

## Introduction

### AGRICULTURAL RESEARCH SERVICE ANNUAL PERFORMANCE REPORT FOR FY 2006

The Agricultural Research Service (ARS) was established on November 2, 1953, pursuant to authority vested in the Secretary of Agriculture by 5 U.S.C. 301 and Reorganization Plan No. 2 of 1953, and other authorities.

ARS is the principal in-house research agency of the U.S. Department of Agriculture (USDA). Congress first authorized federally supported agricultural research in the Organic Act of 1862, which established what is now USDA. That statute directed the Commissioner of Agriculture "... To acquire and preserve in his Department all information he can obtain by means of books and correspondence, and by practical and scientific experiments..." The scope of USDA's agricultural research programs has been expanded and extended more than 60 times since the Department was created.

ARS research is authorized by the Department of Agriculture Organic Act of 1862 (7 U.S.C. 2201 note), Agricultural Research Act of 1935 (7 U.S.C. 427), Research and Marketing Act of 1946 (P.L. 79-733), as amended (7 U.S.C. 427, 1621 note), Food and Agriculture Act of 1977 (P.L. 95-113), as amended (7 U.S.C. 1281 note), Food Security Act of 1985 (P.L. 99-198) (7 U.S.C. 3101 note), Food, Agriculture, Conservation, and Trade Act of 1990 (P.L. 101-624) (7 U.S.C. 1421 note), Federal Agriculture Improvement and Reform Act of 1996 (P.L. 104-127), and Agricultural Research, Extension, and Education Reform Act of 1998 (P.L. 105-185). ARS derived most of its objectives from statutory language, specifically the "Purposes of Agricultural Research, Extension, and Education" set forth in Section 801 of FAIR.

The ARS mission is to conduct 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; and provide economic opportunities for rural citizens, communities, and society as a whole.

The Agency's research focuses on achieving the goals identified in the USDA and Research, Education, and Economics (REE) mission area Strategic Plans. The Government Performance and Results Act (GPRA) mandates each agency to establish general goals that will contribute to achieving beneficial societal outcomes that shape and drive the work of the Agency during the five years covered by the plan.

**Verification, Validation and Program Evaluation:** ARS conducts a series of review processes designed to ensure the relevance and quality of its research work and to maintain the highest possible standards for its scientists. This process involves customer input to help keep the research focused on the needs of the American food and agricultural system. Each of the approximately 1,000 research projects, which are organized into 22 National Programs, undergoes a thorough independent external prospective peer review conducted by the Office of Scientific Quality Review (OSQR). All ARS employees, including the scientific workforce, are subject to annual performance reviews. Senior scientists undergo a rigorous peer review (Research Position Evaluation System-RPES) on a 3- to 5-year cycle. These processes ensure the continuing high quality output of the ARS research addressing the needs of American agriculture.

ARS has also completed two program evaluations that are included in the **President's Management Agenda (PMA)**. The PMA is designed to strengthen the management of Federal programs and increase program accountability. In the FY 2006 budget cycle, ARS conducted a

**Program Assessment Rating Tool (PART)** analysis on all the research conducted under Strategic Plan Goal 1, Enhance Economic Opportunities for Agricultural Producers. This Goal includes research on new and improved high quality value added products and processes, livestock production, and crop production. In FY 2007 budget cycle, a PART analysis was conducted on Goal 3, Research on Protection and Safety of Agricultural Food Supply, covering research on Food Safety, Livestock Protection, and Crop Protection. The PART assessment seeks to measure four aspects of a program: program purpose and design, strategic planning, program management, and program results/accountability. The PART analysis for both Goals 1 and 3 received a “moderately effective” rating from OMB. ARS is conducting two additional PART analyses during the FY 2008 budget cycle covering Goal 4, Nutrition and Health, and Goal 5, Natural Resource Base and Environment.

Beginning in FY 2005, ARS’ National Program Leaders (NPLs) and Area Directors reviewed more than 1,000 research projects by applying the **Research and Development (R&D) Investment Criteria of relevancy, performance, and quality**. The information gained from this review helped the Agency to identify low performing and/or low priority research. This information was used in shaping the FY 2007 budget; it will also be used to make future program management decisions. The R&D investment criteria were applied as follows:

For **relevancy**, the NPLs assessed whether ARS’ research is consistent with the Agency’s mission and relevant to the needs of American agriculture, as identified by the Administration and ARS’ customers and stakeholders.

For **performance**, the NPLs reviewed the annual project reports submitted by each research unit. Beginning with FY 2004, these reports provided information on how well each research project did in achieving the milestones in its Project Plan.

For **quality**, the Area Directors relied on data from the ARS OSQR reviews of each research project at the beginning of its 5-year program cycle. OSQR conducts rigorous reviews of ARS’ research projects by independent external peer panels to ensure their quality. In addition, the Area Directors used information from the RPES reviews of individual scientists in making this assessment. RPES conducts rigorous peer reviews of ARS’ scientists on a regular schedule (i.e., every three, four, or five years). The Area Directors also assessed the capacity (i.e., facilities, human and fiscal resources, equipment, etc.) of each project to meet its research objectives, an important consideration for intramural programs.

The National Programs focus the work of the Agency on achieving the goals defined in the ARS Strategic Plan 2003-2007. The research priorities for each National Program are established with extensive input from customers, stakeholders, and partners, which is received, in part, at a series of National Program Workshops. A detailed Action Plan developed for each National Program is available on the ARS home page, [www.ars.usda.gov](http://www.ars.usda.gov); open “Research” and select the National Program of interest. The GPRA Annual Performance Plans, the GPRA Annual Performance Reports, and the National Program Annual Reports which serve to keep the work of the Agency focused on achieving the goals established in the ARS Strategic Plan are also available on this website. The aggregate effect of these processes is a strengthened research program and an accountability system that measures more effectively the progress made towards achieving established goals and outcomes.

**Key External Factors that Affect the Ability of ARS to Achieve its Goals and Objectives:** The future of American agriculture depends on its ability to respond to critical external factors. Effective planning within ARS will take these factors into consideration when establishing and executing the Agency’s research programs.

**Globalization:** The globalization of all aspects of the food and fiber system is having a major impact on American agriculture. Profound changes are seen worldwide from competitive markets around the world, from diseases not limited to national boundaries, to population growth and

evolving diets. These changes have led to a dramatically new trade environment, threats of exotic diseases and pests to domestic production, and international controversies over the use of biotechnology. To remain competitive, the food and agriculture sector needs to respond to these developments.

**Information Access and Communication:** The explosion of information technology, the worldwide use of the Internet, and the major advancements of cyberspace communications are changing the way private industry, government, and individuals conduct daily business. Vast amounts of information are available in “real time,” more people from around the world will be able to retrieve the information, and advanced computer software will make the information more useful and meaningful. Advancements in communication technology offer benefits and opportunities for everyone involved in the American food and agriculture sector.

**Workforce:** A very important employment issue is the need to recruit and retain a highly skilled and technically well trained Federal workforce. The relatively low U.S. unemployment rate makes recruitment highly competitive. This competitive environment is expected to require more employer emphasis on recruitment, retention, student employment, upward mobility, and training/retraining programs. The public sector will need to recruit a diversity of people and to maintain a highly qualified and technically competent workforce. Expanding job opportunities for women and minorities in science and engineering will help to tap the Nation’s human potential.

**Technology:** Advances in technology--such as bioengineering, precision agriculture, remote sensing, and decision modeling--enable agricultural production to enhance nutrition, protect the environment, and continue to make the food supply safe. Biotechnology offers great promise for increasing production efficiency, improving food quality, and enhancing nutritional value. However, concerns about genetically modified organisms (GMOs) have had a marked impact on international exports of affected commodities, and prompted questions about the potential benefits and risks. Precision agriculture, remote sensing, and decision modeling will both increase production efficiency and mitigate adverse environmental impacts of agriculture. Public concern about food safety has led to new rapid detection technologies that, when fully implemented, will make the food supply safer.

**Changing Demographics:** Growing global populations, demographic changes, and economic growth will substantially increase the demand for agricultural products, thus creating new markets for U.S. products. At the same time, however, increased agricultural competitiveness from other countries will force U.S. agriculture to become more efficient. Because arable agricultural land is limited, the growing demands will increase pressure to maximize yields, protect marginal areas from unsustainable development, and minimize the harmful effects of agriculture on the environment and the natural resource base.

**Changing Structure of Agriculture:** The structure of the food and fiber system--from farm to market--changed dramatically in the last decades of the 20th century, and is likely to continue. Change can be seen all across the food and agriculture sectors. An increasing share of U.S. food and fiber is being produced on fewer, larger, and more specialized farms. Production and marketing are more vertically and horizontally integrated. Concentration is greater causing sharp declines in the number of buyers and sellers of a product. Consumer preferences, new technologies, and global markets bring about continuing changes that affect farmers, processors, marketers, and consumers.

**Congressional Support:** The ability of ARS to respond to the diverse needs of producers and consumers is determined by the level of Congressional support. As a consequence of inflation and higher operating costs associated with advances in research equipment and technology, the ARS scientific workforce, which reached a maximum of about 3,400 scientists in 1970, decreased by almost 40 percent during the ensuing 25 years. More recently, appropriations have allowed the Agency to expand its research program and hire additional scientists to bring the current number of scientists to almost 2,200.

**Drug-Free Workplace:** ARS will continue to use the applicable contract clauses and regulations to ensure compliance with drug-free workplace debarment and suspension requirements in all of its acquisition programs.

**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.

**GOAL 1: ENHANCE INTERNATIONAL COMPETITIVENESS OF AMERICAN AGRICULTURE**

**Means and Strategies:** To successfully accomplish the research activities under this goal, ARS will need the resources reflected in the table above.

**Verification and Validation:** ARS currently conducts a series of review processes designed to ensure the relevance and quality of its research work, and to maintain the highest possible standards for its scientists. A more detailed description of the evaluation plans can be found in the introduction of this plan.

**OBJECTIVE 1.1: Expand and Maintain International Export Opportunities**  
**This objective is under the jurisdiction of other USDA agencies.**

**OBJECTIVE 1.2: Support International Economic Development And Trade Capacity Building**

**This objective is under the jurisdiction of other USDA agencies.**

**STRATEGIC RESULT: Increased Export Opportunities For U.S. Agriculture**

**OBJECTIVE 1.3: IMPROVED SANITARY AND PHYTOSANITARY (SPS) SYSTEM TO FACILITATE AGRICULTURAL TRADE**

**Performance Measure 1.1.1:** Provide fundamental and applied scientific information and technologies to action agencies, producers, exporters, and importers of commercially important plant and animal products in support of exclusion, early detection and eradication, including the use of technically and economically feasible alternatives to methyl bromide approved for control of quarantine pests and pathogens that can impede foreign trade.

**The ARS research in support of Strategic Goal 1, Objective 1.3 is reported under Strategic Goal 4, Objective 4.2. Performance Measure 4.2.3**

**GOAL 2: ENHANCE THE COMPETITIVENESS AND SUSTAINABILITY OF RURAL AND FARM ECONOMIES**

GOAL 2 PROGRAMS	FY 2007	FY 2008	FY 2009
Product Quality, Value Added	\$93,786	\$Not Available	\$Not Available
Livestock Production	69,767		
Crop Production	150,780		
<b>Total</b>	<b>\$314,333</b>	<b>\$Not Available</b>	<b>\$Not Available</b>

NOTE: Dollars in Thousands.

**STRATEGIC RESULT: Provide New Scientific and Technological Capabilities That Will Expand Domestic Markets For Agricultural Producers**

**OBJECTIVE 2.1: Expand Domestic Market Opportunities**

**Means and Strategies:** To successfully accomplish the research activities under this goal, ARS will need the resources reflected in the table above.

**Verification and Validation:** ARS currently conducts a series of review processes designed to ensure the relevance and quality of its research work, and to maintain the highest possible standards for its scientists. A more detailed description of the evaluation plans can be found in the introduction of this plan.

<b>Performance Measure 2.1.1:</b> Create new or significantly expand existing feedstocks for use in biorefining.
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**Indicators:**

**DURING FY 2006, ARS will**

*develop new production practices and decision support tools that increase profitability and improve environmental quality.*

**ACCOMPLISHMENT 1:** The first gene sequences for Brachypodium, a model grass plant, and switchgrass were published. In addition, ARS is leading national efforts, funded by DOE's community sequencing program at the Joint Genome Institute, to sequence the entire genome for Brachypodium as well as most of the genes in switchgrass.

**IMPACT/OUTCOME 1:** The sequence data generated will accelerate efforts to breed better varieties of perennial, herbaceous energy crops such as switchgrass.

**ACCOMPLISHMENT 2:** Beta-glucosidase enzymes were found to solve the problems of viscosity and low ethanol yield associated with producing ethanol from barley grain.

**IMPACT/OUTCOME 2:** This discovery should enable the building of ethanol plants outside the corn belt and in the barley-growing regions such as the East Coast, Northwest, and Upper Midwest. Having barley as a viable feedstock could provide an additional 1-2 billion gallons of fuel ethanol in the United States.

**ACCOMPLISHMENT 3:** Produced bioactive peptides by treating corn germ with certain protease enzymes such as thermolysin or flavourzyme. These peptides could lower blood pressure in humans since they inhibit Angiotensin 1 Converting Enzyme.

**IMPACT/OUTCOME 3:** The ability to produce valuable nutraceuticals from the proteins in corn would improve the long-term business stability of corn-ethanol producers.

**ACCOMPLISHMENT 4:** Genetically engineered *Trichoderma reesei*, the common microbe for the production of cellulases, to produce high yields of a highly-active xylanase derived from *Orpinomyces* fungi. The work required the creation of a synthetic gene to overcome problems with codon-bias in the new hosts.

**IMPACT/OUTCOME 4:** The engineered *T. reesei* strain now excretes a mixture of enzymes that are more efficient at degrading cellulosic biomass into fermentable sugars.

**ACCOMPLISHMENT 5:** Developed new enzyme preparations-prepared by growing fungi on corn fiber pretreated with liquid hot water (LHW) – that achieve high yields of monosaccharides from corn fiber.

**IMPACT/OUTCOME 5:** Corn fiber, a low-value co-product of corn wet milling, would be an excellent feedstock for ethanol production if the sugars are hydrolyzed into a fermentable monosaccharides.

**ACCOMPLISHMENT 6:** Demonstrated that wheat straw pretreated with alkaline peroxide can be completely hydrolyzed to fermentable sugars without producing fermentation inhibitors.

**IMPACT/OUTCOME 6:** Crop residues such as wheat straw are very low cost feedstocks for fuel ethanol production.

**ACCOMPLISHMENT 7:** An automated method to screen large numbers of samples is needed to help identify new microbial strains and enzymes that can be used for efficient production of ethanol and other value-added products from agricultural feedstocks. ARS constructed a plasmid-based functional proteomic workcell for high-throughput assembly, optimization, and modification of gene libraries and microbial strains. Mechanical hardware has been integrated and controlling software developed to provide a robotic platform that picks colonies, cultures bacteria, prepares plasmid DNA, performs in vitro transcription/translation, and assays enzyme activity.

**IMPACT/OUTCOME 7:** The workcell and high-throughput methodology will be used to identify strains of yeast capable of fermenting xylose to ethanol.

**ACCOMPLISHMENT 8:** The current ethanol industry uses a process requiring gelatinization of corn starch at high temperature before the addition of amylase enzymes for starch hydrolysis. ARS developed amylase enzymes that can hydrolyze starch without an energy-intensive gelatinization step.

**IMPACT/OUTCOME 8:** These new enzymes will decrease the cost and improve the energy efficiency of producing ethanol from starchy grains.

**2.1.1: SUMMARY OF THE MAJOR TECHNOLOGIES DEVELOPED, TRANSFERRED, AND USED IN FY 2006:**

**DURING FY 2006, ARS**

reported on four technological breakthroughs or scientific advancements that made significant contributions toward reducing the cost and increasing profitability, improving the efficiency, increasing the yield, and increasing the sustainability of producing or converting biobased feedstocks into biofuels that are in use.

**DESCRIBE THE TECHNOLOGY 1:** Convert inexpensive soapstock feedstocks into fatty acids

**DESCRIBE THE TRANSFER 1:** published work

**IDENTIFY THE CUSTOMER/USER 1:** Runyon Industries (TN)

**IMPACT/OUTCOME 1:** Customer is using to build 4 million lb/yr business for feed supplement to boost milk production in dairy cows.

**DESCRIBE THE TECHNOLOGY 2:** Producing fuel ethanol from barley

**DESCRIBE THE TRANSFER 2:** published work

**IDENTIFY THE CUSTOMER/USER 2:** Osage (VA)

**IMPACT/OUTCOME 2:** Customer is using ARS data to secure funding for a barley-to ethanol plant.

**DESCRIBE THE TECHNOLOGY 3:** Computer-based process economic models for biorefineries

**DESCRIBE THE TRANSFER 3:** published work

**IDENTIFY THE CUSTOMER/USER 3:** over 100 different users

**IMPACT/OUTCOME 3:** Being used to identify potential R&D goals for reducing costs of ethanol or biodiesel production.

**DESCRIBE THE TECHNOLOGY 4:** Raw starch hydrolysis

**DESCRIBE THE TRANSFER 4:** published work

**IDENTIFY THE CUSTOMER/USER 4:** ADM, Broin, ICM, Novozymes, Genencor

**IMPACT/OUTCOME 4:** Technology reduces energy usage and process costs by avoiding the need to precook starch before enzymatic hydrolysis. Technology has been adopted as the industry standard for new dry grind corn mills.

**Performance Measure 2.1.2:** Develop cost effective, functional industrial and consumer products, including higher quality, healthy foods, that satisfy consumer demand in the United States and abroad.

**Indicators:**

**DURING FY 2006, ARS will**

*develop technologies leading to new or improved products from renewable agricultural resources, residues and wastes*

**ACCOMPLISHMENT 1:** New processing technologies are needed to increase the consumption of fruits and vegetables by American consumers. Researchers at Albany, California, worked with an industrial Cooperative Research and Development Agreement (CRADA) partner to commercialize fruit and vegetable based films for application in a variety of food products.

**IMPACT/OUTCOME 1:** In one of these applications, the films function as healthy, colorful alternatives to the seaweed wrap "nori" in a novel line of 7-day sushi-like fusion rolls sold at Costco supermarkets. This year, the films were also introduced commercially into a wide variety of upscale restaurant entrees, and they were used as healthy, flavorful glazes for hams and turkeys.

**ACCOMPLISHMENT 2:** The recent increase in biodiesel manufacturing has resulted in a surplus of glycerol, a coproduct of the commercial biodiesel production process. Similarly, strong demand in the food sector for soy protein isolates and concentrates has brought about a surplus of soy molasses. To address the need to develop new uses for these coproducts, researchers at Wyndmoor, Pennsylvania, devised fermentation processes to convert them into industrial biosurfactants. They recently achieved a significant increase (up to 3-fold) in product yields through the modification of the fermentation and isolation procedures with soy molasses as feedstock. To test the applications of these biosurfactants in its commercial products, ARS established a CRADA with an industrial partner and filed a patent describing the bioconversion of bioglycerol to these biosurfactants.

**IMPACT/OUTCOME 2:** This bioconversion technology is expected to lower the feedstock cost of biosurfactant production and address the disposal issue faced by the biodiesel and soy processing industries.

**ACCOMPLISHMENT 3:** Food manufacturers and commercial users of frying oils such as restaurants need alternatives to hydrogenated oils for frying because of the trans fatty acid content imparted by hydrogenation. In continuing studies on expeller pressed oils as an alternative to hydrogenated oils, scientists at Peoria, Illinois, found that if low linolenic acid soybean oil is expeller pressed rather than processed conventionally by hexane extraction, the stability of the oil during frying is similar to that of hydrogenated soybean oil. In pilot plant frying

studies conducted by the ARS Potato Research Worksite in East Grand Forks, Minnesota, and in batch frying tests conducted at Peoria, scientists found that the combination of expeller pressing and using low linolenic acid soybean oil produced a better frying oil than either expeller pressed regular soybean oil or non-expeller pressed low linolenic acid soybean oil.

**IMPACT/OUTCOME 3:** Oil processors and food manufacturers now have new oil--expeller pressed low linolenic acid soybean oil--as a trans-free alternative to hydrogenation or added antioxidants in edible oils.

**ACCOMPLISHMENT 4:** A major unmet need in nursing homes is bedridden and burn patients with non-healing and burn wounds. Researchers at New Orleans, Louisiana, developed a continuous pilot scale process for producing phosphorylated cotton (cotton modified by adding phosphate groups) gauze for new cotton-based wound dressings that will selectively interact with either chronic wounds or burn wounds.

**IMPACT/OUTCOME 4:** In July 2006, the FDA approved the cotton chronic wound dressing for use in patients. The improved wound dressings aid consumers and also benefit cotton farmers and the American textile industry by increasing the volume of value added cotton product sales in the United States.

*develop new or improved methods to measure or predict quality, or to sort by quality*

**ACCOMPLISHMENT 1:** Starch is an unwanted compound in sugar refineries that is largely associated with sugarcane trash. The application of alpha-amylases enzyme to breakdown starch in U.S. sugar factories is not optimized. Laboratory studies showed that commercial U.S. alpha-amylases exist in low and high activity forms that do not always reflect the difference in price. U.S. alpha-amylases also exist in high and intermediate temperature stable forms, and residual activity of the former in raw sugar is a large problem for refiners and end users of sugar and molasses. Researchers at New Orleans, LA, evaluated and optimized the application of alpha-amylase (an enzyme that speeds up the reaction of the breakdown of starch) at three Louisiana sugarcane factories in the 2005 processing season.

**IMPACT/OUTCOME 1:** This research has already had impact in U.S. sugar manufacture. One factory has already stopped using low activity alpha-amylase, and several factories have stopped applying high temperature stable alpha-amylases. Several factories are now applying working solutions of high activity alpha-amylase to syrups and more are expected.

#### **2.1.2 SUMMARY OF THE MAJOR TECHNOLOGIES DEVELOPED, TRANSFERRED, AND USED IN FY 2006:**

##### **DURING FY 2006**

Reported on four new technologies 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 product; and valuable con-products from agricultural residues and processing wastes that are in use.

**DESCRIBE THE TECHNOLOGY 1:** Researchers at Lubbock, TX working with a CRADA partner, developed a hydromulch out of cotton gin by products that was effective at controlling erosion and which provided soil cover equal to, or better than, conventional wood hydromulches.

**DESCRIBE THE TRANSFER 1:** The findings from this research were instrumental in the first commercial cotton-based hydromulch product being manufactured. Hydromulch from this facility is currently being marketed under the trademark name GeoSkin.

**IDENTIFY THE CUSTOMER/USER 1:** Cotton manufactures

**IMPACT/OUTCOME 1:** An economical means of processing gin waste that should allow cotton gins and producers the opportunity to turn a financial liability into revenue.

**DESCRIBE THE TECHNOLOGY 2:** New processing technologies are needed to increase utilization and consumption of fruits and vegetables by American consumers. One of these applications uses the films as healthy, colorful alternatives to the seaweed wrap 'nori' in a novel line of 7-day sushi-like fusion rolls on sale at Costco supermarkets. This year, the films were also introduced commercially on a wide variety of up-scale restaurant entrees, as well as for healthy, flavorful glazes for hams and turkeys.

**DESCRIBE THE TRANSFER 2:** Researchers at Albany, CA worked with an industrial CRADA partner to commercialize the patent-pending, fruit and vegetable based films in a variety of final food product applications.

**IDENTIFY THE CUSTOMER/USER 2:** Restaurants, farmers, and consumers

**IMPACT/OUTCOME 2:** This technology has expanded markets for growers, enhancing profits for farmers and improving consumer nutrition.

**DESCRIBE THE TECHNOLOGY 3:** Starch is an unwanted compound in sugar refineries that is largely associated with sugarcane trash. The application of alpha-amylase enzyme to breakdown starch in U.S. sugar factories is not optimized. Laboratory studies showed that commercial U.S. alpha amylases exist in low and high activity forms that do not always reflect the difference in price. U.S. alpha-amylases also exist in high and intermediate temperature stable forms, and residual activity of the former in raw sugar is a large problem for refiners and end users of sugar and molasses. Researchers at New Orleans, LA, evaluated and optimized the application of alpha-amylase (an enzyme that speeds up the reaction of the breakdown of starch) at three Louisiana sugarcane factories in the 2005 processing season.

**DESCRIBE THE TRANSFER 3:** Critical information on how to measure dextranase and enzyme activities at the factory, as well as how and where to add these different enzymes in the factory was communicated to farmers, processors, and scientists through invited presentations at the meeting of the American Society of Sugar Cane Technologies in Baton Rouge, LA, and the Industrial Enzyme Symposium at the national meeting of the American Chemical Society in Washington, D.C.

**IDENTIFY THE CUSTOMER/USER 3:** Sugar manufacturers

**IMPACT/OUTCOME 3:** This technology has already had impact in U.S. sugar manufacture. One factory has already stopped using low activity alpha-amylase, and several factories have stopped applying high temperature stable alpha-amylase. Several factories are now applying working solutions of high activity alpha-amylase to syrups and more are expected.

**DESCRIBE THE TECHNOLOGY 4:** The Fantesk™ process was developed by researchers at Peoria, IL. This one product has had an impact in two areas. Fantesk™ was used to prepare a starch-lipid gel that can be reduced in particle size and then blended into low-fat ground meat products, such as beef or turkey. The resulting meat products are healthier for the consumer because of their lower fat content; however, their tenderness, juiciness and flavor are similar to those of higher fat products. Fantesk™-based had lotion was also developed. Unlike other antibacterial lotions, the oil component in the Fantesk™ lotion causes it to retain its antibacterial properties, even after several hand washings.

**DESCRIBE THE TRANSFER 4:** A CRADA partner and licensee of the technology are currently working with a manufacturer to produce commercial quantities of the Fandesk™ product. They

will market the new product under the trade name NutriGras. The product line is being expanded to include ground pork and poultry products. Peoria-based scientists are cooperating with a company in Peoria, IL to set up a manufacturing facility for toll-producing the Fantesk™ lotion.

**IDENTIFY THE CUSTOMER/USER 4:** Consumers.

**IMPACT/OUTCOME 4:** Meat products are healthier for the consumer because of their lower fat content; however, their tenderness, juiciness and flavor are similar to those of higher fat products. Fantesk™-based hand lotion will help alleviate the spread of disease by human contact. Both products will offer new markets for crop-based starches and oils.

**OBJECTIVE 2.2: Increase The Efficiency Of Domestic Agricultural Production And Marketing Systems**

<b>Performance Measure 2.2.1:</b> Develop systems and technologies to reduce production costs and risks while enhancing natural resource quality.
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**INDICATORS:**

**DURING FY 2006, ARS will**

*develop new production practices and decision support tools that increase profitability and improve environmental quality.*

**ACCOMPLISHMENT:** Aquatic and terrestrial habitats on farmland can protect many fish and wildlife species during crop production. ARS scientists at Corvallis, Oregon, cooperating with Oregon State University and the University of Massachusetts, found that seasonal streams originating in western Oregon grass seed fields provided refuge for native fish and amphibians during the winter high flow periods in Oregon's South Willamette River Basin. Aquatic biota were not harmed by nutrient concentrations in the seasonal streams, and when streambeds were vegetated, invertebrate populations exploded--a boon to fish and bird predators. As the amount of tree cover along these streams increased, so did the abundance and diversity of wintering bird populations.

**IMPACT/OUTCOME:** These studies provide farmers with guidelines for identifying where to locate USDA conservation projects to optimize economic and environmental benefits, and provide comprehensive information on managing upland agricultural landscapes in western Oregon watersheds to create habitat for native fish and wildlife—some of which are listed in the Endangered Species Act—on agricultural landscapes.

**2.2.1: SUMMARY OF THE MAJOR TECHNOLOGIES DEVELOPED, TRANSFERRED, AND USED IN FY 2006:**

**DURING FY 2006, ARS**

reported on four new technologies and systems developed and used by customers that utilize new configurations of practices and technologies to reduce the cost and increase profitability, improve the efficiency or increase the yield, and increase the sustainability of production.

**DESCRIBE THE TECHNOLOGY 1:** Farm-scale gasifier

**DESCRIBE THE TRANSFER 1:** Transferred farm-scale gasifier that was developed through Specific Cooperative Agreement with Western Research Institute for conversion of straw into energy to farmsite in Spokane County WA.

**IDENTIFY THE CUSTOMER/USER 1:** Farm Power, a non-profit organization formed to encourage the development of farm-scale technologies to convert excess straw into energy.

**IMPACT/OUTCOME 1:** The gasifier enabled on-farm testing of the feasibility of small scale distributed energy production utilizing excess biomass produced by cereal and seed producing operations in the Pacific Northwest.

**DESCRIBE THE TECHNOLOGY 2:** Nitrogen Decision Aid

**DESCRIBE THE TRANSFER 2:**

<http://www.ars.usda.gov/services/software/download.htm?softwareid=85>

**IDENTIFY THE CUSTOMER/USER 2:** The Nitrogen Decision Aid was downloaded by 63 customers in 2006 (nearly 1500 downloads since its release in 1999): 15 for use in their farming operations, 15 for field research, 2 for software development, and 31 did not identify the intended use.

**IMPACT/OUTCOME 2:** Being used by farmers across the U.S. to improve nitrogen fertilizer application decisions, helping producers determine amounts needed for crop production, while reducing potential for environmental and economic losses due to over application.

**DESCRIBE THE TECHNOLOGY 3:** Utilization of Pseudomonas Species as Bioherbicides in Weed Management

**DESCRIBE THE TRANSFER 3:** CRADA with Northwest Agricultural Products, Inc.

**IDENTIFY THE CUSTOMER/USER 3:** Northwest Agricultural Products, Inc., Pasco, WA

**IMPACT/OUTCOME 3:** Targets the development of Pseudomonas fluorescent strains as commercial products for biological control of grass weeds (i.e. downy brome and jointed goatgrass). ARS scientists are assisting Northwest Agricultural Products, Inc. in the selection of growth media suitable for scaling up production of strains in commercial fermentors and in the development of formulations and delivery systems for these organisms.

**DESCRIBE THE TECHNOLOGY 4:** rollers/crimpers for USDA NRCS State Agronomist

**DESCRIBE THE TRANSFER 4:** Members of the Conservation Systems Research (CSR) Team of the USDA-ARS National Soil Dynamics Laboratory assisted in designing rollers/crimpers for USDA NRCS State Agronomist in Virginia and participated in presenting this technology in a field day in March, 2006.

**IDENTIFY THE CUSTOMER/USER:** Virginia producers, USDA-NRCS, and Extension service

**IMPACT/OUTCOME 4:** Several producers in this region of Virginia have adopted this technology.

<p><b>Performance Measure 2.2.2:</b> Develop new technologies, tools, and information contributing to improved precision animal production systems to meet current and future food animal production needs of diversified consumers, while simultaneously minimizing the environmental footprint of production systems and enhancing animal well-being.</p>
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**Indicators:**

**DURING FY 2006, ARS will**

*identify underlying genetic and physiologic mechanisms impacting reproductive efficiency, nutrient conversion, and growth in food animals.*

**ACCOMPLISHMENT 1:** The lignin component of the plant cell wall limits the ability of dairy and beef cattle to use polysaccharides. Down-regulation of the gene for C3H in alfalfa results in lignin that is derived from 65% of a lignin monomer, p-coumaryl alcohol, which is normally present at very low levels. The compositional and structural changes result in improved digestibility of the plant cell wall. In collaboration with the Noble Foundation who produced transgenic plants for evaluation, ARS scientists at Madison, Wisconsin, performed detailed structural and compositional analysis, and involved the industry in field trials for digestibility. C3H-down-regulation provides a new approach to improving digestibility of forages.

**IMPACT/OUTCOME 1:** A 10 percent improvement in cell-wall digestibility of forages by dairy cows in the U.S. is estimated to annually increase milk sales by \$350 million while reducing manure solid production by 2.8 million tons and lowering grain supplement needs by 2 million tons on an annual basis.

**ACCOMPLISHMENT 2:** Pinkeye is one of the most economically important diseases in cattle. ARS research at Clay Center, Nebraska, has identified two putative quantitative trait loci for this trait, one on chromosome 1 and the other on chromosome 20. A gene known to be involved in pathogen resistance has been located under the quantitative trait loci on chromosome 1.

**IMPACT/OUTCOME 2:** These findings should motivate future studies aimed to identify the genetic base of pinkeye.

*develop technologies leading to improved marketability of animal products.*

**ACCOMPLISHMENT 1:** Research conducted at West Lafayette, Indiana, showed that use of a clean lairage (temporary holding environment) and maintained social structure for a period of 8 hours was beneficial to pigs during transport. Lairage in a known clean environment had benefits of diminished stress and immune stimulation, even 2 weeks after transport. Measures of behavior on the truck, during the lairage, and after the transport showed effects of increased transport stress in continuously transported pigs. Rehydration during the lairage was beneficial and access to feed improved intestinal microbial population stability, potentially altering the ability of the pig to use the nutrients that it eats.

**IMPACT/OUTCOME 1:** These results will aid producers and scientists in managing transported swine more efficiently while simultaneously decreasing losses due to animal stress.

**ACCOMPLISHMENT 2:** A primary determinant of beef carcass value is USDA quality grade, which is largely a function of the degree of marbling as estimated subjectively by USDA graders. Because marbling score determination is subjective, the grading system has been widely scrutinized due to perceived variation in application from plant to plant and among graders within plants. USDA and the beef industry have sought to develop methods to determine beef carcass marbling scores more objectively. ARS scientists at Clay Center, Nebraska, collaborated with an instrument manufacturer to develop accurate methods for marbling score determination as an additional function of the U.S. Meat Animal Research Center (USMARC) beef carcass image analysis system. In collaboration with Agricultural Marketing Service (AMS) scientists and meat grading coordinators, data was collected to develop standards for marbling. Additionally, a series of cooperative studies were conducted to gain AMS approval for use of the USMARC beef carcass image analysis system for marbling determination.

**IMPACT/OUTCOME 2:** This technology, which is expected to have an annual multi-million dollar impact on the beef industry, should benefit consumers and all sectors of the beef industry.

**ACCOMPLISHMENT 3:** Mortality of catfish eggs and fry in commercial hatcheries ranges from 10 to 30 percent of eggs brought to the hatchery, based upon data collected at twenty commercial hatcheries. ARS scientists at Stoneville, Mississippi, and collaborators at Mississippi State University Extension Service determined oxygen requirements of catfish eggs and fry from the current management practices of the twenty hatcheries.

**IMPACT/OUTCOME 3:** Recommendations for hatchery managers were developed and are now in use, and could result in a 10-20 percent increase in fry production by the catfish industry.

**ACCOMPLISHMENT 4:** A traditional method of diagnosis requires about a week to arrive at a definitive identification, by which time the opportunity to treat or salvage uninfected stock has passed. ARS scientists at Auburn, Alabama, developed a multiplex-polymerase chain reaction technique to enable simultaneous and accurate identification of *Edwardsiella ictaluri* (ESC), *Flavobacterium columnare* (columnaris disease), and *Aeromonas hydrophila*, (motile aeromonad septicemia).

**IMPACT/OUTCOME 4:** This test will enable fish farmers to identify the presence of these pathogens within several hours of observing signs of disease or mortalities and to make management decisions to avert the spread of disease.

**ACCOMPLISHMENT 5:** Handling and moving is stressful to fish and results in injuries and mortalities. ARS partners at the Conservation Fund Freshwater Institute, Shepherdstown, West Virginia, developed technology, based upon the rainbow trout's ability to sense and avoid carbon dioxide dissolved at elevated levels in water, to move rainbow trout from tank to tank for management purposes or harvesting.

**IMPACT/OUTCOME 5:** This technique is inexpensive, safe, and humane for transferring fish in circular aquaculture tanks.  
*identify genes and their function leading to DNA tests for use in food animal genetic improvement programs.*

**ACCOMPLISHMENT:** ARS scientists at Stoneville, Mississippi, and Leetown, West Virginia, discovered genetic components of resistance to the disease-causing pathogens *Edwardsiella ictaluri* in catfish and to *Flavobacterium psychrophilum* in rainbow trout. Field evaluation is underway for an improved strain of catfish. Scientists have found that the toll-like receptor gene is expressed at a lower level in resistant catfish, and will evaluate the gene as a candidate for marker assisted selection of catfish for survivability.

**IMPACT/OUTCOME:** Marker assisted selection could improve the accuracy of selection for this elusive trait.

*develop genomics infrastructure and tools that will enhance efficiency and speed of gene identification, and utilization of DNA data in genetic improvement programs of food animals.*

**ACCOMPLISHMENT 1:** Through an internationally funded effort, the Baylor College of Medicine Human Genome Sequencing Center led an effort in generating sequences and assembling the bovine genome sequence into contigs--contiguous sequences of DNA created by assembling overlapping sequenced fragments of a chromosome. ARS scientists at Clay Center, Nebraska, constructed an integrated genetic map comprised of approximately 17,000 markers from several genetic linkage and radiation hybrid maps from around the world. This integrated map was used in the bovine genome sequencing project to serve as the scaffold for assigning sequence contigs to chromosomal positions. In addition, over 1,500 full length cDNA sequences, the gold standards for annotating genes on a genome, were generated and annotated.

**IMPACT/OUTCOME 1:** These accomplishments will greatly accelerate the discovery of DNA markers suitable for marker-assisted selection and fine mapping of genes for economically important traits in cattle.

**ACCOMPLISHMENT 2:** MicroRNA genes are a recently discovered form of genetic regulation with enormous impact on a variety of traits including growth, development, and tissue homeostasis. ARS scientists at Clay Center, Nebraska, performed the first survey of microRNA in cattle and swine muscle, and identified similarities and differences between reports from human and mouse muscle microRNA expression profiles. The small RNA fraction containing putative microRNAs was isolated, cloned, and sequenced to identify regulatory molecules. The first experimentally verified cattle microRNA sequences were deposited in the public database, and comparisons with published data from other species were made to identify potential ruminant specific molecules.

**IMPACT/OUTCOME 2:** These results have significant impact on understanding the biology of ruminant muscle, and help scientists address the general problem of annotation and subsequent analysis of the bovine genome sequence.

**ACCOMPLISHMENT 3:** The availability of the chicken genome sequence offers many opportunities to understand complex biological questions, such as how genetic variation influences economically important traits. As a prelude to this advancement, researchers at East Lansing, Michigan, evaluated a large number of chicken lines, including birds from 36 elite commercial lines. By scoring 3,072 SNP markers on 2,580 different chickens, scientists were able to screen the genome for unique or common alleles among the various chicken lines. This result is relevant to scientists and poultry breeding companies as it helps determine what genes are under genetic selection for economically important traits in industry broiler and layer lines. It is now possible to “trace back” poultry products to individual companies and lines through DNA fingerprinting using these markers. An additional aspect of this project is the development of a linkage disequilibrium map of the chicken genome (i.e., haplotype map), which will facilitate the evaluation of whole genome selection methodology.

**IMPACT/OUTCOME 3:** This is the first comprehensive genetic profile of virtually an entire commodity group, and the research provides substantial contributions to poultry breeding and food safety.

*continue to characterize germplasm of food animals for traits of importance.*

**ACCOMPLISHMENT 1:** The slick hair coat phenotype has been observed in tropical breeds of *Bos taurus* cattle. It has been found to be beneficial for heat tolerance, often producing body temperatures 0.5° C lower for slick haired animals than for their normal-haired half-sibs during hot summer days. ARS researchers at Brooksville, Florida, conducted a genome scan to map the slick hair gene in Senepol-derived cattle. The gene was localized to a specific region of bovine chromosome 20 bound by two very tightly linked microsatellite markers. The mapping of the slick hair locus is the first step toward the eventual identification of the causative mutation that would constitute the definitive test for the slick hair coat phenotype.

**IMPACT/OUTCOME 1:** The results will facilitate efforts toward introgressing this gene into important temperate *Bos taurus* breeds (such as Angus and Charolais), to enhance their adaptation to tropical environments.

**ACCOMPLISHMENT 2:** A single nucleotide polymorphism (SNP) in the osteopontin gene on bovine chromosome 6 was found to be associated with birth weight, weaning weight, and yearling weight, but not twinning or ovulation rate, in a large multi-generation, cross-bred cattle population at the U.S. Meat Animal Research Center at Clay Center, Nebraska. Frequency of the minor allele in this cattle population was estimated to be 5.2 percent, with the allele producing a difference of 1.14 kg for birth weight and 5.16 kg for 205-day weaning weight. This polymorphism

is a probable functional mutation candidate that successfully tracks functional alleles affecting growth.

**IMPACT/OUTCOME 2:** Marker-assisted selection for the favorable genotype could have a beneficial effect on growth in cattle.

*improve cryopreservation technology for storage of animal germplasm and continue to increase the stocks of germplasm stored within the National Animal Germplasm Program repository.*

**ACCOMPLISHMENT 1:** The security of U.S. animal genetic resources was significantly enhanced in the past year. Samples in the ARS National Germplasm Collection at Fort Collins, Colorado, increased from 229,110 to 296,555, a 29 percent increase. The collection contains germplasm and tissue samples from 7,322 animals from 25 livestock, poultry, and aquatic species.

**IMPACT/OUTCOME 1:** In addition to collecting samples, the repository released genetic material enabling research in quantitative trait loci discovery, impacting the genetic distancing of cattle breeds, and broadening the genetic base of a rare cattle breed.

## **2.2.2 SUMMARY OF THE MAJOR TECHNOLOGIES DEVELOPED, TRANSFERRED, AND USED IN FY 2006:**

**DURING FY 2006, ARS**

reported on five 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.

**DESCRIBE THE TECHNOLOGY 1:**

**DESCRIBE THE TRANSFER 1:**

**IDENTIFY THE CUSTOMER/USER 1:**

**IMPACT/OUTCOME 1:**

**DESCRIBE THE TECHNOLOGY 2:**

**DESCRIBE THE TRANSFER 2:**

**IDENTIFY THE CUSTOMER/USER 2:**

**IMPACT/OUTCOME 2:**

**DESCRIBE THE TECHNOLOGY 3:**

**DESCRIBE THE TRANSFER 3:**

**IDENTIFY THE CUSTOMER/USER 3:**

**IMPACT/OUTCOME 3:**

**DESCRIBE THE TECHNOLOGY 4:**

**DESCRIBE THE TRANSFER 4:**

**IDENTIFY THE CUSTOMER/USER 4:**

**IMPACT/OUTCOME 4:**

**DESCRIBE THE TECHNOLOGY 5:**

**DESCRIBE THE TRANSFER 5:**

**IDENTIFY THE CUSTOMER/USER 5:**

**IMPACT/OUTCOME 5:**

**Performance Measure 2.2.3:** Expand, maintain, and protect our genetic resource base, increase our knowledge of genes, genomes, and biological processes, and provide economically and environmentally sound technologies that will improve the production efficiency, health, and value of our nation's crops.

**Indicators:**

**DURING FY 2006, ARS will**

*develop crop production systems and technologies that harness genetic potential, optimize crop productivity and quality, mitigate losses due to weeds, nematodes, pathogens, and arthropod pests, and utilize appropriate automation to provide a secure food, fiber, and flower supply that is competitive in the global marketplace.*

**ACCOMPLISHMENT 1:** One of the most critical elements in the establishment of a new orchard is the quality and the architecture (size, number of branches, and branch angle) of the trees that are being planted, because good quality trees enable early productivity and profitability of the orchard. ARS scientists at Geneva, New York, in collaboration with Washington State University scientists and a private nursery discovered and described how a diverse group of apple rootstocks can predictably modify the branch angle and number of finished trees, thereby increasing the mature tree's quality.

**IMPACT/OUTCOME 1:** This research also has implications for future mechanization technologies that require specific tree architecture.

**ACCOMPLISHMENT 2:** When temperatures drop below -15°C, blackberry canes and buds can be damaged, resulting in low productivity. ARS scientists in Kearneysville, West Virginia, developed a novel technique to mitigate winter injury, which involves a rotating cross-arm trellis system and cane training technique reorienting a vertical summer canopy to a low profile canopy in winter without breaking canes. The studies showed that even cultivars developed in the Pacific Northwest such as "Siskiyou," a USDA release, produced 3 to 4 times more fruit than unprotected plants and blackberry plants that were covered in winter and produced fruit 2 to 3 weeks earlier.

**IMPACT/OUTCOME 2:** This production technique enables blackberries to ripen during the red raspberry season and can help to extend the harvest season. The new cropping system improves farm diversification and enhances the grower's competitive advantage by allowing the blackberry growers to produce a variety of berry crops for niche markets.

**ACCOMPLISHMENT 3:** The Trellis Tension Monitor, U.S. Patent No. 6,854,337, was developed by ARS scientists at Prosser, Washington, and has been exploited for its sensitivity to subtle changes in trellised vineyards due to vine growth, fruit growth, and certain farming practices that influence the weight that is borne by the trellis wire. This technology can be used to estimate, in real time, information that is important to growers and processors for making decisions about irrigation, crop thinning, and supplemental manual sampling.

**IMPACT/OUTCOME 3:** Access to continuous information about the status of the vineyard will allow growers to continuously adjust some of their farming practices as the crop responds to the weather, irrigation, or other inputs. Currently, information at this temporal resolution is not available to growers, processors, or wineries from existing technologies. The Trellis Tension Monitor is applicable worldwide to any trellised crop in which there is a significant weight-bearing wire integral to the trellis system.

*maintain genetic and genomic databases and make information accessible via standard software from the Internet.*

**ACCOMPLISHMENT 1:** Development of bioinformatics tools to construct a physical map of the soybean genome: A genetically anchored physical map of chromosomes is essential for the isolation of genes underlying agronomically important quantitative trait loci. ARS scientists at Ames, Iowa, have built a relational database to hold all of the physical and genetic map data for soybeans. This database can display the physical map overlaid onto the genetic map and is populated with agronomically important quantitative trait loci. In addition, an online tutorial for the Web-based map displays and databases was also developed.

**IMPACT/OUTCOME 1:** This database will be helpful for analyzing and interpreting the entire genome sequence for soybean generated by the Department of Energy.

**ACCOMPLISHMENT 2:** The mischaracterization of cocoa germplasm accessions and the absence of new accessions of properly characterized wild materials are hampering genebank curation and cocoa breeding in producing countries. ARS scientists made great strides in identifying wild and previously unknown cocoa varieties by publishing the current molecular-based identifications for 1,124 key accessions of wild Upper Amazonian cocoa and depositing the data in the international molecular database (CocoaGenDB) in Montpellier, France. Many clones maintained in the two international collections at Costa Rica and Trinidad were profiled genetically (2,047 in total) and the genetic data were submitted to the international phenotypic database in Reading, United Kingdom, and CocoaGenDB. Analysis and publication of wild populations of cocoa in French Guiana established that they form a very separate and heretofore relatively unknown source of genetic diversity.

**IMPACT/OUTCOME 2:** Analysis and publication of wild populations of cocoa in French Guiana established that they form a very separate and heretofore relatively unknown source of genetic diversity.

*describe in model plants and crop plants the structure, function, and regulation of agriculturally important genes that control plant composition and yield.*

**ACCOMPLISHMENT 1:** ARS scientists at Beltsville, Maryland; Urbana, Illinois; and Ft. Detrick, Maryland, and the Monsanto Company have identified a simple sequence repeat (SSR) genetic marker (BARC\_Sat\_187) that is 99.2 percent accurate in predicting soybean breeding lines that carry resistance to Asian Soybean Rust at the Rpp1 resistance locus. Asian Soybean Rust caused by *Phakopsora pachyrhizi* was first found in the continental United States in 2004, and poses a major threat to the U.S. soybean crop.

**IMPACT/OUTCOME 1:** Four genes in soybean confer resistance to Asian Soybean Rust (Rpp1, Rpp2, Rpp3, and Rpp4), but the utility of these genes in crop improvement has been impeded by a lack of genetic markers. The new SSR marker (BARC\_Sat\_187) will be useful for integrating Rpp1 resistance into modern cultivars.

**ACCOMPLISHMENT 2:** ARS scientists at Beltsville, Maryland, identified numerous proteins that may be important to the infections of soybean with Asian soybean rust (ASR). Researchers used mass spectrometry to identify proteins from rust spores, and found that a majority of the proteins were heat-shock proteins, translation elongation factors, and other proteins. Novel proteins were also discovered, and these proteins may be unique targets for chemical inhibition. The results suggest that an abundance of heat-shock proteins, translation elongation factors, and other protein making machinery enable rust spores to jump-start protein production upon germination and withstand environmental extremes. These abilities likely help improve a spore's ability to survive and infect plants.

**IMPACT/OUTCOME 2:** These findings will help the scientists in identifying soybean proteins and genes involved in susceptibility and resistance to ASR, so that soybean can be engineered with broader resistance to ASR. The protein data will also be useful for designing new fungicides to fight rust diseases.

**ACCOMPLISHMENT 3:** Millers and bakers need high quality wheat, but the elements constituting such wheat are not well understood. ARS researchers at Albany, California, have used wheat biotechnology to determine the effects of two wheat glutenin proteins on dough quality and strength. Researchers also determined the dough mixing properties of transgenic wheat flours that contained increased levels of either glutenin or protein or both.

**IMPACT/OUTCOME 3:** These results can be used to develop wheat lines with a range of dough strengths that could be valuable to the food industry.

**ACCOMPLISHMENT 4:** Tomatoes are a rich source of carotenoids, which are compounds necessary for human health (precursors to vitamin A) in addition to being strong antioxidants. Understanding the nutritional value of carotenoids requires better knowledge of the complex biochemical pathways that affect the availability and nutritional value of different carotenoids as constituents of the human diet. ARS researchers at Ithaca, New York, have identified a new molecular mechanism involving feedback regulation that governs the carotenoid biosynthetic pathway.

**IMPACT/OUTCOME 4:** This discovery will benefit other researchers and plant breeders who are attempting to modify carotenoid accumulation in crop plants, and it could provide a more effective means for enhancing the nutritional value of carotenoids in fruits and vegetables.

*improve plant genetic transformation systems to expand their usefulness and improve exploitation of genome sequence information to identify valuable genes in raw germplasm collections.*

**ACCOMPLISHMENT 1:** Leaves from grass species, such as corn (maize) or switchgrass, will likely be a significant feedstock resource for a bio-based economy. ARS researchers at Albany, California, have cloned the corngrass mutation of maize. Corngrass mutants cause maize to produce many more tillers that are vegetative and have reduced lignin. In collaboration with the researchers at HortResearch, New Zealand, ARS researchers have also cloned a maize gene (“milkweed pod”) that regulates tissue and vascular development of the maize leaf.

**IMPACT/OUTCOME 1:** Cloning these genes that affect maize cell wall content and plant architecture will be an important step toward developing plants with increased energy availability for biofuel production.

*develop new genetic methods and tools to identify specific genes that affect end-product traits desired by consumers, such as oil and grain quality, disease resistance, and stress tolerance in agricultural crops.*

**ACCOMPLISHMENT 1:** Researchers at ARS crop genebanks and their university collaborators developed and/or applied powerful molecular diagnostic tools for ensuring that germplasm is free of key diseases. Examples include molecular diagnostic tests for seedborne Stewart’s wilt in maize and bacterial fruit blotch of melons (ARS Ames, Iowa genebank); Citrus leprosis virus (ARS Riverside, California genebank); Phytoplasmas in hazelnut, strawberry, pear, and blueberry (ARS Corvallis, Oregon genebank); alfalfa mosaic virus in crotolaria (ARS Griffin, Georgia genebank); and cucumber mosaic, banana streak, and banana mild mosaic viruses (ARS Mayagüez, Puerto Rico genebank).

**IMPACT/OUTCOME 1:** These molecular diagnostic tests enable rapid, inexpensive, and accurate detection of key pathogens, which is critical for maintaining germplasm health and permitting international and domestic germplasm exchange. Ready access to vigorous and healthy plant germplasm is integral to accelerating progress in crop genetic resource conservation and breeding.

*construct and maintain physical, genetic, and transcript maps to facilitate comparative analyses among plant genomes.*

**ACCOMPLISHMENT 1:** Improving agricultural traits via standard genetic mapping approaches and many molecular markers, although faster than traditional breeding methods, can be a slow process. ARS researchers at Ithaca, New York, and Cornell University researchers have developed a new statistical genetic design for dissecting complex traits in corn at the gene level. Although standard mapping approaches result in low resolution of complex traits, this new approach, Nested Association Mapping, combines high-throughput DNA sequencing with new statistical approaches that yield very high resolution mapping.

**IMPACT/OUTCOME 1:** These new genetic analysis methods can be extended beyond corn for more precisely manipulating traits in many types of crops.

*identify, acquire, and expand the genetic base of crops through new accessions to enhance the diversity of plant germplasm collections.*

**ACCOMPLISHMENT 1:** During FY 2006, the 20-plus genebanks in the ARS National Plant Germplasm System (NPGS) added more than 9,000 separate samples of more than 500 plant species to their collections, creating a total of more than 474,000 samples of more than 11,800 plant species conserved by NPGS genebanks. Scientific interest in this germplasm has increased tangibly during the last few years, with the average number of samples distributed per year now totaling more than 130,000, 30,000 more than the average a decade ago.

**IMPACT/OUTCOME 1:** Availability of these materials are keys for continued progress in crop genetics and breeding, which are essential to ensure future food security.

*strengthen breeding and evaluating of specialty crops that have increasing economic importance.*

**ACCOMPLISHMENT 1:** There is a growing interest in development of sugarcane varieties that provide cold hardiness (to increase the range of cane production in temperate climates), have increased sugar, and show potential for use in biofuels. ARS scientists in New Orleans, Louisiana, have developed several new germplasm lines that incorporate *Saccharum spontaneum*, a weedy species of sugarcane better adapted to sub-tropical environments, as the female parent. Several of these lines have sucrose contents that match those of current commercially grown varieties, which trace their ancestry to one female parent incapable of surviving most winters in Louisiana and points north.

**IMPACT/OUTCOME 1:** These lines will be used as parents during the 2006 crossing season to develop sugarcane varieties with improved cane and sugar yields over a range of environments.

**ACCOMPLISHMENT 2:** Four new restorer germplasm lines (RHA 461 to RHA 464) were released by ARS and the North Dakota Agricultural Experiment Station. These germplasm have been selected for their tolerance to Sclerotinia head rot, a major sunflower disease. RHA 462 provides tolerance to Phomopsis stem canker; RHA 464 has resistance to the most virulent North American races of rust and downy mildew.

**IMPACT/OUTCOME 2:** These germplasms are available for use by industry and public researchers to create hybrids, parental lines, or germplasms with increased disease tolerance.

**ACCOMPLISHMENT 3:** ARS released three improved germplasm lines of upland cotton to the public (jointly with Cotton Incorporated) that possess superior fiber length and strength characteristics and improved yield performance under heat stress environments. Future profitability for U.S. cotton growers requires improvements in fiber quality and plant productivity under abiotic stress, including high heat conditions.

**IMPACT/OUTCOME 3:** The lines provide public and private breeders with resources for concurrent improvement of fiber quality and heat tolerance in upland cottons for the mid-South and Southeastern United States. The lines also serve as genetic resources for improving heat tolerance in Acala cottons of the Southwestern and Western United States. The new germplasm has the potential to impact cotton production over a larger portion of the cotton belt in the U.S.

**ACCOMPLISHMENT 4:** ARS scientists at Columbia, Missouri, in collaboration with DuPont, Inc., transformed soybeans with a barley gene, that catalyzes the first step in the synthesis of the tocotrienol form of vitamin E. Gene expression for the barley HGGT under the control of a strong seed specific promoter was accompanied by four to six fold increases in the total vitamin E antioxidant content of soybean seeds. The vitamin E produced in the engineered seeds was principally delta- and gamma-tocotrienol, which are most effective at stabilizing vegetable oils in frying applications. In addition, the increase in total vitamin E antioxidant achieved in these studies greatly exceeds the gains obtained to date by conventional breeding or by biotechnological approaches that have targeted only one gene.

**IMPACT/OUTCOME 4:** It is anticipated that vegetable oils from these genetically enhanced seeds will have improved oxidative stability for food processing and high temperature lubricant applications. In addition, the use of these antioxidant-enriched seeds in livestock feed may result in meats with improved appearance and shelf life. End users of these seeds will likely include soybean oil processors and biobased lubricant manufacturers.

**ACCOMPLISHMENT 5:** The newly released pear variety “Sunrise” fills the need for an early season pear cultivar with excellent fruit quality and appearance and resistance to the devastating disease known as fire blight. Evaluations by ARS scientists at Kearneysville, West Virginia, and cooperators documented excellent overall consumer acceptance in comparison with existing commercial varieties.

**IMPACT/OUTCOME 5:** “Sunrise” may reduce grower losses and provide superior economic return to fruit orchards, especially in regions where the annual risk of fire blight disease limits pear production.

### **2.2.3: SUMMARY OF THE MAJOR TECHNOLOGIES DEVELOPED, TRANSFERRED, AND USED IN FY 2006:**

**During FY 2006, ARS**

reported on five new technologies developed and used to increase production efficiency and enhance the economic value and quality of U.S. crop production while decreasing the environmental **IMPACT?**.

#### **Describe the Technology 1:**

ARS collaborated with major commercial pecan farming operations to re-evaluate the previously discarded concept of mechanical hedge pruning of orchards to control crowding, the light environment, and alternate bearing. The integration of farmer experience and willingness to test new approaches, lessons learned from previous failures, and ARS’ expertise resulted in the use of large hedging machines as a horticultural tool to solve major profit and yield-limiting problems. The ARS scientist also interacted with owners and designers of hedging machines regarding the design and usage of such machines to ensure that grower needs were satisfied; and with a State extension specialist to facilitate refinement and ultimate adoption of the approach.

#### **Describe the Transfer 1:**

The transfer of the technology began when an ARS scientist spoke at several pecan industry meetings about concepts and approaches, published basic principles in grower-oriented magazines, and published in a scientific journal. Adoption of the technology has recently

exploded throughout southwestern United States, after key successful farmers reported remarkable results at grower meetings and field-days.

**Identify the Customer/User 1:**

The U.S. customers using the technology are commercial scale pecan farmers in California, Arizona, New Mexico, and Texas where sunlight levels are relatively high. It is now also widely used in Mexico, Australia, and South Africa. Technology for low sunlight environments typified by the southeastern United States is currently under research.

**Impact/Outcome 1:**

The technology was adopted by roughly 80 percent of large, commercial-scale orchard operations throughout the southwestern United States and impacts roughly 40 percent of the annual U.S. pecan crop (about 150 million pounds of nuts). The technology reduces the magnitude of alternate bearing and associated yield losses, increases orchard profitability and yield, and potentially improves pest control while reducing environmental harm.

**Describe the Technology 2:**

The rotating cross-arm trellis consists of a short post and a long cross-arm that can be rotated about a pivot point at the top of the post. Using a special cane training technique developed by ARS scientists, and timed rotation of the cross-arm, floricanes and primocanes of blackberry plants can be positioned spatially apart. The floricanes can be positioned close to the ground in winter for installing protective covers over the canes, and later in spring, can position nearly all fruit on one side of the row for three-fold increase in harvest efficiency.

**Describe the Transfer 2:**

ARS scientists have described the trellis design, cane training technique, and cross-arm manipulation at grower and scientific meetings. Also, several papers have been published in scientific journals and conference proceedings.

**Identify the Customer/User 2:**

Blackberry growers in New Jersey, Indiana, California, and Utah have installed trellises based on ARS' design. Extension specialists in several states have established demonstration plots using the rotating cross-arm trellis design.

**Impact/Outcome 2:**

Rotating cross-arm trellises can modify the crop environment to decrease weather-related stresses and improve productivity and fruit quality. The adaptation of ARS' new trellis design and cane training technique reduced sun burn damage on blackberries in California's Central Valley and improved harvesting blackberries at u-pick farms in the eastern United States. Recent studies showed that in combination with winter protection covers reduced winter injury, and contributed to increased planting of blackberries in areas like Utah and New England where low winter temperatures have limited production.

**Describe the Technology 3:**

ARS scientists at Beltsville, Maryland; Urbana Illinois; and Ft. Detrick, Maryland, working with researchers at the Monsanto Company, have identified a simple sequence repeat (SSR) genetic marker that is 99.2 percent accurate in predicting which soybean breeding lines carry resistance to Asian soybean rust at the Rpp1 resistance locus.

**Describe the Transfer 3:**

ARS scientists and collaborators have publicly released and published the DNA sequence.

**Identify the Customer/User 3:**

Four genes in soybean confer resistance to Asian soybean rust (Rpp1, Rpp2, Rpp3 and Rpp4), but incorporating these resistance genes into soybean varieties has been slowed by the lack of

effective genetic markers. Plant breeders and other soybean scientists will use the SSR marker to incorporate Rpp1 resistance into modern soybean cultivars

**Impact/Outcome 3:**

Asian soybean rust was first found in the continental United States in 2004, and poses a potentially major threat to the U.S. soybean crop. The DNA marker will accelerate efficient genetic selection for soybean rust resistance and development of new commercial cultivars with effective resistance to soybean rust.

**Describe the Technology 4:**

Improving agricultural traits through standard genetic mapping approaches and many molecular markers can be a slow process. ARS researchers at Ithaca, New York, working with Cornell University researchers, have developed a new statistical genetic design for dissecting complex traits in corn at the gene level. This new approach is called Nested Association Mapping.

**Describe the Transfer 4:**

ARS researchers have published and publicly released the new genetic selection method.

**Identify the Customer/User 4:**

Plant geneticists, breeders, and other plant scientists will benefit from using this new statistical and genetic method.

**Impact/Outcome 4:**

Standard mapping approaches result in low resolution for genetic mapping of complex traits. This new approach combines high-throughput DNA sequencing with new statistical approaches that yield very high resolution mapping. These new genetic analysis methods can be extended beyond corn for manipulating traits and accelerating plant breeding in many types of crops.

**Describe the Technology 5:**

ARS developed three improved germplasm lines of upland cotton (jointly with Cotton Incorporated) with superior fiber length and strength characteristics and improved yield performance under heat stress environments.

**Describe the Transfer 5:**

ARS released the three germplasm cotton lines to the public (with Cotton Incorporated).

**Identify the Customer/User 5:**

The lines provide public and private breeders with resources for concurrent improvement of fiber quality and heat tolerance in upland cottons for the mid-south and southeastern United States. The lines also serve as genetic resources for improving heat tolerance in Acala cottons of the southwestern and western United States.

**Impact/Outcome 5:**

Future profitability for U.S. cotton growers requires improvements in fiber quality and plant productivity under abiotic stress, including high heat conditions. Thus the new germplasm may provide superior germplasm that will improve cotton production over a larger portion of the cotton belt in the United States.

**GOAL 3: SUPPORT INCREASED ECONOMIC OPPORTUNITIES AND IMPROVED QUALITY OF LIFE IN RURAL AMERICA**

**ARS research in support of Goal 3 is conducted and reported under strategic Goals 2, 4, 5 and 6**

**GOAL 4: ENHANCE PROTECTION AND SAFETY OF THE NATION'S AGRICULTURE AND FOOD SUPPLY**

<b>GOAL 4 PROGRAMS</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>
Food Safety	\$108,071	\$Not Available	\$Not Available
Livestock Protection	97,975		
Crop Protection	181,646		
<b>Total</b>	<b>\$387,692</b>	<b>\$Not Available</b>	<b>\$Not Available</b>

NOTE: Dollars in Thousands.

**Means and Strategies:** To successfully accomplish the research activities under this goal, ARS will need the resources reflected in the table above.

**Verification and Validation:** ARS currently conducts a series of review processes designed, to ensure the relevance and quality of its research work, and to maintain the highest possible standards for its scientists. A more detailed description of the evaluation plans can be found in the introduction of this plan.

**STRATEGIC RESULTS: A Safe U.S. Food Supply And Agricultural Production System**

**OBJECTIVE 4.1: Provide The Scientific Knowledge To Reduce The Incidence Of Foodborne Illnesses In The U.S.**

**Performance Measure 4.1.1:** Develop new technologies that assist ARS customers to detect, identify, and control foodborne diseases affecting human health.

**Indicators:**

**DURING 2006, ARS will**

*using new detection and quantitative methodologies, including genomic technologies, and through the study of epidemiology, ecology and host pathogen relationships, intervention strategies, and antibiotic resistance in food producing animals, develop practices, products, and information that will reduce preharvest pathogen and toxic residue contamination of animal-derived food products. Ensure that these technologies can be utilized by regulatory agencies and/or producers to help assure safe food products.*

**ACCOMPLISHMENT 1:** Foodborne pathogens can live in the gastrointestinal tract of food animals. Researchers from College Station, Texas, and Athens, Georgia, have devised diverse strategies to reduce pathogenic bacteria in food animals during the production chain. An antimicrobial protein was discovered that reduces Salmonella infections in egg-laying chickens by stimulating the birds' own immune system. As a feed additive, this protein shows great promise in reducing Salmonella in poultry and is being subjected to further real world testing. Other researchers have shown that the addition of a bacterial protein (called a bacteriocin) can reduce Campylobacter populations in chickens. In cattle and swine, the pharmaceutical product Ractopamine that is used to promote growth and increase lean muscle mass was found to reduce *E. coli* O157:H7 intestinal colonization and fecal shedding in feedlot cattle.

**IMPACT/OUTCOME 1:** All of these pathogen reduction strategies are important because they do not use traditional antibiotics, which increase antibiotic resistance.

**ACCOMPLISHMENT 2:** *Campylobacter* and *Salmonella* are the two most common food-borne pathogenic bacteria affecting the U.S. and are both associated with poultry; they cost the U.S. economy approximately \$4 billion per year in direct and indirect costs. Scientists in Athens, Georgia, and Gainesville, Florida, found that flies could transmit *Salmonella* through direct

surface contact or being eaten by hens. Researchers found that flies could spread *Salmonella* between rooms and houses that have been decontaminated. Other scientists in College Station, Texas, found that the tray liners used to transport newly hatched chicks from commercial hatcheries could contain *Campylobacter*, thus serving as a vector to the newly hatched bird.

**IMPACT/OUTCOME 2:** Combined, the results of these research projects suggest two new critical control points where we can attack the spread of *Salmonella* and *Campylobacter* on the farm.

*using new detection and quantitation methodologies, including genomic technologies, and through the study of crop/fungal/toxin relationships, production practices and expert systems, breeding targets for resistant crops, biocontrol technologies and chemical toxicity, develop practices, products, and information that will reduce preharvest fungal/toxin contamination of plant-derived food products. Ensure that these technologies can be utilized by regulatory agencies and/or producers to help assure safe food products.*

**ACCOMPLISHMENT 1:** Numerous outbreaks of *E. coli* O157:H7 have been linked to produce grown and processed in California. Knowledge of the epidemiology and ecology of *E. coli* O157:H7 in this agricultural environment is critical for preventing contamination of raw produce in the fields. ARS scientists in Albany, California, in collaboration with the California Department of Health Services, Central Coast Regional Water Quality Control Board, and FDA, sampled numerous watershed sites in Salinas Valley, California. Multiple *E. coli* O157:H7 strains, sources of dissemination, and persistence related to the watershed were identified.

**IMPACT/OUTCOME 1:** This information was critical to the industry and regulatory agencies in their analysis of the recent spinach related *E. coli* O157:H7 foodborne illness outbreak.

**ACCOMPLISHMENT 2:** Tree nuts sales are estimated at \$2 billion per year; approximately 60 to 70 percent of the crop is exported. Aflatoxin is a serious threat to human health and agricultural trade because it is a potent natural carcinogen produced by a fungus. Levels of aflatoxin in tree nuts are closely monitored by importing nations. Research in Albany, California, has demonstrated that some antioxidants reduce fungal synthesis of aflatoxin by enhancing the natural breakdown of aflatoxin by the fungus that produces it.

**IMPACT/OUTCOME 2:** Antioxidant levels can be increased through selective breeding or direct application to tree nuts, making them safer for consumers and more acceptable to trading partners.

*develop innovative methods and advanced technology systems that: rapidly and accurately detect, identify, and differentiate the most critical and economically important foodborne contaminants, such as bacterial, viral, and protozoan pathogens; drug and chemical residues; and pathophysiological and processing surface contamination. Ensure that the technologies are transferred to the Food Safety Inspection Service (FSIS) and the Food and Drug Administration (FDA); the Department of Homeland Security; and industry for implementation into Hazard Analysis Critical Control Point (HACCP) programs, and Good Manufacturing Practice (GMP) protocols for both large and small producers and processors.*

**ACCOMPLISHMENT 1:** In order to quantify the risks associated with the slaughter of animals that may harbor or shed *E. coli* O157:H7 or *Salmonella* species, accurate estimates of the prevalence and frequency of pathogen distribution and relative concentration on hides and in feces is needed. ARS scientists at the Clay Center, Nebraska, developed two methods for the direct enumeration of *E. coli* O157:H7 and *Salmonella* species.

**IMPACT/OUTCOME 1:** Use of the methods for pathogen enumeration data, in combination with pathogen prevalence, will provide processors and regulatory agencies with greater control of potential pathogen contamination and further improve the safety of beef for consumers.

**ACCOMPLISHMENT 2:** There is a need to differentiate between live and dead bacteria in foods. Scientists at Wyndmoor, Pennsylvania, in collaboration with Purdue University, have developed a test using specialized spectroscopy methods to readily differentiate live versus dead cells of *E. coli* O157:H7. This test permits rapid differentiation for cells killed by the various processing techniques used in industry. Because of the relative speed of this multi-step procedure, large numbers of cells could be quantitatively analyzed.

**IMPACT/OUTCOME 2:** Regulatory agencies will greatly benefit from the implementation of this technology.

**ACCOMPLISHMENT 3:** Norwalk virus cannot be cultured, and therefore detection relies on capture and concentration of the virus. Scientists at Albany, California, developed a novel Polymerase Chain Reaction (PCR) method involving an immunochemical capture step and real-time PCR (rtI-PCR). The sensitivity of this rtI-PCR technology is significantly increased over the standard ELISA and traditional reverse transcriptase (RT) PCR for the detection of virus in stool and food samples.

**IMPACT/OUTCOME 3:** This technology meets the critical need of public health agencies for simpler, faster, and more sensitive detection methods for this common viral food contaminant.

**ACCOMPLISHMENT 4:** There are a wide variety of mycotoxins that are structurally different and have different modes of action. The differences in toxin structure makes identification of the specific toxin involved in illnesses or crop death difficult and time consuming. Researchers in Peoria, Illinois, have synthesized and characterized molecularly imprinted polymers that bind the mycotoxin moniliformin. The synthesis of the imprinted polymers will allow for rapid diagnostics and for evaluation of strategies to bind toxins in feeds, foods, and humans. Other researchers at Peoria have produced monoclonal antibodies that recognize the mycotoxins nivalenol and vomitoxin.

**IMPACT/OUTCOME 4:** These antibodies can be used simultaneously to screen corn, wheat, and barley for these important toxins through a simple ELISA test, and prevent them from affecting humans, animals, or plants.

*determine the microbial ecology and transmission of human pathogens during animal, plant, and seafood (shellfish) processing, and identify the critical control points to reduce contamination. Develop innovative postharvest intervention strategies for improving the microbial and chemical safety of foods while reducing the impact on quality and consumer acceptance. Ensure that these technologies can be implemented into HACCP and GMP protocols and have efficacy for approval by FSIS and FDA.*

**ACCOMPLISHMENT 1:** Scientists at Beltsville, Maryland, designed two handheld portable inspection devices equipped with head mount displays and wireless image-voice central communication capabilities for sanitary inspections of food processing plants. The technology has applications for the inspection of foods and processing plant sanitation, such as for fecal contamination on stainless steel plates that are typically used for manufacturing plant equipment.

**IMPACT/OUTCOME 1:** Various food safety regulatory agencies, security agencies, and commodity organizations have shown considerable interest in the technology. A U.S. patent application for the technology has been submitted.

**ACCOMPLISHMENT 2:** Furan and acrylamide are chemicals of concern found in many thermally processed foods. Scientists at Wyndmoor, Pennsylvania, conducted studies to

determine if ionizing radiation could decrease the amount of furan and acrylamide in various foods. Low dose ionizing radiation significantly reduced furan levels in ready-to-eat meats, but had a limited effect on the inactivation of acrylamide in oils and potato chips.

**IMPACT/OUTCOME 2:** This data will directly assist the Food and Drug Administration in evaluating a petition currently under review to allow irradiation of ready-to-eat foods.

*undertake genomic and proteomic analyses of pathogens affecting food safety. 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 and food security.*

**ACCOMPLISHMENT 1:** A computer modeling program was developed to simulate the heat transfer process during hot water immersion heating of frankfurter packages to eliminate L. monocytogenes. This model was capable of predicting the internal temperature distribution of frankfurters and estimating the process of thermal inactivation within 1-log accuracy.

**IMPACT/OUTCOME 1:** The models assist Federal regulatory agencies is developing risk assessment information.

**ACCOMPLISHMENT 2:** Studies estimated the lethal dose for pure and crude ricin toxin. The effect of food on absorption of toxin, and the effects of cooking on the stability of toxin in the foods was evaluated.

**IMPACT/OUTCOME 2:** This project facilitated a threat assessment to determine the potential for bioterror using ricin in specific food commodities.

#### **4.1.1: SUMMARY OF THE MAJOR TECHNOLOGIES DEVELOPED, TRANSFERRED, AND USED IN FY 2006:**

##### **DURING FY 2006, ARS**

reported on five new technologies developed and used to 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, AHHIS, ERS, CDC, FDA, DHS, DoD, Risk Assessment Consortium, Codex Alimentarius Commission, academia, and consumer and commodity organizations.

**DESCRIBE THE TRANSFER 1:** Developed and validated a mechanism to determine the likelihood of inflicting harm through contaminating the food supply.

**DESCRIBE THE TRANSFER 1:** Determined the dosage and bioavailability of ricin that could kill 50% of the exposed individuals.

**IDENTIFY THE CUSTOMER/USER 1:** FSIS, FDA, DHS, FBI, and CIA.

**IMPACT/OUTCOME 1:** Information was used to specifically conduct an accurate vulnerability assessment (CARVER + SHOCK) of the food supply. Assessment documents require security clearance to review.

**DESCRIBE THE TECHNOLOGY 2:** Pathogen Modeling Program (PMP 7.0). The predictive microbiology application was designed as a research and instructional tool for estimating the effects of multiple variables on the growth, inactivation or survival of food borne pathogens.

**DESCRIBE THE TRANSFER 2:** PMP 7.0 represents a new direction from a programming perspective, in that it utilizes the new Microsoft.Net programming architecture.

**IDENTIFY THE CUSTOMER/USER 2:** Numerous regulatory and research agencies, academia, and industry: For example FSIS, FDA-CFSAN, Risk Assessment Consortium, Codex, various industry, academia, other international, for example: Australian Food Safety Center Excellence, UK-Food Standards Agency.

**IMPACT/OUTCOME 2:** Recent accomplishments of this research program include new models of the growth of Salmonella in poultry products which have been used in risk assessments developed by the World Health Organization and the Food & Agriculture Organization. Each year, the PMP is downloaded from the Internet by approximately 5,000 users in 35 countries.

**DESCRIBE THE TECHNOLOGY 3:** Method to extract norovirus from shellfish. Noroviruses are the primary cause of food-related illness in North America. They are frequently associated with the consumption of contaminated water or food such as oysters and clams. They have also been associated with outbreaks in schools, hospitals, and nursing homes, and on cruise ships.

**DESCRIBE THE TRANSFER 3:** Development of a rapid and efficient method for reverse transcription-PCR detection of hepatitis A and Norwalk-like viruses in shellfish.

**IDENTIFY THE CUSTOMER/USER 3:** Numerous public health agencies: Seven laboratories in Canada and three in the United States participated in testing and validating the method including laboratories at Health Canada, the Canadian Food Inspection Agency, Agriculture and Agri-Food Canada, the British Columbia (BC) Centre for Disease Control, the Centre québécois d'inspection des aliments et de santé animale, the University of California at Davis, the U.S. Food and Drug Administration, and the Alaska Environmental Health Laboratory.

**IMPACT/OUTCOME 3:** Production of a reliable test that public health laboratories can use to help ensure that shellfish such as oysters and clams are free of viruses. The method has now been officially incorporated into "The Compendium of Analytical Methods" a reference of microbiological methods used by public health agencies worldwide. The developers of the method Dr. Kingsley and Dr. Richards were given a special USDA-ARS award for their discovery.

**DESCRIBE THE TECHNOLOGY 4:** A "DA Lure" for codling moths was developed and validated in partnership with Trécé, Inc. The use of moth catches in pheromone traps for timing insecticide applications and assessing pest pressure is fundamental to orchard scouting and integrated pest management

**DESCRIBE THE TRANSFER 4:** The lure is actually a natural volatile chemical from pears (one of the host fruits of the codling moth), however, the lure works very well in walnut orchards, another host of the codling moth. An advantage over pheromone lures is that DA attracts both sexes of moths, whereas the pheromone only attracts males. The DA lure can be used to monitor female populations and can be used in combination with pheromone to significantly augment mating disruption in the codling moth.

**IDENTIFY THE CUSTOMER/USER 4:** Producers of tree nuts particularly walnut, almond and pistachio.

**IMPACT/OUTCOME 4:** The pheromone provides a more effective product than has been previously available to control coddling moth on highly valuable tree nut orchards. It also decreases the amounts of highly toxic pesticides that need to be used by growers. Coddling moth will be more effectively controlled, lower amounts of the fungus producing aflatoxin will be present, and fewer tree nuts will contain discernable amounts of aflatoxin, thus improving human health and increasing farm returns.

**DESCRIBE THE TECHNOLOGY 5:** A national audit and verification Program (export market inspection program) for *Trichinella* was developed and implemented in association with private industry (SafePath Labs), National Pork Board, APHIS and FSIS.

**DESCRIBE THE TRANSFER 5:** An audit and verification system was developed and implemented to allow livestock to be certified free from *Trichinella* infection on the farm. The audit is based on evaluation of management practices which are known to limit risk of exposure of animals to infection, and the use of a *T. spiralis* diagnostic kit. ARS provides training to 20-25 meat inspectors per year in support of the Program

**IDENTIFY THE CUSTOMER/USER 5:** National Pork Board, USDA-APHIS, USDA-FSIS, USDA-AMS, US export market.

**IMPACT/OUTCOME 5:** The Program preserves an export market for U.S. exporters exceeding \$150 million dollars annually. The Program satisfies export requirements of the EU, Russia, and Singapore for fresh pork or horsemeat originating in the U.S. which cannot be exported unless exporting meat packers participate in the Program. The Program provides the data necessary to fully validate *Trichinella* detection protocols to meet ISO 17025 import standards proposed for all countries. A bank of international reference serum for use in the harmonization of serological assays for trichinellosis has been established and tested following OIE guidelines; the serum bank is currently available to the international scientific community through the International *Tichiniella* Reference Center in Rome, Italy.

**OBJECTIVE 4.2: Reduce the Number, Severity, and Distribution Of Agricultural Pest And Disease Outbreaks**

<p><b>Performance Measure 4.2.1:</b> Provide scientific information to protect animals, humans, and property from the negative effects of pests, infectious diseases, and other disease-causing entities.</p>
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**Indicators:**

**DURING FY 2006, ARS will**

*further investigate the biology and genomics of important animal pathogens (target two priority diseases) arthropods that transmit pathogens to humans and animals, and arthropods that damage property to better understand essential life cycle processes, interaction with commodities that require protection, and means of detection.*

**ACCOMPLISHMENT 1:** Leptospirosis is one of the most common zoonotic diseases in the world, resulting in high morbidity and mortality in humans and affecting global livestock production. Most infections are caused by either *Leptospira borgpetersenii* or *Leptospira interrogans* bacteria that vary in their distribution in nature and rely on different modes of transmission. ARS scientists at the National Animal Disease Center in Ames, Iowa, and colleagues in Australia reported the complete genomic sequences of two strains of *L. borgpetersenii* serovar *Hardjo* that have distinct phenotypes and virulence. Most interestingly, the *L. borgpetersenii* genome is ~700 kb smaller than *L. interrogans*. Loss of gene function is not random but is centered on impairment of environmental sensing and metabolite transport and utilization. These features distinguish *L. borgpetersenii* from *L. interrogans*, a species that survives extended passage in aquatic environments before encountering a mammalian host. Unlike other leptospiral strains that depend on the environment for transmission, this landmark study indicates that *L. borgpetersenii* is evolving toward dependence on a strict host-to-host transmission cycle.

**IMPACT/OUTCOME 1:** The results of this study provide new targets for vaccine and drug development against this important pathogen.

**ACCOMPLISHMENT 2:** Scientists at the National Animal Disease Center (NADC) in Ames, Iowa, capitalizing on the completion of their work sequencing the whole genome of *M. paratuberculosis* (bovine isolate K10), are now conducting comparative microbial genomics studies. The researchers are identifying unique sequences to generate diagnostics to study the epidemiology and ecology of *M. paratuberculosis*. They isolated the genomic DNA from 35 *M. paratuberculosis* isolates and compared them to the sequenced *M. paratuberculosis* K10 isolate by competitive hybridization to DNA microarrays. Isolates were obtained from a variety of host species, including cattle, goats, sheep, bison, starlings, and humans. Analyses of the data generated from these studies is revealing that *M. paratuberculosis* isolates from sheep can be characterized by a series of inserted and deleted gene clusters, while the isolates obtained from other host species are highly similar to the sequenced isolate *M. paratuberculosis* K10.

**IMPACT/OUTCOME 2:** These findings will allow us to develop a more comprehensive understanding of the genetic diversity present among *M. paratuberculosis* isolates and may answer questions of transmission of *M. paratuberculosis* from one species to another, along with environmental and host pressures on the evolution of the microorganism.

**ACCOMPLISHMENT 3:** Chronic Wasting Disease (CWD) is a member of the Transmissible Spongiform Encephalopathy (TSE) family of disorders that includes Scrapie, Bovine Spongiform Encephalopathy (BSE), and Creutzfeldt-Jacob disease. CWD is a relatively uncharacterized TSE with novel patterns of transmission and agent distribution, and represents the considerable challenge of controlling a persistent disease in free ranging wildlife. CWD in North America has resulted in the loss of domestic and foreign markets, restrictions on trade and movement of live animals, and substantial costs associated with the surveillance of hunter-killed animals. ARS scientists at Pullman, Washington, working in collaboration with the ARS National Animal Disease Center in Ames, Iowa, Colorado State University, and APHIS Veterinary Services and Wildlife Services, documented the first association between the Prnp codon 132 genotype and the incubation time in elk with experimental CWD. The research characterized the disease phenotype in elk as either homozygous or heterozygous for the highly susceptible Prnp allele, and demonstrated that there were no differences in the eventual outcome of the disease, only in the incubation period.

**IMPACT/OUTCOME 3:** This information will be useful for producers and regulatory groups in establishing minimum quarantine periods and elk movement requirements and in providing guidance to investigators performing pathogenesis trials.

**ACCOMPLISHMENT 4:** Biting midges transmit bluetongue and vesicular stomatitis viruses to cattle and other ruminants. These infections affect the health of the animals and greatly complicate what should be routine movement of animals for trade. Scientists at Laramie, Wyoming, have accomplished the nearly impossible by extracting saliva from these tiny insects and then analyzing its components. The result has been an impressive variety of proteins, many of which have strong physiological effects on mammals that are bitten.

**IMPACT/OUTCOME 4:** These basic discoveries will lead to new ways to protect cattle from biting midges and possibly provide better control techniques for other species that bite humans.

**ACCOMPLISHMENT 5:** Ticks are a major threat to the livestock industry and to human health, because particular species transmit pathogens that cause serious diseases. Some of those diseases are already a problem, and others could be introduced to the United States with disastrous results for the agricultural economy. ARS scientists at Kerrville, Texas, and College Station, Texas, in collaboration with academic institutions and industry, have analyzed the mechanics of tick physiology to discover the DNA sequences responsible for pesticide resistance, susceptibility to disease transmission, and essential metabolic processes.

**IMPACT/OUTCOME 5:** This work has opened an entirely new range of possibilities for tick control. Salivary components of ticks have been identified and genetically defined, creating candidates for anti-tick vaccines. Scientists described the first signal transmitter chemicals of the tick brain, establishing a new mode of action for toxicants. Researchers used the sequence of genes that produce insecticide resistance enzymes as the basis for the development of rapid tests to determine an infestation's susceptibility to a particular treatment. The products of this research provide the advances necessary to maintain the current barrier against cattle fever, keep diseases like heartwater out of the U.S., and prevent tragic human illness from Lyme disease and other pathogens.

*further investigate the epidemiology and ecology of important animal pathogens (target two priority diseases) arthropods that transmit pathogens to humans and animals, and arthropods that damage property to improve risk assessment, surveillance, prevention, and control by veterinarians and entomologists.*

**ACCOMPLISHMENT 1:** A study completed by ARS scientists at the National Animal Disease Center in Ames, Iowa, in collaboration with Iowa State University demonstrates that the retina responds to the accumulation of abnormal prion protein in a way that may affect visual system function. In their study of scrapie-infected sheep, scientists found that abnormal prions accumulating in the retina were immunoreactive, demonstrating that specific cell populations of the retina were affected. This study provides the first report that a prion disease in a natural host causes the accumulation of abnormal prions in the retina that is associated with disease, in the absence of overt changes in the retina that are normally indicative of retinal degeneration.

**IMPACT/OUTCOME 1:** This study provides additional information on abnormal prion tissue migration, and may provide new opportunities for early detection of prion diseases in animals prior to clinical signs.

<p><b>Performance Measure 4.2.2:</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.</p>
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**Indicators:**

**DURING FY 2006, ARS will**

***Waiting on Drs. Strickman and Gay 2-5-07***

*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.*

**None!!**

*form new partnerships and continue old partnerships with industry, universities, and other Government agencies in order to promote production and marketing of mathematical models, evidence-based procedures, computerized spatial analysis systems, and other tools that measure risk of animal pathogens, arthropods that pathogens and arthropods that destroy property.*

**ACCOMPLISHMENT 1:** Different strains of Bovine Viral Diarrhea Virus (BVDV) cause different disease syndromes, some causing very severe clinical disease and some causing very mild clinical disease. To date, the only way to determine if a virus caused severe disease (*i.e.*, was a virulent virus) or caused mild disease (*i.e.*, was an avirulent virus) was to infect animals with the virus and observe the results. This limited the research that could be done to determine why some viruses were virulent and others avirulent. ARS scientists at the National Animal Disease

Center in Ames, Iowa, developed a model that uses cultured cells rather than live animals to differentiate between virulent and avirulent viruses.

**IMPACT/OUTCOME 1:** This model may reduce the need to use live animals and will significantly cut the cost and difficulty of studying virulence in BVDV strains. Preliminary results generated with this model indicate that BVDV virulence leads to the death of cells associated with the immune system.

**ACCOMPLISHMENT 2:** The threat of mosquito-borne diseases that already exist in the U.S., like West Nile, or diseases that might be introduced, like Rift Valley fever, has raised awareness of the need for community mosquito control. Each mosquito abatement district tends to know its own area well, but areas between districts or areas where new districts should be formed may have large concentrations of mosquitoes in some parts. Scarce control resources need to be targeted according to the threat. ARS scientists at Gainesville, Florida, and Laramie, Wyoming, working in cooperation with academia, mosquito abatement districts, State governments, and other Federal agencies, have assembled a series of models of mosquito distribution that range from continental to local scale.

**IMPACT/OUTCOME 2:** Following further development and distribution, these models, combined with temperature-based models of disease transmission risk, will be an essential tool for decision makers to determine what areas are in greatest need of mosquito control resources, in order to use those resources to have the greatest impact against disease transmission.

**ACCOMPLISHMENT 3:** The Formosan Subterranean Termite is a devastating pest of property and trees, nesting in the ground, walls, or in living trees. Treatment of trees is particularly difficult because of poor access to the interior and the challenge of detecting the termites within. ARS scientists at New Orleans, Louisiana, working in collaboration with academia, industry, and local government, performed research showing that termites could be detected by their unique head-bumping sounds. A device was developed to listen for the termites in trees, and was successfully applied to show that 60 percent of trees in a portion of New Orleans were infested. Trees were successfully treated using an ARS-developed procedure of applying keratin-based foam with spores of an insecticidal fungus.

**IMPACT/OUTCOME 3:** This procedure provides the pest control industry with a safe, efficient way to eliminate Formosan Subterranean Termites from trees. Combined with other control techniques, this development increases the possibility of eradicating the termites from local areas.

*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.*

**ACCOMPLISHMENT 1:** The screwworm fly was a devastating pest of cattle and other livestock throughout the southern and central U.S. until the 1950s. At that time, USDA developed a plan to eliminate the fly by releasing billions of sterile male flies, overwhelming the reproductive systems of the species. The program has progressed to the point that the screwworm fly has been eradicated all the way south to Colombia. To maintain this barrier, billions of flies must be reared, sterilized, and released. Until this year, the diet for rearing the immature flies (maggots) included a gelling agent that made the mix palatable to the flies. The gelling agent was expensive and had to be disposed as hazardous waste. ARS scientists working at the Screwworm Research Unit in Tuxtla-Gutierrez, Mexico, developed a cellulose-based diet that used ground-up newsprint instead of the gelling agent.

**IMPACT/OUTCOME 1:** The diet has been adopted by the fly-production plant and saves approximately \$300,000 per year, in addition to preventing an environmental problem.

**ACCOMPLISHMENT 2:** Military personnel deployed overseas are particularly susceptible to diseases that are transmitted by insects, ticks, or mites. ARS scientists have been funded by the Department of Defense to work toward the development of new insecticides. Working at Beltsville, Maryland; Gainesville, Florida; College Station, Texas; and New Orleans, Louisiana, chemists and entomologists have invented four entirely new insecticidal chemistries and discovered that two existing pesticides might have applications for preserving public health.

**IMPACT/OUTCOME 2:** After performing the basic work to identify these new insecticides and test their range of uses, ARS will hand off the chemicals to industry for development and marketing. The military will be able to use these new registered insecticides to help safeguard their deployed forces.

**4.2.2: SUMMARY OF THE MAJOR TECHNOLOGIES DEVELOPED, TRANSFERRED, AND USED IN FY 2006:**

**DURING FY 2006, ARS**

reported ten technologies used by the commercial and government sectors relevant to the protection of humans, property, and domestic animals.

**DESCRIBE THE TECHNOLOGY 1:**

**DESCRIBE THE TRANSFER 1:**

**IDENTIFY THE CUSTOMER/USER 1:**

**IMPACT/OUTCOME 1:**

**DESCRIBE THE TECHNOLOGY 2:**

**DESCRIBE THE TRANSFER 2:**

**IDENTIFY THE CUSTOMER/USER 2:**

**IMPACT/OUTCOME 2:**

**DESCRIBE THE TECHNOLOGY 3:**

**DESCRIBE THE TRANSFER 3:**

**IDENTIFY THE CUSTOMER/USER 3:**

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**DESCRIBE THE TECHNOLOGY 4:**

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**IDENTIFY THE CUSTOMER/USER 4:**

**IMPACT/OUTCOME 4:**

**DESCRIBE THE TECHNOLOGY 5:**

**DESCRIBE THE TRANSFER 5:**

**IDENTIFY THE CUSTOMER/USER 5:**

**IMPACT/OUTCOME 5:**

**DESCRIBE THE TECHNOLOGY 6:**

**DESCRIBE THE TRANSFER 6:**

**IDENTIFY THE CUSTOMER/USER 6:**

**IMPACT/OUTCOME 6:**

**DESCRIBE THE TECHNOLOGY 7:**

**DESCRIBE THE TRANSFER 7:**

**IDENTIFY THE CUSTOMER/USER 7:  
IMPACT/OUTCOME 7:**

**DESCRIBE THE TECHNOLOGY 8:**

**DESCRIBE THE TRANSFER 8:**

**IDENTIFY THE CUSTOMER/USER 8:**

**IMPACT/OUTCOME 8:**

**DESCRIBE THE TECHNOLOGY 9:**

**DESCRIBE THE TRANSFER 9:**

**IDENTIFY THE CUSTOMER/USER 9:**

**IMPACT/OUTCOME 9:**

**DESCRIBE THE TECHNOLOGY 10:**

**DESCRIBE THE TRANSFER 10:**

**IDENTIFY THE CUSTOMER/USER 10:**

**IMPACT/OUTCOME 10:**

**Performance Measure 4.2.3:** Develop control strategies based on fundamental and applied research to reduce losses caused by plant diseases, nematodes, arthropods, and weeds that are effective and affordable while maintaining environmental quality. Develop technically and economically feasible alternatives to preplant and postharvest use of methyl bromide.

**Indicators:**

**DURING FY 2006, ARS will**

*develop methods to reduce emissions of harmful gases from crop production systems and postharvest/quarantine treatments.*

**ACCOMPLISHMENT 1:** Field trials conducted by ARS scientists at the Water Management Research Unit, Parlier, California, in commercial certified tree crop nurseries demonstrated that drip application technologies that are comparable to standard shank-injection in coarse textured soils (sandy loams) are not as effective at controlling plant parasitic nematodes as shank-injection in fine textured soils (loam and clay loam). Growers of certified propagative material for orchards and vineyards must be able to produce crops that are free of plant parasitic nematodes at the end of 1- and 2-year crops. Distribution of some fumigants is not adequate following shank-injection in fine-textured soils and drip fumigation is suggested as a possible solution to obtain better distribution of fumigants in fine textured soils. Iodomethane + chloropicrin (pic), 1,3-dichloropropene (1,3-D) alone, and 1,3-D + Pic were applied by standard shank-injection methods and as emulsified formulations through drip irrigation systems and compared to standard methyl bromide fumigation for nematode control in sandy loam, loam, and clay loam soils. Although nematodes at the 15 and 30 cm depths were killed by drip fumigation, nematodes at the 60 and 90 cm depths survived. Drip fumigation was shown to be inadequate for nematode control for certified nurseries grown on fine textured soils.

**IMPACT/OUTCOME 1:** Drip fumigation was shown to be inadequate for nematode control for certified nurseries grown on fine textured soils. This finding will help scientists to determine the most effective alternatives to methyl bromide use.

**ACCOMPLISHMENT 2:** In greenhouse studies conducted by ARS scientists at the ARS Crop Protection and Management Research Unit in Tifton, Georgia, purple and yellow nutsedge growth was monitored in pots covered with black polyethylene mulch, clear polyethylene mulch, or not covered. Relative to the non-mulched treatments, mulches reduced yellow nutsedge tuber production 50 percent and shoot populations 96 percent, while there were no differences among the treatments for purple nutsedge.

**IMPACT/OUTCOME 2:** Polyethylene mulch can be an important component of a yellow nutsedge management system, while other factors will need to be explored for successful management of purple nutsedge. These results were validated in field trials and integrated into an alternative system of weed management in the absence of methyl bromide.

**ACCOMPLISHMENT 3:** ARS scientists at the Pacific Basin Agricultural Research Center in Hilo, Hawaii, developed the first ever quarantine irradiation treatments for coconut scale and white peach scale, two high risk quarantine pests of banana and papaya. Research showed that an irradiation dose of 150 Gy is sufficient to provide quarantine security for both pests. The research on white peach scale provides information to lower the papaya irradiation treatment from 400 Gy to 150 Gy, which will significantly reduce treatment costs, as approximately five million pounds of papayas are currently exported from Hawaii to the U.S. mainland using irradiation.

**IMPACT/OUTCOME 3:** Irradiation can be an important alternative to fumigation with methyl bromide when it is effective and does not cause unacceptable phytotoxic effects.

*continue to identify and characterize genes of insect 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.*

**ACCOMPLISHMENT 1:** ARS scientists at Stoneville, Mississippi, have released the advanced breeding line JTN-5503 with resistance to soybean cyst nematode, frogeye leaf spot, stem canker, and charcoal rot. The soybean cyst nematode is a serious pest of soybean in all the soybean production regions in the United States, and public soybean breeders have identified resistance to this pest as a major breeding objective; the other diseases can also cause significant yield losses. JTN-5503 was grown in nine States in the USDA Southern Uniform Tests program in 2004 and 2005 and was one of the two top yielding entries in its maturity group.

**IMPACT/OUTCOME 1:** Soybean breeders will use this germplasm line as a parent to develop soybean varieties for soybean producers.

**ACCOMPLISHMENT 2:** Anthracnose is causing increasing damage to U.S. sorghum production and is difficult to combat because there are multiple biotypes of anthracnose. ARS researchers at College Station, Texas, and Mayaguez, Puerto Rico, have employed artificial inoculation methods to identify 12 sorghum accessions in the U.S. sorghum collection that are highly resistant to anthracnose.

**IMPACT/OUTCOME 2:** With this knowledge, researchers will be able to characterize these resistant sources in order to effectively manage the disease. In addition, the identification of these resistant lines will provide sorghum breeders with critical new germplasm for developing needed resistance to anthracnose.

**ACCOMPLISHMENT 3:** Soybean rust, *Phakopsora pachyrhizi*, can drastically reduce yields and increase production costs for U.S. producers. Yield losses in some countries in Africa, Asia, and South America have been significant, and since the report of soybean rust in Hawaii in 1994, ARS has renewed its support for soybean rust research. ARS scientists at Ft. Detrick, Frederick, Maryland, screened over 16,000 soybean accessions in the USDA Germplasm Collection located at Urbana, Illinois, and evaluated them for resistance to *P. pachyrhizi* in Biosafety Level 3 containment greenhouses.

**IMPACT/OUTCOME 3:** In analyzing these accessions, scientists identified many new sources of resistance, which may provide the resistance genes needed for future development of soybean cultivars with soybean rust resistance. This information will be critical to soybean researchers who are seeking sources of resistance to soybean rust.

*continue to develop fundamental knowledge about insect biology and ecology that provides the foundation for strategies to exclude, detect, and mitigate pest infestations.*

**ACCOMPLISHMENT 1:** Some fungi can infect many insect pests, making them useful for development as insect biological control agents. However, it is important to identify key bioactive chemistries that are present in the organism prior to use as a biological control agent. ARS scientists have recently identified two compounds of a *Fusarium* species as mutagenic.

**IMPACT/OUTCOME 1:** While the relevance of this is currently unknown, it heightens the need to develop a more complete understanding of these products.

**ACCOMPLISHMENT 1:** After years of study, ARS scientists have discovered a means for using RNA silencing (RNAi) in honey bees. Scientists have shown that soaking or feeding bees with a new class of regulatory compounds leads to changes in bees' genetic material.

**IMPACT/OUTCOME 1:** The RNAi technique will enable researchers to investigate the action of a specific gene (e.g., genes for resistance to diseases and parasites, reproduction, or ability to pollinate crops) by turning off the expression of that gene and observing the effects on the bee.

**ACCOMPLISHMENT 2:** The honey bee immune response may reduce reliance on commercial antibiotics. Using genomic approaches, ARS scientists have showed that harmless bacteria can induce an immune response that proves helpful in warding off infection by a disease-causing bacterium in honey bees.

**IMPACT/OUTCOME 2:** This research addresses the need for understanding the underlying basis for bee responses to disease agents, and has already led to findings by ARS scientists that the bee has a less developed immune response than any other insect, perhaps relying on more socially-related hygienic behavior for colony protection against diseases.

*continue to develop fundamental knowledge about weed biology and ecology that provides the foundation for strategies to exclude, detect, and mitigate weed infestations.*

**ACCOMPLISHMENT 1:** Tropical spiderwort, *Commelina benghalensis*, an exotic invasive weed, has quickly spread in the Southeast Coastal Plain and is the second most troublesome weed in peanut crops. Researchers from the ARS Crop Protection and Management Research Unit in Tifton and Dawson, Georgia, cooperated with University of Georgia scientists to conduct field studies to determine the length of time that peanut fields need to be kept free of tropical spiderwort to minimize yield losses. Research demonstrated that tropical spiderwort was capable of causing 100 percent peanut yield loss after just six weeks of competition. Peanut yield loss was less than 10 percent when plots were kept free of spiderwort for 3- to 6-weeks after peanut planting. This critical period of weed control coincided with peak spiderwort emergence.

**IMPACT/OUTCOME 1:** Growers will use this information to implement a strategy that eliminates spiderwort competition during this interval, saving considerable resources.

*continue to develop fundamental knowledge about plant disease biology and ecology that provides the foundation for strategies to exclude, detect, and mitigate disease outbreaks.*

**ACCOMPLISHMENT 1:** Phytoplasmas and spiroplasmas cause many agriculturally important diseases of plants, but the development of effective disease control measures is hampered by difficulties in identifying the pathogens' strains and species. ARS scientists at Beltsville, Maryland, identified candidate molecular biomarkers that can distinguish strains and species of these pathogens and that are of potential significance in the survival of the pathogens in their hosts and in the development of plant diseases.

**IMPACT/OUTCOME 1:** This accomplishment provides new knowledge important for understanding the mechanisms involved in pathogenicity and transmission of the pathogen by insect vectors.

**ACCOMPLISHMENT 2:** The Western corn rootworm is the most destructive pest of corn in the United States and is now in several European countries after first being detected near Belgrade in 1992. ARS scientists using DNA markers were able to show that the species is invading Europe not only by spreading from the original introduction but also through repeated new introductions from North America.

**IMPACT/OUTCOME 2:** These results show the role of transoceanic transport of harmful pest species and indicate that more attention should be paid to controlling pests on intercontinental flights.

**ACCOMPLISHMENT 3:** Root-knot nematodes cause severe damage and reduce yields in watermelon in the United States. Watermelon germplasm (USDA Plant Introductions) was evaluated by ARS scientists at Charleston, South Carolina, for resistance to southern root-knot nematode in greenhouse tests. Information on resistance and evaluation methodology was transferred to vegetable seed companies, who have begun screening watermelon germplasm, and to USDA Plant Introductions for resistance to root-knot nematodes.

**IMPACT/OUTCOME 3:** Discovery of resistance to southern root-knot nematode in watermelon germplasm could lead to the development of resistant watermelon varieties, which would be an important development due to the restricted availability of methyl bromide as a soil fumigant and the pending loss of other nematicides because of environmental concerns.

#### **4.2.3: SUMMARY OF THE MAJOR TECHNOLOGIES DEVELOPED, TRANSFERRED, AND USED IN FY 2006:**

**During FY 2006, ARS**

reported two new environmentally sound management practices that include crop resistance/tolerance through breeding and biotechnology, rapid and reliable diagnostics, pesticide and cultural and biological control developed and used to protect agriculturally important plants from pests and pathogens.

##### **Describe the Technology 1:**

One focus for the ARS methyl bromide alternatives research program has been developing more effective ways of applying the few available registered alternatives to improve their efficacy. Drip irrigation is used in many of the crops where methyl bromide is applied and ARS perfected applying alternative fumigants, especially Telone, via drip irrigation. This has greatly improved the effectiveness of this chemical, which had fallen into disuse over the years in favor of the more-effective methyl bromide. Not only is drip-applied Telone as effective as methyl bromide in many instances, but applying the fumigant via drip irrigation removes some of the incidental health and environmental issues that result from other application methods.

##### **Describe the Transfer 1:**

This technology was transferred through drip-irrigation demonstrations on growers' fields, by hosting field days attended by growers, and through presentations at industry group meetings.

##### **Identify the Customer/User 1:**

At the moment, California strawberry growers are benefiting the most from this technology, though it has potential for other crops.

##### **Impact/Outcome 1:**

This technology has become widely adopted in those crops where drip irrigation is used. Although there are some soil types and slope issues that preclude complete adoption of this technology, more than 50 percent of California strawberry growers, representing well over 15,000 acres of crop, have adopted drip-applied soil fumigants to replace methyl bromide.

##### **Describe the Technology 2:**

A unique strain of the bacterium *Pseudomonas putida* is effective as a biocontrol agent for replant disease of fruits.

**Describe the Transfer 2:**

A unique bacterial strain of *Pseudomonas putida* was isolated from apples in Washington State. The strain was incorporated into compositions suitable for application to tree fruit crops and mixed with an agriculturally acceptable carrier.

**Identify the Customer/User 2:**

The customers of this technology are commercial fruit tree producers in California where replant disease occurs in old orchards, and in nurseries where previous plantings of fruit trees were grown for 1 or 2 years.

**Impact/Outcome 2:**

**Replant disease is a major impediment to establishing an economically viable orchard on a site previously cropped to older fruit trees. In Washington State alone, failure to control replant disease results in a \$40,000 per acre reduction in gross returns over a 10-year period. In addition to tree replacement costs, trees affected by the disease begin bearing fruit 2-3 years later than normal and fail to attain yields comparable to those obtained in orchards free of the disease. This technology will reduce disease incidence, resulting in improved yields and reduced management costs.**

**Performance Measure 4.2.4:** Provide needed scientific information and technology that is environmentally acceptable to producers of agriculturally important plants in support of exclusion, early detection and eradication, control, and monitoring of invasive arthropods, weeds, nematodes, and pathogens; enhanced sustainability; and restoration of affected areas. Conduct biologically based integrated and area-wide management of key invasive species.

**Indicators:**

**DURING FY 2006, ARS will**

*continue to develop and demonstrate technologies for excluding, detecting, and mitigating native and invasive insect pests, including integrated pest management (IPM) and areawide approaches, and deliver IPM components and systems to ARS customers.*

**ACCOMPLISHMENT 1:** A lure mixture of ammonia, methylamine, and putrescine was developed into an attractant for the South American fruit fly. The South American fruit fly is a major pest of citrus and other commercial fruits in South America; its range extends into Central America and Mexico, where it attacks various non-citrus fruits. Better lures are needed to detect, monitor, and eliminate this pest. The chemicals were put into a preliminary formulation and their effectiveness was evaluated in Brazilian citrus orchards, where they produced better results than existing attractants. The work was accomplished through a cooperative project between the ARS Crop Quality and Fruit Insects Research Unit in Weslaco, Texas, and ISCA Technologies, Inc., Riverside, California.

**IMPACT/OUTCOME 1:** An effective lure will result in more effective control of this fly in South America, which in turn will help prevent its introduction into the citrus growing areas of the United States. It will also assist in the detection and eradication of the fly should accidental introduction occur.

**ACCOMPLISHMENT 2:** Lures are needed to monitor and manage stink bugs, including the newly invasive brown marmorated stink bug (BMSB), because these insects are immune to genetically modified crops such as cotton. Potential attractants (methyl 2,4,6-decatrienoates) were field-tested by ARS scientists in the Plant Sciences Institute at the Beltsville Agricultural Research Center in Beltsville, Maryland, resulting in the first captures of adult and nymph BMSBs, and the unexpected finding that various isomers of the tested chemicals attract certain native stink bugs.

**IMPACT/OUTCOME 2:** This discovery may lead to the development of lures useful in controlling stink bugs.

*continue to develop and demonstrate technologies, including risk analysis, for excluding, detecting, and mitigating native and invasive weed pests, including IPM and areawide approaches, and deliver IPM components and systems to ARS customers.*

**ACCOMPLISHMENT 1:** ARS scientists have initiated a biological control program for the invasive weed giant reed or carrizo cane, *Arundo donax*. Scientists at the Beneficial Insects Research Unit in Weslaco, Texas, have imported three potential biological control agents from Europe into USDA quarantine facilities in Texas for biological control of giant reed. These biological control agents are a shoot-feeding wasp (*Tetramesa romana*), a cane-burrowing fly (*Cryptonevra* spp.), and a rhizome-infesting scale (*Rhizaspidotus donacis*). There is significant interest and support for the program from several U.S. and Mexico-based government organizations.

**IMPACT/OUTCOME 1:** This development holds significant promise in controlling this serious invasive weed. Giant reed is a serious ecological threat to the Rio Grande River Basin, because it displaces beneficial vegetation and uses excessive water needed to grow crops, and it also places Customs and Border Protection officers from the Department of Homeland Security at risk, because smugglers hide in dense infestations.

**ACCOMPLISHMENT 2:** The invasive marine algal weed, *Caulerpa taxifolia* (Caulerpa), was eradicated from California through a cooperative interagency effort. Caulerpa had spread to over 30,000 acres in the Mediterranean Sea from 1985 to 1999, and in 2000, the first two U.S. infestations of this species were discovered in California. These infestations threatened over 600 miles of Western coastal subtidal habitat. ARS scientists at the Davis, California, worksite of the Exotic and Invasive Weed Research Unit conducted research and provided technology transfer as part of a multi-agency eradication effort during the past five years. This work was essential in the development and implementation of methods for the effective eradication of Caulerpa. This also served as a very rare example of a successful quantitative evaluation of eradication efficacy, and helped establish scientifically-based criteria for determining how and when eradication of an invasive weed could be achieved.

**IMPACT/OUTCOME 2:** Results have culminated in a formal declaration of eradication by the California Department of Fish and Game (July 12, 2006). The program has likely saved California millions of dollars by reducing damage and control costs and averting a potential environmental disaster.

*continue to develop and demonstrate technologies for excluding, detecting, and mitigating emerging and re-emerging plant disease pests, including IPM and areawide approaches, and deliver IPM components and systems to ARS customers.*

**ACCOMPLISHMENT 1:** Black Widow spiders are often found in table grapes and must be killed before the grapes are exported. Research conducted by ARS scientists at the San Joaquin Valley Agricultural Sciences Center in Parlier, California, showed that ozone could be utilized to kill the spiders in a short period of time and that the addition of carbon dioxide was not necessary to enhance the efficacy of this method.

**IMPACT/OUTCOME 1:** These results show that using ozone could be an effective method to eliminate live Black Widow spiders from table grapes, making grape importation more acceptable to foreign countries.

**ACCOMPLISHMENT 2:** Fire blight is a serious bacterial disease of apple and pear trees. ARS scientists at Wenatchee, Washington, utilized new techniques for evaluating beneficial microorganisms on blossoms, the site of primary infections. This led to the discovery of a new, effective biocontrol agent, and to a patent license agreement with a private company that has interest in its commercial development. Research cooperation with the company from 1999 has improved fermentation and formulation methods, establishment of effective field rates, and information required by regulatory agencies in the United States and Canada.

**IMPACT/OUTCOME 2:** In September 2006, a formulated product consisting of E325 as the active ingredient was fully registered with the EPA, allowing its availability to fruit growers for fire blight management during the spring of 2007 and creating the potential for improved control of this disease.

#### **4.2.4: SUMMARY OF THE MAJOR TECHNOLOGIES DEVELOPED, TRANSFERRED, AND USED IN FY 2006:**

**During FY 2006, ARS**

reported improved knowledge and understanding of the ecology, physiology, epidemiology, and molecular biology and genomics of endemic and emerging diseases and pest. Incorporate this knowledge into at least 2 management strategies that were developed and implemented to minimize chemical inputs and increase production.

##### **Describe the Technology 1 – Fireblight Biocontrol Agent:**

ARS scientists at Wenatchee, Washington, discovered an effective biocontrol agent which reduces infection on apples by fireblight through competitive exclusion of the pathogen. The competitive microbe prevents infection on apple blossoms, the site of primary fireblight infection.

##### **Describe the Transfer 1:**

In September 2006, a formulated product consisting of the competitive biocontrol strain was fully registered through the Environmental Protection Agency, allowing its availability to fruit growers for fire blight management during the spring of 2007 and the potential for improved control of this disease.

##### **Identify the Customer/User 1:**

The customers for this technology are commercial apple producers throughout the United States and regulatory agencies engaged in fireblight control.

##### **Impact/Outcome 1:**

This technology will reduce incidence of fireblight via a biologically based approach and through an integrated regional-wide management system. U.S. export markets for apples to countries without fireblight will be favorably affected by reduced disease incidence.

##### **Describe the Technology 2:**

ARS and cooperators conducted an area-wide pest management (AWPM) strategy to thwart the tarnished plant bug, a serious pest of cotton and other crops, in four Southern states. The main technology being used is a low-cost method consisting of one properly timed application of an herbicide that selectively kills key broadleaf plant and weed hosts used by the tarnished plant bug in the spring to survive in cotton growing areas, coupled with monitoring populations and remote sensing.

##### **Describe the Transfer 2:**

Transfer of the technology on an area-wide basis was through partnerships initially with 20 cotton producers in Mississippi and Mississippi State University to demonstrate the technology and AWPM concept. Since then, another 30 cotton producers and Louisiana State University, the

University of Arkansas and the University of Tennessee, have joined the AWPM program. ARS and its partners implemented educational and technology transfer programs and held grower and consultant outreach and education meetings.

**Identify the Customer/User 2:**

The primary recipients of the technology are the cotton producers in the southeastern U.S. cotton belt, and extension and county agents, and consultants.

**Impact/Outcome 2:**

Cotton grower adoption of the technology was at 86 percent in the Mississippi Delta, where the technology was first introduced, and about 33 percent in Arkansas, Louisiana, and Tennessee. Economists at Mississippi State University conducted a cost/benefit analysis of the program on over 21,000 acres and found benefits as high as \$10.28 for every dollar spent on the technology. The economists further showed the technology produced a \$5.48 savings per acre in reduced insecticide costs. An environmental impact study conducted by Louisiana State University detected no-to-extremely low levels of herbicide residue in run-off water from the program.

<p><b>Performance Measure 4.2.5:</b> Provide environmentally sound fundamental and applied scientific information and technologies to action agencies, producers, exporters, and importers of commercially important plant and animal products in support of exclusion, early detection, and eradication of quarantine pests and pathogens that can impede foreign trade.</p>
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**Indicators:**

**DURING FY 2006, ARS will**

*continue to develop diagnostic assays to detect and differentiate existing, new and/or emerging quarantine arthropod pests, weeds, nematodes, and pathogens.*

**ACCOMPLISHMENT 1:** The arrival of citrus greening, Huanglongbing, represents a serious threat to citrus production in Florida. ARS scientists at Beltsville, Maryland, developed and validated the first real time, quantitative PCR assay for the greening pathogen. This assay was used by APHIS and the Florida Department of Agriculture to confirm the presence of citrus greening in Florida.

**IMPACT/OUTCOME 1:** Producers will benefit from early detection of this serious citrus disease, and genetic improvement for resistance will be accelerated.

**ACCOMPLISHMENT 2:** Barley and cereal yellow dwarf viruses (five strains), wheat spindle streak mosaic, wheat soil-borne mosaic virus, and wheat streak mosaic virus represent the most economically important group of viruses that infect wheat. ARS researchers at West Lafayette, Indiana, have developed a single, rapid test that can simultaneously detect all eight viruses.

**IMPACT/OUTCOME 2:** This new assay enables rapid and accurate diagnosis of the cause of wheat disease damage, allowing producers to benefit from early detection and accelerating genetic improvement for resistance.

*continue to expand interdisciplinary research to include means of excluding, managing and/or eradicating quarantine arthropod pests, weeds, nematodes and pathogens.*

**ACCOMPLISHMENT:** Redvine, *Brunnichia ovata*, and trumpet creeper, *Campsis radican*, are perennial, deep rooted vines found extensively in crop and noncrop lands in the Lower Mississippi Delta region. Glyphosate alone cannot provide complete control of these weeds, so

additional management tactics are needed that are affordable and sustainable. Scientists at the Southern Weed Science Research Unit in Stoneville, Mississippi, completed a 4-year field study to determine the effectiveness of fall deep tillage and glyphosate on redvine and trumpet creeper populations and soybean yield. Fall deep tillage (about 18 inches) reduced redvine density compared with shallow tillage (about 6 inches), but deep tillage did not reduce trumpet creeper density; soybean yields were higher with deep tillage. Glyphosate applied before planting and after crop emergence reduced trumpet creeper density, but not redvine density.

**IMPACT/OUTCOME:** These results demonstrate that integration of fall deep tillage and glyphosate applications could be an effective strategy to manage these vines in glyphosate resistant soybean.

*apply essential taxonomy and systematics for organisms toward the correct identification and diagnosis and control of target arthropod pests, weeds, nematodes, and pathogens.*

**ACCOMPLISHMENT:** Correct identification of oomycete pathogens from strawberry is a time-consuming process that requires growing out the cultures and then correctly identifying the species based on morphological features—a task complicated by the variation levels that are often observed in some species. Molecular markers (species-specific primers, as well as Restriction Fragment Length Polymorphism analysis) have been developed for identifying oomycete species recovered from strawberry. ARS scientists in Salinas, California, and Davis, California, are adapting this marker system for oomycete detection in strawberry nursery production, as well as developing specific markers for the three species causing disease in strawberry production systems.

**IMPACT/OUTCOME:** Collaborative projects with other ARS and university scientists to use the marker system with other oomycete species are in progress.

*expand new knowledge in epidemiology, host-parasite relationships and new means of developing host resistance toward exclusion, eradication, and management of quarantine arthropod pests, weeds, nematodes, and pathogens.*

**ACCOMPLISHMENT 1:** *Meloidogyne floridensis* is a recently described species of root-knot nematode isolated in several Florida locations that reproduces on certain root-knot nematode resistant rootstocks, including Guardian, Nemaguard, Nemared, and Okinawa peach rootstocks. Host range studies were carried out by personnel at the U.S. Horticultural Research Laboratory in Ft. Pierce, Florida, to determine whether five commonly-used cover crops and five common weed species can serve as hosts for *M. floridensis*. Good hosts included clover, rape, and cypressvine. Sunn hemp and sesame were poor hosts, while jimsonweed and sorghum sudangrass were nonhosts.

**IMPACT/OUTCOME 1:** This information will be useful for growers who have *M. floridensis* infestations in selecting cover crops and managing weeds for controlling this nematode in the absence of soil fumigation.

**ACCOMPLISHMENT 2:** Previous research in this project found that *Fusarium oxysporum* strain CS-20 reduced the incidence of Fusarium wilt, caused by *F. oxysporum*, in tomato and other plants. Further, tests demonstrated that the main mechanism of control is resistance in the plant induced by strain CS-20. In fiscal year 2006, research was conducted to identify specific chemical changes induced by strain CS-20. Phenolic compounds are known to be involved in induced resistance in many plants, and four phenolic compounds (vanillic, caffeic and ferulic acids, and an unknown) were found to be produced by tomato roots in response to *F. oxysporum* strain CS-20 (biocontrol strain), but not plant pathogenic *F. oxysporum*. Experiments are in progress to establish the role of these phenolic compounds in induced resistance of tomato to Fusarium wilt.

**IMPACT/OUTCOME 2:** Fundamental knowledge of induced resistance in plants will contribute to development of novel disease management strategies.

**ACCOMPLISHMENT 3:** In collaboration with scientists from the University of California, Davis, ARS scientists at Davis, California, discovered necrotic union disorder, a viral disease, in California on the pinot noir grape on 110R rootstock. A survey of several vineyard blocks of four different pinot noir clones documented a disease incidence ranging from 5 to 45 percent, suggesting a rapid spread of the new disease.

**IMPACT/OUTCOME 3:** Building on this research, ARS has established a project to identify and characterize the causal agent for the disease and to study the disease development and spread and to find effective control measures for this new viral disease.

*support interagency collaboration for tracking successful exclusion, eradication where possible, and management of quarantine arthropods, weeds, nematodes, and pathogens*

**ACCOMPLISHMENT 1:** ARS scientists in Davis, California, and partners in the Southern California Caulerpa Eradication Action Team (SCCAT) – including NOAA, U.S. Department of the Interior, California Department of Fish and Game, San Diego and Santa Anna Regional Water Quality Control Boards, and private sector community-based groups – successfully eradicated Caulerpa, an invasive marine alga from its two known locations. Also referred to as “killer algae,” Caulerpa was popular in home aquariums and likely introduced accidentally into California's waters more than 6 years ago. In the Mediterranean Sea, Caulerpa rapidly and permanently displaced native marine plants and animals.

**IMPACT/OUTCOME 1:** This is one of only a few known eradications of an invasive marine alga species. Eradication of Caulerpa has likely saved California millions of dollars by reducing damage and control costs and averting a potential environmental disaster. The cooperative nature and scientific response utilized by SCCAT is being viewed as an effective model for the eradication of invasive species.

#### **4.2.5: SUMMARY OF THE MAJOR TECHNOLOGIES DEVELOPED, TRANSFERRED, AND USED IN FY 2006:**

**During FY 2006, ARS**

*reported improved knowledge and understanding of quarantine pest and pathogen biology and epidemiology, leading to six new technologies implemented by industry or other action agencies to mitigate risk of pests and pathogens resulting in expanded export markets while protecting the safety and security of American agriculture.*

##### **Describe the Technology 1:**

ARS scientists at Beltsville and Fort Detrick, Maryland, developed and validated the first real-time and quantitative PCR assay for early detection of the citrus greening pathogen.

##### **Describe the Transfer 1:**

The transfer of the technology was initiated after citrus producers, the Florida Department of Agriculture, APHIS, and ARS scientists met in Florida to discuss the recent outbreak of citrus greening. Management options were formulated.

##### **Identify the Customer/User 1:**

This assay was used by APHIS and the Florida Department of Agriculture and Consumer Services to confirm the presence of citrus greening in Florida.

**Impact/Outcome 1:**

Producers will benefit from early detection of the disease and genetic improvement for resistance will be accelerated.

**Describe the Technology 2:**

A highly detailed identification was made of the pale potato cyst nematode, one of the most important regulated nematode pathogens to appear in the United States since the golden potato cyst nematode appeared in the early 1940's on Long Island.

**Describe the Transfer 2:**

The information was disseminated through journal articles, regulatory meetings, and protocol and material provision to a local APHIS diagnostic laboratory.

**Identify the Customer/User 2:**

The National Plant Germplasm and Biotechnology Laboratory belonging to the Plant Protection Quarantine Division's Center for Plant Health Science Technology (CPHST) of the USDA Animal and Plant Health Inspection Service. This lab provides exhaustive diagnostic protocols of various plant pathogens to state, regional, and commercial diagnostic laboratories.

**Impact/Outcome 2:**

ARS developed methodologies for quickly and accurately identifying an important exotic pest of potato that is a quarantine item. This enabled rapid response by regulatory agencies and diagnostic labs to enable eradication efforts that are currently underway.

**Describe the Technology 3:**

Development of a sugarbeet germplasm line that is resistant to a new strain of Beet necrotic yellow vein virus (BNYVV), the cause of rhizomania, which had overcome the standard single gene-resistance that was widely used commercially. This development was accomplished by introgressing a second major gene for resistance from wild beet sources into cultivated sugarbeet germplasm.

**Describe the Transfer 3:**

Germplasm was released to sugarbeet seed companies for cultivar development.

**Identify the Customer/User 3:**

Sugarbeet seed companies and growers/producers/processors.

**Impact/Outcome 3:**

Rhizomania is one of the most destructive diseases of sugarbeet worldwide. Without resistance to this new resistance-breaking strain of BNYVV, management of Rhizomania would not be possible in affected areas.

**Describe the Technology 4:**

ARS developed a PCR test for the virus that causes Watermelon vine decline, a critical disease that has caused farm losses of over \$60 million in the past 6 years. ARS, working as part of an inter-agency team, determined that this virus, named *squash vein yellowing virus*, is a new member of the Potyvirus family that is transmitted by whiteflies.

**Describe the Transfer 4:**

Information about the PCR test was transferred via a referred publication, presentations and training at two University of Florida Plant Disease clinics, to major seed companies, and other researchers who are studying vine decline in other geographic areas.

**Identify the Customer/User 4:**

Users include the scientific community and diagnosticians who are working to control this disease.

**Impact/Outcome 4:**

This PCR test, an important contribution to early detection and management of the disease, is being used university and ARS researchers and diagnosticians in plant disease clinics to manage and characterize this disease. An extensive survey for the disease in watermelon growing areas was conducted with university, state, and federal members using this technique.

**Describe the Technology 5:**

Following the 2004 hurricanes, ARS scientists in Florida developed a predictive model to explain storm-related spread of Asiatic Citrus Canker (ACC), a devastating bacterial disease of citrus, exotic to the United States that causes severe yield and quality losses to the citrus crop. The model was developed with geospatially referenced ACC data from infections, which was examined in relation to wind and rain conditions during the hurricanes. The model applies a "threshold" concept for wind and rains that, in-effect, incorporates only biologically significant weather parameters in the calculations, including a wind-rose analysis that takes advantage of wind speed, duration, and direction to calculate a wind/rain-vector index for estimating the direction pathogen spread and subsequent disease development.

**Describe the Transfer 5:**

This technology was shared with users through a series of regulatory/industry meetings, which included researchers, stakeholders, and citrus industry leaders involved in the Citrus Canker Eradication Program (CCEP). Its use for predicting and detecting new disease outbreaks was explained. Results of the study were reviewed by a team of scientists familiar with citrus canker biology, epidemiology, and eradication and subsequently by the two requesting agencies, Florida Department of Agriculture and Consumer Services and USDA Animal and Plant Health Inspection Service, as well as the major Florida citrus grower associations so as to evaluate the feasibility of continued ACC eradication.

**Identify the Customer/User 5:**

The users of this technology include residents of the state of Florida, Florida State Department of Agriculture and Consumer Services, USDA-APHIS, ARS, members of the Florida citrus industry and grower associations, and the scientific research community.

**Impact/Outcome 5:**

The predictive model has led the regulatory agencies, citrus industry representatives, and research scientists to conclude that the disease had become endemic in Florida and resulted in the termination of the 10-year, \$1 billion canker eradication program. Halting the citrus canker eradication program and a tumultuous era in plant pathology and Florida history will potentially save the State and U.S. taxpayers \$100 million/year in continued eradication costs.

**Describe the Technology 6:**

ARS developed a biologically based, integrated vegetation program to manage the invasive Australian tree, *Melaleuca quinquenervia*, a serious invader of the Florida Everglades. ARS first searched northern Australia for natural enemies of the tree. Dozens of species of insects and pathogens were found on melaleuca in Australia. Most of these attacked other plants, so were not considered further. Two species in particular were found after testing to be specific to melaleuca, a weevil (*Oxyops vitiosa*) and a psyllid sucking insect (*Boreioglycaspis melaleucae*). Both species were approved by regulatory agencies for release in the field.

**Describe the Transfer 6:**

The weevil and the psyllid were mass-reared by ARS scientists in Ft. Lauderdale, Florida, and released in the field at carefully selected research sites.

**Identify the Customer/User 6:**

Many valued customers, stakeholders and partners contributed funds that enabled this project to be conducted, including the South Florida Water Management District, U.S. Army Corps of Engineers, U.S. Department of Interior, Dade County, and Lee County.

**Impact/Outcome 6:**

Melaleuca has been controlled by introduction of the weevil and psyllid, and is no longer considered to be invasive in the Florida Everglades.

**GOAL 5: IMPROVE THE NATION’S NUTRITION AND HEALTH**

GOAL 5 PROGRAMS	FY 2006	FY 2007	FY 2008
Human Nutrition	\$84,777	\$84,442	\$Not Available
<b>Total</b>	<b>\$84,777</b>	<b>\$84,442</b>	<b>\$Not Available</b>

NOTE: Dollars in Thousands.

**Means and Strategies:** To successfully accomplish the research activities under this goal, ARS will need the resources reflected in the table above.

**Verification and Validation:** ARS currently conducts a series of review processes designed to ensure the relevance and quality of its research work, and to maintain the highest possible standards for its scientists. A more detailed description of the evaluation plans can be found in the introduction to this plan.

**STRATEGIC RESULT: Significant Change In The Nation’s Nutrition Status**

**OBJECTIVE 5.1: Ensure Access To Nutritious Food**

**This objective is under the jurisdiction of other USDA agencies.**

**OBJECTIVE 5.2 Promote Healthier Eating Habits and Lifestyles**

**Performance Measure 5.2.1:** Monitor food consumption intake/patterns of Americans, including those of different ages, ethnicity, regions, and income levels, and measure nutrients and other beneficial components in the food supply. Provide the information in databases to enable ARS customers to evaluate the healthfulness of the American food supply and the nutrient content of the American diet.

**Indicators:**

**DURING FY 2006, ARS will**

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

**ACCOMPLISHMENT 1:** Using data from the “What We Eat in America/NHANES 2001-2002” national dietary survey, ARS scientists in Beltsville, Maryland, found a high prevalence of vitamins A, E, and C deficiencies among most age and gender groups in the U.S.

**IMPACT/OUTCOME 1:** This is the only source of nationally representative dietary intake data and is essential to tracking the health and well-being of the American population. The findings allow better dietary recommendations and/or fortification of the food supply for these shortfall nutrients.

*develop new methods, conduct food composition analyses, and compile databases for known, emerging, and new classes of nutrients.*

**ACCOMPLISHMENT 1:** Five new databases on nutrient content and dietary intake were released by ARS. These are summarized below as major technologies.

**IMPACT/OUTCOME 1:** The primary product of this research is the invaluable information of what Americans are eating in order to assess their food consumption in relation to dietary recommendations designed to maintain health and prevent chronic diseases.

#### **5.2.1 SUMMARY OF THE MAJOR TECHNOLOGIES DEVELOPED, TRANSFERRED, AND USED IN FY 2006:**

##### **DURING FY 2006, ARS**

reported improved five new databases developed and released to ARS customers to establish Federal dietary policy guidelines, food assistance and feeding programs, and food labeling to safeguard the health of the American people.

**DESCRIBE THE TECHNOLOGY 1:** Release 19 of the USDA National Nutrient Database for Standard Reference was compiled and made public. This is an annual update of the primary nutrient database of foods available in the U.S. up to 160 nutrients in over 7,000 foods are included.

**DESCRIBE THE TRANSFER 1:** The database is freely available and searchable on the ARS Web site. Downloadable versions are also available for use on personal computers and handheld personal digital assistants.

**IDENTIFY THE CUSTOMER/USER 1:** Users of this technology include other government agencies, health professional, academic researchers, companies that sell diet analysis software and consumers.

**IMPACT/OUTCOME 1:** This database is widely used by USDA’s REE and FNS agencies for research, evaluating food assistance programs, and policy formulation; and by other federal agencies such as FDA’s food labeling program. Individuals and health professional make use of this information in analyzing or planning diets.

**DESCRIBE THE TECHNOLOGY 2:** ARS released a Ground Beef Calculator, a new software tool that provides nutrient profiles for retail ground beef products containing any level of fat from 5% to 30%.

**DESCRIBE THE TRANSFER 2:** This tool is freely available via the ARS Website.

**IDENTIFY THE CUSTOMER/USER 2:** Users of this technology include health professionals, the general public, academic researchers and the beef industry.

**IMPACT/OUTCOME 2:** Approximately half the beef in the U.S. is consumed as ground beef and there are far more available options in fat and lean content than previously. Accurate nutrient profiles can now be obtained by use of this software. This tool provides the beef industry with a means to calculate ground beef nutrient values, a requirement of the proposed FSIS labeling regulation on single-ingredient meat products.

**DESCRIBE THE TECHNOLOGY 3:** ARS released a new database listing added sugars in foods.

**DESCRIBE THE TRANSFER 3:** This database is freely available for download from the ARS Web site.

**IMPACT/OUTCOME 3:** Federal dietary guidelines call for limits on consumption of added sugars. Since amounts of these sugars can not be determined analytically, calculations using this database provide estimates of added sugars for planning diets to meet the federal guidelines. This is important for federal food assistance programs such as the School Lunch Program.

**DESCRIBE THE TECHNOLOGY 4:** The “What We Eat in America-National Health and Nutrition Examination Survey/NHANES” database for 2003-2004 was release. This is the only nationally representative dietary data for the U.S. and enumerates the most commonly eaten foods and what nutrients they supply. This survey is part of the National Health and Nutrition Examination Survey (NHANES).

**DESCRIBE THE TRANSFER 4:** This information is made freely available to anyone from the Web site of the HHS’ Centers for Disease Prevention and Control, ARS’ partner for this national survey.

**IDENTIFY THE CUSTOMER/USER 4:** The major users of this information are academic researchers, government agencies, and the food industry.

**IMPACT/OUTCOME 4:** Analysis of nationally representative food consumption data allows evaluation of current federal nutrition policy, points to problems of inadequate intake of certain nutrients, and allows tracking of changes in foods consumed over time.

**DESCRIBE THE TECHNOLOGY 5:** Version 2.0 of the USDA Food and Nutrient Database for Dietary Studies ((FNDDA) was released.

**DESCRIBE THE TRANSFER 5:** This database was released via the ARS Web site and made freely available to all.

**IDENTIFY THE CUSTOMER/USERS 5:** Other federal agencies that recommend or implement federal dietary policy, especially the USDA’s Center for Nutrition Policy and Promotion.

**IMPACT/OUTCOME 5:** This database underpins the USDA’s MyPyramid Web site’s interactive tools for diet analysis; this Web site has become one of the most used federal Web site with about 80 million users to date. The data are also used to establish the USDA Pyramid Servings Database.

<p><b>Performance Measure 5.2.2:</b> Define the role of nutrients, foods, and dietary patterns in growth, maintenance of health, and prevention of obesity and other chronic diseases. Assess bioavailability and health benefits of food components. Conduct research that forms the basis for, and evaluates nutrition standards and Federal dietary recommendations.</p>
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**Indicators:**

**DURING FY 2006, ARS will**

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

**ACCOMPLISHMENT 1:** The prevalence of type 2 diabetes has increased rapidly in the U.S. and worldwide. ARS scientists in Boston, Massachusetts, found that women with a combined daily intake meeting the Recommended Dietary Intakes for both calcium and vitamin D had a 33 percent lower risk of developing type 2 diabetes than those with lower intake levels.

**IMPACT/OUTCOME 1:** The findings from this study, which followed nearly 84,000 women for 20 years, suggest a possible dietary strategy for lowering the risk for type 2 diabetes. Since fluid milk is the main source of these two nutrients, the results underscore federal nutrition policy to consume three servings daily.

**ACCOMPLISHMENT 2:** ARS scientists in Little Rock, Arkansas, showed that over consumption of carbohydrates produced significant weight gain and fat deposition in both human infants and a mouse model. In a related study, ARS scientists in Boston, Massachusetts, found that obese adults on a weight loss diet providing a low glycemic index (carbohydrates that raise blood sugar slightly) experience greater weight loss over one year than volunteers on a weight loss diet providing a high glycemic index.

**IMPACT/OUTCOME 2:** These studies will help refine dietary recommendations for maintenance of healthy weight.

*determine the functions, bioavailability, interactions, and requirements for known, emerging, and new classes of nutrients across the lifecycles.*

**ACCOMPLISHMENT 1:** Folic acid fortification is mandated by Federal law to help prevent certain birth defects. ARS scientists in Boston, Massachusetts, found that 4 of 5 postmenopausal women have unmetabolized (indicating excess) folic acid in their blood. This was correlated with impaired functioning of part of the immune system.

**IMPACT/OUTCOME 1:** This observation illustrates the importance of continuously monitoring the food supply along with benefits and risks of nutrient intake. Concern over detrimental, high levels of folic acid in the blood is being raised by recent studies on nutrition and health. FDA uses this information to set or modify the mandatory fortification of certain foods with folate.

**ACCOMPLISHMENT 2:** ARS scientists in Davis, California, demonstrated that calcium intake during the early menopausal years is more important for maintaining adequate bone density than calcium intake during childhood years, in contrast to previously published reports.

**IMPACT/OUTCOME 2:** Dietary strategies to alleviating postmenopausal bone mineral loss help lower health care costs and improve the quality of life for American women.

**ACCOMPLISHMENT 3:** Analysis of blood from elderly men and women revealed that those with the highest levels of omega-3 fatty acids from fish were half as likely to develop dementia, including Alzheimer's disease. ARS scientists in Boston, Massachusetts, studying a group of 900 people, found that eating more than two servings of fish weekly was associated with maintenance of normal brain function over nine years of follow-up.

**IMPACT/OUTCOME 3:** This study contributes to solving the controversy about the quantity of omega-3 fats required for optimal health.

**ACCOMPLISHMENT 4:** ARS scientists previously found that consumption of cinnamon lowers blood sugar levels in diabetics. This year, ARS scientists in Beltsville, Maryland, showed that feeding large amounts of cinnamon to rats with hereditary hypertension reduced blood pressure to normal.

**IMPACT/OUTCOME 4:** This observation has potential for preventing or treating high blood pressure in humans.

#### **5.2.2: SUMMARY OF THE MAJOR TECHNOLOGIES DEVELOPED, TRANSFERRED, AND USED IN FY 2006:**

##### **DURING FY 2006, ARS**

reported four new reports using ARS research to develop authoritative positions on nutrition and health issues are used to establish Federal nutrition policy and regulations that employ ARS research results in formulating recommendations to safeguard the health of the American people.

**DESCRIBE THE TECHNOLOGY 1:** The Institute of Medicine published a report in March 2006 on Mineral Requirements for Military Personnel: Levels Needed for Cognitive and Physical Performance During Garrison Training. ARS research on mineral requirements was cited repeatedly in this report.

**DESCRIBE THE TRANSFER 1:** The report was published by National Academy Press (NAP) and is available on the NAP Web site.

**IDENTIFY THE CUSTOMER/USER 1:** The primary user is the Department of Defense; secondary users are scientists who study mineral requirements.

**IMPACT/OUTCOME 1:** This report document that stressful situations increase requirements for certain minerals and the studies as normally conducted do not cover many situations military personnel face. The information is used to inform the military nutritional requirements process and may lead to changes in military rations and/or feeding programs in order to improve performance of the armed forces.

**DESCRIBE THE TECHNOLOGY 2:** An updated report on Preventing Childhood Obesity was published by the Institute of Medicine in April 2006. Work by several ARS scientists was cited in it.

**DESCRIBE THE TRANSFER 2:** The report was published by National Academy Press (NAP) and is available on the NAP Web site.

**IDENTIFY THE CUSTOMER/USER 2:** Users of this report included researchers studying how to prevent childhood obesity, federal research program leaders, school boards that are required to have health plans, and legislators.

**IMPACT/OUTCOME 2:** This report highlighted behaviors and areas that can be changed in the environment to address the obesity epidemic among children.

**DESCRIBE THE TECHNOLOGY 3:** The Institute of Medicine sponsored a symposium and produced a database on research gaps for the Dietary Reference Intakes, the nutritional standards for the U.S. population. ARS cosponsored this symposium. ARS NP 107 Program scientists participated as speakers, and numerous Program research studies were cited.

**DESCRIBE THE TRANSFER 3:** The report was published by National Academy Press (NAP) and is available on the NAP Web site. Also, the database is available from the IOM Web site for download.

**IDENTIFY THE CUSTOMER/USER 3:** The primary customers are federal research program leaders and researchers in nutrition and public health.

**IMPACT/OUTCOME 3:** Researchers on dietary requirements can better identify and rank the importance of unanswered research questions for all nutrients covered by Dietary Reference Intakes. This should also help focus funding agencies like SCREES or NIH on issues of greater public health relevance.

**DESCRIBE THE TECHNOLOGY 4:** An Institute of Medicine report entitled Dietary Reference Intakes: the Essential Guide to Nutrient Requirements was published in September 2006 ARS' NP 107 Program provide a substantial proportion of the research used in establishing these nutritional standards.

**DESCRIBE THE TRANSFER 4:** The report was published by National Academy Press (NAP) and is available on the NAP Web site.

**IDENTIFY THE CUSTOMER/USER 4:** This report is aimed at health professional and non-researchers who are interested in applying nutrient requirement information. This group ranges from dietitians to food scientists to the general public.

**IMPACT/OUTCOME 4:** This report summarizes eight previous volumes on Dietary Reference Intakes and makes the information more accessible to health professionals, food companies, and the consumer.

<p><b>Performance Measure 5.2.3:</b> Publish research findings not encompassed under the other performance measures for this objective likely to significantly advance the knowledge of human nutrition, extensively influence other researchers in the same or related field, or yield important new directions for research.</p>
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**Indicators:**

**DURING FY 2006, ARS will**

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

**ACCOMPLISHMENT 1:** In the Framingham Heart Offspring cohort study, ARS scientists in Boston, Massachusetts, found a 50 percent lower prevalence of metabolic syndrome in men and women who adhered strictly to the Dietary Guidelines. Metabolic syndrome, characterized by abdominal obesity and the inability to use insulin efficiently, is a forerunner of type 2 diabetes and increases risk for coronary heart disease.

**IMPACT/OUTCOME 1:** This information underpins the Dietary Guidelines for American, the basis for federal nutrition policy and may be useful to help control the incidence of these diseases in adults. USDA and HHS share responsibility for revising the Dietary Guidelines for Americans every five years.

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

**ACCOMPLISHMENT 1:** ARS scientists reported that genistein, a chemical found in soybeans, feeding of pregnant, genetically-obese mice affects methylation of genes in their offspring that leads to better health and normal body weight.

**IMPACT/OUTCOME 1:** This research paper has already been cited 15 times in less than one year because of the fundamental scientific principle discovered. This is the first observation that epigenetic alteration of gene expression during fetal growth can permanently alter the epigenome and modify adult characteristics.

**5.2.3: SUMMARY OF THE MAJOR TECHNOLOGIES DEVELOPED, TRANSFERRED, AND USED IN FY 2006:**

**DURING FY 2006, ARS**

reported five new scientific papers will be published that generate high impact among the research community with the potential to strongly influence the field of human nutrition or have demonstrated impact through high citation rates.

**DESCRIBE THE TECHNOLOGY 1:** Two scientific publications on the same topic but studying different population groups have been cited a total of 31 times so far linking the role of B vitamins with bone mineral density in adults. Replication of the findings in more than one population greatly increases the likelihood of a significant finding.

**DESCRIBE THE TRANSFER 1:** Publications in peer-reviewed scientific literature.

**IDENTIFY THE CUSTOMER/USER 1:** The primary users are other scientists who will attempt to confirm or refute these findings. Secondary users will be panels of scientists responsible for establishing the national nutrient standards, i.e. Dietary Reference Intake values (DRIs), and federal agencies responsible for nutrition programs that must meet the DRIs.

**IMPACT/OUTCOME 1:** If these results are confirmed, the recommended amount of vitamin B12 may need to be increased, particularly for older Americans. The food industry may provide additional fortified foods to meet this requirement.

**DESCRIBE THE TECHNOLOGY 2:** A research publication reported the discovery that the three naturally-occurring variant forms of the vitamin D receptor affect calcium absorption and bone mineral density during puberty.

**DESCRIBE THE TRANSFER 2:** Publication in peer-reviewed scientific literature.

**IDENTIFY THE CUSTOMER/USER 2:** The primary users are other researchers who will attempt to confirm or refute these findings. Secondary users will be scientists who set Dietary Reference Intake values and federal agencies responsible for nutrition programs that must meet the DRI's.

**IMPACT/OUTCOME 2:** If these results are confirmed, the recommended amount of vitamin D may need to be increased. The food industry may provide additional fortified foods to meet this requirement.

**DESCRIBE THE TECHNOLOGY 3:** ARS scientists reported that feeding a chemical naturally found in soybeans to pregnant, genetically-obese mice affects methylation of genes in their offspring that leads to better health and normal body weight. This is the first demonstration of permanent alteration of the epigenome as well as the first demonstration this can be accomplished via changes in nutritional status.

**DESCRIBE THE TRANSFER 3:** Publication in peer-reviewed scientific literature.

**IDENTIFY THE CUSTOMER/USER 3:** Users of this research are other scientists who will apply this new paradigm to other models of food-based effects on fetal development.

**IMPACT/OUTCOME 3:** As a first demonstration of the concept that maternal nutrition can permanently alter genetic status of the offspring without altering the genes themselves, this serves as a model that has wide ranging implications for nutrition and health recommendations. Although this cannot be directly tested in human studies it will be followed up by experimentalists and there are profound implications for prevention of adverse outcomes in humans through improved nutrition.

**DESCRIBE THE TECHNOLOGY 4:** ARS scientists published findings that consumption of barley fiber reduced blood glucose and insulin levels. This follows earlier ARS studies that showed barley fiber lowers serum cholesterol concentrations.

**DESCRIBE THE TRANSFER 4:** Publications in peer-reviewed scientific literature.

**IDENTIFY THE CUSTOMER/USER 4:** The primary users are other researchers who will cite this work and build upon it. Secondary users will be regulatory agencies.

**IMPACT/OUTCOME 4:** The FDA approved a health claim for barley as the result of the earlier work that its consumption reduces the risk of heart disease. The recent work may lead to better dietary recommendations to prevent abnormal metabolism.

**DESCRIBE THE TECHNOLOGY 5:** A publication on the effects of different types of fat on serum indicators of inflammation was produced by ARS scientists in 2004 that was cited 22 times in 2006 with a cumulative total of 41 citations since publication.

**DESCRIBE THE TRANSFER 5:** Publication in peer-reviewed scientific literature.

**IDENTIFY THE CUSTOMER/USER 5:** The primary users are other researchers who will cite this work and build upon it. Secondary users will be regulatory agencies.

**IMPACT/OUTCOME 5:** This study compared trans fat, different types of saturated fat, and combinations of fat types. It demonstrated that dietary fat not only influences serum cholesterol levels but alters indicators of inflammation. Scientists will pursue this idea and regulatory agencies will need to consider these findings in making decisions about the safety of trans fat consumption and trans fat food labeling.

**GOAL 6: PROTECT AND ENHANCE THE NATION’S NATURAL RESOURCE BASE AND ENVIRONMENT**

<b>GOAL 6 PROGRAMS</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>
Environmental Stewardship	\$172,298	\$Not Available	\$Not Available
<b>Total</b>	<b>\$172,298</b>	<b>\$Not Available</b>	<b>\$Not Available</b>

NOTE: Dollars in Thousands.

**Means and Strategies:** To successfully accomplish the research activities under this goal, ARS will need the resources reflected in the table above.

**Verification and Validation:** ARS currently conducts a series of review processes designed to ensure the relevance and quality of its research work, and to maintain the highest possible standards for its scientists. A more detailed description of the evaluation plans can be found in the introduction to this plan.

**STRATEGIC RESULT: Healthy Watersheds, High Quality Soils, and Sustainable Agricultural Systems**

**OBJECTIVE 6.1: Enhance Watersheds Capacities To Deliver Safe And Reliable Fresh Water**

**Performance Measure 6.1.1:** Develop technology and practices to reduce the delivery of agricultural pollutants by water on farms and ranches and quantify the environmental benefit of conservation practices in watersheds.

**Indicators:**

**DURING FY 2006, ARS will**

*develop at least one precision irrigation system for site-specific management in the production of high-value agricultural crops.*

**ACCOMPLISHMENT 1:** ARS scientists at the Water Management Research Unit in Parlier, CA, have developed methods to predict crop water use and irrigation scheduling that can be generalized to a wide range of horticultural crops. They used sophisticated weighing lysimeter and multi-spectral photography to show that the water use of lettuce, peppers, and garlic were all closely related to plant canopy cover and the percent of light the plants intercepted. In a complementary study, the Soil and Water Management Research Unit in Bushland, TX, in collaboration with university scientists and private consultants, released new sets of standardized equations for crop water use.

**IMPACT/OUTCOME 1:** These improvements are being used by the Texas Cooperative Extension (TCE) AgrilPartner program, the Panhandle Water District, the North Plains ET Network, numerous Federal and state Agencies, producers, professional societies, and the international community via the United Nations; a web site (<http://txhighplainset.tamu.edu/>) provides current information to producers and the general public worldwide. These results have significant impact on irrigation management to increase agricultural water use efficiency. According to NRCS data, USDA conservation programs provided cost sharing incentives for total irrigation water management, which increased irrigation scheduling in combination with some irrigation practice improvements, on nearly 4 million acres in 2005 and 2006. The associated water and pumping cost savings from primarily improved irrigation scheduling should exceed tens of millions of dollars per year.

**ACCOMPLISHMENT 2:** ARS scientists developed new ways to improve water conservation through the development of a multiple inlet rice irrigation system. The multiple-inlet irrigation uses a pipe with multiple gates so that each paddy is watered simultaneously. This makes it simpler to apply the exact amount of water needed without runoff.

**IMPACT/OUTCOME 2:** The multiple inlet system required 24% less irrigation water than conventional flooding with no yield loss. This more efficient water management system for rice will result in lower costs to the producers, allow more effective irrigation of other crops that share the water supply, reduce soil erosion rates, and help relieve some of the water shortage being encountered in rice producing areas.

*develop at least one assessment technology and model that predicts the effects of salinity on crops, soils, and water quality at farm and watershed scales.*

**ACCOMPLISHMENT:** Improving irrigation efficiency in arid environments in the western US requires the identification of sensitive spectral indices associated with salinity and water deficit. ARS scientists at the George E. Brown, Jr., Salinity Laboratory at Riverside, CA, conducted lysimeter studies using two forage crops ('Salado' alfalfa and 'Jose' tall wheatgrass) to show that

remotely-sensed crop response offers growers, irrigation managers, and extension specialists a reliable tool for detecting plant stress prior to the onset of visual signs of crop injury and for preventing irreversible stress-induced changes that reduce crop yields. In a complementary study, ARS researchers at the Arid Land Agricultural Research Center in Maricopa, AZ, developed wheat crop coefficients (Kc) via remote sensing for accurate determinations of crop water use during the growing season.

**IMPACT/OUTCOME:** According to the NRCS Performance Result System, remote sensing and/or plant stress detection practices similar to these are currently used on about 2000 acres, with the goal optimizing irrigation scheduling and reducing irrigation water application amounts by a least 10 percent. Use of these practices is projected by NRCS to exceed one million acres by 2010.

*develop and validate field, watershed, and basin scale watershed assessment decision support system tools that can be utilized by NRCS and EPA to determine the economic and environmental benefits of conservation practices in reducing nutrient and sediment loading to the Nation's lakes, streams, and rivers in support of the 2002 Farm Bill.*

**ACCOMPLISHMENT 1:** The PC-based Automated Geospatial Watershed Assessment (AGWA) tool provides rapid qualitative estimates of runoff and erosion relative to land use change. AGWA is multi-purpose environmental analysis system that integrates a geographical information system (GIS), national watershed data, and state-of-the-art environmental assessment and modeling tools into one convenient package. Full documentation and tutorials were released in April, 2006, by the Southwest Watershed Research Center at Tucson, AZ, and can be downloaded at <http://www.tucson.ars.ag.gov/agwa>.

**IMPACT/OUTCOME 1:** AGWA currently has over 1200 users from local, State and Federal agencies, universities, environmental groups, and consulting firms; over 75 countries are using this decision support tool. The decision aid is available through the U.S. EPA Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) water quality website: <http://www.epa.gov/waterscience/BASINS/>. The AGWA decision aid is being used by watershed managers to develop basin wide plans to meet local and national water quality standards.

**ACCOMPLISHMENT 2:** Three computer-implemented ARS erosion prediction models were combined and improved (the Water Erosion Prediction Project (WEPP), the Revised Universal Soil Loss Equation (RUSLE), and the Kinematic Runoff and Erosion Model (KINEROS) into a single object orientated soil erosion model for use by NRCS. This was a combined effort of ARS and NRCS scientists at West Lafayette, IN, Oxford, MS, Boise, ID, Tucson, AZ and Ft. Collins, CO.

**IMPACT/OUTCOME 2:** This new model is being adopted by NRCS to support the implementation of the Conservation Security Program on cropland watersheds across the Nation.

**ACCOMPLISHMENT 3:** ARS scientists in Tucson, AZ, developed the world's largest rangeland erosion database with over 2000 rainfall-erosion events. This information was used to develop the internet-based Hillslope Erosion Mode (HEM) for use on rangelands. The HEM model is available at <http://eisnr.tucson.ars.ag.gov>.

**IMPACT/OUTCOME 3:** The model is being used by the NRCS and BLM across the western United States to improve the management and productivity of rangelands.

**ACCOMPLISHMENT 4:** Ecosystems in agricultural watershed streams throughout the US have been degraded by severe erosion, but the links between ecological damage and erosion are often unclear, complicating restoration planning. ARS scientists at Oxford, MS, studied one form of erosion-related stream damage, examining streambed carbon concentrations and fish communities in four streams in northern MS with varying degrees of channel erosion. In general,

lightly degraded streams had higher carbon concentrations and more natural, diverse fish communities, suggesting that rehabilitation of stream ecosystems requires restoring riparian vegetation and in-channel features that retain carbon-rich debris and sediments.

**IMPACT/OUTCOME 4:** These findings are being used by the Natural Resources Conservation Service in planning and designing stream channel restoration and management in the southeastern United States.

**6.1.1 SUMMARY OF THE MAJOR TECHNOLOGIES DEVELOPED, TRANSFERRED, AND USED IN FY 2006:**

**DURING FY 2006, ARS**

reported two agricultural practices and technologies developed and used by customers to enhance water quality and availability.

**DESCRIBE THE TECHNOLOGY 1:**

**DESCRIBE THE TRANSFER 1:**

**IDENTIFY THE CUSTOMER/USER 1:**

**IMPACT/OUTCOME 1:**

**DESCRIBE THE TECHNOLOGY 1:**

**DESCRIBE THE TRANSFER 1:**

**IDENTIFY THE CUSTOMER/USER 1:**

**IMPACT/OUTCOME 1:**

**OBJECTIVE 6.2: Improve Soil and Air Quality To Enhance Crop Production And Environmental Quality**

**Performance Measure 6.2.1:** Develop practices and technologies to enhance soil resources and reduce emissions of particulate matter and gases from crop production lands, processing operations, and animal production systems.

**Indicators:**

**DURING FY 2006, ARS will**

*assess the potential risks and benefits to agricultural systems that may arise from global change, and develop agricultural management practices and decision support strategies that enable producers to take advantage of beneficial effects and mitigate adverse impacts.*

**ACCOMPLISHMENT 1:** Climate variations can greatly affect the productivity of winter wheat-grazing operations of the Southern Great Plains. A climate impact assessment tool is needed to evaluate planning and management alternatives in terms of forecasted climate conditions. A new grazing-cattle growth model was developed and incorporated into a commercial wheat production model for this purpose.

**IMPACT/OUTCOME 1:** Use of the wheat production and grazing model provides the means to plan and manage wheat-grazing systems under anticipated climate variations and forecasts and will help producers adapt to changing global climate conditions.

**ACCOMPLISHMENT 2:** Increased atmospheric carbon dioxide concentration has been shown to enhance carbon supply in the above ground (shoot) plant components of wheat. However, the interaction of the effects of water stress and nitrogen under elevated carbon dioxide conditions are unknown. Research by ARS scientists at the U.S. Arid Land Agricultural Research Center in Maricopa, Arizona, showed that elevated carbon dioxide and ample water and nitrogen (N) increased root and shoot mass by 18 percent and 16 percent, respectively. Under drought conditions, elevated atmospheric carbon dioxide caused an increase of root exploration into deeper soil layers, whereas under N deficits it increased root growth in the upper soil layers.

**IMPACT/OUTCOME 2:** These results will enhance our ability to adapt wheat crop production management to increasing atmospheric carbon dioxide by better managing water and N resources.

**ACCOMPLISHMENT 3:** Concerns about global change have centered on the rapid increase in atmospheric concentrations of primary greenhouse gases carbon dioxide, methane and nitrous oxide. A state-of-the-state report on global change in rangelands and pasturelands identifies three significant advances in understanding how plants and soil respond to increasing atmospheric carbon dioxide, as well as how land management practices can mitigate global change: 1) elevated carbon dioxide levels can significantly impact rangeland plant community dynamics, increase water use efficiency and reduce nitrogen content of the plant material; 2) land management practices—such as grazing, fertilization, fire, and introduction of legumes and improved grass species—can increase soil organic carbon storage in rangelands and pasturelands; and 3) the development of non-interference methods may be effective for monitoring methane emissions from isolated animals in large feedlots.

**IMPACT/OUTCOME 3:** These findings will aid scientists in developing improved agricultural management practices to account for global climate change.

*identify the processes that control the rate at which agricultural systems release and absorb greenhouse gases, and develop agricultural management practices that contribute to reductions in the Nation's net greenhouse gas emissions.*

**ACCOMPLISHMENT 1:** Substantial greenhouse gas (GHG) emission reductions in confined swine operations can result when anaerobic swine lagoons are replaced with advanced technologies that use aerobic treatment. A swine wastewater treatment technology developed by ARS scientists in Florence, South Carolina and industry cooperators reduces or eliminates ammonia emissions, nutrient losses, odors, and pathogens. In addition, this system is more effective than anaerobic lagoons and anaerobic digesters reducing GHG emissions. Replacing an anaerobic lagoon at a 4,360-head swine operation with the new treatment technology reduced GHG emissions from 4,972 tons of carbon dioxide equivalents per year to 50 tons of carbon dioxide equivalents per year.

**IMPACT/OUTCOME 1:** This GHG reduction translates into a direct economic benefit to the producer of approximately \$4.50 per pig capacity per year at a Chicago Climate Exchange trading value of \$4 per ton of carbon dioxide equivalent emissions reduction. GHG emission reduction credits can compensate for the higher installation cost of new aerobic treatment systems and will encourage producers to replace anaerobic lagoons with environmentally superior technologies.

**ACCOMPLISHMENT 2:** Measuring the exchange of greenhouse gases such as nitrous oxide between the soil and atmosphere is key to assessing the effects of farming practices on global climate. ARS scientists from the Air Quality and Agricultural Systems Research Laboratory in Ames, Iowa, measured nitrous oxide emissions from corn-soybean systems with full width tillage, no-till, and no-till with rye winter cover crop for two years. No significant tillage or cover crop effects on nitrous oxide emission were observed. However, comparing the actual measurements with estimates calculated using the Intergovernmental Panel on Climate Change default emission factor indicated that the estimated fluxes underestimate the measured emissions at the Iowa sites by a factor of three.

**IMPACT/OUTCOME 2:** The research indicates that worldwide assessments of nitrous oxide greenhouse gas emissions may seriously underestimate the actual emissions amounts, and that a reassessment of the impact of nitrous oxides from agriculture on global climate is needed.

*develop management practices and technologies which control pathogenic microorganisms in manure that may threaten human health.*

**ACCOMPLISHMENT 1:** Water and foodborne pathogens can pose a significant threat to human health, as illustrated by the recent problems associated with *E. coli* 0157:H7 contamination of spinach. Methods are needed to detect *E. coli* 0157:H7 in a variety of matrices and to minimize its survival and transport in the environment. ARS scientists from Riverside, California, have developed a methodology that allows them to quantify *E. coli* 0157:H7 at levels less than 100 cells per gram of soil, manure, or water. This method was used to demonstrate that *E. coli* 0157:H7 can survive at least 45 days in soil even if the moisture content is as low as three percent. This information suggests that aggressive methods will be needed to control *E. coli* 0157:H7 in the environment. Scientists from Mississippi State, Mississippi have identified and collected viruses called bacteriophages from swine lagoons. These bacteriophages kill *Salmonella*, a pathogen that can infect humans and animals.

**IMPACT/OUTCOME 1:** Information gained in these studies will contribute to the development of management practices to limit survival and transport of pathogenic microorganisms to water or food sources where they may threaten human health.

**ACCOMPLISHMENT 2:** ARS scientists from Kimberly, Idaho found that treatment of wastewater and irrigation tailwater with polyacrylamide (PAM) polymer is highly effective in removing fecal coliforms. Their research demonstrated that treatment of wastewater with PAM, PAM + alum, or PAM + hydrated lime reduced fecal coliforms released from cattle, fish or swine manure by 99%.

**IMPACT/OUTCOME 2:** USDA Conservation Programs already provide financial incentives for use of PAM to control sediment in irrigation water runoff. The ability of PAM to remove manure pathogens from wastewaters is an added benefit of this treatment.

*develop management practices and technologies which control pathogenic microorganisms in manure that may threaten human health.*

**ACCOMPLISHMENT 1:** Soils degraded by human activities and natural processes cannot effectively support crop production or vegetative cover, require greater inputs to establish and maintain plant production, and pose a threat to the environment. The U.S. Army has significant land areas that require remediation due to physical, chemical, and biological soil constraints resulting from military training activities. ARS scientist from Auburn, Alabama, are working with the U.S. Army Corp of Engineers to remediate degraded sites at Fort Campbell, Kentucky, and Fort Benning, Georgia, using an “aggregate cellulose pulp” made from solid waste generated at military bases. The pulp byproduct has improved soil conditions and resulted in enhanced plant growth.

**IMPACT/OUTCOME 1:** Beneficial use of this material will reduce disposal costs at Army bases by \$100 million per year and will provide environmental benefits through remediation of military lands.

*develop practices which remediate degraded soils.*

**ACCOMPLISHMENT 1:** Sandy soils in semi-arid regions are susceptible to wind erosion and reduced soil quality as a result of agricultural operations. ARS scientists at Lubbock, Texas, measured the impact of conservation tillage, conventional tillage, conservation grassland, and native rangeland on soil properties considered important for crop production, including soil aggregation and soil organic carbon. They found that long-term conservation tillage management provided more favorable soil chemical, biological, and physical properties for ecosystem functioning than conventionally tilled systems. The study showed that conservation tillage in the Texas High Plains was as beneficial to soils as placing the soils in a grassland reserve.

**IMPACT/OUTCOME 1:** This information could help conservation planners suggest the appropriate USDA Conservation Program—either the Conservation Security Program or the Conservation Security Program--for producer participation.

**ACCOMPLISHMENT 2:** Loss of organic matter is a major cause of soil degradation. Tools are needed to predict changes in soil carbon storage in agricultural systems. ARS scientists at Pendleton, OR and Fort Collins, CO have developed a carbon sequestration model (CQESTR) to predict the effect of cropping systems, management practices, climate and soil conditions on carbon storage in agricultural soils. The model has been delivered to the Natural Resources Conservation Service (NRCS) for beta testing and evaluation.

**IMPACT/OUTCOME 2:** CQESTR will help advisors and land managers predict field scale carbon sequestration to assess soil quality improvements and to provide information for soil carbon credit trading.

*develop practices and approaches which mitigate the detrimental effects of tropospheric ozone on agricultural crops.*

**ACCOMPLISHMENT 1:** Ground-level ozone concentrations are sufficient to suppress crop yields in many agricultural areas and may increase to the point where crops such as soybeans may suffer significant yield losses. Thirty soybean ancestors representing a majority of genes in modern U.S. cultivars were screened for ozone sensitivity under greenhouse conditions by scientists of the ARS Plant Science Research Unit and the ARS Soybean and Nitrogen Fixation

Research Unit in Raleigh, North Carolina. Two ancestors exhibited minimal ozone injury following a 5-day exposure to elevated ozone levels.

**IMPACT/OUTCOME 1:** These ozone-tolerant ancestors could represent sources of genes for development of new ozone tolerant cultivars to maintain current levels of productivity under future climate scenarios where ambient ozone concentration are expected to be much higher than current levels.

#### **6.1.2 SUMMARY OF THE MAJOR TECHNOLOGIES DEVELOPED, TRANSFERRED, AND USED IN FY 2006:**

##### **DURING FY 2006, ARS**

reported three agricultural practices and technologies to enhance soil and air natural resources will be developed and used by customers and partners.

**DESCRIBE THE TECHNOLOGY 1:** Phosphorus runoff to surface waters and ammonia emissions are two of the biggest problems facing animal production operations. An ARS scientist from Fayetteville, Arkansas discovered that alum (aluminum sulfate), when added to poultry litter in commercial broiler houses greatly lowers ammonia levels in the houses and results in healthier birds. Birds grown in alum-treated houses are significantly heavier, have better feed conversion, lower mortality, and have lower heating costs during winter months since less ventilation is required to remove ammonia. Detailed studies over several years have shown that application of alum treated poultry litter to pastures reduced phosphorus runoff by 75% compared to untreated litter.

**DESCRIBE THE TRANSFER 1:** The alum technology was demonstrated through trials in 15 states involving more than 30 million broilers. The environmental benefits were documented and the technology was recognized as a standard practice eligible for funding through USDA Conservation Programs. The technology was patented, licensed for use, and made commercially available under the trade name AL+Clear.

**IDENTIFY THE CUSTOMER/USER 1:** Customers of this research include poultry producers, poultry integrators, the agricultural chemical industry and the USDA-Natural Resources Conservation Service.

**IMPACT/OUTCOME 1:** The use of alum in poultry houses is very cost-effective; producers make an additional two dollars for every dollar spent. As a result, approximately 15% of the broilers produced annually in the US are grown on alum treated litter. Alum treatment of poultry litter is an approved practice funded by USDA-Natural Resources Conservation Service through the Environmental Quality Incentives Program.

**DESCRIBE THE TECHNOLOGY 2:** Soils contaminated by mining and smelter activities often become barren and severely eroded when soil acidity is combined with zinc, copper and nickel contamination. ARS scientists from Beltsville, Maryland developed "tailor-made" remediation mixtures of biosolids, alkaline byproduct, and oxides of iron and manganese to bind toxic metals. This approach has been used successfully to improve soil properties, bind toxic levels of zinc and restore vegetative cover on Environmental Protection Agency Superfund sites at Palmerton, Pennsylvania and Bunker Hill, Idaho where simple application of chemical fertilizer, limestone and seed did not yield persistent revegetation.

**DESCRIBE THE TRANSFER 2:** ARS scientists worked with university and US-Environmental Protection Agency cooperators to demonstrate the effectiveness of the technology at Superfund sites. The results were documented in scientific manuscripts, reports and presentations to US-Environmental Protection Agency.

**IDENTIFY THE CUSTOMER/USER 2:** Customers of this research include the US-Environmental Protection Agency, consultants and land reclamation contractors.

**IMPACT/OUTCOME 2:** The “tailor-made” mixtures approach has been identified by US-Environmental Protection Agency Superfund managers as a Presumptive Remedy for remediation of metal contaminated soils. The cost of the remediation approach is 100-fold less than the currently used practice of soil removal and replacement, which costs \$1M per acre-foot. There are over 50, 000 sites nationwide that could benefit from this in-situ remediation procedure.

**DESCRIBE THE TECHNOLOGY 3:** Soils in the Southeastern US have poor physical and chemical properties and are susceptible to erosion. Although these soils could greatly benefit from use of conservation tillage, adoption rates of these practices were approximately 15% in the early 1990’s. ARS scientists at Auburn, Alabama developed improved conservation tillage practices reduced erosion, improved water storage and use, reduced contamination of surface waters, reduced energy inputs and increased crop yields. These new systems increased the conservation tillage adoption rates in the Southeastern US to 42.5%.

**DESCRIBE THE TRANSFER 3:** ARS scientists worked with producers, university and USDA-Natural Resources Conservation Service cooperators to develop and evaluate these conservation tillage systems. Information was transferred to customers through field days, extension bulletins, popular press articles and scientific presentations. The conservation tillage system was recognized as a standard practice by USDA-Natural Resources Conservation Service and adoption by producers was promoted by financial and technical assistance provided by USDA Conservation Programs. Information about this technology also was distributed by the Conservation Tillage Information Center.

**IDENTIFY THE CUSTOMER/USER 3:** Customers of this research include producers, consultants, extension agents and USDA-Natural Resources Conservation Service.

**IMPACT/OUTCOME 3:** Increased adoption of conservation tillage systems in the Southeastern US resulted in significant economic and environmental benefits. Using an estimated fuel and labor savings of \$20 per acre, producers received an additional \$40M in annual profit from using these conservation practices. Estimates of off-site benefits of conservation tillage areas high as \$103 per acre based on erosion rates in the Southeast.

**OBJECTIVE 6.3: Conserve And Use Pasture And Rangelands Efficiently**

**Performance Measure 6.3.1:** Improved management practices and technologies for managing and rangelands to improve economic profitability and enhance environmental values.

**Indicators:**

**DURING FY 2006, ARS will**

*provide increased understanding of genetic resources, genomics, and molecular processes of grasses, legumes, and other herbaceous plants that affect establishment, persistence, production and use so that improved germplasm and cultivars can be released for pasture, harvested forages, turf, biofuels, rangeland restoration, and conservation.*

**ACCOMPLISHMENT 1:** On-farm trials are required to determine the economic feasibility of producing Switchgrass as a bioenergy crop in the Eastern Great Plains so the Nation can accurately assess the feasibility of this energy option. ARS scientists at Lincoln, Nebraska, in cooperation with the University of Nebraska, managed and assessed Switchgrass production for 5 years on 10 farms in Nebraska, North Dakota, and South Dakota. Average Switchgrass yield was 3.4 tons/acre with average production cost of \$33/ton, plus \$17/ton for land rent. Prorating the establishment costs over nine years would reduce costs by \$6/ton. Two farmers experienced

in Switchgrass production were able to produce the biomass for less than \$40/ton, including land costs. Given these costs, the farm-gate feedstock cost per gallon of ethanol produced would be about \$0.50 per gallon.

**IMPACT/OUTCOME 1:** These results suggest that Switchgrass is an economically-feasible biofuel crop for agricultural producers, and that its overall economic viability as a biofuel depends on transportation costs to the processing plant and subsequent conversion costs.

**ACCOMPLISHMENT 2:** Eastern gamagrass is a highly productive and digestible native grass with significant potential in livestock and bioenergy production. However, utilizing the potential offered by Eastern gamagrass could be limited by its seed availability. ARS scientists at Woodward, Oklahoma, applied high-throughput molecular genetics techniques to speed the selection of seed production traits. They found a mutant form of gamagrass that only produces female flowers, as opposed to the predominately male type found in the wild.

**IMPACT/OUTCOME 2:** Identifying the mutant form caused by recessive genes and identifying suitable plants to cross will allow scientists to develop gamagrass varieties that will greatly increase seed production, which will provide another option for improving livestock and bioenergy production.

*provide forage and pasture management technologies and strategies that reduce inputs while improving livestock performance and sustaining the environment.*

**ACCOMPLISHMENT 1:** Broom Snakeweed is a native invasive plant that chokes out more desirable vegetation, degrades wildlife habitat, and may cause abortions in cows, sheep and goats. Scientists at Logan, Utah, studied how grazing affected sagebrush plant communities experiencing invasion from Snakeweed. After many years of spring grazing, degradation resulted in dense Wyoming big sagebrush stands, with sandberg bluegrass understory and some Snakeweed. Fall grazing every other year maintained a plant community characterized by a healthy mix of perennial bunchgrass and intermittent big sagebrush that crowded out Snakeweed over a four-year study period. Fire on the spring grazing site knocked out the sagebrush, which allowed Snakeweed to dominate the site. However, fire did not create significant impacts on the fall grazing site.

**IMPACT/OUTCOME 1:** This information provides ranchers and public land managers with grazing management tools to improve rangeland health and protect livestock from abortions caused by a toxic weed.

**ACCOMPLISHMENT 2:** Extending the length of the grazing season significantly increases the profitability of the livestock industry because it reduces the need to feed livestock with hay and other harvested forages. A key factor in determining the length of the grazing season is how quickly forage plants shift from vegetative growth to seed production, when both the quality and quantity of forages drops. ARS scientists at Corvallis, Oregon, working with the University of Florida, have released a new cultivar of Italian Ryegrass called Floregon, an important winter pasture grass in the Southeast. The new cultivar meets the needs of the Oregon seed industry with robust seed production, as well as the needs of Southeastern livestock producers, who want a longer grazing season.

**IMPACT/OUTCOME 2:** An estimated two million pounds of seed will be available for market at the end of the 2007 growing season.

*provide rangeland management technologies and strategies that reduce inputs while improving livestock performance and sustaining the environment, including reducing the risks of wildfires, invasive weeds, and other threats, by stabilizing, restoring, and monitoring degraded rangeland in an affordable and sustainable manner.*

**ACCOMPLISHMENT 1:** Cheatgrass, which has spread across millions of acres of western rangelands, is currently one of the most invasive weeds affecting these rangelands. In just one year in Nevada, over \$80 million was spent fighting wildfires and restoring critical areas damaged by cheatgrass; even more losses were incurred from degraded soil and water resources, burned forages unavailable to wildlife and livestock, and overall ecosystem damage. Botanists used to believe that cheatgrass was self-pollinating and limited in its ability to adapt to changing conditions, such as changes in range management practices. ARS scientists at Reno, Nevada applied molecular genetics techniques to characterize cheatgrass populations and documented that cheatgrass does out-cross to some extent. This cross-pollination between plants results in increased genetic diversity that allows cheatgrass to adapt to new environments more quickly. This discovery may complicate future attempts at controlling cheatgrass but the out-crossing between plants may open up new lines of controls based on genomic manipulation.

**IMPACT/OUTCOME 1:** This information will let scientists and land managers develop methods of controlling cheatgrass more effectively by applying limited funds to the most promising avenues of control.

**ACCOMPLISHMENT 2:** Wildfires, droughts, and other agents of ecosystem degradation strip the land of vegetation essential for protecting watersheds, providing wildlife habitat, feeding livestock, and enhancing recreational activities. Following degradation, managers need affordable seeds from native vegetation that have a high probability of successful establishment and that will conserve biodiversity. ARS scientists at Logan, Utah, have released a new variety of Slender Wheatgrass, a key restoration species, called FirstStrike.

**IMPACT/OUTCOME 2:** In field trials in Idaho, Utah, and Wyoming, FirstStrike proved to be equal to or superior to other commercial varieties in seedling establishment, number of seedlings per unit area, initial stand and persistence, and dry matter yield. FirstStrike has been adapted by 42 Department of Defense facilities encompassing 1.3 million acres of land regularly reseeded following training exercises.

### **6.3.1: SUMMARY OF THE MAJOR TECHNOLOGIES DEVELOPED, TRANSFERRED, AND USED IN FY 2006:**

#### **DURING FY 2006, ARS**

reported five new technologies or strategies provided to pasture, forage and range land managers and used to conserve and restore natural resources while supporting profitable production.

**DESCRIBE THE TECHNOLOGY 1:** A new grass variety 'Cache' meadow brome grass intended for grazing and hay production on irrigated pastures in the Intermountain West was developed by a research team at the USDA-ARS, Forage and Range Research Laboratory at Utah State University, Logan, UT. It was released on 2 Feb. 2004 in cooperation with the Utah Agricultural Experiment Station. This new variety of brome grass has enhanced seedling establishment with increased forage yields on irrigated and semi-irrigated pastures in the Intermountain Region and Northern Great Plains of western U.S.A

**DESCRIBE THE TRANSFER 1:** Cache meadow brome grass was a public release with no proprietary restrictions. Plant protection under the U.S. Plant Variety Protection Act has been applied for so the seed can only be marketed as certified seed to ensure quality. Foundation seed is being produced by the USDA-ARS at Logan and distributed to seed growers by the Utah Crop Improvement Association.

**IDENTIFY THE CUSTOMER/USER 1:** Seed growers and seed companies benefit from the production and sale of certified seed. Private farmers/ranchers benefit economically as a result of

increased forage productivity and animal carrying capacity on pasture lands that are environmentally sustainable.

**IMPACT/OUTCOME 1:** Bases on sales and commitments through spring 2007, a total of 3,750 lbs of Foundation Seed have been distributed through Utah Crop Improvement Association. Foundation Seed is used to grow certified seed to be marketed to farmers and ranchers. Certified seed produced from 3,750 pounds of Foundation Seed will have an approximate market value of \$469,000 annually for the life of the seed field (about 5 years). Sufficient certified seed will be available to seed about 900,000 acres of pasture annually and the use of this improved grass will result in increased production of livestock products cost effectively.

**DESCRIBE THE TECHNOLOGY 2:** New protocols for the rangelands component of the National Resources Inventory (NRI) conducted by the USDA Natural Resources Conservation Service (NRCS) were developed by ARS scientists at the Jornada Experimental Range in Las Cruces, New Mexico, and integrated with existing NRI protocols developed by NRCS and other scientists. Plot sampling for several protocols was modified, redundant protocols were eliminated to reduce field time without a significant reduction in statistical power for reporting, and quality control procedures were developed to increase data quality.

**DESCRIBE THE TRANSFER 2:** Jornada ARS scientists had worked closely for many years with NRCS personnel to test, demonstrate, and finalize protocols in a multi-state pilot project. From 2003-2006 ARS scientists assisted NRCS in increasing sampling efficiency and providing training to NRCS field personnel.

**IDENTIFY THE CUSTOMER/USER 2:** In the short-term, NRCS-RIAD (Resource Inventory and Assessment Division) and other NRCS programs benefited from the availability of scientifically supported inventory protocols that are more cost effective and meet the recommendations of the 1994 National Research Council report, *"Rangeland Health: New Methods to Classify, Inventory, and Monitor Rangelands"*. In the long-term, the data will be used to prepare national reports on the status of the nation's rangelands that government agencies and Congress can use with greater confidence to assess the impact of conservation programs and to assist landowners in conservation and land management.

**IMPACT/OUTCOME 2:** The protocols have been universally applied by NRCS at over 10,000 sampling points on approximately 400 million acres of rangelands in the continental United States. The data were collected at lower cost with an average savings of 4 person hours per plot, or a reduction of 38% in time required, and with a higher confidence in data quality.

**DESCRIBE THE TECHNOLOGY 3:** A new native grass variety, FirstStrike Slender Wheatgrass, was released by ARS scientists at Logan, Utah for use in rehabilitating degraded rangelands to provide vegetation for livestock and wildlife while protecting watersheds.

**DESCRIBE THE TRANSFER 3:** FirstStrike was a public release with no proprietary restrictions. Plant protection under the U.S. Plant Variety Protection Act has been applied for so the seed can only be marketed as certified seed to ensure quality. Foundation seed is being produced by the USDA-ARS at Logan and distributed to seed growers by the Utah Crop Improvement Association.

**IDENTIFY THE CUSTOMER/USER 3:** Public land managers; ranchers; and, seed producers.

**IMPACT/OUTCOME 3:** The Department of Defense has adopted FirstStrike for use on 42 of its installations that encompass 1.3 million acres of land that needs to be regularly reseeded following training exercises.

**DESCRIBE THE TECHNOLOGY 4:** Analysis of on-farm trials determined the economic feasibility of producing Switchgrass as a bioenergy crop in the Eastern Great Plains. ARS scientists at Lincoln, Nebraska, in cooperation with the University of Nebraska, managed and

assessed Switchgrass production for 5 years on 10 farms in Nebraska, North Dakota, and South Dakota. Average Switchgrass yield was 3.4 tons/acre with average production cost of \$33/ton, plus \$17/ton for land rent. Prorating the establishment costs over nine years would reduce costs by \$6/ton. Two farmers experienced in Switchgrass production were able to produce the biomass for less than \$40/ton, including land costs.

**DESCRIBE THE TRANSFER 4:** Demonstration, publications and presentations.

**IDENTIFY THE CUSTOMER/USER 4:** Government policy makers and private investors who need to make investments to meet the nation's renewable energy goals in a timely and cost-effective manner.

**IMPACT/OUTCOME 4:** The Nation can more accurately assess the feasibility of the switchgrass energy option based the results of this analysis that the farm-gate feedstock cost per gallon of ethanol produced would be about \$0.50 per gallon. These results indicate that Switchgrass is an economically-feasible biofuel crop for farmers, but its overall economic viability as a biofuel also depends on transportation costs to the processing plant and subsequent conversion costs.

**DESCRIBE THE TECHNOLOGY 5:** ARS scientists at Corvallis, Oregon working with the University of Florida have released a new cultivar of Italian Ryegrass called Floregon to provide winter pasture for livestock in the southeastern states.

**DESCRIBE THE TRANSFER 5:** Floregon was released by ARS. Plant protection under the U.S. Plant Variety Protection Act has been applied for so the seed can only be marketed as certified seed to ensure quality. Seed has been distributed to four growers and five seed companies. In addition to marketing Floregon seed companies will use the variety in their own breeding programs.

**IDENTIFY THE CUSTOMER/USER 5:** Seed producers and livestock producers in the southeastern states.

**IMPACT/OUTCOME 5:** Seed growers expect to harvest 22,000 - 25,000 lbs of Foundation Seed in 2007. This seed is worth about \$2.50/lb. This Foundation Seed will be planted for certified seed production in 2008 and is projected to produce about 6,250,000lbs of seed. At \$0.32/lb, this would provide \$2million market value and over time this quantity of seed could be used to plant about 312,500 acres for forage production.

**MANAGEMENT INITIATIVE 1: Ensuring The Quality, Relevance, And Performance Of ARS Research (Covers All Research Objectives)**

**Means and Strategies:** To successfully accomplish the research activities under this initiative, ARS will need the resources reflected in the table above.

**Verification and Validation:** ARS currently conducts a series of review processes designed to ensure the relevance and quality of its research work, and to maintain the highest possible standards for its scientists. A more detailed description of the evaluation plans can be found in the introduction to this plan.

**OBJECTIVE 6.3: Provide Mechanisms To Ensure The Relevance, Quality, And Performance Of The ARS Research Program.**

<p><b>Performance Measure MI 1.1:</b> Relevance—ARS' basic, applied, and developmental research programs are well conceived, have specific programmatic goals, address high priority national needs, and have direct relevancy in achieving ARS' long-term goals.</p>
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**Indicators:**

**DURING FY 2006, ARS will**

**DURING FY 2007, ARS will**

**DURING FY 2008, ARS will**

**DURING FY 2009, ARS will**

**Performance Measure MI 1.2:** Quality: ARS' research projects are reviewed for quality by National Program using independent external peer review panels for quality at the beginning of the 5-year program cycle.

**Indicators:**

**DURING FY 2006, ARS will**

*report summary information on the number and percentage of projects reviewed for prospective quality, and the number in each Office of Scientific Quality Review (OSQR) category; summary data from the Research Position Evaluation System (RPES) peer reviews of agency scientists.*

**Performance Measure MI 1.3:** Performance: ARS will monitor the percentage of annual research project milestones met.

**Indicators:**

**DURING FY 2006, ARS will**

*report summary information that measures specific activities that indicate, to some extent, how well the overall ARS research program is performing. These activities include the number of papers published, number of CRADAs executed, number of patents issued, number of licenses granted, and the number of new plant varieties and breeding lines released. ARS asks each research leader to assess his/her project's progress against their currently approved milestones; and to indicate whether each milestone was fully met, substantially met, or not met. An explanation of why a milestone is not met is also requested.*

**MANAGEMENT INITIATIVE 2: Ensure Provision And Permanent Access Of Quality Agricultural Information For USDA, The Nation, And The Global Agricultural Community Via The National Agricultural Library.**

<b>GOAL 6 MANAGEMENT INITIATIVES</b>	<b>FY 2006</b>	<b>FY 2006</b>	<b>FY 2008</b>
National Agricultural Library	\$21,813	\$24,970	\$Not Available
<b>Total</b>	<b>\$21,813</b>	<b>\$24,970</b>	<b>\$Not Available</b>

NOTE: Dollars in Thousands.

**Means and Strategies:** To successfully accomplish the research activities under this initiative, ARS will need the resources reflected in the table above.

**Verification and Validation:** ARS currently conducts a series of review processes designed to ensure the relevance and quality of its research work, and to maintain the highest possible standards for its scientists. A more detailed description of the evaluation plans can be found in the introduction to this plan.

**OBJECTIVE 6.1: Provide Rapid, Comprehensive, and Long-Term Access to the Full Range of Agricultural Information Resources Through a Variety of National Agricultural Library (NAL) Delivery Systems, with Particular Emphasis on Digital Technologies.**

**Performance Measure MI 2.1:** The services and collections of the National Agricultural Library continue to meet the needs of its customers.

**Indicators:**

**DURING FY 2006, NAL will**

*continue to expand and improve services based on customer usage and satisfaction data.*

**ACCOMPLISHMENT 1:** The Library's total volume of direct customer services grew to over 92 million transactions in FY 2006, a more than 7 percent increase from FY 2005, largely because of increased usage of NAL Web-based products and services. Due to new technology that reduces the number of steps needed to find information on the NAL Web site, the rate of increase in NAL Web hits slowed in FY 2006, and this pattern may continue over the next few years. The redesign and migration of the NAL Web site [www.nal.usda.gov](http://www.nal.usda.gov) following new USDA style guidelines was a major priority for NAL in 2006. In order to accomplish this major priority, an organizational structure to provide leadership and facilitate communications was implemented, and was comprised of an Oversight Committee and six teams: External Relations and Requirements, Existing Web Pages, Landing and Sub-landing Pages, IT Assistance, NAL-Created Web Content Archiving, and the Web Site Taxonomy and Metadata. NAL staff met all USDA-mandated migration deadlines by developing software tools, content templates, and style guidelines needed to transition NAL's 64,000 page Web presence.

**IMPACT/OUTCOME 1:** The new NAL Web site requires fewer steps to find information and also includes a single search box (developed for [www.science.gov](http://www.science.gov)) to allow users to search NAL databases (such as AGRICOLA) as well as Web pages. NAL developed new and formalized existing Librarywide practices for linking to public facing Web sites. These practices guide agency functions, assure adherence to appropriate quality standards, and comply with maintenance standards required by OMB and USDA.

**ACCOMPLISHMENT 2:** During FY 2006, NAL continued to refine and expand digital content subscription offerings to USDA employees around the world through the USDA Digital Desktop Library service (DigiTop). A new metasearch tool called Central Search was deployed to enhance access and retrieval of DigiTop resources. Numerous in-person and virtual training sessions were conducted at USDA locations throughout the country. During FY 2006, NAL added new scientific journal articles and retrospective backfiles for over 2,660 titles, significantly increasing and expanding the value of this popular service to USDA. NAL continues to pursue

sustained funding from USDA agencies to support future development and availability of USDA access to DigiTop beyond FY 2006. Agencies contributed a total of \$2.5 million to NAL for this purpose. During FY 2006, the Library's DigiTop-Current Awareness Literature Service integrated current awareness alert services through Dialog and EBSCO, and expanded the USDA user base for the current awareness chargeback services. Further, the USDA DigiTop service integrated full-text (context sensitive) links to select DigiTop subscribed databases using software from Serial Solutions. NAL implemented federated cross-searching solutions to increase the effectiveness of DigiTop user experience. In addition, the DigiTop Web site was redesigned for increased accessibility.

**IMPACT/OUTCOME 2:** Usage of DigiTop resources continues to increase at a rate of about 13% annually. A total of 678,000 articles were downloaded by USDA employees in FY 2006, indicating the success of this enhanced service.

**ACCOMPLISHMENT 3:** The NAL cataloging branch is recognized as the premier national authority for description of agricultural books and periodicals. The metadata NAL catalogers create the fundamental building block that permits the identification and retrieval of agricultural information relied upon by libraries across the nation and around the world. In FY 2006, NAL began a partnership with the Library of Congress through which NAL helps catalog new agricultural books prior to their publication. Working from electronic galleys of the book, NAL prepares catalog metadata for inclusion in the printed books. In return, NAL receives a copy of the published work at no charge.

**IMPACT/OUTCOME 3:** When in full operation, this program will permit NAL to acquire 1,000-1,500 books per year with a value of \$50,000 to \$75,000.

**ACCOMPLISHMENT 4:** Examples of products and services developed in 2006 include an Agricultural History research guide; soybean rust disease Web pages; search strategies for the IBIDS dietary supplements database; an "Organic Roots" database of USDA documents on organic agriculture published before 1942 (before synthetic chemicals became widely used); dynamic bibliographies on CEAP (USDA Conservation Effects Assessment Project) topics and comprehensive bibliographies on wetlands and grazing lands; BooleanCUBE (Boolean Canned URL-Based Experience), which allows complex searches of AGRICOLA and creates permanent URLs that re-run searches with just a mouse click; a biofuels weblog and new content on funding sources available for construction of ethanol and biodiesel plants; and extensive database searches to support a utility locating technology project. Also in 2006, the "DigiKnow?" Information Makeover Series was launched. This series of presentations at the USDA South Building NAL Reference Center addresses topics of interest to the USDA community while featuring NAL resources and services. "DigiKnow?" 2006 presentations covered such topics as obesity prevention, benefits of whole grains, invasive garden species, community supported agriculture, key databases in DigiTop, document delivery, and highlights from the library's Special Collections.

**IMPACT/OUTCOME 4:** These expanded services promise to improve NAL's capacity to meet the needs of its customers.

<p><b>Performance Measure MI 2.2:</b> The National Agricultural Library and partners implement the National Digital Library for Agriculture.</p>
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**Indicators:**

**DURING FY 2006, NAL will**

*continue to increase the amount and types of agricultural information covered by AGRICOLA, particularly online full text publications, reduce the time required for indexing top priority journal articles, and improve ways of finding information in AGRICOLA.*

**ACCOMPLISHMENT:** AGRICOLA ([agricola.nal.usda.gov](http://agricola.nal.usda.gov)) is the catalog and index to the collections of NAL, as well as a primary free of charge public source for worldwide access to agricultural information. NAL has completed a process of redefining the scope of the AGRICOLA indexing operation to reflect the Library's current capacity and capabilities. Rather than pursue a goal of comprehensiveness, AGRICOLA will focus on indexing information that directly supports the operations of NAL and serves customer needs as much as possible. The combination of items will include USDA publications, articles authored by USDA scientists, core agricultural serial titles, as well as digital and printed content material not indexed by commercial indexing services.

**IMPACT/OUTCOME:** The re-scoped AGRICOLA index will continue to serve as the search tool to access NAL's collections and as the search portal to the National Agricultural Library Digital Repository.

**Performance Measure 6.1.3:** Ensure long-term access to the resources of the NAL NDLA.

**Indicators:**

**DURING FY 2006, NAL will**

*continue to preserve, protect, and secure its national collection of agricultural information.*

**ACCOMPLISHMENT 1:** In 2005, the Library began formal consultations with customers, stakeholders, and potential partners about developing the National Digital Library for Agricultural (NDLA). In 2006, the Library began development of a Web site, expected to be launched by early 2007, for display and testing of a design concept for the NDLA.

**IMPACT/OUTCOME 1:** The NDLA website will ensure that long-term accessibility of NAL resources.

**ACCOMPLISHMENT 2:** In 2005, the Library began formal consultations with customers, stakeholders, and potential partners about developing the National Digital Library for Agricultural (NDLA). In 2006, the Library began development of a Web site, expected to be launched by early 2007, for display and testing of a design concept for the NDLA.

**IMPACT/OUTCOME 2:** The new Web site will help ensure that NDLA resources are accessible over the long term.

**MANAGEMENT INITIATIVE 2: ENSURE PROVISION AND PERMANENT ACCESS OF QUALITY AGRICULTURAL INFORMATION FOR USDA, THE NATION, AND THE GLOBAL AGRICULTURAL COMMUNITY VIA THE NATIONAL AGRICULTURAL LIBRARY**

GOAL 6 MANAGEMENT INITIATIVES	FY 2006	FY 2007	FY 2008
National Agricultural Library	\$21,813	\$24,970	\$Not Available
<b>Total</b>	<b>\$21,813</b>	<b>\$24,970</b>	<b>\$Not Available</b>

NOTE: Dollars in Thousands.

**Means and Strategies:** To successfully accomplish the research activities under this initiative, ARS will need the resources reflected in the table above.

**Verification and Validation:** NAL collects information about customer satisfaction with its Web-based services by using a Foresee Results American Customer Satisfaction Index (ASCI) survey approved by OMB for Federal Web sites. Data are also gathered on a continuous basis about

the volume of direct customer service transactions, and about customer information needs via OMB-approved surveys.

**Performance Measure 6.2.1:** The services and collections of the National Agricultural Library continue to meet the needs of its customers.

**Indicators:**

**DURING FY 2006, NAL will**

*continue to expand and improve services based on customer usage and satisfaction data.*

**ACCOMPLISHMENTS:** Customer Needs Assessment. A large-scale Web-based survey approved by OMB was executed in 2006 and received more than 6,000 responses. Valuable data about NAL's current customer base, non-customers, and a high level of satisfaction with current services were recorded and many suggestions for new services were received.

**IMPACT/OUTCOME:** The data from the survey, along with results from the ACSI (American Customer Satisfaction Index) survey that is integrated with the NAL Web site, will enable NAL management to align NAL operations to meet customer needs.

**ACCOMPLISHMENTS:** Increased volume of direct customer services. In FY 2006 the total volume of NAL direct customer service transactions increased to more than 93 million transactions, about 9 per cent.

**IMPACT/OUTCOME:** NAL continued to increase services to its broad and large customer base, with an emphasis on digital information products and services.

**ACCOMPLISHMENTS:** E-metrics. NAL staff improved a management statistics database that enables analysis of cost and usage statistics pertaining to electronic reference sources, full text and non-full text journals, Web sites and catalogs, books, and digitized materials in support of the Association of Research Libraries' E-metrics project. The database was made available to other ARL member libraries.

**IMPACT/OUTCOME:** By developing this data resource, NAL simplified data collection and provided a mechanism for accessing and analyzing key statistical measures on demand that could also be useful for other major research libraries. With this new resource, NAL management is equipped to improve services and identify and act upon trends.

**ACCOMPLISHMENTS:** Web Migration. In 2006, NAL completed the Web migration project for the NAL Web sites-[www.nal.usda.gov](http://www.nal.usda.gov) – in order to conform to new USDA style guidelines and improve services delivered via the Web site. The redesign and migration of the NAL Web site [www.nal.usda.gov](http://www.nal.usda.gov) following new USDA style guidelines was a major priority for the Library. An organizational structure to provide leadership co-ordination and facilitate communications was implemented, comprised of an Oversight Committee and six teams: External Relations and Requirements; Existing Web Pages; Landing and Sub-landing Pages; IT Assistance; NAL-Created Web Content Archiving; and the Web Site Taxonomy and Metadata. NAL staff met all USDA- mandated migration deadlines by developing software tools, content templates, and style guidelines needed to transition NAL's 64,000 page Web presence. The new NAL Web presence includes functionality that reduces the number of click-throughs needed to find information and also supports searching of NAL databases (such as AGRICOLA) as well as Web pages, from a single search box (functionality initially developed for [www.science.gov](http://www.science.gov)). Due to new technology that reduces the number of click-throughs needed to find information on the NAL Web site, the rate of increase in NAL Web hits slowed in FY 2006 and this pattern may continue over the next few years. NAL developed new and formalized existing Library-wide practices for linking to public

facing Web sites. These practices guide agency functions, assure adherence to appropriate quality standards, and comply with maintenance standards required by OMB and USDA.

**INPACT/OUTCOME:** Customers now can find NAL's Web-based information more easily and quickly. The redesigned Web site improves services for NAL customers with organization of the site by subject and enhanced search functionality that permits searching of all the databases and Web pages of the site from a single search box. The redesigned Web site serves as a gateway connecting users swiftly with the services of NAL and with the billions of pages of agricultural information within NAL collections and information resources.

**ACCOMPLISHMENTS:** DigiTop and DigiCALS. During FY 2006, NAL continued the refinement and expansion of digital content subscription offerings to USDA employees throughout the world through the USDA Digital Desktop Library service (DigiTop). Usage of DigiTop resources continues to increase at a rate of about 13% annually. A total of 678,000 article downloads by USDA employees in FY 2006 indicates the success of this enhanced service. A new metasearching tool called Central Search was deployed to enhance access and retrieval of DigiTop resources. Numerous in-person and virtual training sessions were conducted at USDA locations throughout the country. During FY 2006, NAL added new scientific journal articles and retrospective backfiles for over 2,660 titles, significantly increasing and expanding the value of this popular service to USDA. NAL continues to pursue sustained funding from USDA Agencies to support future development and availability of USDA access to DigiTop beyond FY 2006, the Library's DigiTop-CALS service integrated current awareness alert services through Dialog and EBSCO, and expanded the USDA user base for the current awareness charge-back services. Further, the USDA DigiTop service integrated full-text (context sensitive) linking too select DigiTop subscribed databases using software from Serial Solutions. NAL implemented federated cross-searching solutions to increase the effectiveness of DigiTop user experience. In addition, the DigiTop Web site was redesigned for increased ease-of-use.

**IMPACT/OUTCOME:** More online content was made available to USDA employees. Integration of CALS into DigiTop increases efficiency of USDA customer access to digital services. Improved systems infrastructure reliability and saves customer time, by providing seamless delivery of documents from one integrated source rather that the previous two distinct systems.

**ACCOMPLISHMENTS:** Web-based document delivery. The Library maintained a two-day turnaround time for all document delivery and interlibrary loan requests. The percentage of document delivery requests delivered electronically continues to rise. In FY 2006, 90% of all journal articles supplied by NAL were delivered electronically, an increase of 3% over FY 2005. While NAL will continue to use an array of methods, as requested by our customers, to deliver documents to them, NAL now receives documents requests only via the Web. NAL streamlined document delivery workflow, increased management control over the document fulfillment process, and saved time for customers requesting documents.

**IMPACT/OUTCOME:** NAL maintained its excellent level of document delivery service and saved time for customers requesting documents.

**ACCOMPLISHMENTS:** AGRICOLS Re-scope. AGRICOLA (Agricola.nal.usda.gov) is the online catalog and index to the NAL collections as well as a primary free of charge public source for world-wide access to agricultural information. The value and relevance of AGRICOLA eroded seriously over the last two decades because NAL has been unable to fund AGRICOLA operational production at a level sufficient for maintaining a comprehensive index of agricultural literature. To address this challenge, NAL has completed a process of redefining the scope of the AGRICOLA indexing operation to reflect the Library's current capacity and capabilities. Rather than pursue a goal of comprehensiveness. AGRICOLA will focus on indexing information that directly supports the operations of NAL and serves customer needs as much as possible. The mix of items will include USDA publication, articles authored by USDA scientists, core agricultural serial titles, as well as digital and printed content material not indexed by commercial indexing

services. The re-scoped AGRICOLA index will continue to serve as the search tool to access NAL's collections and as the search portal to AgSpace, the National Agricultural Library's digital repository.

**IMPACT/OUTCOME:** NAL identified a new scope for AGRICOLA which clarified what customers can expect to find in the database.

**ACCOMPLISHMENTS:** Purchasing Books and Journals. The collections of the National Agricultural Library constitute a national treasure and inventory of agricultural information to support USDA and American citizens. Unfortunately, essentially static funding over the past two decades has eroded seriously the Library's budget for purchasing new items for the collections. During this time, the cost of acquiring serials and monographs has increased at rates that exceed core inflation rates and has reduced NAL's materials budget purchasing power by an estimated \$1.6 million. In FY 2006 NAL set a minimum funding level of \$1.8 million for materials purchases, with a goal of ending the erosion of the collections. To fund the minimum level, NAL abolished positions and made other budget reductions. This level is the absolute minimum for NAL's collection purchases, below which there can be no pretense of continuing to build a national collection of agricultural information.

**IMPACT/OUTCOME:** NAL established a minimum funding level for purchasing books and journals, below which there can be no pretense of continuing to build a national collection of agricultural information.

**ACCOMPLISHMENTS:** Cataloging-in-Publication. The NAL cataloging branch is recognized as the premier national authority for description of agricultural books and periodicals. The metadata NAL catalogers create, the fundamental building block that permits the identification and retrieval of agricultural information, are relied upon by libraries across the nation and around the world. In FY 2006, NAL began a partnership with the Library of Congress through which NAL helps catalog new agricultural books prior to their publication. Working from electronic galleys of the book, NAL prepares catalog metadata for inclusion in the printed books. In return, NAL receives a copy of the published work at no charge. When in full operation, this program will permit NAL to acquire 1,000-1,500 books per year with a value of \$50,000 to \$75,000.

**IMPACT/OUTCOME:** NAL and the Library of Congress have minimized duplication of effort and NAL will acquire books at no charge to a value of \$50-75,000.

**ACCOMPLISHMENT:** Special Collections. NAL hosted an exhibition in 2006 of botanical illustration art, *Inspiration and Translation: Botanical and Horticultural Lithographs of Joseph Prestele and Sons*, in conjunction with the Hunt Institute for Botanical Documentation and the US National Arboretum. In addition, a catalog of the exhibition was published. Three new NAL products, based on the nursery and seed trade catalog collection and focusing on cherry blossoms, were produced in collaboration with Galison publishers. Sixteen products based on the Prestele exhibition were developed for sale. A portion of the proceeds funds the conservation treatment of materials within the collection. 2006 conservation activities included creating protective boxes for 700 items too fragile to re-bind, microfilming of 50 requested titles and photo-duplication of ten items which are no longer in a condition to circulate. Also conserved were the papers, watercolors, and lithographs of William Henry Prestele, more than 262 original sketches, watercolors, lithographs, and other works of art, and the sketchbook of Charles Valentine Riley. A collection survey of the USDA Collection and selected rare books was completed by a contract conservator. A collection of nursery catalogs was donated by a retired University of Maryland horticulture professor. The collection includes historic catalogs and two very rare catalogs from Japan which are valued over \$5,000.00 each. NAL staff presented two review sessions of last year's "Reacting to a Water Event" program in preparation for the 2006 hurricane and thunder storm season. NAL is installing the remaining shelving for the Abraham Lincoln building special collections fifth floor and moving its rare and valuable items to this floor while rearranging all collections to accommodate future growth.

**IMPACT/OUTCOME:** NAL continued to highlight and preserve its rare and valuable materials.

**ACCOMPLISHMENTS:** Information Product and Services Development. Examples of products and services developed in 2006 include: an Agricultural History research guide; soybean rust disease Web pages; search strategies for the IBIDS dietary supplements database; an "Organic Roots" database of USDA documents on organic agriculture published before 1942 (before synthetic chemicals became widely used); dynamic bibliographies on CEAP (USDA Conservation Effects Assessment Project) topics and comprehensive bibliographies on wetlands and grazing lands; Boolean CUBE (Boolean Canned URL-Based Experience), which allows complex searches of AGRICOLA and creates permanent URNs that re-run searches with just a mouse click; biofuels Weblog and new content on funding sources available for construction of ethanol and biodiesel plants; and extensive database searches to support a utility locating technology project. The "DigiKnow?" Information Makeover Series was launched. This series of presentations at the USDA South Building NAL Reference Center addresses topics of interest to the USDA community while featuring NAL resources and services. "DigiKnow?" 2006 presentations covered such topics as obesity prevention, benefits of whole grains, invasive garden species, and community supported agriculture, key databases in DigiTop, document delivery, and highlights from the library's Special Collections.

**IMPACT/OUTCOME:** NAL continued to develop and deliver information products and services targeted to the information needs of its customers.

**ACCOMPLISHMENTS:** Information Center Accomplishments. **Alternative Farming Systems Information Center (AFSIC).** Published a third edition of the popular digital publication, "Organic Agricultural Products: Marketing and Trade Resources," a comprehensive guide to more than 1,000 online information resources about organic markets, marketing, and trade, available in pdf and html on a free CD or at the AFSIC Web site: <http://www.nal.usda.gov/afsic>. **Animal Welfare Information Center (AWIC)** staff conducted 2 on-site and 8 external workshops to train people how to search for information about alternatives to the use of animals in research and exhibited at 10 professional meetings. AWIC produced several new Web-based publications, and 7 CD information product on animal diseases, farm and lab animal care and welfare, searching for alternatives to animal use, care of panda and other key topics for those species regulated under the Animal Welfare Act. **Food and Nutrition Information Center (FNIC)** staff developed a database of recipes (<http://foodstamp.nal.usda.gov/recipes.php>) for nutrition educators working with the Food Stamp Program eligible population. Recipe costs are based on information provided by the USDA Economic Research Service (ERS) which purchased data from AC Nielson. The majority of recipes in the database were submitted by nutrition educators in the Food Stamp Program. **Nutrition.gov**, supported by funding from USDA and HHS agencies, received over 3.3 million hits in FY 2006. More web sites are linking to Nutrition.gov with the addition of metadata to enhance search results, resulting in improved visibility. Nutrition.gov received a record high 347,000 hits in February 2006, and a Google search for "nutrition" now shows Nutrition.gov with #1 ranking. **Food Safety Information Center (FSIC)** staff collaborated with the University of Mississippi's National Institute of Food Service Management to develop an online application for generating HACCP forms specific to food service employee needs. As an example of **Rural Information Center (RIC)** services, RIC staff provided information about funding sources to a small medical transportation company which led to the receipt of a grant from one of the foundations. **Technology Transfer Information Center (TTIC)** MTACRADA partner, Artifex Equipment Inc., reported sales of its super slurper book drying product, Zorbix, to a number of major libraries worldwide as well as several private conservators. The WIC Learning Online Module was approved for 3.9 contact hours for nurses by the Maryland Nurses Association. The pilot version of IBIDS Clinical contains bibliographic records describing studies and organizational statements pertaining to three dietary supplements: Chromium, Cinkgo, and Vitamin E.

**MANAGEMENT INITIATIVE 3: Develop A Model Equal Employment Opportunity (EEO) Program That Will Provide Infrastructure Necessary To Create And Maintain A Diversified Workplace Free From Discrimination, Harassment, Or Retaliation, And Characterized By An Atmosphere Of Inclusion And Career Development Opportunities.**

**OBJECTIVE 6.3: ARS is committed to being proactive in the prevention of discrimination by providing, promoting, and maintaining policies and procedures based on EEO laws and regulations for all employees, applicants for employment, and customers.**

**Performance Measure MI 3.1:** Take proactive steps to increase representation of minorities, women, and employees with targeted disabilities in the workforce: improve retention; increase career development opportunities; and increase diversity in award recognition programs. Accountability of being proactive to maintain an environment free from discrimination and harassment.

**Indicators:**

**DURING FY 2006, ARS will**

*provide information and recommendations to the Administrator and Area/Staff Directors on being proactive to maintain an environment free from discrimination and harassment.*

**Performance Measure 6.3.2:** Implement proactive measures to maintain a work environment free from discrimination.

**Indicators:**

**DURING FY 2006, ARS will**

*provide to all employees new/updated EEO civil rights policies and procedures and training on the EEO process. All employees will be held accountable through annual performance ratings.*