock production systems	Identify two enhanced region-specific system configurations that take advantage of the complimentary benefits of combining crop and livestock production enterprises to reduce the need for purchased inputs and reduce whole-system costs and risks

2.6.D Develop and integrate technology and decision support tools to increase production system efficiency.

Baseline 2012	Target 2017
Single natural resource and plant growth assessment models calibrated for local conditions	Natural resource assessment and plant growth models applied to regional crop production systems and integration of economic factors

Measure 1.2.6 Summary of the Major Technologies Developed, Transferred, and Used in FY 2015:

During FY 2015, ARS reported on four new technologies adopted for uses that provide management strategies to increase sustainability and economic viability.

Describe the Technology	Describe the Transfer	Identify the Customer	Impact
Updated Cover Crop Chart (CCC) to help producers select cover crops meeting specific production and natural resource goals	Available via the Internet	Nationwide producers employing cover crops	Increased use of cover crops resulting in better soil quality and reduced soil erosion
Guidance for nitrogen inputs with conservation tillage	Scientific journals, presentations at scientific conferences and to grower groups	Alabama wheat farmers	Saves time, fuel, and labor; promotes soil health; and keeps N usage within current recommended levels to limit excess losses to the environment
Genome sequence of the cover crop hairy vetch (*Vicia villosa*) cultivar Purple Prosperity®	iPlant Collaborative cloud platform, scientific journals articles, and conference presentations.	Cover crop breeders	Development of more cover crop options
Runoff curves for no-till cropping systems	Scientific journals, presentations at conferences, direct transfer to customers	NRCS, EPA, and state and local agencies using water runoff models	Reduced effects of agriculture on water quantity and quality

Measure 1.2.6: Develop integrated solutions to solve challenges related to agricultural system productivity, profitability, energy efficiency, and natural resource stewardship

During FY 2016, ARS will:

Develop integrated solutions to solve challenges related to agricultural system productivity, profitability, energy efficiency, and natural resource stewardship.

During FY 2017, ARS will:

Develop integrated solutions to solve challenges related to agricultural system productivity, profitability, energy efficiency, and natural resource stewardship.

During FY 2018, ARS will:

Develop integrated solutions to increase agricultural system productivity, profitability and natural resource stewardship with metrics to describe the sustainability of the solutions.

Strategic Goal Area 3:
Crop Production and Protection

Research conducted by ARS's Crop Production and Protection Program (CPP) National Programs will deliver science-based information and technologies to meet

- Producers' needs for increased crop productivity and quality, protection from diseases and pests, and economically and environmentally sustainable methods of crop production;
- Consumers' demands for a ready supply of high quality, safe, affordable and nutritious food;
- Worker's needs for a safe working environment;
- The public's desire to protect the environment; and
- The global community's needs for food security.

To meet these needs, ARS will conduct research that addresses the national priorities of genetic resource conservation, genomics, and genetic improvement; prevention and treatment of plant diseases; identification and management of arthropod and weed pests, including quarantine pests; improved crop management strategies; and the development of methyl bromide alternatives. The research of the Crop Production and Protection National Programs is well integrated with other ARS research in Animal Protection and Production; Natural Resources and Sustainable Agricultural Systems; and Nutrition, Food Safety and Quality. Through the National Invasive Species Information Center and Alternative Farming Systems Center of the National Agricultural Library, key information will be disseminated to agricultural producers, the research and education community, and the general public.

GOAL 3.1 – PROTECT, EXPAND, AND ENHANCE THE UNITED STATES' CROP GENETIC RESOURCE BASE, INCREASE SCIENTIFIC KNOWLEDGE OF CROP GENES, GENOMES, BIOLOGICAL PROCESSES AND SYSTEMS, AND DELIVER ECONOMICALLY AND ENVIRONMENTALLY SOUND TECHNOLOGIES THAT IMPROVE THE PRODUCTION EFFICIENCY, QUALITY, HEALTH AND VALUE OF THE NATION'S CROPS.

NATIONAL PROGRAM 301 - PLANT GENETIC RESOURCES, GENOMICS, AND GENETIC IMPROVEMENT
NATIONAL PROGRAM 305 - CROP PRODUCTION

U.S. crop production depends on new and improved varieties of crops—developed faster and for less cost—that are competitive in the market, increasingly tailored to meet the complex demands for food, feed, fiber, ornamentals, and energy; and adapted to an increasingly challenging global climate. To do so, ARS research will harness the inherent genetic potential of plants. This research will develop, and effectively apply, new knowledge of crop genes, genomes, and the control and expression of genes, to accelerate productivity and improve the quality of crops; realized via traditional and novel plant breeding methods.

Genetic resources are an important foundation of our agricultural future. ARS crop gene banks contain the sources of resistance to biotic and abiotic stresses and new genes to improve the quantity and quality of food, feed, energy, fiber, and ornamental crops. To ensure that these genes are available for research and breeding, ARS will continue to acquire and conserve crop genetic resources, develop more effective screening methods for identifying superior traits, characterize the genetic profiles of gene bank holdings, ensure that genetic resources are distributed where and when they are needed, and safeguard these collections and their associated information for future generations.

New ARS genetic technologies will address the specific needs for higher crop yields; more durable and effective tolerance to abiotic stresses including drought, heat, cold, freezing, and flooding; more efficient crop use of key inputs such as water and nutrients; more durable and effective pest and disease resistance; control of flowering time; enhanced product composition and nutritional quality; value-added traits; and conversion efficiency to biofuels. ARS research will elucidate how crop traits are controlled by underlying genetic systems, how these traits are affected by environmental factors during crop production, and how to enhance traits by incorporating novel sources of genetic variation from underexploited genetic resources or by genetically-engineering such traits. ARS will devise new crop genetic improvement methods that incorporate advances in genome sequencing and analysis, molecular genetics, computational biology, and metabolic engineering. New crop breeding theories and strategies will be developed to more effectively capture the intrinsic genetic potential of germplasm—especially to improve key agronomic and horticultural traits—resulting in crops tailored for consumer and producer needs.

ARS will continue to lead the development of crop genetic and genomic information management and database systems that broadly support and enhance crop research, from germplasm improvement and breeding to genetic and genomic analyses. New tools will be generated to efficiently incorporate valuable new data into databases, extract key information from the massive quantity of data safeguarded in those databases, identify the important properties of genes, apply that knowledge to crop improvement, and build on genetic advances in one crop so as to accelerate genetic gains in others.

The Nation's economic vitality depends on the ability of U.S. crop producers to grow and market food, fiber, ornamentals, industrial products, feed, and fuels profitably; while enhancing the natural resource base on which crop production depends. Future economic success for U.S. producers depends on increased productivity, access to new markets for specialized products, new technologies that generate new opportunities for U.S. farmers, and new tools and information to mitigate risks and enable rapid adjustments to changing market conditions. The agricultural sector is challenged by a wide variety of resource, climatic, economic, and social factors that require an equally diverse array of strategies and solutions for successfully meeting those challenges.

Contemporary U.S. crop enterprises for annual, perennial, and greenhouse crop production are complex and depend on access to and successful integration of highly diverse components, such as a steady stream of superior crop varieties, new strategies for mitigation of crop losses from biotic and abiotic stresses, and mechanization and automation of undesirable or labor intensive activities. The development of successful new production systems to sustain or increase crop yield and quality requires focusing on 1) productive and profitable crop management strategies for new and traditional crops that conserve natural resources; 2) efficient and effective integrated management strategies for multiple pests; 3) mechanization of management activities to address labor constraints; and 4) improved crop management models and decision aids.

Pollination is a critical element in agriculture as well, because honey bees pollinate more than 130 crops in the United States and add $15 billion in crop value annually. Declining honeybee populations and honey production due to Colony Collapse Disorder (CCD) require special attention. CCD has now increased honey bee mortality to more than 30 percent. Also, as new crops are introduced and stresses on honeybees increase, pollinators will be continuously required for specific crops or protected environments.

Improved production systems must address the needs of small, intermediate, and large field-, greenhouse-, orchard-, and vineyard-based farming enterprises for more efficient conventional, organic, and controlled-environment production methods and strategies. New crop production technologies must increase production efficiency, conserve energy and natural resources, and provide resilience in the face of abiotic and biotic stresses; while maintaining or enhancing productivity and product quality.

Key outcomes of this research will be new technologies (such as superior crop varieties; enhanced breeding stock; more effective crop and pest management strategies; improved sensors, robotics, and spray application equipment; improved decision support systems; more efficient production systems) and information that sustain U. S. crop production and enable producers to compete more effectively in the global market place. The U. S. national capacity to exploit the genetic potential of crops efficiently and effectively is maintained, and U.S. crop productivity and efficiency are enhanced.

Performance Measure

1.3.1 Develop knowledge, strategies, systems and technologies that maximize the production efficiency of our annual, perennial, greenhouse and nursery cropping systems. Develop new technologies and tools contributing to improving these systems to meet current and future food crop production needs of diverse consumers, while ensuring economic and environmental sustainability and production efficiency, health, and value of our nation's crops.

Indicator 1: ***During 2015, ARS will breed superior new crops, varieties, and enhanced germplasm.***

FY 2015 Accomplishments*:*

1. U.S. potato production, currently valued at more than $4 billion a year, as well as potato production internationally, are continually threatened by the devastating potato early and late blight diseases, requiring many fungicide applications every year. ARS scientists in Madison, WI, have evaluated potato germplasm to determine the genetic basis of disease resistance. This information enabled them to identify key resistance genes and incorporate them into three potato clones with resistance to both diseases.

   ***Impact*:** The development of potato varieties with resistance to both diseases would reduce the environmental impacts of fungicide application, improve profitability for growers, and is not available in commercial potato cultivars.

2. During the past 12 years, race 4 of the fungus causing *Fusarium* wilt disease (FOV race 4) has negatively impacted cotton production in California. Cotton varieties resistant to FOV race 4 could reduce yield losses, providing an economical approach for controlling this fungal disease. Recent breeding efforts have identified cultivars/germplasm tolerant to FOV race 4, but growing them in a pathogen-infested field can increase the fungal infestation and the disease-tolerant cultivar/germplasm might become susceptible over time. Thus, new mechanisms of resistance are needed. To continue providing germplasm with good levels of resistance, ARS researchers in Lubbock, TX, with their university colleagues, jointly developed five Pima cotton germplasm lines with resistance to FOV race 4, and which also have good yield and fiber quality.

   ***Impact*:** These lines provide needed alternative sources of FOV race 4 resistance to cotton breeders and are broadening the genetic base for Pima cotton, which is critical to maintaining a healthy, disease-free Pima cotton industry in California's San Joaquin Valley.

3. Seed number per panicle (head) is a major determinant of grain yield in sorghum and other cereal crops and increasing seed number is an efficient way of increasing production and profitability for farmers without increasing acreage farmed. From the sorghum experimental lines maintained at their location, ARS researchers in Lubbock, TX, isolated several multi-seeded mutants with potential to double seed number and significantly enhance the seed weight per panicle in sorghum. In

collaboration with ARS researchers in Ithaca, NY, the scientists then identified two genes underlying the multi-seeded trait through next-generation sequencing.

***Impact*:** The genes with multi-seed traits have been distributed to researchers and seed companies for the development of high yield sorghum hybrids.

4. Tepary bean is a highly heat- and drought-stress tolerant crop, native to the Southwestern United States and Mexico. However, there has been limited research on its genetics, nutritional value, and cooking characteristics, key aspects when considering the potential for broader, global adoption. ARS researchers in Mayagüez, PR, assembled the Tepary Diversity Panel (TDP), composed of 320 tepary bean samples representing all of the publically available tepary germplasm in the Americas. Subsets of the TDP were evaluated for response to bean common mosaic virus (BCMV), biological nitrogen fixation, root rot resistance, and heat tolerance; several samples were identified with BCMV resistance. ARS researchers in Mayagüez, PR; East Lansing, MI; and Houston, TX, also found that tepary beans had half the fat and double the sucrose concentration compared to common bean.

   ***Impact*:** Several tepary bean lines showed consistently shorter cooking times and higher water uptake than common bean. The genetic variability of seed composition and cooking characteristics provides critical raw material for genetically improving this highly nutritious crop.

5. Virginia peanuts have the largest kernels of all peanut types and are often sold as gourmet snacks. They are grown mainly in southeastern Virginia, northeastern North Carolina, and South Carolina, but there is an important niche in the southwestern United States. In this peanut production region (largely Oklahoma and Texas), all cultivated peanut varieties are high-oleic except for Virginia type peanuts, largely due to the lack of available high-oleic Virginia cultivars. High oleic acid makes peanut oil stay naturally fresh longer in products, i.e., more shelf-stable. A problem that high-oleic peanut varieties faced in this region was that their desirable oil quality came with lower yields, often so low that their nutritional quality and longer shelf-life values could not compensate; plus they were more susceptible to fungal diseases, forcing farmers to endure high fungicide costs and lower yields. ARS scientists in Stillwater, OK released a new high oleic peanut cultivar with good yields, enhanced grade, and excellent disease resistance

   ***Impact*:** The first high oleic Virginia peanut cultivar developed for the southwestern United States, "VENUS," will fill a void in the peanut industry for high oleic Virginia peanut production (for producers, shellers, and manufacturers) in the southwestern United States, which, in 2014 was comprised of 45 percent Virginia peanuts. Production of this Virginia cultivar will save producers $50 to $100 per acre in disease control costs and will add $7 to $10 million annually to the economy.

Indicator 2: ***During 2015, ARS will devise innovative approaches to crop genetic improvement and trait analysis.***

FY 2015 Accomplishments*:*

1. Breeding of strawberry, a fruit with many valuable nutritional properties, is slow, partly because seedlings derived from crosses must be grown to maturity before evaluating many traits, including whether the plant will produce fruit spring through fall, or just a brief period in the spring. The breeding process would be more efficient and greatly accelerated if potential parent plants and the resulting seedlings could be tested in the laboratory to predict which have the desired traits. ARS scientists in Beltsville, MD, and Corvallis, OR, with their university cooperators, discovered genetic

markers for selecting strawberry seedlings that when mature will bear fruit from spring through fall, i.e., have extended fruiting time.

***Impact*:** Strawberry breeders worldwide can apply these markers to more efficiently develop improved repeat-fruiting strawberry varieties that can avoid the economically damaging effects of weather extremes, such as spring frosts and summer heat waves.

2. Reliable detection and quantification of *Candidatus Liberibacter asiaticus* (CLas, presumed agent of citrus greening) is crucial for regulatory management strategies to prevent epidemics. Sensitivity of the standard assay protocol (quantitative polymerase chain reaction or qPCR) is constantly challenged, but without data to support the challenges. ARS scientists in Fort Pierce, FL, conducted experiments to test the effects of various assay parameters on qPCR detection of CLas. The results demonstrated that the test used and validated by APHIS to detect citrus greening was accurate enough to detect as few as one bacterial cell, whether from citrus or the Asian citrus psyllid vector. However, the scientists improved the parameters of the assay test based on their research to reduce the chance of false negatives, thus improving the reliability of the test.

   ***Impact*:** Considering the immediate threat of citrus greening to the California citrus industry, and the danger posed by false negative diagnoses of *Liberibacter*, these results have considerable significance. Based on the research, APHIS has incorporated these changes into their test protocols for *Liberibacter*.

3. The large size and spreading growth habit of trees are limiting factors for orchard planting density and crop yield. Genetically improving tree shapes to enable high density orchard production and limit chemical inputs is hampered by lack of knowledge about the underlying genetic controls of tree architecture. ARS researchers in Kearneysville, WV, applied a new technology that combines knowledge from conventional plant breeding with new DNA sequencing information to identify several genes responsible for naturally occurring architectural traits in peach trees, including dwarf, weeping, and pillar (columnar) growth forms. Molecular markers were developed to facilitate breeding these novel tree forms.

   ***Impact*:** The genes functioned similarly in diverse plant species, therefore, the technology has potentially broad applications for optimizing plant form in a wide range of tree crops, forest species, and woody ornamentals.

4. Dry beans are a dietary staple in regions of Africa and Latin America. They are rich in protein and minerals, such as zinc, which are essential to the human diet, but not all bean varieties have the same nutritional profile. ARS scientists in East Lansing, MI, characterized the genetic diversity for seed protein and zinc in a panel of over 200 diverse bean lines, including many from Africa. These lines represented nine market classes of beans of economic importance, including kidney, yellow, and red mottled seed types. Genetic variability for seed protein ranged from 16 to 31 percent and for seed zinc from 19 to 54 µg g-1. Protein and zinc levels were positively correlated, suggesting that by selecting for one in a breeding program, the other will increase as well.

   ***Impact*:** These published findings are being used to breed more nutritious bean varieties adapted to regional bean seed color and market class preferences.

5. The onion thrip is the most important insect pest of onion for both bulb and seed production, requiring frequent insecticide applications. In addition, thrips are responsible for transmission of Iris yellow spot virus, which is an increasingly damaging virus of onion crops. ARS researchers in

Madison, WI, published information that revealed two major genetic factors that control the amounts and types of leaf surface waxes in onion, which impact both resistance to thrips and the viruses they transmit. Lower amounts of these waxes are associated with resistance to thrips. Deployment of onion cultivars with lower amounts of those waxes should reduce the build-up of thrips populations and virus infection during onion production and reduce the frequency of insecticide sprays, reducing costs for growers and overall environmental impact of pesticide sprays.

***Impact*:** This provides for the first time an approach to controlling this important pest and respective viruses through plant breeding.

Indicator 3: ***During 2015, ARS will expand crop genomic information resources and advanced bioinformatic capabilities.***

FY 2015 Accomplishments*:*

1. Knowledge of the sequence and structure of crop genomes is critical for accelerating progress in crop research and genetic improvement. Such information is particularly important for exploiting the wild relatives of crops for their rich source of genes for increasing yield, enhancing disease resistance, and accelerating adaptation to weather extremes, but the process of assembling individual pieces of genomic data into a coherent picture of crop genomic structure has been slow and expensive, primarily because of the volume of data and the computationally intensive data analyses involved. ARS scientists in Ithaca, NY, and university cooperators at the iPlant Collaborative, a national project to facilitate access to high performance computing, software, and DNA sequence analysis tools, developed a series of coordinated software programs that for the first time will enable a researcher to assemble a rice genome sequence and characterize all of its genes – all in the same day – through the computational resources at iPlant.

   ***Impact*:** This new capacity could substantially accelerate genetic improvement initially in rice and later in other crops.

2. Tausch's goatgrass is a modern wild grass species that directly descended from one of the three ancestors of modern bread wheat. As such, it contains many genes that could improve the baking quality, disease resistance, and growth characteristics of current bread wheat varieties. An international consortium of scientists, including ARS researchers in Albany, CA, has completed an initial version of the genome sequence for Tausch's goatgrass.

   ***Impact*:** The DNA sequence is available online to researchers and wheat breeders can use it to develop molecular markers and map and isolate individual wheat genes. This resource will enable breeders to accelerate genetic improvements in wheat productivity and utilization.

3. U.S. sweet potato production, currently valued at more than $500 million per year, is increasing steadily as the health-promoting qualities of this crop are recognized. Furthermore, sweet potato is a key source of calories and vitamins throughout developing nations. Safeguarding and expanding crop production are high priorities and require a sweet potato plant with better tolerance to extreme temperatures, rainfall, and soil conditions. ARS researchers in Griffin, GA, and their university cooperators identified new geographical locations for sweet potato wild relatives and characterized their genetic relationships.

   ***Impact*:** This new information about genetic relationships is valuable for identifying sweet potato breeding and are the best new sources for the horticultural traits needed to meet U.S. domestic and

international demands for higher yielding sweet potatoes tolerant of environmental extremes, such as high temperatures and drought.

4. Advances in sequencing, imaging, chemical analysis, and robotics are making it easier to assess thousands to millions of sites across the plant genome for genetic diversity through genome-wide association studies (GWAS). However, analyzing the mass of data for meaningful associations between a particular phenotype (trait) and specific genes is complicated. ARS researchers in St. Louis, MO, developed an interactive browser that enables researchers to analyze GWAS data for multiple crop agronomic traits or experiments in the same computer screen window.

   ***Impact*:** This browser can be customized by researchers and breeders for soybean, corn, rice, sorghum, and other crops to find genes for specific traits for their own research data or freely available source code and will greatly facilitate the transformation of genome and genomic-derived data into practical tools for plant breeding.

5. A Simple Sequence Repeat (SSR) is a small segment of DNA that repeats itself a number of times. SSR markers can be used to identify genes or genomic regions that control agronomic and quality traits in crop plants. ARS researchers in Beltsville, MD, developed a database (BARCPvSSR_1.0) containing 13,700 SSR markers in common bean, which were selected from over 85,000 SSRs identified in its genome sequence. Evaluation of a random set of 1100 markers with the DNAs of common bean accessions from five major market classes verified that 92.4 percent of the primer sets amplified a single polymerase chain reaction product and 65.9 percent amplified polymorphic amplicons, the highest success rate for SSR markers reported in common bean.

   ***Impact*:** Marker sequences were provided to researchers in the common bean community for the identification of genes controlling rust diseases and other traits, they can also be used by plant breeders to identify genes that provide resistance to biotic and abiotic stress or that control seed quality and yield.

Indicator 4: ***During 2015, ARS will conserve and encourage the use of plant and microbial genetic resources and associated information.***

FY 2015 Accomplishments*:*

1. By preserving seeds, genebanks can efficiently safeguard genetic diversity of thousands of species valuable to agriculture, but seed survival in genebanks varies considerably, creating challenges for effective genebank management as well as additional costs for implementing customized, idiosyncratic preservation treatments and monitoring changes in seed viability. To develop genebank management tools that are more effective and reduce costs, an ARS researcher in Fort Collins, CO, applied material sciences approaches, more commonly used to evaluate plastics, to explain why some seeds die rapidly and others succumb at different rates during storage.

   ***Impact*:** This new, unified explanation provides a rational framework to optimize seed storage practices and to predict their longevity in genebank storage. The new approach will guide efforts to conserve more species as seeds, as well as reduce expenditures on germination tests that detect seed aging during long-term storage

2. Upland cotton accounts for more than 90 percent of cultivated cotton worldwide and is the primary source of renewable textile fiber. It is a tetraploid species—two genomes in one—and thus is

extremely challenging to sequence and analyze. The cotton genome sequence and structure were completed by Chinese and U.S. researchers, including ARS scientists in Stoneville, MS.

***Impact*:** The team developed the first reference genome of a tetraploid cotton species, which will help breeders develop new U.S. cotton cultivars with longer, stronger fiber; increased yield; and enhanced disease resistance.

3. Understanding the genetic control of important traits in hops is critical for the development of new germplasm and cultivars for the U.S. hop industry. The genetics of disease resistance and important agronomic and chemical properties in hop are rudimentary. ARS scientists in Corvallis, OR, and university colleagues sequenced the hop genome and identified the genomic locations of approximately 25,000 genes in the USDA hop cultivar 'Teamaker.'

   ***Impact*:** This will enable the identification and development of genetic markers for traits such as disease resistance, yield, bittering, and essential oil flavoring and storage-ability.

4. Boxwood is considered the “bread and butter” of the U.S. nursery industry. Each year, more than 13 million boxwood plants are sold in the United States, making boxwood one of the most popular and valuable shrubs in the landscape. A new blight disease, caused by a fungus, significantly threatens the profitability of nurseries and the quality of landscapes throughout the United States. The U.S. National Arboretum houses the world boxwood collection as a valuable resource for disease resistance. ARS scientists at the U.S. National Arboretum, Washington DC, developed molecular markers to assess the genetic diversity of boxwood species and hybrids bred for disease resistance.

   ***Impact*:** The molecular makers and the information published are a critical first step in cultivar identification and genetic conservation, as well as in guiding breeding strategies to deliver blight resistant cultivars to the industry.

5. The ability of legumes to produce their own nitrogen fertilizer through interactions with beneficial nitrogen fixing bacteria is one of the primary factors for legumes being essential crops for rotations with cereals, especially in nutrient-poor soils. Despite the importance of biological nitrogen fixation to sustainable crop production, there are considerable gaps in the understanding of how legumes and these bacteria interact with each other and the surrounding environment. ARS scientists in Pullman, WA, in collaboration with Washington State University, identified chickpea breeding lines and varieties that supported significantly more beneficial bacteria than several commercially grown varieties. A collection of more than 100 strains of root-colonizing bacteria isolated from field grown chickpea, was developed. Genetic data for 150 of the strains showed that many collected from chickpea roots are genetically distinct from ‘commercial’ isolates.

   ***Impact*:** These bacterial strains are being screened for their ability to function at low/acid pH (below 6.0), as acidification of agricultural lands is a growing problem in the Pacific Northwest.

Indicator 5: ***During 2015, ARS will expand fundamental knowledge of plant biological and molecular processes.***

FY 2015 Accomplishments*:*

1. Higher temperatures decrease corn photosynthesis and yield. Research on major crops’ responses to a warmer, carbon dioxide-rich environment has been limited to artificial growth environment experiments or to historical analysis of agricultural outputs. ARS researchers in Urbana, IL,

developed the means to analyze corn growth in elevated carbon dioxide and higher temperature with field-based equipment. This equipment enabled plants to be grown under typical agronomic conditions, while simultaneously modifying their growth environment in a controlled manner. The scientists determined that corn photosynthetic rates decreased when grown in warmer temperatures, reducing harvestable yields. Additionally, the research showed that the sensitivity of corn to warmer temperature was not influenced by growth in higher carbon dioxide.

***Impact*:** The sensitivity of corn growth to higher temperatures warrants further investigation of whether corn can be successfully adapted to the changing global climate.

2. ʻŌhiʻa, Hawaii's most common and widespread native tree, grows from sea level to elevations as high as 8,000 feet in both dry and wet forests and in diverse soils. It is the most ecologically important native Hawaiian tree, defining native forest succession and ecosystem function over broad areas; providing critical habitat for rare and endangered native bird and insect species; and exemplifying the strong links between native Hawaiian culture and the islands' environment. A newly detected disease has been killing many mature ʻŌhiʻa trees in forests and residential areas of the Big Island of Hawaii. ARS scientists in Hilo, HI, partnered with the U.S. Forest Service and university cooperators to identify the causal agent as a vascular wilt fungus.

   ***Impact*:** This identification is a critical first step for enabling researchers to develop control strategies for a pathogen that poses a serious threat to Hawaii's flagship native tree species, the loss of which would be catastrophic for the diversity, structure, and function of Hawaii's remaining native forests and the services they provide.

3. Rhizoctonia root and crown rot (RRCR) is a soilborne fungal disease of sugarbeet that is found in most, if not all, sugarbeet production areas in the United States, and the severity of RRCR symptoms affects the suitability of sugarbeet roots for storage. ARS scientists in Fargo, ND, evaluated the effect of RRCR disease severity on sugar and quality losses during storage and root storageability and determined that roots with mild RRCR symptoms stored nearly as well as undiseased roots, but those with moderate to severe symptoms stored poorly.

   ***Impact*:** The research provides guidance to the sugarbeet industry for managing the storage of sugarbeet roots with RRCR. The research also provides information that assists in determining the severity of RRCR disease symptoms that preclude storage or require segregation of roots for early processing, and helps growers whose roots are refused for storage to justify their insurance claims.

4. Microbial contamination of fresh produce has caused several recent outbreaks of food poisoning. ARS researchers in Salinas and Albany, CA, demonstrated that the plant pathogen that causes downy mildew disease of lettuce changes the plant environment so that human enteric pathogens have higher survival and multiplication rates on lettuce leaves.

   ***Impact*:** The association between a plant pathogen infection and the survival of human pathogens on lettuce indicates that the development of lettuce breeding lines with high resistance to downy mildew is extremely important for both the quality of the final product (less blemishes on lettuce leaves) and product safety (less likely survival of human pathogens) and highlights the value of ongoing ARS research on downy mildew resistant lettuce cultivars to provide a continuous and safe supply of commercial lettuce varieties.

5. Environmental stresses, such as drought, high temperature, and their combination reduce overall growth of cotton plants, cotton lint yield, and fiber quality. Their impact on fiber development is

poorly understood due to associated technical difficulties and the lack of genetic materials for studying developing fiber tissues. ARS researchers in Lubbock, TX, generated transgenic cotton lines with cotton fiber specific promoter and reporter constructs from six cotton fiber specific genes, representing genes that are expressed at different stages of fiber development. These reporter genes, attached to fiber developmental gene switches, serve as visual indicators allowing scientists to see when specific developmental genes are turned on. Drought and heat stress studies showed a correlation between the decrease in promoter activities and fiber length, increase in micronaire, and changes in other fiber quality traits in the transgenic lines grown under stressed condition.

***Impact*:** Novel molecular tools for studying the effects of abiotic stresses on fiber development, which can be used to study cotton fiber development genes and, eventually, to genetically manipulate fiber quality.

Indicator 6: ***During 2015, ARS will develop more effective means for plant biotechnology risk assessment.***

FY 2015 Accomplishments*:*

1. A model of pollinator movements can be applied to different scenarios to predict associated risk of gene escape. In collaboration with University of Wisconsin scientists, ARS researchers in Madison, WI, developed a simulation model of pollinator movements based on field-collected data. The simulation model includes statistical models of the relationships between distance traveled and number of flowers visited per raceme and transition probability matrices for directions traveled between successive racemes.

   ***Impact*:** The model describes and predicts how three types of pollinators move within alfalfa fields; better understanding these pollinators' movements improves predictions of how far they can carry pollen, providing strong estimates of the risk of gene escape.

Indicator 7: ***During 2015, ARS will develop crop production strategies to optimize crop genetic potential, mitigate losses due to biotic and abiotic stresses, and increase production efficiency.***

FY 2015 Accomplishments*:*

1. Currently, there is no commercially acceptable yield monitoring system available for sugarcane harvesters. ARS scientists in Houma, LA, working with Louisiana State University cooperators, developed and tested a new optical yield monitor for use on a billet type sugarcane harvester. The system uses three lasers mounted on the top of the harvester elevator and measures the cane yield directly in the field. A calibration equation that was developed with data from the monitor indicated the amount of cane on the elevator, harvested distance, harvester speed, and direction of cut, all significantly correlated with weight. On larger truck loads (over 60 metric tons), the system predicted loads with errors below 2 percent.

   ***Impact*:** The system is currently under commercial testing at several sugarcane farms throughout Louisiana. The yield monitoring system will help sugarcane growers better manage their fields with the ultimate goal of growing better yielding crop and increasing profits.

2. Drought is a major abiotic stress constraining agricultural production. Plants have evolved diverse strategies to respond to drought and increased abscisic acid (ABA) concentrations by closing stomates to reduce transpiration. An ARS researcher in Davis, CA, in collaboration with researchers

at the University of California, Davis, produced transgenic petunias containing a tomato gene which increases ABA levels and is switched on only under drought stress. The plants were not only resistant to severe drought, but fully recovered when water stress was lifted, and showed no negative effects under normal conditions.

***Impact*:** The research may lead to successful development of drought-resistant horticultural crops.

3. Winter camelina dual-cropped with soybean used as a “cash” cover crop provides environmental benefits. Competition between growing biofuel and food crops on agricultural lands has been a growing cause of concern so ARS researchers in Morris, MN, looked at methods of producing both on the same land in a single season. The researchers demonstrated that winter camelina used as a "cash" cover crop for biofuel feedstock can be sustainably dual cropped with soybean in the Corn Belt (of the Midwestern United States).

   ***Impact*:** Interseeding (a.k.a. "relay-cropping") soybean into winter camelina in the spring led to combined seed yields that were economically competitive with a single full-season soybean crop. Moreover, a camelina-soybean dual crop system, which adds a cover crop to the rotation, offers environmental benefits such as reduced soil erosion and sequestration of nitrogen and phosphorus that a simple corn-soybean rotation does not.

4. In most countries, including the United States, drip irrigation has rapidly become the most popular method to irrigate blueberries. An ARS scientist in Corvallis, OR, determined that young blueberry plants often grow better with drip irrigation than with conventional sprinkler systems, but little information was available on the use of drip irrigation in mature plantings. In cooperative work with Agriculture and Agri-Food Canada, researchers found that blueberry plants became more sensitive to soil water limitations with age and required more irrigation to have profitable production. Antioxidants in the fruit were also higher with than without drip irrigation, and therefore, drip irrigation, if properly managed, could help to improve the health benefits (increase antioxidants) of blueberries.

   ***Impact*:** The information that drip irrigation helps to improve the health benefits of blueberries was used to develop new irrigation guidelines for highbush blueberry, which have been adopted by the industry to improve production and quality in the Pacific Northwest.

5. As ozone levels are positively related to air temperature and growing season temperatures are expected to increase due to climate change, ozone levels will rise. ARS scientists in Kearneysville, WV, studied calcined kaolin applied to apple trees over a 6-year period and evaluated fruit yield and quality and ambient ozone levels. The calcined kaolin particles catalyzed the degradation of ozone and stimulated non-pathogenic microbial populations on the leaf surface, which further increased ozone degradation and increased apple quality.

   ***Impact*:** Calcined kaolin particles mitigated ozone damage in apple and they may be a tool to mitigate increased ozone stress generally.

Indicator 8: ***During 2015, ARS will improve pollinator health, bee systematics and germplasm lines, and pollination.***

FY 2015 Accomplishments*:*

1. Honey bees are attacked by a large number of pathogens, however little is known about their immune response. Through collaborative work with an international consortium from 30-plus institutions, ARS researchers in Beltsville, MD, sequenced the full genome of two Asian honey bee species; the North American bumble bee species used most for commercial pollination, Bombus impatiens; and the Alfalfa leaf cutting bee, Megachile rotundata. This work helped identify genes associated with the behavioral-and disease-related traits of these species and developed insights into social behavior and key biology traits.

   ***Impact*:** Researchers can target genes for immune proteins that are especially responsive to disease agents. This information will be used for the management of pollinator species in croplands and to improve management strategies for better bee health.

2. Diet can often affect honey bees' gut microbiota leading to health problems. ARS scientists in Tucson, AZ, found that a common pollen substitute, Megabee, fed to honey bees during pollen dearth did not affect the diversity or abundance of gut bacterial communities at 3 or 7 days post bacterial inoculation. This provides evidence that the transmission of core gut bacteria by honey bees does not rely on contact with older nest mates as previously speculated. Moreover, bacterial succession in the gut is highly resilient to changes in the nutritional environment, suggesting that selection by the host's gut is the most critical determinant of gut bacterial colonization in honey bees.

   ***Impact*:** Results suggest that artificial pollen supplements are unlikely to affect bee health via alteration of the gut bacterial community.

3. To establish a honey bee germplasm repository, a standardized semen storage protocol is needed. Current efforts to cryopreserve honey bee semen use Harbo Extender Medium (Harbo EM) which produces viable spermatozoa after cryopreservation but has limited efficacy as it was based on mammalian spermatozoa's physiological needs. ARS researchers in Fargo, ND, recently developed an improved medium, basing it on insect spermatozoa physiology, the USDA Honey bee Extender Medium. Although the improvement to survival immediately after storage is modest (70-80 percent survival for Harbo EM compared to 90 percent for USDA Honey bee EM), the effects on sperm longevity are more profound. Spermatozoa preserved with Harbo EM rapidly succumb at room temperature, while more than 75 percent of those preserved in USDA Honey bee EM remain viable even after 6 months at room temperature.

   ***Impact*:** This protocol is critical to the practical success of a honey bee germplasm repository. Honey bee queens store spermatozoa for extended periods of time after artificial insemination in their spermatheca and if a queen is storing unviable sperm this will result in the rapid demise of her colony.

4. Varroa (mite) is the most serious pest of honey bees and a leading cause of colony loss during winter. ARS researchers in Tucson, AZ, documented that these mites migrate into colonies on foraging bees. The highest levels of migration are in the fall, causing mite populations to be higher than expected, particularly following late summer miticide treatments.

   ***Impact*:** Beekeepers need to monitor mite levels until foraging ends (in the fall). Multiple fall miticide applications may be needed to keep mite levels low enough for bee colonies to survive over the winter.

5. To preserve bee diversity during land restorations, better knowledge of bee forage plants is needed. ARS researchers in Logan, UT, with Utah State University collaborators, found that in both weekly and across-the-season samples, bumble bees forage for less diverse sources of pollen than co-located honey bees. However, individual bumble bees were more likely to visit multiple pollen sources within a foraging trip than individual honey bee workers. Thus, pollen diet requirements for floral provision strips on cropland should be broad enough to feed multiple bee species.

   ***Impact*:** This information will be useful for land managers in land reclamation efforts where they wish to ensure a sufficiently diverse food source for a variety of bees.

Performance Targets

3.1.A Develop and Maintain Superior Crop Genetic Resources and Associated Information, Genetic, Genomic, Bioinformatic, and Breeding Tools, Techniques, and Analytical Approaches, Crop Production Systems, and Technologies to Harness Crops' Genetic Potential and Optimize Productivity and Profitability of U.S. Crop Production. The Preceding Will Underpin a Safe, Affordable and Sustainable Supply of Nutritious Foods and Superior Crop Products for the U.S. and Other Nations, Protect the Environment, and Contribute Strongly to Global Market Competitiveness of U.S. Agriculture.

Baseline 2012	Target 2017
Ten new technologies are developed by ARS and used by ARS customers, leading to increased production efficiency and enhanced economic value and quality of U.S. crop production, while reducing any negative environmental impact	Fifty new technologies are developed by ARS and used by ARS customers, leading to increased production efficiency and enhanced economic value and quality of U.S. crop production, while reducing any negative environmental impact

Measure 1.3.1 Summary of the Major Technologies Developed, Transferred, and Used in FY 2015:

During FY 2015, ARS reported on 17 new technologies adopted for uses that provide environmentally sound management practices, including crop resistance/tolerance through breeding and biotechnology, rapid and reliable diagnostics, environmentally safe pesticides, and cultural and biological control methods to protect agriculturally important plants from pests and pathogens.

Describe the Technology	Describe the Transfer	Identify the Customer	Impact
New optical sugarcane yield monitor for use on a billet type harvester	Being commercially tested at several LA sugarcane farms	Sugarcane growers and processors	Growing a better yielding crop and increasing profits
USDA Honey bee Extender Medium, which has more than 75 percent viability of spermatozoa after cryopreservation	Testing artificial insemination after cryopreservation	Beekeepers and users of pollination services	Critical to the practical success of a honey bee germplasm repository

Method to test the effectiveness of RNA interference (RNAi) to prevent accumulation of aflatoxins (a mycotoxin) in peanut seeds	Public release	Peanut growers, consumers, and research scientists	Partnering to apply the novel technology in countries severely affected by mycotoxins (aflatoxins) to increase food security and quality of food crops available for human consumption
Two new germplasm lines of cotton resistant to cotton leaf curl virus	Germplasm lines have been made available to breeders for developing cotton leaf curl virus-resistant varieties	Cotton breeders, growers and international partners	Resistant cotton varieties developed in advance of the disease reaching the U.S. will keep any incursion well controlled
Method for automated detection of decay in salad-cut lettuce held in modified atmosphere plastic bags	Published results in *Postharvest Biology and Technology*	Lettuce growers and processors	Enables rapid and repeated evaluation of samples over time and presents the opportunity for development of a commercial, high throughput scanner
New potato variety "Payette Russet" with 75 percent less acrylamide than industry standard variety (Russet Burbank)	Release of new variety	Potato growers and U.S. consumers	Reduce acrylamide content in processed potato products
A new high oleic Virginia type peanut cultivar (VENUS) with improved shelf life developed for the Southwestern U.S.	Release of new cultivar	Peanut growers, distributers, and consumers	Filling a void in the peanut industry in this region, saving producers $50–$100/acre in disease control costs and adding $7-$10 million annually to the economy
Superior new productive, disease resistant apple rootstock, G.213, which improves bud break and productivity in low chill environments	Release of rootstock to growers	Apple growers and consumers	Increase production of high quality fruit in apple growing regions that are affected by low winter chilling hours
New late-season apricot, Goshen Gold, which provides growers with a self-fruitful tree that is both vigorous and productive, can be marketed fresh and cut, and dries to a high-color premium product	Released to growers	Apricot growers and U.S. consumers	Goshen Gold extends apricot sales season improving profitability for growers and availability for consumers

Giant, thornless blackberry, Columbia Giant, which produces good yields of tasty, very large blackberries that can be machine-harvested for the processing market and sold in the fresh market	Development of new blackberry	Blackberry growers	Increased profitability for blackberry growers due to improved ease of harvest (thornless and longest trailing) and increased fruit size that maintains flavor
Productive and high quality mid-late season new rabbiteye blueberry cultivar, Bluesfest, with an extended harvest season, exceptionally light blue color, and berry size exceeding the fruit of Powderblue	Development of new blueberry	Blueberry growers and consumers	Extended harvest season for growers in the region and insurance against damage from late spring frosts
An interactive browser that enables researchers to analyze genome-wide association studies (GWAS) data for multiple crop agronomic traits or experiments	Public release	Any researcher analyzing GWAS data and the public	Will greatly facilitate the transformation of genome and genomic-derived data into practical tools for plant breeding
Five Pima cotton germplasm lines with resistance to FOV race 4, and good yield and fiber quality	Released to cotton breeders	Pima cotton growers	Alternative sources of FOV race 4 resistance and broadened genetic base for Pima cotton
Several inbred hybrid sorghum lines incorporating genes for waxy traits producing grain yield similar to standard hybrids	Public release	Sorghum growers	Enable public-sector and seed company breeders to produce high-yielding, waxy sorghum hybrids
PhotoSim, a decision-support software tool for plant production in protected horticulture systems	Released to growers	Horticulturists, growers of bedding and potted crop species	Gives growers the ability to estimate the impact that changing light, temperature, or CO_2 will have on plant growth, enabling better greenhouse management, improved plant growth, and reduced production costs

Automatic real-time premixing inline injection system that ensures efficiency of variable-rate sprayers	Released to ornamental nurseries	Ornamental nurseries	Improved spray application efficiency and environmental stewardship of variable-rate precision sprayers
Relational database for world-class bee reference collection	Made available to the public and the scientific community	Scientists worldwide and the general public	This reference collection is visited and used by scientists from all over the world

Measure 1.3.1: Develop knowledge, strategies, systems and technologies that maximize the production efficiency of our annual, perennial, greenhouse and nursery cropping systems. Develop new technologies and tools contributing to improving these systems to meet current and future food crop production needs of diversified consumers, while ensuring economic and environmental sustainability and production efficiency, health, and value of our nations crops.

During FY 2016, ARS will:

Breed superior new crops, varieties, and enhanced germplasm.

Devise innovative approaches to crop genetic improvement and trait analysis.

Expand crop genomic information resources and advanced bioinformatic capabilities.

Conserve and encourage the use of plant and microbial genetic resources and associated information.

Expand fundamental knowledge of plant biological and molecular processes.

Develop more effective methods to enhance biotechnology for crop improvement.

Develop crop production strategies to optimize crop genetic potential, mitigate losses due to biotic and abiotic stresses, and increase production efficiency.

Improve pollinator health, bee systematics and germplasm lines, and pollination.

During FY 2017, ARS will:

Breed superior new crops, varieties, and enhanced germplasm.

Devise innovative approaches to crop genetic improvement and trait analysis.

Expand crop genomic information resources and advanced bioinformatic capabilities.

Conserve and encourage the use of plant and microbial genetic resources and associated information.

Expand fundamental knowledge of plant biological and molecular processes.

Develop more effective methods to enhance biotechnology for crop improvement.

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Improve pollinator health, bee systematics and germplasm lines, and pollination.

During FY 2018, ARS will:

Breed superior new crops, varieties, and enhanced germplasm.

Devise innovative approaches to crop genetic improvement and trait analysis.

Expand crop genomic information resources and advanced bioinformatic capabilities.

Conserve and encourage the use of plant and microbial genetic resources and associated information.

Expand fundamental knowledge of plant biological and molecular processes.

Develop more effective methods to enhance biotechnology for crop improvement.

Develop crop production strategies to optimize crop genetic potential, mitigate losses due to biotic and abiotic stresses, and increase production efficiency.

Improve pollinator health, bee systematics and germplasm lines, and pollination.

GOAL 3.2 – PROTECT OUR NATION'S CROPS

NATIONAL PROGRAM 303 - PLANT DISEASES
NATIONAL PROGRAM 304 - CROP PROTECTION AND QUARANTINE

Economic losses of agricultural crops and natural ecosystems due to arthropods, plant pathogens, nematodes and weeds are considerable, with estimates in the tens of billions of dollars each year to agriculture, landscapes, and forests in the United States. Losses are due to reduced yields, lower product quality or shelf-life, decreased aesthetic or nutritional value, and food and feed contaminated with toxic compounds. Pest management strategies include cultural, biological, physical, and chemical methods. Non-chemical methods based on biological knowledge continue to expand, but the United States continues to depend heavily on chemical control to produce agricultural commodities. For instance, in 2007 more than 850 million pounds of pesticides (including herbicides, insecticides, fungicides, and nematicides) were applied to agricultural crops in the United States to protect these commodities from pests and pathogens (Pesticides and Industry Sales and Usage; 2007 and 2007 Market Estimates, EPA).

Maintenance of our arsenal of valuable management strategies is a constant challenge, as inherent disease and pest resistance in crops declines while pests become resistant to chemical controls, new pest problems emerge, new regulatory requirements are enacted, and production costs increase with rising energy costs. Further, the problem of losses due to pests and plant diseases does not end in the field or with the harvest. Insects and diseases reduce the quality of stored grain and other stored products, and it is estimated that post-harvest losses to corn and wheat alone amount to as much as $2.5 billion annually. Pests and diseases can also impede foreign trade. Imported commodities as well as those destined for export must be protected from endemic and exotic pests. Exotic insect, disease, and weed pests that threaten our food, fiber, and natural ecosystems are another mounting concern, as world trade and travel continues to expand. Invasive species such as the brown marmorated stinkbug and the Asian soybean rust directly threaten U.S. agricultural crops, while other invasive insects transmit devastating viral and bacterial diseases, such as citrus greening, that threaten entire agricultural

industries. Still other invasive insects, such as the Asian longhorned beetle, and the sudden oak death pathogen decimate our forests and urban landscapes, while invasive weeds reduce biodiversity, displace native species, and cost billions of dollars annually to control. Management of arthropod pests, plant diseases, and weeds is essential for providing an adequate supply of food, feed, fiber, and ornamental crops, but effective control depends on understanding the biology and ecology of these deleterious organisms as well as beneficial ones.

Numerous, diverse approaches are needed to protect U.S. crops from arthropods, plant pathogens, nematodes, and weeds. To manage plant pathogens and nematodes, ARS will: 1) develop and improve rapid and reliable methods for detection and identification of plant pathogens and nematodes; 2) enhance knowledge of the etiology of plant diseases and systematics of their pathogens; 3) provide in-depth knowledge of the biology, ecology, and epidemiology of plant pathogens and their interactions with hosts and vectors to identify targets for new disease management strategies; 4) develop and deploy host resistance against plant diseases and nematodes, and 5) develop biologically based and integrated disease management strategies.

To reduce the impact of weeds on the nation's agricultural and natural systems, ARS will 1) develop novel weed management solutions to control the reproduction and spread of invasive and weedy plants—based on new knowledge derived from plant genomics, biochemistry, and physiology; 2) expand integrated weed management programs by incorporating newly identified natural products or natural enemies, such as fungi, bacteria, viruses, nematodes, and insects; 3) determine the mechanisms of herbicide resistance in weeds and enhance knowledge of the biology, physiology, and ecology of weeds, so as to develop cropping system methods that mitigate herbicide resistance development and spread; 4) develop spatial models to monitor and control invasive plants in complex landscapes; 5) develop recommendations for restoring natural systems in ways that prevent weed invasions following effective biological control; and 6) identify effective weed management solutions for reduced tillage, low herbicide input, and organic production systems.

To ensure the cost effective management and control of native and invasive arthropod plant pests, ARS will 1) develop new bioinformatic tools that enhance insect species identification; 2) identify genetic, biological, and ecological determinants of plant insect pests that can be manipulated to improve their control; 3) determine critical factors involved in disease transmission by insects; 4) improve insect monitoring and capturing methodologies by identifying, synthesizing, and field-testing semiochemicals; 5) develop new biological, chemical, and cultural methodologies to control plant insect pests; 6) improve or develop sterile insect technique technologies to eradicate insect pests; and 7) develop systems for rearing natural enemies that have been demonstrated to be effective and safe biological control agents.

The key outcomes of this research will be the knowledge and improved capacity needed to protect plants in agricultural and natural systems—including the safe production and trade of food, feed, fiber, ornamentals, industrial products, and biofuels. This research and the transfer of resulting technologies will provide globally competitive and sustainable agricultural systems, safe and nutritious food, and healthy landscapes.

Performance Measure

4.3.2 Provide scientific information to increase our knowledge of plant genes, genomes and biological and molecular processes to protect crops and cropping systems from the negative effects of pests and infectious diseases. Develop sustainable control strategies for crop pests and pathogens based on fundamental and applied research that are effective and affordable, while maintaining food safety and environmental quality.

Indicator 1: ***During 2015, ARS will continue to identify and characterize genes of insect, nematode, and plant pathogen resistance in crop plants, closely related non-crop species, and other species, to enhance opportunities for developing host plant resistance, and to incorporate such genes into commercially acceptable varieties.***

FY 2015 Accomplishments*:*

1. The bacterium *Rathayibacter toxicus* is an APHIS select agent because infections produce a toxin in forage grasses lethal to livestock, causing $40 million of yearly damage in Australia. Despite the potential threat to U.S. agriculture and food supplies, the mechanisms of toxin production for *R. toxicus* were not known. ARS scientists in Ft. Detrick, MD, and Ithaca, NY, sequenced the genome of three *R. toxicus* strains plus an associated bacteriophage and determined that the genes responsible for toxin production are part of a transposable element housed in the *R. toxicus* DNA. Then, using this genome information, assays capable of finding any toxin-producing *Rathayibacter* species were developed.

   Impact**:** The assays will be useful for early detection of the bacterium, protecting the United States against invasion by this select agent. The research also provides information useful for determining the mechanisms by which toxin production is initiated.

2. Wheat stem rust is a fungal disease of wheat that can have significant negative effects on crop yield. A strain of the wheat stem rust fungus known as Ug99 threatens global wheat production due to its ability to infect nearly all wheat varieties. Inadvertent introduction of this pathogen into the United States would have severe negative effects on U.S. wheat production. A stem rust belonging to the Ug99 group, TTKSK, was detected for the first time in Egypt by ARS scientists from St. Paul, MN, and two new races (TTKTK and TTKTT) in this group were identified from samples collected in Kenya. SrTmp is an important gene conferring stem rust resistance and it is carried by several newly released wheat cultivars in eastern Africa. ARS scientists found that the new Ug99 races can infect wheat cultivars with SrTmp.

   Impact**:** These new virulent races explain continued stem rust epidemics in Kenya on newly released Ug99 resistant cultivars and pose an unrelenting threat to wheat production. This information demonstrates the need for ARS scientists' constant vigilance to assure continued development of new resistant wheat varieties for U.S. growers.

3. More than 5,000 aphid species exist, and more than 100 are economically important crop pests. Previously, the sole genomic model for understanding aphid-plant interactions was the pea aphid. Although the pea aphid and Russian wheat aphid share many taxonomic and biological traits, they differ in how they feed on the plant and the plant damage they cause. A multi-institutional, international, collaborative effort was organized and led by ARS scientists in Stillwater, OK, to sequence the genome of the Russian wheat aphid. This effort resulted in a new aphid genome assembly (called Dnoxia_1.0) that is available to the public through GenBank.

   Impact**:** This research provides a new comparative model for understanding aphid-plant interactions because the Russian wheat aphid produces phytotoxins when it feeds whereas the pea aphid does not. This genome also made it possible to develop RNA interference technology for aphid control and will be important to future pest management technologies.

4. *Fusarium* head blight (FHB) is a devastating disease of wheat and barley. U.S. FHB losses are estimated to have exceeded $3 billion since 1990. This disease not only greatly lowers grain yield and quality, but it causes the grain to become contaminated with a dangerous mycotoxin, deoxynivalenol

(DON). DON is harmful to wheat and barley and to humans and animals that consume grain products. ARS scientists in West Lafayette, IN, together with researchers at the University College of Dublin in Ireland, identified two wheat genes that encode transporter proteins that remove DON from plant cells. A gene-silencing system that can stop the expression of chosen wheat genes was used to turn off these transporters, resulting in wheat that became much more sensitive to DON.

***Impact*:** This finding, published in the *Journal of Experimental Botany*, is useful in developing wheat and barley with less sensitivity to the mycotoxin deoxynivalenol (DON) or greater resistance to FHB, because the action of DON is important in the spreading of the fungus.

5. Crown gall (CG) is a disease that debilitates young walnut trees and facilitates the development of other root-destructive diseases in walnuts. ARS scientists in Davis, CA, identified open-pollinated (OP) seedlings of walnut and wingnut (a walnut relative) that exhibited elevated levels of CG resistance, even over multiple dormancy periods. Directed breeding crosses were used to produce CG-resistant hybrid progeny, and these were shown to segregate for CG resistance. CG-resistant trees, both OP genotypes and interspecific hybrids, were cloned through *in vitro* propagation and are being examined for disease resistance in field trials.

   ***Impact*:** CG-resistant walnut trees are needed by the walnut industry, and these wild walnut genotypes provide the genetics that are essential for the development of CG-resistance.

Indicator 2: ***During 2015, ARS will continue to develop fundamental knowledge about biology and ecology that provides the foundation for strategies to exclude, accurately detect and identify, and mitigate arthropod and nematode pests, weeds, and plant pathogens.***

FY 2015 Accomplishments*:*

1. Globally, millions of hectares of Bt transgenic crops are cultivated, but concerns remain in the United States about the risks they may pose to non-target and/or beneficial organisms such as arthropods that are natural enemies of crop pests and that supply important ecological services. ARS scientists in Maricopa, AZ, and Ames, IA, with researchers at Cornell University and Agroscope in Zurich, Switzerland, showed that over multiple generations the development and reproduction of a parasitic wasp, a predatory beetle, three predatory true bugs, a predatory mite, and a predatory green lacewing were not affected by ingestion of prey that had fed on Bt plants/crops. The natural enemy species that were tested represent some of the most abundant and important species in cropping systems. The prey used were either resistant to or not susceptible to the Bt proteins in the crop plants. This approach eliminates prey quality issues, allowing the direct effects of Bt proteins to be accurately assessed under realistic exposure scenarios.

   ***Impact*:** These results showing that transgenic Bt crops do not negatively affect important beneficial arthropod parasitoids and predators may be valuable to governmental authorities who are responsible for regulating transgenic crops, scientists who are concerned with developing integrated pest management strategies for pest control, and the general public, which is concerned with the environmental effects of biotechnology.

2. Weedy amaranth plants (pigweed), especially herbicide-resistant biotypes, are problematic in many crops. ARS scientists have shown that there is hybridization between Palmer and spiny amaranth, and these naturally occurring crosses can transfer acetolactate synthase (ALS)-inhibitor genes, weed genes that confer glyphosate resistance. Glyphosate-resistant Palmer amaranth populations in the Mississippi Delta contain two different ALS point mutations, each conferring resistance, but only one was found in the hybrids. The ALS point mutations have been sequenced and are the type that gives

broad spectrum resistance to all five classes of ALS inhibitor herbicides; resistance to four different herbicides was confirmed in greenhouse tests.

***Impact*:** Herbicide resistance genes can move among amaranth species, and further use of glyphosate and other ALS herbicides will result in selection and proliferation of these traits in multiple amaranth weeds.

3. Codling moth, the major insect pest of apple, is controlled with a combination of pheromonal mating disruption and multiple applications of chemical insecticides. There is concern that the multiplicity of chemical insecticides may have negative effects on beneficial insects, such as honey bees. Two classes of insecticides commonly used in codling moth control programs are neonicotinoids and spinosads, each of which target nicotinic acetylcholine receptors present in the insect nervous system. ARS researchers in Wapato, WA, identified and characterized the expression of gene transcripts encoding 12 different codling moth nicotinic acetylcholine receptor subunits. Comparison of these subunits with those expressed in the honey bee, a beneficial insect that is sensitive to neonicotinoids, revealed the presence of two codling moth proteins that are not present in the honey bee.

   ***Impact*:** This information provides the background needed to develop new insecticides designed specifically to control codling moth, yet be safe for honey bees.

4. A new pathogenic fungus was isolated from Red River Valley sugarbeet plants. This pathogen appeared to be a species from the *Fusarium* genus but it showed distinct symptoms from other known Fusarium species, e.g., it caused disease earlier in the growing season. ARS scientists in Fargo, ND, in collaboration with researchers at North Dakota State University and the Institute of Sugar Beet Research in Göttingen, Germany, carried out molecular and morphological analyses to formally describe and name this pathogen as a new species, *Fusarium secorum*, the causative agent for *Fusarium* yellowing decline.

   ***Impact*:** The incidences of *Fusarium* yellowing decline have been increasing in the Northern Plains sugarbeet-growing region, and the identification and characterization of the causal agent is a significant first step in the development of disease management strategies.

5. A new strain of raspberry bushy dwarf virus (RBDV) was identified in commercial blackberry (*Rubus glaucus*) in Azuay, province of Ecuador, and named RBDV-Ec-Az. The virus contains an extra RNA compared with all other RBDV isolates sequenced. This extra RNA contains a complete copy of RNA2, plus an extra copy of the coat protein in reverse order at the 5' end of the RNA. The significant of this unique duplication, the first seen among plant viruses, is still unknown. The extra RNA was present in approximately 40 percent of the isolates from Azuay province, but it was not detected in Tungurahua province, which is the main blackberry production region for Ecuador. The ends of RNA2 of this strain of RBDV were similar to the resistance breaking strain reported from the United Kingdom, whereas the portion of RNA2 that codes for proteins was more similar to isolates from Slovenia.

   ***Impact*:** This strain of Raspberry bushy dwarf virus (RBDV) may be a combination of several different strains of RBDV from widely diverse regions, suggesting the international movement of RBDV in plant material.

Indicator 3: ***During 2015, ARS will perform applied research and development to provide new, useful and safe products to exclude, accurately detect and identify, and mitigate arthropod and nematode pests, weeds, and plant pathogens.***

FY 2015 Accomplishments*:*

1. An ARS scientist, working with dog trainers, demonstrated that canines are highly effective at detecting citrus trees infected with canker and citrus greening disease. Disease detection research culminated in training 10 dogs to detect Huanglongbing, the causative agent for citrus greening. Three dogs were also trained to detect citrus canker. Dogs detect citrus pathogens with at least 99.97 percent reliability. Dogs will be deployed over the next 2 years to various affected States and commercialization plans are in progress with dog training companies.

   ***Impact*:** This is the only method to quickly detect citrus greening in trees prior to symptom development. Early detection will aid in management of the disease.

2. New methods are urgently needed to maintain the productivity of citrus trees infected with citrus greening disease. The disease is caused by bacteria (*Candidatus Liberibacter asiaticus*) that reside in the tree phloem, just beneath the bark. ARS researchers in Fort Pierce, FL, developed bactericidal formulations applied in topical sprays, which penetrate through the citrus bark to the phloem. In field trials, titers of the causal disease organism were reduced, tree vigor improved, and no non-target effects were detectable to beneficial insects or honey bees.

   ***Impact*:** Development of a successful bactericide therapy for citrus greening disease

3. Water hyacinth is considered among the worst floating aquatic weeds on earth. It has become especially problematic in Florida and the Sacramento–San Joaquin River Delta in California as it impedes navigation, mosquito abatement, and the use of scarce water resources in a time of severe drought. ARS scientists and collaborators developed two new tools to improve adaptive area wide water hyacinth control/management. First developed was an accurate mapping application that, using Landsat multispectral satellite images and automated image processing, detects water hyacinth among other species of floating plants. It also tracks seasonal development of water hyacinth populations, allowing pest control operators to track success and target nursery populations. Second, a new biological control agent against water hyacinth was identified, the planthopper insect, *Megamelus scutellaris*, and is being produced and released. Nearly 400,000 have been released throughout Florida and a robust population has been established in the Sacramento River watershed. Damage inflicted by biological control agents makes the plant more susceptible to other control methods.

   ***Impact*:** These new tools make possible successful, adaptive, and integrated management of water hyacinth and other aquatic weeds.

4. Cereal aphids such as greenbug and the Russian wheat aphid are the primary pests of wheat and infestations can require yearly insecticide applications. The development of aphid-resistant wheat lines has been the most economical solution for control, however, both aphids have developed new biotypes that overcome wheat resistance. New technologies are needed that are not specific to an aphid biotype. Double-stranded RNA (dsRNA) constructs that are complementary to specific aphid genes can prevent those genes from functioning and kill the insect. ARS scientists in Stillwater, OK, developed two dsRNA constructs that have proven highly effective in Russian wheat aphid mortality in laboratory tests. Testing for greenbug is in process.

***Impact*:** This technology offers a novel approach in breeding wheat plants with highly specific resistance to aphids. A U.S. patent has been filed on these two constructs.

5. Strawberry growers have had to shift away from using methyl bromide for pre-plant soil treatments and postharvest quarantine due to the damage this chemical causes to the upper atmosphere. *Fusarium* wilt is a soilborne plant disease that has increased to new levels of significance with the elimination of methyl bromide soil treatments. ARS scientists identified strawberry cultivars with high levels of genetic resistance to *Fusarium* wilt. The strawberry plant varieties Fronteras, Portola, and San Andreas were among the most resistant, whereas others such as Albion and Monterey were much more susceptible. After berry harvest, ARS scientists improved fruit quality during storage and quarantine using short treatments of nitric oxide. Nitric oxide use helped control quarantined pests such as western flower thrips and improve postharvest storage life.

   ***Impact*:** These new strategies for pest control in strawberry provide the means for continued production and export of high-quality strawberries without the need for methyl bromide.

Performance Target

3.2.A Develop sustainable control strategies for crop pests and pathogens based on fundamental and applied research that are effective and affordable, while maintaining food safety and environmental quality.

Baseline 2012	Target 2017
Technologies produced by ARS were transferred to growers and producers, action agencies, the research community, and exporters and importers of agronomic products to exclude, eradicate and/or better manage disease and pest outbreaks as they occur in the United States or prior to their arrival on our shores	At least 30 new or improved technologies produced by ARS will be transferred to growers and producers, action agencies, the research community, and exporters and importers of agronomic products to exclude, eradicate and/or better manage disease and pest outbreaks as they occur in the United States or prior to their arrival on our shores

Measure 4.3.2 Summary of the Major Technologies Developed, Transferred, and Used in FY 2015:

During FY 2015, ARS reported on 35 new technologies adopted for uses that provide rapid and reliable diagnostics; pesticide and cultural and biological control developed and used to protect agriculturally important plants from pests and pathogens; and improved knowledge and understanding of quarantine pest and pathogen biology and epidemiology to mitigate risk of pests and pathogens, resulting in expanded export markets while protecting the safety and security of American agriculture.

Describe the Technology	Describe the Transfer	Identify the Customer	Impact
Soybean variety, JTN-5203, with broad resistance to two different nematode species and multiple fungal pathogens-- frogeye leafspot, stem canker, sudden death syndrome, and reniform nematode	Now the "standard check" for the USDA-Southern Soybean Uniform Tests	Soybean growers	Decreased soybean losses for growers

Efficacy of selected chemical sterilants against boxwood blight microsclerotia included in mitigation measures recommended by the State of Virginia Extension Service	Information was made available to stakeholders in the nursery industry	Nursery industry stakeholders	This information will play a critical role in reducing the negative economic effect of boxwood blight
Fungicides' concentrations and combinations effective against *Puccinia horiana,* a foliar plant pathogen that causes the disease chrysanthemum white rust (CWR)	Released to growers	Chrysanthemum growers	Information will be useful to government, academic, and private sector researchers to target fungicides for CWR control and reduce the opportunity for the pathogen population to develop resistance
Ten dogs trained to detect Huanglongbing and three to detect citrus canker at greater than 99.97 percent reliability	Dogs will be deployed over the next 2 years to various affected States and commercialization plans are in progress	Citrus growers	The only method to quickly detect citrus greening in trees prior to symptom development
Assays capable of finding any toxin-producing *Rathayibacter* bacterial species	Public release	APHIS and U.S. growers	The assays will be useful for protecting against the introduction of the select agent plant pathogen to the United States and for studying the mechanisms by which toxin production is initiated
A new *Brassica juncea* mustard green cultivar, Carolina Broadleaf, with resistance to a new bacterial disease, Brassica leaf blight, in both small-and large-scale production that is acceptable for both fresh-cut and canning/processing markets	Public release and discussions with several seed companies about production of the commercial quantities of seed needed to meet grower demands	Growers of leafy *Brassica* greens	The only known mustard green cultivar and the only *Brassica* leafy green cultivar with resistance to this disease
Multiplex PCR assay to detect and differentiate the select agent strains of *Ralstonia solanacearum*	Public release	APHIS and potato growers	Assist regulatory agencies make timely and appropriate recommendations to exclude this select agent from the United States
Diagnostic assay to detect all isolates of the virus associated with Blueberry mosaic disease	Publicly release	Blueberry growers	Testing blueberries in the National Clean Plant Network and available for certification and quarantine purposes

Two new tools for adaptive area-wide management of water hyacinth including an accurate mapping application and that also tracks seasonal development of water hyacinth populations and a new biological control agent against water hyacinth utilizing the planthopper insect, *Megamelus scutellaris*	Public release	Growers that need water hyacinth management tools and mosquito abatement program managers	These new tools make possible successful, adaptive, and integrated management of water hyacinth and other aquatic weeds
Phenyl propionate identified as a non-pheromonal attractant that can be combined with a known pheromone attractant to improve trap capture in navel orange worm monitoring systems	Released to growers and pest control adviser of the pistachio and almond industry	Almond and pistachio growers	Improved integrated pest management of navel orangeworm will delay further resistance in navel orange worm, enhancing the quality and yield of almond and pistachio
Identified a specific 3-week period of susceptibility in juvenile hops cones and discovered that the outcome of entire disease management programs largely depends on the efficacy of disease control measures applied during that period	Results have been widely distributed to the U.S. hops industry	U.S. hops industry	Nearly doubled the degree of disease control resulting in reduced yield loss from powdery mildew in susceptible varieties by 2.6 percent industry-wide (more than $2 million annually)
New aphid genome assembly (called Dnoxia_1.0) that is available to the public through GenBank	The new genome was released to the public	Growers	Provided a new comparative model for understanding aphid-plant interactions and made it possible to develop RNA interference technology for aphid control
A gene-silencing system to stop the expression of two newly identified wheat genes that encode transporter proteins that remove deoxynivalenol (DON) from plant cells	Published in the *Journal of Experimental Botany*	Growers wheat, barley, and of other crops at risk.	Useful to develop wheat & barley with less sensitivity to DON or greater resistance to Fusarium head blight
Bactericidal formulations applied in topical sprays, which penetrate through the citrus bark to the phloem	Released via an EPA Emergency Label	Citrus growers	Development of a successful bactericide therapy for citrus greening disease
A cost effective liquid fermentation method for producing high concentrations of stable microsclerotia and conidia of *Trichoderma* species	A number of agro-industrial companies are interested in the technology and one has applied for an exclusive license	Farmers, land managers, and home owners	This new method will make *Trichoderma* more available for use in improving plant health and controlling root-diseases

Double strand RNA interference (RNAi) based molecular biopesticides for brown marmorated stink bug (BMSB) control	Invention disclosure will lead to patent and potential commercialization by insect biocontrol companies	Companies interested in technologies for killing BMSB	These biopesticides could be used for managing BMSB
Double strand RNA interference (RNAi) based molecular biopesticides for gypsy moth (*Lymantria dispar*) control	Invention disclosure will lead to patent and potential commercialization by insect biocontrol companies	Companies interested in technologies for killing gypsy moth	These biopesticides could be used for managing gypsy moth larvae
Two double-stranded RNA (dsRNA) constructs proven highly effective in Russian wheat aphid mortality in laboratory tests	A U.S. patent application has been filed	Wheat growers	Novel approach for breeding wheat plants with highly specific aphid resistance
Chemical compounds for increased delivery of double-stranded RNA into plants	Technology transferred to agrochemical companies	Agricultural industries	Increased management of insect pests and pathogens in plants
Double stranded RNA sequences that target and silence complimentary genes when ingested by or topically applied to aphids causing high aphid mortality	Patent application filed	Seed companies, pesticide manufacturers, scientists, & researchers	Can be used in plant mediated expression to make plants resistant to aphid attack
Genes encoding enzymes responsible for synthesis of insecticidal compounds	Patent application in development	Insecticide producers and growers	Ability to produce active constituents of *Chromobacterium subtsugae* in a different organism can improve the efficiency of production and lower costs
Identified natural compounds from apple juice fermentation as either efficient attractants or repellent and potent biopesticides for Spotted Wing Drosophila (SWD)	Invention disclosure	Pheromones manufacturers and fruit growers whose crops are attacked by SWD	Attractants are useful for detecting early SWD infestation and population monitoring while biopesticides will enable the development of control technologies
Novel isolates of insecticidal bacteria related to *Chromobacterium subtsugae* that are toxic to Lepidoptera	Patent application in development	Manufacturers of microbial insect control products and organic growers requiring control of Lepidoteran pests	An alternative to *Bt kurstaki* that can be used to control the development of resistance

Novel strains of *Chromobacterium vaccinii* that exhibit activity against dipteran insects such as mosquitos and seedcorn maggot	Patent application in development	Manufacturers of microbial insect control products and organic growers requiring control of dipteran pests	Alternatives to *Bt israelensis* for mosquito control and control dipteran species that not affected by B*t israelensis.*
Three strains of the insect pathogenic fungus, *Beauveria pseudobassiana* and one of *Metarhizuim flavoviride* isolated from diapausing wheat stem sawfly (*Cephus cinctus*) larvae	Invention disclosure	Wheat and other cereal crop growers	Potential for control of Hessian Fly (*Mayetiola destructor*) in wheat
Six volatile carboxylic acids (VCAs) were identified as aggregation pheromones for German cockroach that attracts significantly more fifth instar nymphs than a previously identified VCA blend	Invention disclosure	Pheromones manufacturer and the general public, including restaurants, hospitals, and hotels	Development of new and more efficient tool for cockroach population detection, monitoring, and control
Improved liquid fermentation method for rapidly producing high yields of a blastospore composition (of insect-killing fungi including *Beauveria bassiana*) that is desiccation tolerant with excellent shelf-life and has improved efficacy in controlling insect pests.	Patent application	Companies, farmers, land managers, and home owners	Will change the way entomopathogenic fungi are produced leading to their widespread use as non-chemical insect control tools and providing an effective, non-chemical control for numerous serious insect pests
A method of killing Hemipteran insects through disruption of their feeding process	Patent application	Growers of many agricultural crops	Improved pest control
New isolates of the fall armyworm baculovirus that exhibit superior insecticidal activity and might be the basis for a safe, environmentally friendly insecticide	Patent application filed; two isolates are being licensed to the cooperator (for use in rice & corn)	Manufacturers of microbial biocontrol products and growers whose crops are attacked by the fall armyworm	Potential tool for management of fall armyworm infestations in organic agriculture or other systems where chemical insecticide use is not desirable
Identified gene regulatory elements capable of directing strong root hair-specific transgene expression	Patent	USDA-ARS, NPURU for metabolic engineering of biopesticide production in root hair cells	Potential for the production of crops with reduced requirements for pesticide input

Identified several parasitoids for biocontrol of the emerald ash borer (EAB) beetle, including the discovery of *Spathius galinae*, a larval parasitoid	Released as an EAB biocontrol agent	Private land owners, federal, state, and local park or land managers, foresters, and researchers	Adapted in 19 EAB-infested states providing them with new EAB biocontrol agents and a strategy for identifying additional ones
An electronic identification tool for the nearly 300 species of *Anastrepha*, the largest and most economically important group of fruit flies in the American tropics	Released online	Scientists and regulatory agencies	Help scientists and regulatory agencies improve management and control of pest fruit flies
StageCast, a computer model that helps growers synchronize pollinators with crop bloom	Beta test version is expected to be made available with a user's guide and related programmer's guide	Growers of multiple crops	Improve the synchrony of bees with crops to increase producers' profitability

4.3.2: Provide scientific information to increase our knowledge of plant genes, genomes and biological and molecular processes to protect crops and cropping systems from the negative effects of pests and infectious diseases. Develop sustainable control strategies for crop pests and pathogens based on fundamental and applied research that are effective and affordable, while maintaining food safety and environmental quality.

During FY 2016, ARS will:

Continue to identify and characterize resistance genes in crop plants for insect, nematode, and plant pathogens, to enhance opportunities for developing host plant resistance, and to incorporate such genes into commercially acceptable varieties.

Continue to develop fundamental knowledge about biology and ecology that provides the foundation for strategies to exclude, accurately detect and identify, and mitigate arthropod and nematode pests, weeds, and plant pathogens.

Perform applied research and development to provide new, useful and safe methods and products to accurately detect, identify and diagnose, arthropod and nematode pests, weeds, and plant pathogens.

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During FY 2018, ARS will:

Continue to identify and characterize resistance genes in crop plants for insect, nematode, and plant pathogens, to enhance opportunities for developing host plant resistance, and to incorporate such genes into commercially acceptable varieties.

Continue to develop fundamental knowledge about biology and ecology that provides the foundation for strategies to exclude, accurately detect and identify, and mitigate arthropod and nematode pests, weeds, and plant pathogens.

Perform applied research and development to provide new, useful and safe methods and products to accurately detect, identify and diagnose, arthropod and nematode pests, weeds, and plant pathogens.

Strategic Goal Area 4:
Animal Production and Protection

The mission of the ARS Animal Production and Protection (APP) national programs is to provide the scientific information and tools to help support the U.S. food animal industries to continue to compete successfully in worldwide trade, provide the supply of nutritional animal products required by the Nation, and contribute toward global food security. APP will accomplish this mission by maximizing production efficiency and animal health through scientific innovation and the discovery and development of new technologies focused on national priorities. Strategic public-private partnerships will be established to achieve our mission, including support of government action and regulatory agencies responsible for trade, biodefense, and global food security. Emphasis will be given to genetic improvements of traits related to production and production efficiencies and germplasm conservation; understanding the mechanisms of disease resistance, and the development of tools to prevent, control, or eradicate diseases that threaten our food supply and public health; and identifying and developing sustainable systems for production of high quality meat, fish, milk, and eggs that also ensure animal health and well-being. The portion of the program that produces new solutions to the many veterinary problems created by arthropod pests and vectors will be leveraged to solve related problems affecting human health and the well-being of American citizens.

Goal 4.1 – Provide Scientific Information and Biotechnologies to Enhance Management Practices that will Ensure an Abundant Supply of Competitively Priced Animal and Aquaculture Products

National Program 101 - Animal Production
National Program 106 - Aquaculture

U.S. production systems for food animals and aquaculture face formidable challenges. One of the most exacting challenges is successful adaptation to the accelerating demands of society that impact animal productivity and product quality, including increased production, improved production efficiencies, economic and environmental sustainability, ensuring animal well-being and improved product quality and healthfulness for consumers.

The demands placed on the national system of food animal production by a rapidly changing world can only be met by technologies that optimally harness the inherent genetic potential of animal germplasm in concert with industry stakeholders. Production systems that successfully harness that genetic potential will maximize profits, secure supply, increase market competitiveness, sustain small and mid-sized producers, maintain genetic diversity and increase consumer confidence. These optimized production systems will also ensure the economic and environmental sustainability of animal agriculture while enabling production of animal products adequate to meet the dramatically increased demand for animal products worldwide.

Consequently, the overall mission of ARS animal production and aquaculture systems is to 1) safeguard and utilize animal and microbial genetic resources, associated genetic and genomic databases, and develop robust bioinformatics tools; 2) develop a basic understanding of the physiology of livestock, poultry, and aquaculture; 3) develop improved understanding of nutritional requirements for animals, particularly in aquaculture and improve the efficiency of nutrient utilization for animals; and 4) develop information, tools, and technologies that can be used to improve animal production systems, all to ensure an abundant, safe, and inexpensive supply of animal products produced in a healthy, competitive, and sustainable animal agriculture sector of the U.S. economy.

Performance Measure

1.4.1 Provide scientific information to maximize the production efficiency of our food animal production systems. Develop new technologies and tools contributing to improve those systems to meet current and future food animal production needs of diversified consumers, while ensuring economic and environmental sustainability and animal well-being.

Indicator 1: ***During 2015, ARS will identify underlying genetic and/or physiologic mechanisms relating to food animal production and production efficiencies for traits associated with growth physiology, nutrient utilization, reproductive physiology, health, and well-being in food animals.***

FY 2015 Accomplishments*:*

1. Hybrid catfish produced by manual mating of channel catfish females with blue catfish males demonstrate superior production in ponds compared to purebred channel catfish. Induced spawning of channel catfish through the use of peptides (a short string of amino acids) is the only reliable method for producing hybrid catfish embryos in hatcheries. However, the type and dose of peptides used to induce ovulation in catfish must be optimized. ARS scientists in Stoneville, MS, evaluated the efficacy of salmon gonadotropin releasing hormone analog (sGnRHa), a peptide frequently used by the catfish industry, to induce ovulation in channel catfish. The results, which were validated in five commercial hatcheries, demonstrated that 10 micrograms of sGnRHa per kilogram of body weight was the minimum effective dose to induce ovulation in channel catfish. This dose is 10 times lower than the widely used mammalian peptide currently used in catfish hatcheries.

   Impact: Catfish producers have incorporated the use of sGnRHa at the recommended dosage. This could significantly reduce the cost of hybrid embryo production and reduce the volume of hormone utilized.

2. Selection by commercial breeders for increased litter size in swine has resulted in a greater incidence of neonates exhibiting slower growth, which has resulted in an approximate loss of 300 million pounds of pork annually in the United States. Biomarkers are needed that predict postnatal growth rates at birth such that producers can maximize their investments. ARS scientists in Beltsville, MD, showed that piglets that are small at birth or that grow slowly have an increased serum level of the protein alpha 1-acid glycoprotein (AGP). A rapid and reliable assay was developed that quantifies AGP in blood from newborn pigs and can be used to demonstrate the value of AGP for predicting future growth rates in newborn pigs.

   ***Impact*:** This assay is available for predicting growth performance in commercial populations.

Indicator 2: ***During 2015, ARS will develop genomics infrastructure and tools to efficiently identify genes, their function, and interactions with environmental factors for exploitation in genome enabled improvement programs for food animals.***

FY 2015 Accomplishments*:*

1. Historically, genetic improvement for commercial turkeys has been achieved using selective breeding programs based on physically measured traits, such as body size and breast muscle development. To improve production for traits that are expensive or difficult to measure, such as those associated with immunity and reproduction, more sophisticated approaches, such as genomic selection, are needed. Genomic selection requires a large number of genetic markers such as single nucleotide

polymorphisms (SNPs). ARS scientists in Beltsville, MD, in partnership with poultry industry leaders and university collaborators, documented 5.49 million SNPs that are potential markers for genetic improvement, and used this information to develop a commercially available SNP-based assay for the turkey industry.

***Impact*:** This assay provides commercial breeders with a genomic tool on which to base state-of–the-art DNA based breeding strategies, which are particularly useful for traits that are difficult to evaluate.

2. Contemporary Atlantic salmon breeding programs in the United States have not employed genetic markers for improving important aquaculture production traits. One problem facing U.S. salmon farmers is sea lice infestations on their stock, which can cause fin damage, skin erosion, and deep open wounds in adults, or deaths in juvenile salmon. Sea lice are external parasites that attach to the salmon skin and feed on the blood of the fish. ARS scientists in Franklin, ME, and their collaborators identified salmon genetic markers that indicate resistance to sea lice. From the research, the scientists developed a panel of genetic markers to enhance contemporary breeding programs.

   ***Impact*:** A panel of genetic markers has been provided to salmon farmers for use in a commercial breeding program to increase the efficiency of selective breeding for sea lice resistance in Atlantic salmon.

Indicator 3: ***During 2015, ARS will develop and improve sustainable production systems for food animals; incorporating strategies to optimize production system efficiency while ensuring economic and environmental sustainability.***

FY 2015 Accomplishments*:*

1. Non-invasive indicators of welfare are needed to aid with on-farm welfare assessment. Having previously determined that tear staining amounts were related to stress measures, ARS researchers in West Lafayette, IN, and collaborators at the University of Helsinki, Finland, investigated tear staining in pigs housed on farms with different amounts of tail-biting damage and access to different environmental enrichments. Pigs with greater tail damage scores had higher tear staining scores and tear staining was reduced in pigs with access to multiple environmental enrichment objects.

   ***Impact*:** This measure will enable producers and auditors to identify pigs with elevated stress levels at the pen and individual animal level, and thereby carry out timely interventions to improve animal welfare.

2. Hybrid catfish grow rapidly, but not uniformly among all individual fish of the same age. It is not unusual in a pond harvest to have some individuals weighing more than five pounds, while others weight less than a pound. This type of production is undesirable as processors pay reduced prices for harvests that include both large and small fish. ARS scientists in Stoneville, MS, found that the proportion of fish above and below the processor-preferred size range at harvest decreased when fish were graded as fingerlings.

   ***Impact*:** The catfish industry has incorporated the management technique of grading fingerlings as a strategy for producing uniform populations of harvest-sized fish.

Indicator 4: ***During 2015, ARS will characterize nutrient requirements of food animals; measure nutrient availability of traditional and nontraditional feedstuffs; and develop strategies for improving nutrient use efficiency.***

FY 2015 Accomplishments*:*

1. Expansion of the biodiesel industry in the United States has increased the supply of glycerin, a sweet, liquid, non-toxic waste product of biodiesel production. Glycerin is energy dense and can be fed to cattle; however, the energy value is not known. ARS researchers in Clay Center, NE, determined that cattle feed intake decreased with increased glycerin intake. Also, cattle lost less energy in the feces as glycerin inclusion increased in the diet, meaning that glycerin was more digestible than the corn it replaced. Cattle consuming 15 percent glycerin retained the least amount of energy and nitrogen. However, a high metabolic cost associated with glycerin at greater than 10 percent was observed.

   ***Impact*:** Meeting cattle nutrient requirements with byproducts of biodiesel production provides a practical solution for optimizing animal performance.

2. Sub-therapeutic levels of antibiotics are used in swine feeds to promote growth, improve feed efficiency, and reduce susceptibility to bacterial infections. As a result, the use of antibiotics improves profitability. However, swine producers will no longer be able to administer antibiotics for growth promoting purposes starting January 2017 (FDA Guidance #213). Finding safe and effective alternatives to traditional antibiotics will give producers viable options since antibiotics. ARS researchers in Clay Center, NE, determined that feeding an antimicrobial enzyme, lysozyme, to nursery pigs was as effective as traditional antibiotics in increasing growth performance, including growth, nutrient accretion, and feed efficiency.

   ***Impact*:** These results provide a solution for gaining the performance benefits of antibiotics without the negative aspect of contributing to antimicrobial resistance

3. Changes in the composition of catfish diets and feeding regimes can alter fillet yield and composition. Companies that supply feeds to catfish producers remain competitive by identifying less expensive feed ingredients that do not negatively impact yields or product quality. ARS scientists in Stoneville, MS, in cooperation with scientists at Mississippi State University, raised catfish on diets in which soybean meal was partially replaced with cottonseed meal, corn gluten, or corn germ, which are less expensive protein alternatives. The scientists determined that approximately half the soybean meal could be replaced with these alternatives without negatively affecting meat yield or meat quality.

   ***Impact*:** This finding provides feed manufacturers with an alternative feed composition that could effectively lower feed costs.

Indicator 5: ***During 2015, ARS will characterize food animal germplasm for traits of importance and continue to increase the inventory of germplasm stored within the National Animal Germplasm Repository to preserve biodiversity.***

FY 2015 Accomplishments*:*

1. Adding additional genetic markers (single nucleotide polymorphisms or SNPs) to genotyping chips can result in genotypes that increase the accuracy of genomic evaluations. As an improved replacement for a high-density SNP chip used for genotyping dairy cattle, ARS researchers in Beltsville, MD, selected a set of more than 140,000 SNPs for inclusion into a new genotyping chip

that was put into commercial production by Neogen Corporation. ARS researchers tested 140,000 SNPs for their effect on evaluation accuracy; approximately 77,000 of the most informative SNPs were selected for use in genomic evaluations.

***Impact*:** Holstein evaluations resulted in a gain of 1.4 percentage points in accuracy. The Council of Dairy Cattle Breeding is using the 77,000 SNPs as the standard for national evaluations. These genetic evaluations are critical for identifying animals with superior genetic merit.

2. Dermo disease has serious, negative impacts on oyster production throughout the Northeast and Mid-Atlantic United States. ARS scientists in Kingston, RI, established a disease challenge model that subjected eastern oysters to Dermo disease. Subsequently, individual families which are most resistant or susceptible to this disease were identified for inclusion into selective breeding schemes.

   ***Impact*:** The research demonstrated the potential for commercial oyster hatcheries to breed for this trait in their efforts to reduce the effects of this disease and increase productivity and profitability of the shellfish aquaculture industry.

Performance Targets

4.1.A Provide scientific information to maximize the production efficiency of our food animal production systems.

Baseline 2012	Target 2017
Seven research studies on production efficiency published in peer-reviewed scientific journals that contribute evidence to improve food animal production systems.	Cumulatively, 35 new scientific papers will be published in this area of research.

4.1.B Develop new technologies and tools contributing to improved precision animal production systems to meet current and future food animal production needs of diversified consumers, while ensuring economic and environmental sustainability and animal well-being.

Baseline 2012	Target 2017
One new technologies developed and used by ARS customers to increase production efficiency and enhance the economic value and well-being of U.S. food animal production while decreasing the environmental footprint of production systems.	Cumulatively, five new technologies developed and used by ARS customers

Measure 1.4.1 Summary of the Major Technologies Developed, Transferred, and Used in FY 2015:

During FY 2015, ARS reported on four new technologies adopted for uses that provide producers with new or improved means to farm sustainably.

Describe the Technology	Describe the Transfer	Identify the Customer	Impact
New method for measuring dietary starch	Method shared in direct collaboration with end users	Commercial feed companies, feed analysis laboratories	Allows animal feed and pet food labeling to provide producers and consumers with information needed to best feed their animals
Genetic tool for turkey breeders	Developed in partnership with industry	Genotyping servicing companies, turkey breeders and producers	Enhance selection for traits which are expensive or difficult to measure
Genetic marker panel for selective breeding in Atlantic salmon	Developed in partnership with industry	Atlantic salmon breeding companies, genotyping service companies	Improved sea lice resistance in Atlantic salmon
Method to measure fish fecal particle size and durability	Publication	Fish nutrition/feed companies	Optimized fish diets to improve waste management and the quality of water in which the fish are reared

Measure 1.4.1: Provide scientific information to maximize the production efficiency of our food animal production systems. Develop new technologies and tools contributing to improved systems to meet current and future food animal production needs of diversified consumers, while ensuring economic and environmental sustainability and animal well-being.

During FY 2016, ARS will:

Identify underlying genetic and/or physiologic mechanisms relating to food animal production and production efficiencies for traits associated with growth physiology, nutrient utilization, reproductive physiology, health, and well-being in food animals.

Develop genomics infrastructure and tools to efficiently identify genes, their function, and interactions with environmental factors for exploitation in genome enabled improvement programs for food animals

Develop and improve sustainable production systems for food animals; incorporating strategies to optimize production system efficiency while ensuring economic and environmental sustainability.

Characterize nutrient requirements of food animals; measure nutrient availability of traditional and nontraditional feedstuffs; and develop strategies for improving nutrient use efficiency.

Characterize food animal germplasm for traits of importance and continue to increase the inventory of germplasm stored within the National Animal Germplasm Repository to preserve biodiversity.

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Develop genomics infrastructure and tools to efficiently identify genes, their function, and interactions with environmental factors for exploitation in genome enabled improvement programs for food animals.

Develop and improve sustainable production systems for food animals; incorporating strategies to optimize production system efficiency while ensuring economic and environmental sustainability.

Characterize nutrient requirements of food animals; measure nutrient availability of traditional and nontraditional feedstuffs; and develop strategies for improving nutrient use efficiency.

Characterize food animal germplasm for traits of importance and continue to increase the inventory of germplasm stored within the National Animal Germplasm Repository to preserve biodiversity.

GOAL 4.2 - PREVENT AND CONTROL PESTS AND ANIMAL DISEASES THAT POSE A THREAT TO AGRICULTURE, PUBLIC HEALTH, AND THE WELL-BEING OF AMERICAN CITIZENS

NATIONAL PROGRAM 103 - ANIMAL HEALTH
NATIONAL PROGRAM 104 - VETERINARY, MEDICAL AND URBAN ENTOMOLOGY
NATIONAL PROGRAM 106 - AQUACULTURE

Investments in animal protection research are critical to the growth and resilience of the supply of food for tomorrow and feed the future initiatives. Enhancing the health of animals in agricultural production systems will directly impact food quality and ensure a sufficient supply of macro and micro-nutrients to meet people's basic needs worldwide. When combined with other investments in agricultural development, research-based innovations will address some of the fundamental constraints that give rise to food insecurity by reducing production risks associated with pests and diseases.
Achieving results in animal protection research in the 21st century will demand a systems biology approach in which knowledge obtained from animal genomes, functional genomics, clinical trials, and epidemiology are integrated in the discovery and development of countermeasures for preventing and controlling disease outbreaks.

Entomological research will concentrate on priority problems affecting animal production, human health, and the well-being of American animals and citizens. The research aims to dedicate 30 percent of resources to basic research that provides relevant information about target pests and 70 percent to applied research and product development. The program seeks to attain a balance of skills among its scientists so that it can take full advantage of the latest developments in biology at the same time as applying its efforts to solution of practical problems.

Accordingly, the goal of the ARS animal protection research programs is to protect and ensure the safety of the Nation's agriculture and food supply through improved disease detection, prevention, control, and treatment. Basic and applied research approaches will be applied to solve animal health problems of high national priority. Emphasis will be given to methods and procedures to control animal diseases through the discovery and development of:

- Diagnostics and tools for identification of pests/vectors
- Vaccines
- Biotherapeutics
- Pesticides, repellents, attractants, traps, and other innovative products for pest/vector control
- Animal, pest, and vector genomics applications
- Disease management systems and integrated pest/vector management systems
- Animal disease models
- Farm biosecurity measures
- Applications of global information systems
- Chemical ecology of pests and vectors

Animal protection national programs have eight strategic objectives:

1. Develop an integrated animal, arthropod, and microbial genomics research program
2. Launch research programs to provide alternatives to antibiotics in food animal production
3. Build a technology-driven vaccine and diagnostic discovery research program
4. Develop core competencies in field epidemiology and predictive biology
5. Develop expert collaborative research laboratories recognized by the World Organization for Animal Health (OIE) and the United Nation's Food and Agriculture Organization (FAO)
6. Develop a model technology transfer program to achieve the full impact of our research discoveries
7. Perform the full spectrum of research for improvement of veterinary, public, and military entomology
8. Develop safe and effective methods for prevention of damage caused by arthropods to homes and households

Performance Measure

4.4.2 Provide scientific information to protect animals, humans, and property from the negative effects of pests and infectious diseases. Develop and transfer tools to the agricultural community, commercial partners, and government agencies to control or eradicate domestic and exotic diseases and pests that affect animal and human health.

Indicator 1: ***During 2015, ARS will describe 5 new discoveries or developments significant for their scientific or applied value.***

FY 2015 Accomplishments*:*

1. Diseases are a major cause of casualties during military operations, greatly outnumbering injuries and death from battle injuries. ARS scientists in Gainesville, FL, conducted a Good Laboratory Practice study that generated data on etofenprox treatment of U.S. military clothing. The data were reported to the EPA in July 2015. Registration of this product, which protects the clothes wearer from bites of mosquitoes and other arthropods, is expected in July 2016. Use of the product is expected to be extended to civilian clothing.

   ***Impact*:** Etofenprox will be the only alternative to permethrin for arthropod repellent for clothing. It will be the only treatment available for use on undergarments and clothing made of multiple fabric types. The protocol used for this study will become an EPA guideline for the future registration of repellent-treated clothing.

2. Protection of U.S. military personnel from bites of disease-carrying arthropods is important to the success of military operations. ARS researchers in Gainesville, FL, demonstrated that a reduction in adult mosquitoes could be achieved by aerial-applied insecticide treatment of U.S. military blast walls containing geotextile material and radar scattering camouflage netting.

   ***Impact*:** Significant improvement in adult mosquito death after release of the pesticides pallethrin and sumithrin at times of the day when adult mosquitoes were present in highest numbers. Provided evidence that existing models of spray deposition used to guide aerial applications of pesticides in the United States do not adequately represent actual spray deposition, and may be improved to reduce pesticide use and better track the fate of sprayed pesticide droplets. These findings will be integrated into future versions of the Mobile Pesticide App,

3. Discovering why some Avian Influenza vaccines fail is critical in protecting birds, animals, and people in developing countries like Indonesia where the H5N1 highly pathogenic avian influenza virus has become endemic. Indonesia has implemented a vaccination program, but some of its commercial vaccines have failed to protect poultry. An international collaboration of government officials, regulators, and a team of scientists from ARS, investigated outbreaks in Indonesian flocks that were vaccinated. The team evaluated 14 Indonesian licensed vaccines to identify the seed strain—type of virus—included in the vaccines and variant field viruses to find out why these vaccines were failing. The results of this study showed that 11 of the 14 vaccines contained the manufacturer's listed vaccine seed strains, but 3 vaccines contained different seed strains than the ones listed on the label. Scientists immunized chickens with each of the 14 vaccines and found that protection varied greatly. Tests showed some vaccines contained a lot of antigens and some had only a little. The antigen, a protein from the virus, allows birds to produce antibodies to build up immunity. Vaccinated birds were challenged with three different field viruses. All vaccines protected against one of the viruses, some protected against the second virus, and none protected against the third.
   ***Impact*:** This research demonstrated the need to evaluate vaccines often and replace vaccine seed strains with more effective ones as new field viruses emerge that are resistant to older vaccines. Improving vaccines and ensuring they work not only helps control avian influenza outbreaks, but also adds new vaccines to the U.S. emergency stockpile.

4. The high prevalence of brucellosis in free-ranging wildlife in the Greater Yellowstone Area (areas surrounding Yellowstone National Park) pose a risk for reintroduction of disease to cattle. Over the last 15 years, approximately 25 cattle herds have been infected with brucellosis in the Greater Yellowstone Area. In collaboration with scientists from the University of Wyoming, ARS researchers evaluated the efficacy of single, double, or triple vaccinations with RB51 and compared protection against experimental challenge to animals that had not been vaccinated (controls). The results of

this study indicates that booster vaccination of cattle prevented abortion and reduced infection with animals receiving two or three vaccinations demonstrating greater protection.

***Impact*:** This study demonstrated that booster vaccination of cattle with RB51 will provide a high degree of protection against brucellosis and be an effective strategy for implementation in the brucellosis eradication program.

5. African swine fever virus (ASFV) is the etiological agent of a contagious and often lethal disease of domestic pigs that has significant economic consequences for the swine industry. The control of African Swine Fever (ASF) has been hampered by the unavailability of vaccines. ASFV is one of the largest virus known, and the function of most of the viral genes are unknown. Experimental vaccines have been developed using genetically modified-live attenuated ASFV where viral genes were removed from the genome. However, to date, none of these viruses have proven to be fully safe or effective. ARS scientists have engineered a recombinant virus by specifically deleting six genes thought to be associated with virulence. Studies conducted in pigs showed that when this recombinant virus was inoculated in pigs, the virus was completely attenuated and did not cause disease. Importantly, when these animals were subsequently exposed to highly virulent ASFV strain, no signs of the disease were observed.

   ***Impact*:** This is the first report demonstrating the role of specific genes acting as independent determinants of ASFV virulence. Additionally, this is the first experimental vaccine reported to induce protection when challenged against this very virulent strain.

Indicator 2: ***During 2015, ARS will form new partnerships and continue old partnerships with industry, universities, and other government agencies in order to promote production and marketing of new methods for detection and identification of animal pathogens, arthropods that transmit pathogens, and arthropods that destroy property; including genetic markers, new methods of detecting gene sequences or antibodies or proteins, and comprehensive guides to morphological identification.***

FY 2015 Accomplishments*:*

1. Horn flies bite cattle, horses, bison and other livestock, resulting in pain to the animal, decreased lactation rates in cattle, and reduction in growth for calves. The genome of an organism is a master template that guides its development, metabolism, and responses to environmental perturbations, and determines the organism's success within its ecosystem. ARS scientists in Kerrville, TX, in collaboration with researchers at the National Center for Genome Resources in Santa Fe, NM, completed the sequencing of the horn fly genome. The genome sequence will be computationally assembled and annotated to identify the full complement of genes that make up the horn fly.

   ***Impact*:** Knowing the gene sequences of the horn fly will facilitate the development of new fly control technologies by enabling the identification of specific gene products that can be targets for new insect specific pesticides and anti-fly vaccines.

2. Five years after the initial release of the arundo wasp (*Tetramesa romana*), ARS researchers in Kerrville, TX, have shown that the wasp has thinned out the amount of Giant Cane by 22 percent along the 558 miles of river between Del Rio and Brownsville, TX.

   ***Impact*:** Giant Cane reduction has resulted in significant water conservation (6,000 acre-feet per year), improved visibility of the international border for U.S. Customs and Border Protection agents,

and better access and visibility for mounted patrol inspectors with the USDA-APHIS Cattle Fever Tick Eradication Program.

Indicator 3: ***During 2015, ARS will form new partnerships and continue old partnerships with industry, universities, and other government agencies in order to promote production and marketing of inventions that protect animals from pathogens or manage arthropods that transmit pathogens or damage property.***

FY 2015 Accomplishments*:*

1. The Agricultural Research Service (ARS) developed, in record time, an effective vaccine against the highly pathogenic avian influenza (HPAI) virus strains that caused the death of over 45 million chickens and turkeys in the United States in 2015. Although these HPAI viruses were not the cause of any human deaths, concerns remain that these viruses could mutate and become more harmful. Vaccines constitute a critical veterinary medical countermeasures to respond to biological threats such as avian influenza viruses. Currently, no vaccines for HPAI are licensed or permitted in the United States. The use of HPAI vaccines is dependent on our ability to rapidly develop vaccines with good efficacy against the virus strains that are the cause of the disease outbreak. In response to the first detections of new HPAI viruses (H5N8 and H5N2) in wild waterfowl and captive raptors in the United States in December 2014, ARS refocused its entire team of scientists working on avian influenza research to the most imminent research needs to address the U.S. outbreak, including the rapid development of a vaccine for emergency use. Within weeks, ARS scientists rapidly engineered a vaccine (rg-H5 vaccine) using reverse genetics technology that matches the H5N2 and H5N8 HPAI viruses that was the cause of the disease outbreak. The power of the reverse genetics technology is twofold. First, it allows the manipulation of the genes to change the hemagglutinin (HA) gene from its typical amino acids to having a sequence similar to other Low Pathogenic Avian Influenza (LPAI) viruses. This allows the change of a HPAI virus into a LPAI virus for safe production without affecting the efficacy of the vaccine virus. The second factor is that it allows the creation of a unique vaccine virus by swapping the HA gene with the one that matches the HA genes causing the disease outbreak.

   ***Impact*:** ARS developed and implemented in record time a technology transfer plan that enabled the transfer of the rg-H5 vaccine to a commercial partner for development and production.

2. Medication of poultry feed with ionophore drugs or synthetic chemicals represents a major way to control avian coccidiosis in the poultry industry. However, this approach has become less efficacious because of drug-resistance in *Eimeria* parasites. While there are several different anti-coccidial drugs available, it is impossible to know ahead of time which drug to use on a particular farm because there are no rapid tests for estimating drug-sensitivity in the resident *Eimeria* population. ARS researchers developed an in vitro cell culture assay that utilizes chicken cells inoculated with the parasite in the presence or absence of ionophore drugs. The effect of these drugs on parasite invasion and development was measured by using microscopy or molecular methods, which indicate that in vitro cell culture constitutes a viable, rapid, and less costly alternative to evaluating drug-sensitivity a broiler house.

   ***Impact*:** Development of an in vitro drug-sensitivity test for *Eimeria* will benefit poultry companies and poultry farmers by knowing which anti-coccidial drugs to use to prevent avian coccidiosis outbreaks.

3. Vaccination is an important method used to help prevent the spread of infectious poultry diseases; however, certain vaccines need to be improved to make them safer and more effective. ARS scientists have developed a novel vaccines to help reduce virulent and virus shed—excretion of virus by the host—and disease transmission from infected birds to healthy ones. This novel vaccine was shown to protect chickens against infectious laryngotracheitis virus (ILTV) and Newcastle disease virus (NDV), two of the most economically important infectious diseases of poultry. Both viruses cause sickness and death in domestic and commercial poultry as well as in some wild birds throughout the world. While current ILTV live-attenuated vaccines are effective, some of the viruses used to make them can regain virulence—causing chickens to become chronically ill. Other types of vaccines can protect birds from the disease's clinical signs, but barely reduce the virus shedding in their respiratory secretions after infection. In that sense, those vaccines are not that effective, because they do not reduce the risk of virulent ILTV transmission to uninfected birds. With the support of the ARS Office of Technology Transfer, this novel vaccine is currently under development under a collaborative agreement with a commercial partner.

   ***Impact*:** ARS scientists have developed a novel vaccine effective against ILTV and NDV that has the potential of improving the prevention and control of these important diseases on U.S poultry farms.

Performance Targets

4.2.A Provide scientific information to protect animals, humans, and property from the negative effects of pests and infectious diseases.

Baseline 2012	Target 2017
Seven research studies that had significant impact on the scientific community and/or will lead to new technologies for protection of humans, property, and livestock from harm due to pests or diseases.	Cumulatively, 35 new scientific papers will be published in this area of research.

4.2.B Develop and transfer tools to the agricultural community, commercial partners, and government agencies to control or eradicate domestic and exotic diseases and pests that affect animal and human health.

Baseline 2012	Target 2017
One technology used by the commercial and/or government sectors relevant to the protection of humans, property, and domestic animals.	Cumulatively, transfer five technologies to the commercial and/or government sectors.

Measure 4.4.2 Summary of the Major Technologies Developed, Transferred, and Used in FY 2015:

During FY 2015, ARS reported on six new technologies adopted for uses that provide tools for controlling pests and animal diseases

Describe the Technology	Describe the Transfer	Identify the Customer	Impact
Etofenprox-treated clothing	Study completed for US EPA Registration of a new arthropod repellent for clothing	DOD personnel and U.S. civilians	New clothing repellent which provides a high level of bite protection through 75 washings
Sequencing of the horn fly genome	Developed in partnership with the National Center for Genome Resources	Pest control companies, genotyping service companies	Potential new fly control technologies and vaccines based on specific gene products
Improved insecticide-treated barrier for the U.S. military	Integration of study results into mobile pesticide app	DOD and pesticide applicators	Improved mosquito control and increased understanding of pesticide application
Use of Arundo wasp to control invasive giant cane plants	Completed study that demonstrates efficacy of this approach	Customs and Border Patrol, APHIS	Improved water conservation, control of an invasive plant species
rg-H5 avian influenza vaccine	Developed an effective vaccine and transferred the vaccine to a commercial partner	Commercial partner	Developed and successfully transferred an AI vaccine to a commercial partner in response to the 2014-2015 HPAI outbreak
Newcastle virus-vectored ILTV vaccine	This novel vaccine is currently under development under a collaborative agreement with a commercial partner	Commercial partner	Development of an improved vaccine for NDV and ILTV that is safer and more effective

Measure 4.4.2.: Provide scientific information to protect animals, humans, and property from the negative effects of pests and infectious diseases. Develop and transfer tools to the agricultural community, commercial partners, and government agencies to control or eradicate domestic and exotic diseases and pests that affect animal and human health.

During FY 2016, ARS will:

Describe 5 new discoveries or developments significant for their scientific or applied value.

Form new partnerships and continue old partnerships with industry, universities, and other government agencies in order to promote production and marketing of new methods for detection and identification of animal pathogens, arthropods that transmit pathogens, and arthropods that destroy property; including genetic markers, new methods of detecting gene sequences or antibodies or proteins, and comprehensive guides to morphological identification.

Form new partnerships and continue old partnerships with industry, universities, and other government agencies in order to promote production and marketing of inventions that protect animals from pathogens or manage arthropods that transmit pathogens or damage property.

During FY 2017, ARS will:

Describe 5 new discoveries or developments significant for their scientific or applied value.

Form new partnerships and continue old partnerships with industry, universities, and other government agencies in order to promote production and marketing of new methods for detection and identification of animal pathogens, arthropods that transmit pathogens, and arthropods that destroy property; including genetic markers, new methods of detecting gene sequences or antibodies or proteins, and comprehensive guides to morphological identification.

Form new partnerships and continue old partnerships with industry, universities, and other government agencies in order to promote production and marketing of inventions that protect animals from pathogens or manage arthropods that transmit pathogens or damage property.

During FY 2018, ARS will:

Describe 5 new discoveries or developments significant for their scientific or applied value.

Form new partnerships and continue old partnerships with industry, universities, and other government agencies in order to promote production and marketing of new methods for detection and identification of animal pathogens, arthropods that transmit pathogens, and arthropods that destroy property; including genetic markers, new methods of detecting gene sequences or antibodies or proteins, and comprehensive guides to morphological identification.

Form new partnerships and continue old partnerships with industry, universities, and other government agencies in order to promote production and marketing of inventions that protect animals from pathogens or manage arthropods that transmit pathogens or damage property.

Appendix A:
Strategic Consultations & Inter-Agency Working Groups

ARS regularly consults with external groups – from customers to policy experts, to industry and consumer groups – about the effectiveness of its programs and the need for improvement. While many of these consultations are not conducted expressly for the purpose of the strategic plan, they influence strategic goals, objectives, strategies, and targets. ARS Associate Administrators, Deputy Administrators, and National Program Leaders serve on many committees, taskforces and inter-agency working groups where they lend their expertise to solving agricultural problems on both a domestic and global scale.

ARS Inter-Agency Working Group Participation

Group name	Sponsoring Organization	Brief purpose
Academy of Finland	USDA/Finland	Collaborate on food safety research; share food safety information
ADODR on Confidentiality Agreements	Food Companies	To discuss mutual interests related to functional foods
Agricultural Air Quality Task Force	Chief of NRCS, Office of the Secretary	FACA dealing with air quality, climate change and sometimes bioenergy research & policy
Agricultural Trilateral Working Group Pakistan, Afghanistan (NEW)	FSA	To promote food security for Pakistan and Afghanistan in partnership with USDA
Air Quality Research Subcommittee	CENR	Federal agency information sharing
Alternative Feeds for Aquaculture Initiative	USDA/NOAA	Spur progress in development of aquaculture feedstuffs not reliant on marine pelagic fisheries
American Bakers Association	ABA	To exchange information and assess industry research needs and priorities.
American College of Veterinary Preventative Medicine	AVMA	board certification association for veterinary preventive medicine- I'm a diplomat
American Leather Chemists Association	ALCA	To share information and assess priority needs of the hides and leather industries
American Meat Science Association	Meat and Livestock Industry and Universities	Coordinate public research in meat quality, and safety
American Society of Microbiology	ASM	share microbiologic information
American Veterinary Medical Association	AVMA	sharing of information on veterinary medicine
AMI Scientific Steering Committee	American Meat Institute (AMI)	Set research priorities and review grants
AMI, NCBA, AMI, Pork Board, UFFV,	Commodity	Exchange information on priorities
APHIS Plant Protection and Quarantine Board of Advisors	USDA, APHIS, PPQ	Coordination and Customer Needs for APHIS PPQ
APHIS Research Priorities Steering Committee	APHIS, ARS, NIFA	Interagency Coordination
APHIS Technical Advisory Group for Biological Control Agents for Weeds	APHIS	Provide Technical guidance to APHIS on risks associated with biological control agent releases
Aquatic Nuisance Species Task Force	Federal Interagency	Provide Technical Guidance to Federal Invasive Species Response (Aquatic Nuisance Species)
Armed Forces Pest Management Board	DoD	Consultant
ARS Liaison to FSIS Biosecurity Division	USDA	Coordinates biosecurity related research conducted for DHS or FSIS by ARS. Assist in conducting Carver-Shock analysis on biosecurity agents
ARS MOU with DMI, Inc.	DMI, Inc.	To cooperate in developing innovative new products to expand markets for U.S. dairy producers and processors

ARS Inter-Agency Working Group Participation		
Group name	**Sponsoring Organization**	**Brief purpose**
ARS MOU with the United Soybean Board	United Soybean Board	To improve coordination between the two organizations to better leverage resources applied to the research necessary to develop value-added non-food, non-feed, products using soybeans as a feedstock
ARS partnership with DMI, Inc., the National Dairy Council, and the Department of Defense, Combat Feeding	DMI, Inc.	Designed to leverage government, industry and university resources to greater overall effectiveness and efficiencies, increase collaboration, and help to achieve a more profitable dairy industry
Asian Tiger Mosquito Areawide IPM Project	ARS	Coordination and consultant
ASM Steering Committee for Research Colloquium	American Society of Microbiology (ASM)	To occur in 2011 on Meeting Global Water Needs (includes food safety)
Association of Public Health Veterinarians	AVMA	Communicate public health information among veterinarians working in state, local and federal govt
BEP Animal Health Initiatives	ARS, DoS	Scientific Diplomacy
Biobased Products and Bioenergy Coordination Council	REE Undersecretary	The Biobased Products and Bioenergy Coordination Council (BBCC) was established by the Secretary of Agriculture to provide a forum through which USDA agencies will coordinate, facilitate and promote research, development, transfer of technology, commercialization, and marketing of biobased products and Bioenergy using renewable domestic agricultural and forestry materials. This includes promoting information sharing, strategic planning and providing policy advice to the Secretary. (see www.ars.usda.gov/bbcc)
Biochem 20/20	Contractor	Biosecurity
Biodefense Backstopping	subPCC - DoD	Coordinate International collaborative efforts in developing countries
Bioenergy Crop Assistance Program (BCAP) Project Area Selection Criteria Working Group	Farm Service Agency	BioEnergy Science Team assisting FSA in developing science-based criteria for evaluation BCAP proposals
Biofuels Sustainability Criteria and Indicators Sub-committee	Biomass Research & Development Board	Develop criteria and indicators for sustainable biomass production
Biological Threat Reduction Program	DOD	Coordinate international collaborative efforts to enhance the development of a veterinary infrastructure and animal health research in developing countries
Biomass Conversion Interagency Working Group	Biomass R&D Initiative Board	coordinate Federal-wide efforts in support of converting ligno-cellulosics to fuels
Biomass R&D Board - Environmental Health & Safety	Congress/EPA/USDA	Identify EH&S hazards and benefits related to practices and technologies of components of the biofuels supply chain
Biosurety working group	NSABB	Advise federal government on developing personnel reliability standards
Biotechnology Coordinating Committee	Across USDA	Consistent communication regarding Biotech w/in USDA
Borlaug Global Rust Initiative	USDA, CG Centers, Gates Foundation, multiple wheat growing countries	Address Ug99 and other virulent wheat stem rusts
Cattle Fever Tick Eradication Program	APHIS	Coordination of research and operations
CBRN Countermeasures	Federal	Biosecurity Research
CEAP Working Group	NRCS	coordinate grazingland CEAP activities
Citrus Greening Coordinating Group	ARS, APHIS, Florida Citrus Mutual	To coordinate research to combat citrus greening disease in cooperation with APHIS, University collaborators, and IFAS.

ARS Inter-Agency Working Group Participation		
Group name	**Sponsoring Organization**	**Brief purpose**
Citrus Greening Research Planning Taskforce	ARS	Plan national research programs to develop and implement management strategies for citrus greening and canker.
Classified Life Sciences Research Interagency Working Group	ARS, HHS, DHS, NIH, CDC, USAF, OSTP, FPA, FSIS	To coordinate interagency activities related to classification of research.
Climate Change Carbon Cycle Interagency Working Group	US Climate Change Science Program	Info sharing, research coordination
Climate Change Ecosystems Interagency Working Group	US Climate Change Science Program	Info sharing, research coordination
Climate Change Land Use/Land Cover Interagency Working Group	US Climate Change Science Program	Info sharing, research coordination
Climate Change North American Carbon Project Steering Committee	US Climate Change Science Program	Research coordination
Climate Change Water Cycle Interagency Working Group	US Climate Change Science Program	Info sharing, research coordination
Codex Alimentarius	Codex- FDA coordinating US group	Intergovernmental Task Force on Antimicrobial Resistance
Colony Collapse Disorder Steering Committee	ARS	Coordination of research for Colony Collapse Disorder.
Combase	USDA/FSA-UK	Collaborate on food safety research: share food safety information
COMEXA (Comision Mexicano-Estados Unidos Para La Eradicacion del Gusano Barrenador de Ganados)	APHIS	Coordination
Committee on Environment, Natural Resources, & Sustainability (CENRs) Subcommittee on Water Availability & Quality (SWAQ)	OSTP (USGS and EPA are co-leads)	Coordinate water activities across all Federal agencies with water missions.
COPEG (Comision Panameno-Estados Unidos Para La Eradicacion del Gusano Barrenador de Ganados)	APHIS	Coordination
Core Group	Office of Pest Management Policy (USDA ARS) (participants include all USDA agencies involved in pesticide research or policy development)	Provide coordination of pesticide related issues across USDA
CRWG committee on Practices for Enhancing Personnel Reliability and the Culture of Responsibility in High Containment Labs	Interagency	Evaluate standards for personnel for high containment laboratories
Department of Defense Biological Threat Reduction Program (BTRP) Review	DoS, DoD, HHS, and USDA	Interagency Coordination
Deployed Warfighter Protection Program	DoD	Coordination of research and development
DHS AG/Food Sub IPT	Interagency	Coordination of research and development
DHS Chemical-Biological Capestone IPT	Interagency	Coordination of research and development

ARS Inter-Agency Working Group Participation		
Group name	**Sponsoring Organization**	**Brief purpose**
DHS S&T Chemical Countermeasures	USDA	The mission of the committee is to enhance and coordinate the nation's capability to anticipate, prevent, and protect, respond to and recover from chemical threat attacks through innovative research, development, and transition capabilities. Specific focus NSTC Task Force on Non-Traditional Chemical Agents: Research and Development Plan
DHS/NTA	USDA	The committee identifies and evaluates food and water capability, and countermeasure gaps for non-traditional agents (NTAs)
DHS-OMB-MAX	USDA	3 groups: Coordinating Homeland Security Science and Technology; Agriculture; and Rapid Detection Working Group
Diabetes Mellitus Interagency Coordinating Committee	NIH	Provide input on plans for research/treatment/education of diabetes
Dietary Guidance Working Group	USDA	Review federal nutrition publications for compliance with Dietary Guidelines for Americans
USDA Combined Drought and Water Team	USDA	Coordinate drought research, monitoring, and water-based decision making in USDA; advise Sec'y and agencies.
Dual Use Research working group	NSABB	Advise federal government on developing Dual use research guidelines
EFSA Scientific Colloquium on Assessing HealthBenefits of Controlling Campylobacter in the Food Chain ASM Research Colloquium on Global Food Safety	EFSA	Provide guidance on potential interventions in poultry for Campylobacter
EU-US Safe Food	EC	Share food safety information
FADT Subcommittee, Veterinary Countermeasures	ARS, DHS, APHIS, EPA, DoD	IWG
Fed Emergency Response Network	Federal	Coordinate Emergency responses to biosecurity: methods validation
Federal Experts Security Advisory Panel (FESAP)	Interagency	Security of Select Agent Policies
Federal Interagency Committee for Management of Noxious and Exotic Weeds (FICMNEW)	Federal Interagency	Provide Technical Guidance to Federal Invasive Species Response (Weeds)
Federal Interagency Committee on Invasive Terrestrial Animals and Pathogens (ITAP)	Federal Interagency (USDA and DOI Co-Chair)	Provide Technical Guidance to Federal Invasive Species Response (Invertebrates, Vertebrates, Plant and Animal Pathogens)
Federal-State Potato Research Program	ARS-National Potato Council	To conduct research on emerging pests of potato in a Federal-State partnership to address high priority areas
Feedstock Production Interagency Working Group, Genetic Improvement	Biomass Research & Development Board	Develop Interagency Strategic Plan for Bioenergy
Food Allergy Clinical Guidelines Coordinating Committee	NIAID	Oversee process of developing guidelines on food allergy
Food Defense R&D Interagency Committee	USDA	Coordination of Food Defense research and development between DHS, USDA, HHS, and any other pertinent agencies
Foreign Animal Disease Threat (FADT) Subcommittee, Basic Research Working Group	ARS, NSF, DHS, HHS	IWG
Foreign Animal Disease Threat Subcommittee	NSTC	Coordinate Foreign Animal Disease countermeasures and research
Forest Service	Forest Service	Interagency Coordination

ARS Inter-Agency Working Group Participation		
Group name	**Sponsoring Organization**	**Brief purpose**
FSU Animal Health Initiatives	ARS, DoS	Scientific Diplomacy
Garden Rose Council	Rose Nursery industry	To coordinate research efforts to address issues of high priority to the Garden Rose industry
Global Change Task Force	Office of Chief Economist	Information sharing among USDA agencies with climate change activities
Global Foot-and-Mouth Disease Research Alliance (GFRA)	ARS, APHIS, DHS	Global Foot-and-Mouth Disease Research Alliance to support FAO/OIE global control and eradication initiative
Global Health Initiative (GHI) Interagency Research Committee	ARS, NIH, CDC, NIFA, OSTP	1. To identify several high-impact research questions and potential "game changers" in global health; 2. To determine how the GHI Interagency Research Committee (IRC) can facilitate GHI plus partner country implementation of GHI's Principle #7, "Promote Research and Innovation;"3. To identify how individual agencies/initiatives can align current and planned global health research efforts to advance GHI principles and targets;
Global Research Alliance on Agricultural Greenhouse Gases		To bridge gaps in research on agricultural greenhouse gas emissions, and to coordinate such research on an international scale, ensuring that scientists share their findings with research communities and farmers in other countries as well as their own. Shafer is international Croplands coordinator
Global Water Cycle Interagency Work Group	Climate Change Science Program (CCSP)	Develop new, innovative science concepts to incorporate into the CCSP global water cycle science plan
Human Nutrition Coordinating Committee	USDA	Share information among USDA agencies whose mission includes nutrition-chaired by ARS
Human Studies Review Board	EPA	Expert consultation
ICT-Prague`	USDA/Czech Republic	Collaborate on food safety research; share food safety information
ILSI Carbohydrates Committee	International Life Sciences Institute	Focus on issues of importance to food industry
Implementation Team for Joint China National Energy Administration (NEA)-DOE-USDA MOU	Foreign Agricultural Service	Implement Joint NEA-DOE-USDA MOU for advanced biofuels production research.
Informal interagency group for responding to OIG study on USDA control of genetically-engineered crop holdings	Office of the Secretary, APHIS, ARS	Developed USDA-wide response to OIG study of how USDA managed holdings of genetically-engineered crops
Informal interagency group on OECD biosecurity and biobanks	State Department	Develops US government positions on OECD developed guidelines for biological resource center and related topics
Inter Agency Residue	Federal	Share food safety information
Interagency Cross-Cutting Group on Climate change and Human Health	USGCRP (OSTP)	Develop priorities, outreach, and strategies for adaptation to climate change
Interagency Feedstock Production Working Group	Bioenergy R&D Initiative Board	co-chair, Identify research needs and make recommendations
Interagency Grazinglands Working Group	USDA (ARS & NIFA)	Coordinate grazingland activities between USDA & DOI
Interagency Native Plant Conservation Alliance (PCA)	DOI	Promote & develop interagency and private partnerships
Interagency Water Working Group	State Department	Coordinate federal water agencies/international focus
Interagency Working Group on Climate Change and Public Health	EPA, NIH	Coordination

ARS Inter-Agency Working Group Participation		
Group name	**Sponsoring Organization**	**Brief purpose**
Interagency Working Group on Domestic Animal Genomics	OSTP	Review progress, needs & opportunities in animal genomics research
Intergovernmental Risk Assessment Consortium	All Federal agencies- FDA runs it	Share information on risk assessment
Intergovernmental Select Agents and Toxins Technical Advisory Board	Interagency	Interagency Coordination
International Association for Food Production	IAFP	sharing information on food safety and science issues- yearly meeting and journal
International Bioengagement Program	subPCC- State Department	Coordinate international collaborative animal health research and biosafety activities
IR-4	USDA, NIFA, and ARS (participants include university researchers and crop industry reps,)	Generate data needed to develop research data to support new EPA tolerances and labeled product uses for minor crops (specialty crops)
IWG Molecular Vaccines	DoD, ARS, NIH, FDA	IWG
IWG on Prion Science	NIH, ARS, APHIS, EPA, NSF	IWG
JCR: Food Agriculture Sector, DHS Team	DHS	Biosecurity
Joint Subcommittee on Aquaculture	OSTP	Coordination of Aquaculture activities across federal agencies
Judicious Use of Antibiotics	USDA	Development of action and research goals
Methyl Bromide Alternatives Outreach Conference Program Committee	ARS, EPA, and industry	To plan and organize the annual International Methyl Alternatives and Emissions Control Research Outreach Conference
Methyl Bromide Quarantine taskforce (NEW)	State /EPA/USDA	To provide technical input to State/EPA policy makers on methyl bromide quarantine issues.
Methyl Bromide Technical Options Committee [MBTOC]	United Nations Environmental Programmes	Provide technical input to the signatories of the Montreal Protocol.
Microbe Project Inter- Agency Working Group	Federal	Genomics of organisms
MOST-SJTU	USDA/China	Collaborate food safety Res
MOU with GIPSA/FGIS	GIPSA/FGIS	To address the research priorities of GIPSA/FGIS in development measurement technologies for grain quality
National Barley Improvement Committee/American Malting Barley Association	Barley producers/industry	Barley stakeholder groups
National Berry Crop Initiative	Berry industry (ARS and NIFA participate)	To coordinate industry efforts to address issues of importance, including research, to the berry industry.
National Clean Plant Network	APHIS	Protects U.S. specialty crop agriculture and the environment from the spread, through asexual propagation, of targeted plant pathogens and pests that cause economic damage
National Coalition for Childhood Obesity Research	HHS	Collaboration among USDA, NIH, CDC and Robert Wood Johnson Foundation on prevention of childhood obesity
National Corn Growers Assoc./USDA Corn Germplasm Committee	Corn producers/industry	Corn stakeholder group
National Culture Collection Initiative	American Phytopathological Society	Develop a National System for Preservation and Distribution of Plant-associated Microbes
National Dairy Research Program	Dairy Management Inc., USDA (ARS and NIFA), HHS (National Institutes of Health) and DOD	Coordinate research on issues of importance to the dairy industry

ARS Inter-Agency Working Group Participation		
Group name	**Sponsoring Organization**	**Brief purpose**
National Dairy Research Program, Dairy Management	ARS/NIH/DoD	Partnership to advance research on nutrition and food processing issues of concern to the dairy industry.
National Environmental Protection Act Interagency Working Group	EPA	Info sharing, training
National Grape and Wine Initiative	National Grape and Wine Initiative (participants include representatives from table grape, raisin, wine, and juice sectors of the grape industry, ARS, NIFA, Extension, universities)	Identify industry needs that can be addressed through agricultural research, identify resources for the research, coordinate and conduct the research, transfer new knowledge and technologies from researchers to the industry
National Meeting Program Planning Committee for Plant Breeder Coordinating Committee	Several	Planning 2009 annual meeting at the Monona Terrace Convention Center in Madison, Wisconsin
National Oat Improvement Committee	Oat producers, industry	Oat stakeholder group
National Plant Breeding Coordinating Committee	NIFA	Support of plant breeding
National Plant Disease Recovery System	ARS and Land Grant University Institutions, DHS	As directed by HSPD-9, ARS is lead institution to develop a National Plant Disease Recovery system to respond to intentional and/or natural plant disease outbreaks.
National Plant Germplasm Coordinating Committee	ARS, NIFA, ESCOP	Communicates the value of the National Plant Germplasm System and strives to enhance its support
National Science and Technology Council	Chair – Ann Mills, Deputy Under Secretary for NR&E	Information exchange between Federal agencies on ecosystem services research, programs, and projects.
National Sclerotinia Intitiative	ARS with United Soybean Board, National Sunflower Association, National Canola Association, Peanut Council	To conduct research in partnership with Universities to address white mold related diseases and disorders.
National Sorghum Producers Assoc./USDA Sorghum Germplasm Committee	Sorghum producers, industry, researchers	Sorghum stakeholders
National Swine Improvement Federation	Swine Industry and Universities	Coordinate public swine genomics research and develop infrastructure to incorporate genomics information into the swine genetic evaluation system
National Vegetable Crops Initiative	NIFA	To develop a strategic plan for the continued growth and sustainability of vegetable crop production in the United States.
National Wheat Improvement Committee/National Association of Wheat Growers	Wheat industry, producers, researchers	ARS provides information on the funding needs of the wheat quality labs to the National Improvement Committee to be considered for recommendation to the National Association of Wheat Growers among their legislative priorities
NIDDK Advisory Council	NIDDK	Provide advice to NIDDK director -ARS is one of three ex officio agencies represented (DoD and VA are others)
NIFA	NIFA	Interagency Coordination
NIFA Grant Award External Steering Committee	Kansas State University	Provides scientific and stakeholder input
NIFA/ARS Biotech Risk Assessment Grants Program	ARS, NIFA	Biosafety research grant management and ARS/NIFA coordination
NIFA-FSRRN	USDA	Share food safety information
NIH Nutrition Coordinating Committee	HHS, NIH	Information sharing among NIH Institutes and other federal agencies conducting nutrition research.

ARS Inter-Agency Working Group Participation		
Group name	**Sponsoring Organization**	**Brief purpose**
NIH Trans-Agency Complementary and Alternative Medicine Coordinating Committee	NCCAM	Share information on complementary and alternative medicine research in federal government
Northwest Small Fruit Research Center	Northwest Center for Small Fruit Research	To coordinate high impact research which is responsive to the needs of the small fruit and nursery industries in the Northwest US
NSABB (National Science Advisory Board for Biosecurity)	Interagency	Coordination
NSABB Personnel Reliability Working Group	NIH	Review existing mechanisms and make recommendations for improvements
NSTC Subcommittee on Standards	Interagency	Develop standards for CBRN equipment
Nutrition Coordinating Committee	NIH	Share nutrition information among HHS agencies -ARS is USDA representative
OECD Scientific Collections Activity	OECD (International)	Develop Plan for Managing Collections of OECD Members
Office of Dietary Supplements Inter-agency work group	NIH	Information sharing among federal agencies conducting nutrition research and dietary supplements research
Office of Pesticide Programs	EPA	Development of research goals
Organic Working Group	USDA	Information exchange between USDA agencies on organic programs.
OSTP/IWG on Plant Genomes	OSTP	Coordination of plant genomics research among U.S. federal agencies
OSTP/IWG on Scientific Collections	OSTP	Develop a Plan for Maintaining Federal Scientific Collections
Overseas Biological Control Laboratories	ARS	Administration
Pest Information Platform for Education and Extension (PIPEE) Strategic Planning Committee	NIFA, RMA	To develop an integrated national system facilitated by information technology to provide centralized, useful tools with reliable information for IPM practitioners. Mapping of Soybean rust and soybean aphid
Pierce's Disease Task Force	Wine and Grape Industry	Coordinate ARS Pierce's Disease Research
Plant Breeder Coordinating Committee	Several	The PBCC serves as a forum for issues and opportunities of national and global importance to the public and private sectors of the U.S. national plant breeding effort.
POC for ARS Veterinary Workforce Planning Committee	Interagency (All govt agencies with Veterinarians)	Interagency Coordination
PROCINORTE	ARS	Scientific Diplomacy
Program Planning Committee for Soybean Rust Symposium	ARS	Planning 2009 Soybean Rust Symposium
Public Health Pesticide Committee	CDC	Coordination
RAC Biosafety Working Group	NIH	Provide support and recommendations to the NIH Recombinant DNA Advisory committee on biosafety issues
Rift Valley Fever Coordination	DoS and ARS	Workshop
Risk Assessment Consortium	Federal	Share food safety information
SARE – Sustainable Agriculture, Research & Extension, National Operations Committee	NIFA	Coordinate and communicate SARE activities among regions and other Federal agencies.
Science and Technology task force of JSA	JSA	Develop a strategic research and technology development plan for aquaculture across federal agencies
Science of Science Policy Interagency Task Group	OSTP, NSF	Address the need for better tools, methods, and data for improving our understanding of the efficacy and impact of science and technology policy decisions.

ARS Inter-Agency Working Group Participation		
Group name	**Sponsoring Organization**	**Brief purpose**
Scientific Committee for National Foundation for Infectious Diseases	NFID	Coordinate yearly scientific meetings in infectious disease
Scientific Forum on Invasive Species	APHIS, FS	Coordinate Research and Response to Invasive Species of Forest Areas
Screwworm Eradication Program	APHIS	Coordination of research and operations
Secretary's Bioenergy Decision Tool	Office of Energy Policy and New Uses, Office of the Chief Economist	Develop a place-based decision tool that provides information about USDA programs and resources that can be used by rural communities and investors to develop renewable energy projects.
Select Agent Tiering Committee	Interagency	Tier Select Agents
Small & Beginning Farm Coordinators	USDA	coordinate USDA activities to meet group's needs
South Atlantic Methyl Bromide Areawide project	ARS, EPA, and industry	To plan and prioritize research projects.
Steering Committee for the Food Safety Research and Response Network	USDA	Facilitate university based research food safety
Subcommittee on Sedimentation	USGS, Dept of Interior, Advisory Committee on Water Information, Water Information Coordination Program	Supports development of equipment, methodologies, and calibration for the collection, analysis, interpretation, and interchange of fluvial-sediment data and related technical information.
Sub-PCC on International Bioengagement	DoS, DoD, HHS, and USDA	Interagency Coordination
Sugarcane Research Planning Taskforce	ARS	Provides innovative solutions for sustainable sugarcane production.
Technical Representative to National Beef Cattle Evaluation Consortium	Beef Industry and Universities	Coordinate cattle genomics research and develop infrastructure to incorporate genomics information into the beef cattle genetic evaluation system
Technical Representative to National Pork Board Animal Science Committee	Swine Industry and Universities	Coordinate public swine research for traits relating to production efficiencies, pork quality and genomics
Tekes/Academy Finland	USDA/Finland	Collaborate food safety Res; share food safety information
Transfederal Biosafety Taskforce	USDA-HHS	Assess the current federal biosafety program, identifies gaps and solutions to improve the biosafety system
U.S. Wheat & Barley Scab Initiative	USDA, wheat/barley producers, millers, bakers	Reduce wheat mycotoxins and scab losses
Ug99 Wheat Stem Rust Action Team	ARS, APHIS, NIFA, OPMP	Coordinate Ug99 Wheat Stem Rust Response
UK-Food Standards	USDA/UK	Collaborate on food safety research; share food safety information
UK-International Food Research	USDA/UK	Collaborate on food safety research; share food safety information
US Animal Health Association	USAHA	Share information on animal health and related fields
US Group on Earth Observations (USGEO)	CENR	Fed agency info sharing & coordination; US rep to International GEO
US/EC Taskforce on Biotechnology	USDA, EU	Coordinates US and EC Biotechnology Research
USDA Barley Germplasm Committee	USDA	Barley researchers/industry
USDA BioEnergy Science Team (BEST)	REE, FS, AMS, OEPNU	Provide science support by ARS, ERS, NASS, NIFA, FS, AMS, and OEPNU to other agencies in the Department.
USDA Biotechnology Coordinating Group	USDA (USDA Coordinator, Michael Schectman)	Coordinate Plant and Animal Biotech Regulatory Policy and Research
USDA Corn Germplasm Committee	USDA	Corn researchers/industry

ARS Inter-Agency Working Group Participation		
Group name	**Sponsoring Organization**	**Brief purpose**
USDA Global Research Alliance Steering Committee	USDA	
USDA Invasive Species Coordinator Committee	USDA (USDA Coordinator Hilda Diaz-Soltero, Director)	Coordinate USDA Invasive Species Response
USDA Know Your Farmer Committee	USDA Dep. Sec.	Coordinate efforts to connect citizens with agriculture and nutrition
USDA Market-Based Environmental Stewardship Coordination Council	USDA OSEC	Provide agency-level advisory to the USDA Office of Ecosystem Services and Markets and the Secretary, who co-chairs the interdepartmental Environmental Services Board. Establish guidelines and science-based methods to measure the environmental benefits from conservation and land management activities in support of emerging environmental services markets.
USDA One Health Joint Working Group	ARS, APHIS, FAS, NIFA	Technical group to support One Health MAC
USDA Peoples' Garden	USDA	Promote citizens' involvement with agriculture through the Peoples' Garden
USDA Pollinators' Committee	ARS	Coordinating response to pollinators decline
USDA Remote Sensing Coordination Committee	Office of Chief Economist	Information sharing among USDA agencies
USDA Rice Germplasm Committee	USDA	Rice researchers/industry
USDA Risk Assessment Group	USDA	Share risk assessment info among USDA agencies
USDA Sorghum Germplasm Committee	USDA	Sorghum researchers/industry
USDA Sustainable Development Council	Chief Economist's Office	Coordinate USDA-wide sustainable activities
USDA Water Team	USDA	Coordinate USDA's water activities to meet Secretary's High Priority Performance Goals for Water Chair - Ann Mills, Deputy Under Secretary for NR&E
USDA Wheat Germplasm Committee	USDA	Wheat researchers/industry
USDA-ARS-FDA	USDA	Collaborate on food safety research; share food safety information
USDA-ARS-FSIS	USDA	Collaborate on food safety research; share food safety information
USDA-ARS-NIFA	USDA	Share food safety information
USDA-wide committee	Committee on Environmental & Natural Resources (NSTC)	Advises Executive Office on science and technology to support water availability
US-EC Biotechnology Task Force	OSTP	Foster US-EC science collaborations
USGEO Architecture & Data Mgmt Sub Group		Facilitate data sharing among agencies & others
USGEO Policy Sub Group	CENR	Develop US earth observations policy
USGEO Strategic Assessments Sub Group	CENR	Assess & prioritize US earth observation needs (air, land, sea)
Various committees/ task groups of Office of Environmental Markets	USDA	OEM has a unique role in the federal government's efforts to develop uniform standards and market infrastructure that will facilitate market-based approaches to agriculture, forest, and rangeland conservation.
West Coast Methyl Bromide Areawide project	ARS, EPA, and industry	To plan and prioritize research projects.
Working Group within the risk assessment consortium on nanotechnology	IRAC	Produce recommendations for federal agencies for research and policy